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WIN A PICDEM Lab Development Kit – see page 29

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Salvaging the good bits from a cordless drill and putting them to use

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Rolling Code Keyless Entry System Part 2 – Installation and Setting-up

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SEPT 2009 PRINTED IN THE UK

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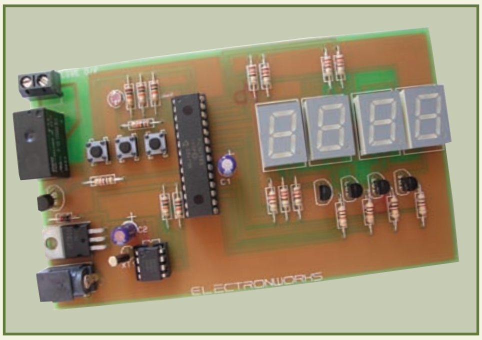
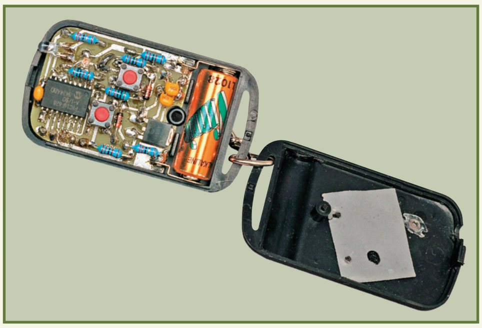
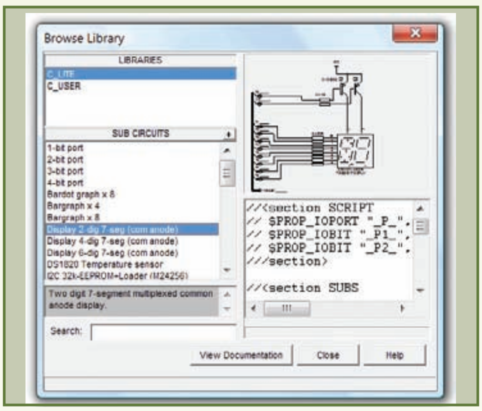






Projects and Circuits

Series and Features

Regulars and Services

Our October 2009 issue will be published on Thursday 10 September 2009, see page 72 for details.

Hot New Products!

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

4-Channel Serial Port Temperature Monitor & Controller Relay Board

4 channel computer serial port temperature monitor and relay controller with four inputs for Dallas DS18S20 or DS18B20 digital thermometer sensors (£3.95 each). Four 5A rated relay channels provide output control. Relays are independent of sensor channels, allowing flexibility to setup the linkage in any way you choose. Commands for reading temperature and relay control sent via the RS232 interface using simple text strings. Control using a simple terminal / comms program (Windows HyperTerminal) or our free Windows application software.
Kit Order Code: 3190KT - **£69.95**
Assembled Order Code: AS3190 - **£84.95**

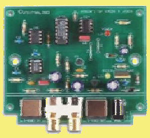
40 Second Message Recorder

Feature packed non-volatile 40 second multi-message sound recorder module using a high quality Winbond sound recorder IC. Stand-alone operation using just six onboard buttons or use onboard SPI interface. Record using built-in microphone or external line in. 8-24 Vdc operation. Just change one resistor for different recording duration/sound quality. sampling frequency 4-12 kHz.
Kit Order Code: 3188KT - **£28.95**
Assembled Order Code: AS3188 - **£36.95**
120 second version also available

Bipolar Stepper Motor Chopper Driver

Get better performance from your stepper motors with this dual full bridge motor driver based on SGS Thompson chips L297 & L298. Motor current for each phase set using on-board potentiometer. Rated to handle motor winding currents up to 2 Amps per phase. Operates on 9-36Vdc supply voltage. Provides all basic motor controls including full or half stepping of bipolar steppers and direction control. Allows multiple driver synchronisation. Perfect for desktop CNC applications.
Kit Order Code: 3187KT - **£39.95**
Assembled Order Code: AS3187 - **£49.95**

Video Signal Cleaner



Digitally cleans the video signal and removes unwanted distortion in video signal. In addition it stabilises picture quality and luminance fluctuations. You will also benefit from improved picture quality on LCD monitors or projectors.
Kit Order Code: K8036KT - **£32.95**
Assembled Order Code: VM106 - **£49.95**

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

Motor Speed Controllers

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

DC Motor Speed Controller (100V/7.5A)

Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£17.95**
Assembled Order Code: AS3067 - **£24.95**

Computer Controlled / Standalone Unipolar Stepper Motor Driver

Drives any 5-35Vdc 5, 6 or 8-lead unipolar stepper motor rated up to 6 Amps. Provides speed and direction control. Operates in stand-alone or PC-controlled mode for CNC use. Connect up to six 3179 driver boards to a single parallel port. Board supply: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£15.95**
Assembled Order Code: AS3179 - **£22.95**

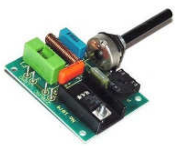
Computer Controlled Bi-Polar Stepper Motor Driver

Drive any 5-50Vdc, 5 Amp bi-polar stepper motor using externally supplied 5V levels for STEP and DIRECTION control. Opto-isolated inputs make it ideal for CNC applications using a PC running suitable software. Board supply: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£23.95**
Assembled Order Code: AS3158 - **£33.95**

Bidirectional DC Motor Speed Controller

Control the speed of most common DC motors (rated up to 32Vdc/10A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections.
Kit Order Code: 3166v2KT - **£22.95**
Assembled Order Code: AS3166v2 - **£32.95**

AC Motor Speed Controller (700W)



Reliable and simple to install project that allows you to adjust the speed of an electric drill or 230V AC single phase induction motor rated up to 700 Watts. Simply turn the potentiometer to adjust the motors RPM. PCB: 48x65mm. Not suitable for use with brushless AC motors.
Kit Order Code: 1074KT - **£14.95**
Assembled Order Code: AS1074—**£23.95**

See www.quasarelectronics.com for lots more motor controllers

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Tools & Test Equipment

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

Two-Channel USB Pc Oscilloscope

This digital storage oscilloscope uses the power of your PC to visualize electrical signals. Its high sensitive display resolution, down to 0.15mV, combined with a high bandwidth and a sampling frequency of up to 1GHz are giving this unit all the power you need.
Order Code: PCSU1000 - **£399.95**

Personal Scope 10MS/s

The Personal Scope is not a graphical multimeter but a complete portable oscilloscope at the size and the cost of a good multimeter. Its high sensitivity - down to 0.1mV/div - and extended scope functions make this unit ideal for hobby, service, automotive and development purposes. Because of its exceptional value for money, the Personal Scope is well suited for educational use.
Order Code: HPS10 - ~~£189.95~~ **£169.95**

See website for more super deals!

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ULTRA-LOW DISTORTION AMPLIFIER MODULE

KC-5470 £27.75 plus postage & packing

Using new ThermalTrak power transistors, this ultra-low distortion amplifier module has no need for a quiescent current adjustment or a Vbe multiplier transistor. Kit supplied with PCB and all electronic components. Heat sink and power supply not included.

Output power: 135WRMS @ 8 ohms & 200WRMS @ 4 ohms
Frequency response: 4Hz to 50kHz, 1m
Harmonic distortion: <0.008% @ 20Hz-20kHz

Also available:
Suitable Balanced Power Supply Kit
KC-5471 £16.25

STUDIO 350 - HIGH POWER AMPLIFIER

KC-5372 £50.75 plus postage & packing

Studio quality sound and distortion with tremendous power output. This will deliver a whopping 350WRMS into 4 ohms, or 200WRMS into 8 ohms. Using eight 250V 200W plastic power transistors, it is super quiet, with a signal to noise ratio of -125dB(A) at full power. Harmonic distortion is just 0.002%, and frequency response is almost flat (less than -1dB) between 15Hz and 60kHz! Kit supplied in short form with PCB & electronic components.

As published in EPE Oct/Nov 2006

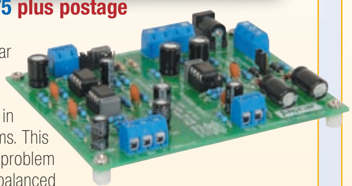
THEREMIN SYNTHESISER MKII

KC-5475 £21.75 plus postage & packing

The ever-popular Theremin is better than ever! From piercing shrieks to menacing growls, create your own eerie science fiction sound effects by simply moving your hand near the antenna. Now easier to set up and build, it also runs on AC to avoid the interference switchmode plugpacks can cause. Complete kit contains PCB with overlay, pre-machined case and all specified components.

BALANCED TO UNBALANCED AUDIO CONVERTER

KC-5468 £9.75 plus postage & packing



Standard audio gear does not have the balanced inputs and outputs found in professional systems. This kit overcomes the problem by adapting an unbalanced input to balanced output and vice versa. This allows domestic equipment to be integrated into a professional installation while maintaining the inherent high immunity to noise pick-up on long cable runs provided by balanced lines.

- PCB and all electronic components included
- ±9-15VDC, or 9-30VDC, or 7-12VAC

STEREO HEADPHONE DISTRIBUTION AMPLIFIER

KC-5417 £10.25 plus postage & packing

Enables you to drive one or two stereo headphones from any line level (1volt peak to peak) input. The circuit features a facility to drive headphones with impedances from about 8-600 ohms. Comes with PCB and components, PCB size 134 x 103mm.

Recommended box HB-6012 £2.00

SPEAKER PROTECTION & MUTING MODULE

KC-5450 £10.25 plus postage & packing

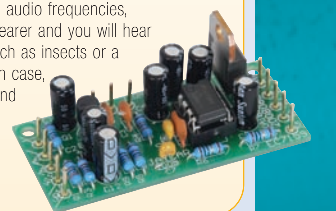
It's primarily designed to protect your expensive speakers against damage in the event of catastrophic amplifier failure. It also banishes those annoying switch on/off thumps and protects against thermal overload. Configurable for 22VDC-70VDC. Supplied with a silk screened PCB and all electronic components.

THE SUPER EAR

KA-1809 £8.25 plus postage & packing

Assists people who have difficulty hearing high audio frequencies, or use as an interesting teaching aid in the classroom. By amplifying high audio frequencies, conversations will be made clearer and you will hear sounds not normally heard such as insects or a watch ticking. Kit supplied with case, front label, PCB, 9V battery, and all electronic components. Headphones required.

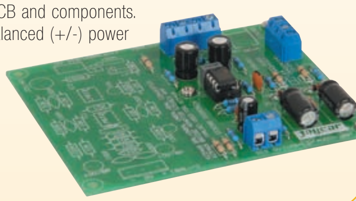
Note: Not a replacement for a proper hearing aid.



BRIDGE MODE ADAPTOR FOR STEREO AMPLIFIERS

KC-5469 £8.25 plus postage & packing

Enables you to run a stereo amplifier in 'Bridged Mode' to effectively double the power available to drive a single speaker. There are no modifications required on the amplifier as this clever kit does the signal processing. Supplied with silk screened PCB and components. Requires balanced (+/-) power supply.

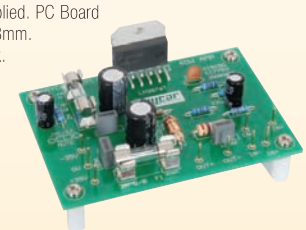


50 WATT AMPLIFIER MODULE

KC-5150 £8.75 plus postage & packing

A single chip module that provides 50WRMS @ 8 ohms with very low distortion. PC Board and electronic components supplied. PC Board size only 84 x 58mm. Requires heatsink. See website for full specs.

Heatsink to suit HH-8590 £5.75



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EVERYDAY PRACTICAL ELECTRONICS

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

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VOL. 38 No. 9 SEPTEMBER 2009

A second North Sea energy bonanza

Britain has been unusually fortunate with the energy resources nature has provided. From the coal that drove the world's first industrial revolution to the oil in the North Sea, we have rarely been without access to much of the raw materials we need to drive industry and generate electrical power. However, oil is not limitless and we know that coal presents serious environmental problems – burning it for decades without carbon capture is no longer considered an option.

What to do? Well, again, nature has been generous to Britain. Around our coasts we have tremendous offshore wind energy resources – estimates vary, but it is generally agreed that at least a third of Europe's best wind energy locations are on our doorstep. In fact, the title of this editorial is misleading, these sites are not just in the North Sea. Current plans will see large-scale wind farms from Brighton to the Orkneys, taking in Wales and the Irish Sea, as well as our long coast facing the North Sea.

I've recently attended several conferences organised by the British Wind Energy Association (**www.bwea.com**) and the scale and ambition of Britain's wind energy industry is impressive – there really is going to be a revolution in how we generate electricity. Gigawatts of capacity, involving structures 150m tall are planned for installation many miles off-shore. This will be a vast engineering exercise, drawing on our considerable oil sector experience of working in hostile marine environments. It will produce tens of thousands engineering jobs in Britain and help to secure much of our energy requirements with greatly reduced CO_2 emissions.

But that's not all. At home, you too can take advantage of free energy with your own turbine thanks to the government's new 'feed-in' tariff legislation, which allows anyone to generate power and sell it at a good price to the grid. I hope to cover this in much more detail in future issues, helping EPE readers to become electrically self-sufficient.

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

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

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

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Email: techdept@epemag.wimborne.co.uk
We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years' old. Letters requiring a personal reply must be accompanied by a stamped self-addressed envelope or a self-addressed envelope and international reply coupons. We are not able to answer technical queries on the phone.

PROJECTS AND CIRCUITS

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

COMPONENT SUPPLIES

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

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

NEWS

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

Joggler

Will O2's new Joggler replace fridge door stickers? Barry Fox investigates.

UK cellphone network O2, set up by BT in 1984, now owned by Telefónica Europe and sole distributor of the iPhone in Britain, is moving into the sale of consumer electronics devices that need no cellphone connection or subscription – and no PC either. The new O2 Joggler, which costs around £150, is a touch-sensitive digital picture frame that connects to walled garden Internet services provided by O2, using Ethernet cable or WiFi connection to any home broadband router.

Joggler has a seven inch, 800 × 480 screen, Intel Atom processor, 1GB of onboard memory and USB connector for additional memory. With no PC needed, it connects to O2's servers and displays a touch menu of Sky news, sport, traffic, and weather, music or movies, games and a family calendar which can be updated and shared by text messages using O2 mobiles.

A free and automatic software update lets the Joggler receive text messages and send 50 free texts a month to any mobile in the UK, with no need for a cellphone subscription. Another promised free update will add Internet radio.

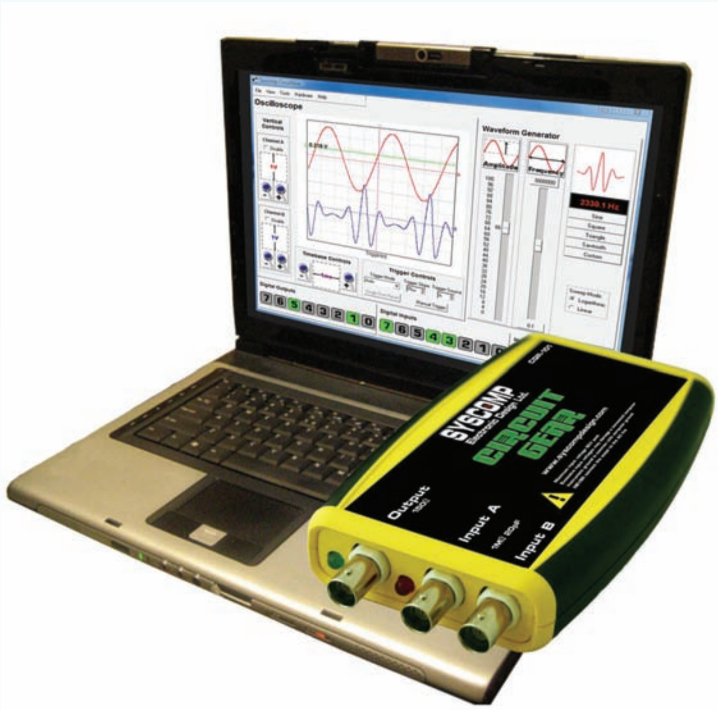
Several common audio and video codecs are built in, but not DivX, and AAC, as needed to play iTunes format files. These codecs may be offered later, inside new applications. To protect children and block malware there is no web browser for open Internet access.

O2 is cagey about how it plans to earn revenue from a device that is sold for a one-off fee and needs no cellphone subscription, but guardedly confirms that Joggler may later be given access to online shopping sites.

Joggler is made in China for O2 by US company OpenPeak, which already supplies a somewhat similar device to Verizon in the USA for use with an ordinary home phone network.

Registering the device online to get an 'O2 portal account' is confusing, for instance the screen several times asks the question "Do you want to view only the webpage content that was delivered securely?" and – against all logic – the user has to click 'No'!, and by implication "I want to risk insecurity". Clicking 'Yes' for Security takes the user round in maddening circles. Also, although the Joggler can read music, video and pictures from some USB Flash sticks, it can't read from others – and O2 is still trying to work out why not!

AUDON'S CGR-101



The Circuitgear CGR-101 from Audon Electronics is a PC-based instrument that provides the features of seven devices in one USB-powered compact box. The device offers the performance of a two-channel 10-bit 20MSa/sec 2MHz oscilloscope, a two-channel spectrum-analyser, and a 3MHz 8-bit arbitrary-waveform/standard-function generator with eight digital I/O lines. It also functions as a network analyser, a noise generator and a PWM output source. Its open-source software runs with Windows, Linux and Mac OS.

The CGR-101's oscilloscope capability provides a two-channel 10-bit ±0.25Vp-p to ±25Vp-p 2MHz basic scope, but with sophisticated marker measurements, triggering (normal, auto, single-shot and pre-trigger) with timebase adjustable from 50ns/division to 100ms/division. With a 1k sample/channel data buffer, the user can even view pre-trigger signals. The two-channel FFT spectrum analyser feature offers marker measurements, and when used with the internal signal generator, displays Bode plots and performs vector network analysis, showing gain and phase values.

The signal generator is an 8-bit 0.1Hz to 3MHz signal source, offering sine/square/triangle/ramp waveforms, as well as being capable of outputting arbitrary or preloaded waveforms such as ECGs. The user can enable the generator, connect its signal to a circuit and perform measurements with the oscilloscope and/or spectrum analyser. The generator can also be set to function as a white noise source. A slider-controlled PWM generator is also provided, with mark-space ratio clearly displayed.

The included visual interface software enables simple control and display of information. The oscilloscope, generator, and digital I/O are operated from a custom open-source Tcl/Tk software GUI included with the hardware. As the software is open source, the code can be read and even added to or customised. The CGR-101 is also Labview compatible and can be controlled by any serial-port-driving software, such as Matlab or Visual Basic.

Project-based electronics lab teaching materials are also available for use with Circuitgear CGR-101. Price £139 + VAT. Audon Electronics, phone: 0115 925 8412, email: info@audon.co.uk, website: **www.audon.co.uk**

Linescan Imaging

The Parallax TSL1401-DB Linescan Imaging Daughterboard provides one-dimensional sight to almost any microcontroller. It is designed for plug-in compatibility with Parallax's BS2pe Motherboard, but can be used with other Parallax BASIC Stamp modules, the Parallax Propeller, the SX, PICs, and AVRs, to name just a few. It is a platform suitable not only for evaluating the TAOS (Texas Advanced Optoelectronic Systems) TSL1401R linear array sensor, but also for incorporation into OEM products, as well as industrial, laboratory, and robotic platforms.

The TSL1401-DB includes the TAOS TSL1401R 128-pixel sensor chip, a 7.9mm focal length imaging lens, and control electronics to aid in capturing images for evaluation. It produces a clocked analogue data output, whose voltage levels correspond to the light intensity at each pixel. By means of an analogue-to-digital converter (or just a digital logic threshold), image data are easily transferred to a microcontroller to detect and analyze objects, edges, gaps, holes, liquid levels, orientation, textures, emissive sources, simple barcodes, and other visible features. Combining it with the BS2pe Motherboard and a suitable output device, one can construct a complete inspection system in a very compact form factor.

For more information, visit **www.parallax.com***, and search 'TSL1401'. The retail price is $49.99 (US)*

NEW ESR ANALYSER

Peak Electronic Design Limited has become well respected over recent years for their clever hand-held test instruments. One of their instruments in particular, the Atlas ESR (Model ESR60) which measures capacitance and ESR (equivalent series resistance) has become widely acknowledged as a market leader. Measuring ESR is a fantastic way of finding faulty electrolytic capacitors, and even for tracing PCB short-circuits.

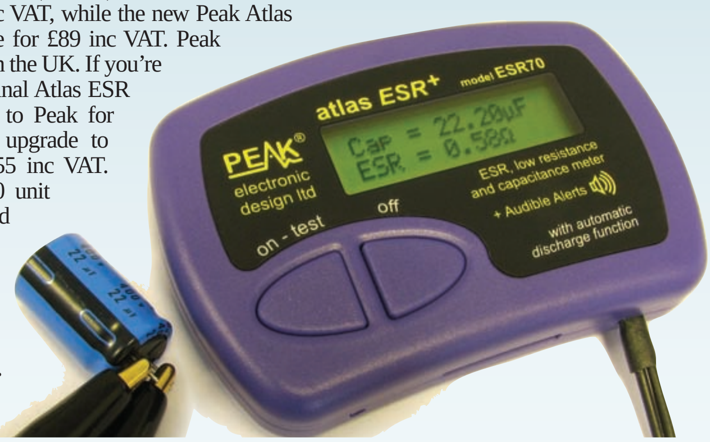
A new addition to the Peak range has now been released, which offers even more than the well established ESR60. The new instrument, the Atlas ESR+ (Model ESR70) adds several features that many hobbyists, technicians and engineers will find invaluable.

The most notable new feature is the inclusion of 'audible alerts'. Every measurement of ESR will be shown on the display as usual of course, but the unit will also produce a variety of tones depending on the value of ESR. And the tones themselves are surprising pleasant, including 'bell-like' pings (a couple of different types for ESR that is below certain values), and also a 'beep-barp' type tone for ESR that is likely to be too high. There is also a reassuring 'blip' when the measurement has started and completed.

The ESR measurement range has also been enhanced, now doubled, measuring from 0 to 40Ω with a resolution as low as 0.01Ω. This remarkably fine resolution is great for assessing large capacitors and even allows you to use the Atlas ESR+ for tracing short-circuits and finding the precise area of a PCB that has that invisible wisp of solder.

The original Peak Atlas ESR (ESR60) unit will continue to be available at a special price of £75 inc VAT, while the new Peak Atlas ESR+ (ESR70) is available for £89 inc VAT. Peak charge just £2 for delivery in the UK. If you're an existing user of the original Atlas ESR (ESR60), you can send it to Peak for a hardware and software upgrade to the ESR70 features for £55 inc VAT. Customers with an ESR60 unit less than three months old can upgrade for just the difference in price between the two units.

Peak Electronic Design Ltd, Tel. 01298 70012, **www.peakelec.co.uk**, sales@peakelec.co.uk



John Becker 1939 to 2009

It is with great sadness that we have to advise that our Consulting Technical Editor, John Becker, has died aged 70 following a massive heart attack. John had been in hospital after the heart attack struck on Sunday, 28 June, but after resuscitation it became clear that there was no hope of recovery and the life support systems were disconnected on Thursday, 2 July.

As many readers will know, John had partly retired, but had been fighting a persistent circulation problem for several years, which had resulted in the partial amputation of one leg. Undaunted, John persevered with his role as Consulting Editor, always working to – and demanding – the highest of professional standards.

Earlier in 2005, John suffered a minor stroke while on his way to work, after which he reluctantly went into semi-retirement, working more from his home in Kent rather than facing a weekly commute to the offices in Wimborne.

Despite these setbacks, nothing could prevent John from enjoying what he did best, and his love of hobby electronics – especially the art of PIC programming – was undiminished. John expertly wrote all our key PICmicro tutorials, including the famous *PIC Toolkit TK3*, as well as designing countless projects. Through his limitless enthusiasm for the hobby, spanning many decades with *Practical Electronics* and *EPE,* he set many readers on the road of discovering the fascinating world of electronics. Countless readers will always be very grateful to him for his inspiring work.

John originally worked in the film industry, was self-taught in electronics and wrote his first constructional article for *Practical Electronics* in the early 70s. He went on to set up and run Phonosonics, a very sucessful kit supplier, mainly supplying audio kits to projects of his own design. John took over as editor of *PE* when it was sold by IPC in 1986. He joined the staff of *EPE* as Technical Editor in 1994.

John and his wife Gill were visiting Wimborne at the time of his heart attack, and John passed away when visiting the place that he loved. John's sudden and untimely death has come as an enormous shock, given that he seemed to be coping quite well after having had so many setbacks with his health and wellbeing.

The staff at Wimborne are deeply saddened by this terrible loss and our sympathies are extended to John's family and friends.

A more extensive tribute to John has been written by Alan Winstanley and appears in his Net Work *item on our website.*

By JOHN CLARKE

Programmable Ig
System For Cars P

Want to program the ignition timing on your car? Now you can, with this completely new design. It can be used in older cars which presently do not have electronic ignition, or used as an 'interceptor' for cars with engine management systems.

THIS latest Programmable Ignition System has fairly advanced features (see panels) for a DIY project, including the ability to produce an accurate 'advance' curve. It also includes a plug-in LCD hand controller, which shows values and setting adjustments on its display.

It is a complete stand-alone ignition system that is triggered by an engine position sensor and then drives the ignition coil. It can be triggered from one of many sensors in a distributor, including points, reluctor, Hall effect, optical trigger and the 5V signal from the car's Engine Control Unit (ECU).

Measuring engine load

In order to measure engine load, the Programmable Ignition can use a Sensym absolute pressure sensor. In fact, provision has been made to mount this sensor directly on the PC board, the sensor then being connected to the engine manifold via plastic tubing.

Alternatively, you can connect the ignition circuit to an existing manifold pressure sensor if present. This is commonly called a 'manifold absolute pressure' (or MAP) sensor and is found on many cars these days. You could also use a secondhand MAP sensor from a car scrapyard.

Changing the timing

A fully effective ignition system needs to increase the timing advance with increasing RPM, and to alter the timing according to engine load – all with a fair degree of precision.

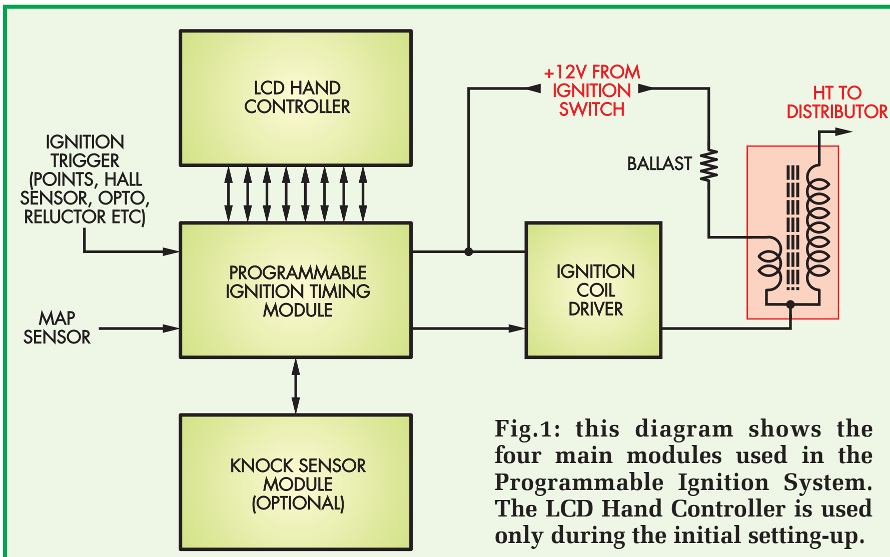


Fig.1: this diagram shows the four main modules used in the Programmable Ignition System. The LCD Hand Controller is used only during the initial setting-up.

Additionally, some means to detect detonation (knock) and retard the timing would be an advantage. In this way, the ignition can be advanced further than would otherwise be possible without knock sensing.

This programmable ignition system incorporates all these features. What's more, there is an option to select between two separate ignition-timing curves using a switch. This option is ideal if you are running both petrol and gas, where a different timing curve is required for each type of fuel.

The complete block schematic of the Programmable Ignition System For Cars is shown in Fig.1. It comes in four modules: an LCD Hand Controller, a Programmable Ignition Timing (PIT) module, an Ignition Coil Driver module and a Knock Sensor module. The first three modules are mandatory, while the fourth, the Knock Sensor module, is optional.

The heart of the system is the Programmable Ignition Timing module, based on a PIC16F88-E/P micro. It is programmed by the LCD Hand Controller and it delivers a signal to the Ignition Coil Driver. The latter, as its name suggests, then drives the ignition coil.

LCD Hand Controller

The Hand Controller is used during the initial setting-up procedure. It plugs into the main unit and can be used while the engine is either running or stopped. It is then disconnected from the main unit after all adjustments have been made.

Using the Hand Controller, you can set all the initial parameters and also program the ignition advance/retard curve. Several pushbutton switches on the Hand Controller enable these changes to be made.

Knock sensor

The optional Knock Sensor module enables 'pinking' (or 'pinging') to be sensed and the ignition timing retarded for a brief period. In brief, engine pinking is monitored by the Knock Sensor and the Programmable Ignition Timing (PIT) module for the first 6ms after each spark. However, at high RPM, there is less than 6ms between each firing, and so knock signal monitoring is carried out between each spark and the start of the next coil dwell period.

When engine knock is detected, the timing is retarded for the next ten sparks. The amount of retardation varies according to the severity of the knock signal. More details on this are given in the specifications.

Different uses

The Programmable Ignition can be used either as an interceptor or for fully mapped ignition timing. In the interceptor role, it can vary the existing ignition timing by advancing or retarding it from its current value – ie, it can be used to alter the timing signals from the car's ECU.

Alternatively, when used to completely replace the existing ignition timing, you will need to obtain the advance/retard curve for your vehicle so that the entire timing curve can be produced by the Programmable Ignition. For some vehicles, you may be able to obtain the curves from the manufacturer. For other cars, you will need to plot out the existing curve and transfer the resulting timing map to the Programmable Ignition.

Plotting out this timing curve is not hard to do and can, in fact, be done using the Programmable Ignition System itself and a timing light.

In practice, the ignition timing is mapped out in an array of either two 11-RPM by 11-engine load site maps, or as a single 15-RPM by 15-engine load site map. Timing arrays (or ignition maps) are the most common method that car manufacturers use to set the ignition advance curve for both RPM and engine load.

Main Features

- Advance and retard adjustment over a wide range
- Plug-in LCD Hand Controller for adjustments
- Hand Controller LCD shows values and settings for adjustment
- Suitable for single-coil ignition systems with a distributor
- Can be used as a timing interceptor or as a replacement ignition
- Ignition timing mapped against RPM and engine load
- Interpolated values used for RPM and load values between sites
- Optional single map or dual timing maps
- Single map has 15 RPM sites × 15 engine load sites
- Dual maps each have 11 RPM sites × 11 engine load sites
- 1° or 0.5° adjustments
- Dwell adjustment
- Knock sensing indication, with optional ignition retard
- Suits 1 to 12-cylinder engines (4-stroke) and 1 to 6-cylinder 2-stroke engines
- Two debounce settings
- High-level or low-level triggering
- Points, reluctor, Hall effect, digital signal or optical triggering
- Works with many pressure sensors (MAP sensors)
- Minimum and maximum RPM adjustments
- Minimum and maximum engine load adjustments
- Diagnostic RPM and load readings
- Add-on knock sensing unit (optional)
- Requires evenly spaced firing between cylinders. For V-twins, you will need two ignition systems and a separate trigger for each cylinder.

Mapping is a way of plotting the advance curve as a series of steps rather than setting an ignition advance or retard value at every possible engine RPM and load value. Thus, mapping sets the ignition advance or retard values at specified preset points for both RPM and engine load.

For example, we can specify the timing advance to be 25° at 3000 RPM and 28° at 3400 RPM. However, we do not specify individual values at 3100, 3200 or 3300 RPM. Instead, the advance values at these RPMs are interpolated (ie, calculated), based on the values set for 3000 and 3400 RPM.

At 3200 RPM, the amount of advance is easily calculated because it is exactly in the middle between the 3000 RPM and 3400 RPM sites. The advance change between 3000 RPM and 3400 RPM is 3° (ie, from 25° to 28°) and half of this is 1.5°. So the advance required at 3200 RPM is simply 25° + 1.5° = 26.5°.

Another calculation is required for engine load values that are in-between the specified load sites.

For our Programmable Ignition, if you require two separate engine advance curves then you need to select the 11×11 arrays. If only one advance curve is required, you then have the option of using a 15×15 array for greater accuracy.

By the way, don't confuse the ignition timing map with the MAP (manifold air pressure) sensor. They are two completely different things.

Plotting the timing values

We used the Programmable Ignition, the LCD Hand Controller and a timing light to plot out the ignition timing values for a 1988 2-litre Ford Telstar. We'll describe exactly how this is done in some detail in a later article.

The resulting timing vs RPM values were tabled (Table 1) and then plotted using Microsoft Excel. These files will be available from the Library section on our website so that you can use the tables and edit the values (just by wiping over the values and rewriting them) to suit your car's engine. It is not really necessary to use Excel though and you can just as easily use a pencil and piece of paper to draw out the map instead.

Table 1: these ignition advance values were measured for a 1988 2-litre Ford Telstar using a timing light and the Programmable Ignition.

	RPM Site	RPM0	Min RPM RPM1	RPM2	RPM3	RPM4	RPM5	RPM6	RPM7	RPM8	RPM9	RPM10	Max RPM RPM11
	Load Site	0	1000	1400	1800	2200	2600	3000	3400	3800	4200	4600	5000
Min load	LOAD1	16	16	18.5	21.5	23	25.5	29	32	36	38	42.5	44
	LOAD2	15	15	17.5	20.5	22	24.5	28	31	35	37	41.5	43
	LOAD3	14	14	16.5	19.5	21	23.5	27	30	34	36	40.5	42
	LOAD4	13	13	15.5	18.5	20	22.5	26	29	33	35	39.5	41
	LOAD5	12	12	14.5	17.5	19	21.5	25	28	32	34	38.5	40
	LOAD6	11	11	13.5	16.5	18	20.5	24	27	31	33	37.5	39
	LOAD7	10	10	12.5	15.5	17	19.5	23	26	30	32	36.5	38
	LOAD8	9	9	11.5	14.5	16	18.5	22	25	29	31	35.5	37
	LOAD9	8	8	10.5	13.5	15	17.5	21	24	28	30	34.5	36
	LOAD10	7	7	9.5	12.5	14	16.5	20	23	27	29	33.5	35
Max load	LOAD11	6	6	8.5	11.5	13	15.5	19	22	26	28	32.5	34

Fig.2 shows the ignition timing versus RPM and engine load from 1000-5000 RPM. Since we have 11 RPM sites, each RPM site covers a span of 400 RPM.

RPM0 is an extra site, and is shown covering the range from 0-1000 RPM. The RPM0 wording is shown on a different line because it is not an actual RPM site and cannot be adjusted. It has the same values as RPM1.

RPM0 is shown because it explains what the advance curve is below the minimum RPM1 site while the engine is being started. The same thing happens for RPM above RPM11. In this case, the advance remains at the RPM11 values.

Engine load is shown with LOAD1 as the minimum engine load, while LOAD11 is the maximum engine load. LOAD1 is usually accessed when the engine is on overrun, while LOAD11 is usually accessed under acceleration or when the car is climbing a hill. The load values were measured using a second-hand pressure sensor from a car scrapyard. These were then converted to load values ranging from 1-11.

The curve can be plotted in three dimensions showing RPM, load and ignition advance. If you use our Excel file, then the curve will be automatically replotted whenever a value is altered.

Using the Hand Controller

As mentioned earlier, the Hand Controller is used to enter the settings and to enter the ignition map. The values are displayed on the 2-line 16-character LCD screen. There are eight direction pushbuttons, a Run/View pushbutton and a Reset.

The Reset switch is recessed to prevent accidental activation. It is used to return all mapped advance or retard values to 0°. The eight direction pushbuttons alter the values and can configure the display to show the different settings or a different load site.

Finally, the Run/View pushbutton only works in the Timing mode. This mode is selected using a jumper link on the Programmable Ignition Timing Module.

RUN modes

The Timing mode has four possible display modes, selected by pressing the Run/View pushbutton. It selects one of four modes – called SITE, FULL, DIAG and VIEW – in cyclic fashion.

Each display mode shows a slightly different aspect of the mapping sites. One feature in common is that they all display the MAP and the current advance or retard value on the top line, although there is a difference in the displayed value as we shall see.

When the 11×11 maps are selected (from the settings mode), the display will show either **MAP**α or **MAP**β,

11 × 11 Ignition Timing Map

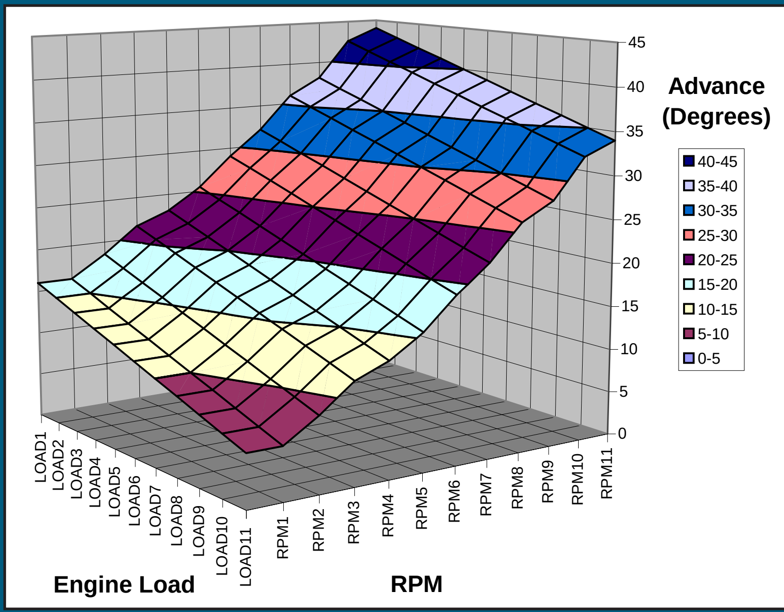


Fig.2: this 3-dimensional graph plots ignition advance against engine RPM and engine load as an 11×11 array – ie, 11 Load sites and 11 RPM sites. Note how the ignition advance increases with RPM and decreases with higher engine load. The graph here was produced for a 1988 2-litre Ford Telstar.

15 × 15 Ignition Timing Map

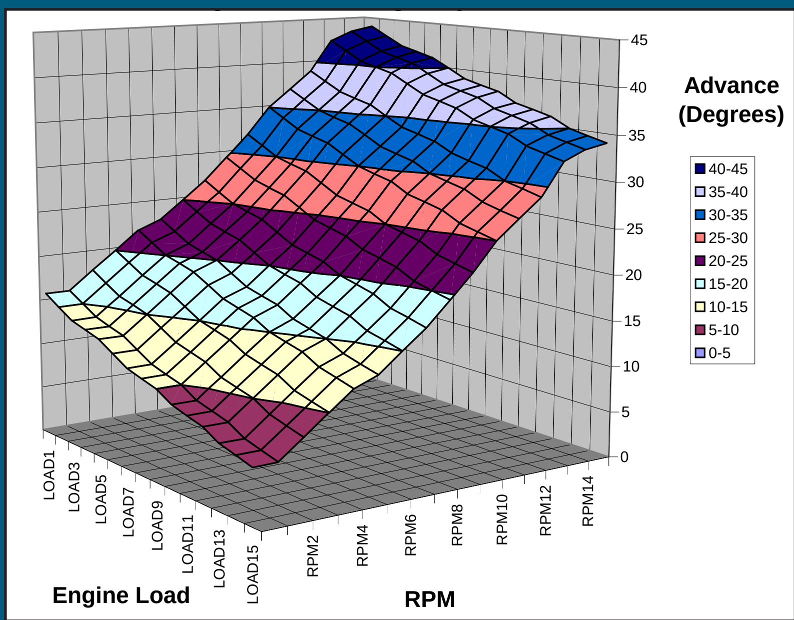


Fig.3: this 3-dimensional graph is also for a 1988 2.0-litre Ford Telstar, but this time the ignition advance is plotted against engine RPM and engine load as a 15×15 map (300 RPM per site).

The LCD Hand Controller connects to the Ignition Timing Module via a standard DB25 RS-232 cable. It's used to program in the various settings and the ignition timing MAP(s) and can display all programmed data on a 2-line 16-character LCD module.

depending on which map is selected. If the 15×15 map is selected, then the display will only show **MAP**, without the alpha or beta symbols.

Following the MAP legend, the display shows the advance or retard value. The display format depends on whether the setting is for 0.5° or 1° resolution. In all cases, a '–' sign indicates a retard value, while a '+' sign indicates an advance value. When there is no change in advance or retard, the value simply shows 0.0 for the 0.5° resolution setting or 0 for the 1° resolution setting.

The advance or retard value is changed using the Up (▲), Down (▼), Step Up (⏫) and Step Down (⏬) pushbuttons. The ▲ and ▼ pushbuttons increase or decrease the setting by the resolution value; ie, by either 0.5° or 1° for each switch press.

By contrast, the ⏫ and ⏬ pushbuttons change the advance/retard value by 2° on 0.5° resolution and by 4° on 1° resolution. The resulting values are stored in memory and remain there even if power is turned off, unless they are changed by the pushbuttons or by the Reset switch.

At the end of the top line, the display shows either SITE, FULL, DIAG or VIEW, to indicate the selected mode. Note that the SITE, FULL and DIAG modes are called the 'Run' modes because they show what sites are accessed while the engine is running.

Site mode

The SITE mode is displayed each time the Programmable Ignition is powered up when the Run/View mode is selected with the jumper link. In this mode, the second line shows the current RPM site and the current LOAD site. These are from sites 1 to 11 when the 11×11 mapping is selected, or from 1 to 15 when the 15×15 mapping is selected.

The advance or retard value is shown as the value entered at that load site. In practice, the LOAD and RPM sites only change with changes in engine RPM and engine load. In other words, this is a real time display that shows the current load and RPM sites and the current advance or retard value setting.

Full mode

Pressing the Run/View pushbutton brings up the FULL mode. In this case, the second line shows the RPM site as before (eg, RPM1) but it also shows the actual position between this site and the next. For example, with the 11×11 ignition timing map (Fig.2), each site is 400 RPM away from the next.

In practice, however, the RPM is measured in 100 RPM steps. As a result, the display shows the RPM 1 position as RPM 1;0, RPM 1;1, RPM 1;2 or RPM 1;3. These values correspond to 1000, 1100, 1200 and 1300 RPM respectively. There is no RPM 1;4 position as this becomes the RPM 2;0 site for 1400 RPM.

If you don't understand this, it will become clearer when we describe how the Programmable Ignition is set up in the forthcoming articles.

Similarly, for the LOAD sites, the position within the site is shown after the semicolon (;). Note that the word LOAD is abbreviated to just LD, so that the values fit within the display line.

In the FULL display mode, the advance or retard value is the interpolated value that is calculated for the positions between each load site.

Let's go back to our earlier example and consider the RPM 6 (3000 RPM) and RPM 7 (3400 RPM) sites. At these sites, the advance is 25° and 28° respectively. This means that at RPM 6;0 the advance value will be displayed as +25.0°, while at RPM 7;0 the value will be shown as + 28.0°.

The interpolated value will be shown for RPM values between these two sites. For example, at 3200 RPM (RPM 6;2), the advance value will be

+26.5°. Consequently, this is the value that will be shown at site RPM6;2.

Note that this is a simplistic example because we are ignoring the fact that the LOAD value could also be in-between LOAD sites. In that case, both the RPM and LOAD values are interpolated to give the advance or retard value.

Note also that if the advance or retard value is increased or decreased in this mode, it will be the interpolated value that is displayed rather than the site value. The site that will be changed is the next lowest RPM and LOAD site.

Having said all that, interpolation can be switched off within the settings if required.

Knock sensing

When knock sensing is set, the display shows the modified timing value after knock retard is taken into account. This means that if the display is showing +26.0° and the knock sensing subsequently introduces a 6° timing retard, the display will then immediately show +20.0°. This is the actual advance value used for ignition.

Note that engine knock detection is indicated by an exclamation mark (!) that is positioned between the RPM site value and the LOAD on the second line of the display. The (!) is shown when knock is detected, regardless as to whether the knock retard feature is on or off. The knock symbol is shown in the SITE, FULL and DIAG display modes.

Diagnostic mode

Pressing the Run/View switch again switches to the DIAG mode. This is the diagnostic mode, and it is very useful when it comes to determining your engine's RPM range, as well as measuring the output range from the MAP sensor.

In this mode, the second line shows the actual RPM with 100 RPM resolution and the actual LOAD value from 0 to 255. The advance/retard value on the top line normally shows the interpolated value in the same way as the FULL mode.

As mentioned above, interpolation can be switched off and this is useful when measuring the manufacturer's advance curve (more on this in a later article).

Specifications

Timing adjustment resolution: 0.5° resolution advance and retard or 1° resolution advance and retard.

Timing adjustment range: ±60° for 12-cylinder engines, ±90° for 8-cylinder engines, ±120° for 6-cylinder engines, ±127° for less than 6 cylinders. Using less than 75% of the limit is recommended to prevent timing 'drop-out' with sudden RPM changes.

Timing adjustment accuracy (above Low RPM setting): 0.2% for a 2-cylinder 4-stroke; 0.3% for a 6-cylinder 4-stroke; 0.4% for an 8-cylinder 4-stroke (note: 0.3% is equivalent to 0.12° at 40° advance or retard for a 6-cylinder engine).

Timing update: the update period is the time between successive firings.

Timing calculation period: 700µs maximum.

Timing jitter: ±5µs at 333Hz (5µs is equivalent to 0.3° for a 6-cylinder engine at 10,000 RPM).

Minimum input frequency: 0.6Hz (corresponds to 36 RPM for a 2-cylinder 4-stroke engine; 18 RPM for a 4-cylinder 4-stroke engine, etc).

Maximum input frequency: 700Hz (corresponds to 14,000 RPM for a 6-cylinder 4-stroke; 7000 RPM for a 12-cylinder 4-stroke.

Cylinder settings: 1 to 12 cylinders for a 4-stroke engine and 1 to 6 cylinders for a 2-stroke engine.

Minimum RPM setting: 0 to 25,500 RPM in 100 RPM steps

Maximum RPM setting: indirectly set by RPM/SITE – 0 to 25,500 RPM in 100 RPM steps.

Minimum load setting: 0 to 255 in steps of 1 (corresponds to 0 to 5V).

Maximum load setting: indirectly adjusted by changing loads per site (0 to 255 in steps of 1).

Debounce adjustment: 0.4ms or 2ms.

Dwell adjustment: 0 to 25.3ms in 0.2048ms steps (multiplied with voltage below 12V).

Dwell variation with supply: x1 for >12V; ×2 for 9V to 12V; ×3 for 7.2V to 9V; × 4 for <7.2V.

Firing edge selection: low or high.

Spark duration: 1ms.

Map settings: two 11×11 maps (MAPα and MAPβ) or single 15×15 map.

Knock input range: 0 to 5V (0 to 1.25V = no retard; 1.25V to 5V = progressive retard in 16 steps). 9° at 3.75V; 12° at 5V for 1° resolution; 4.5° and 6° respectively for 0.5° resolution.

Knock monitoring (requires an additional knock circuit): monitored for the first 6ms after firing. This period is reduced at higher RPM with the start of dwell. Optional 4000 RPM or 6000 RPM sensing limit. Ignition retard activation (when enabled) is set for a minimum of 10 sparks with the onset of knocking.

Internal test oscillator: 4.88Hz.

Response to low RPM setting: 0 to 25,500 RPM in 100 RPM steps. Typically set at around 1000 to 2000 RPM.

Pressing the Run/View pushbutton yet again switches to the VIEW mode. This is not a real-time display because the RPM and LOAD sites do not change with the engine RPM or load. Instead, you can step through each site manually using the Right (▶), Step Right (▶▶), Left (◀) and Step Left (◀◀) pushbuttons.

The ▶ and ◀ pushbuttons increase or decrease the LOAD site value. When increasing the LOAD site value and it reaches its maximum value (either 11 or 15), pressing the switch again causes the RPM site to increase by 1 and the LOAD site to return to 1. In this way, you can step through the entire ignition-timing map.

The same thing happens when decreasing the LOAD site value. After reaching 1, the RPM site value is decreased by 1 on the next switch press and the LOAD site goes to either 11 or 15 (depending on the MAP setting).

The ▶▶ and ◀◀ switches just alter the RPM sites up or down without altering the LOAD site. In this way you can check the ignition advance or retard settings for each RPM site at a particular LOAD site.

Note that the ▶, ▶▶, ◀ and ◀◀ pushbuttons do not operate in the SITE, FULL and DIAG modes. In these modes, the sites are only changed in response to engine RPM and load inputs.

Settings

The Settings display is invoked when jumper link LK1 in the Programmable Ignition Timing Module is moved to the settings position. The display is then used to set up the programmable ignition to suit your engine.

The display will initially show <SETTINGS>. The < and > brackets indicate that each setting can be selected with either the left (◀) or right (▶) pushbutton switch. The values within the settings can then be changed using the ▲ and ▼ pushbuttons. These values (except for the oscillator setting) are stored in memory and do not change unless altered using the Up and Down pushbuttons.

Note that the oscillator setting is always off when power is re-applied to the Programmable Ignition.

Pressing the ▶ pushbutton brings up the Cylinder setting. You can then select cylinder values from 1 to 12 for a 4-stroke engine, and from 1 to 6 for a 2-stroke engine. During this time, the top line of the display will show STROKE and then two numbers – ie, 4 and [2] for 4-stroke 2-stroke engines respectively. Directly below these on the second line is the word CYLINDER and the selected cylinder numbers (the bracketed number is the cylinder value for a 2-stroke engine).

The cylinder value is changed using the ▲ and ▼ pushbuttons. Note that a dash is shown in the two 2-stroke column when odd 4-stroke cylinder numbers are selected, as this is not a valid setting for a 2-stroke engine.

The next four settings are for adjusting the range of the RPM sites and the LOAD sites. These are crucial in ensuring you get the full use of the available sites. In other words, there is not much point in having the RPM sites cover a range from 0 to 25,000 RPM when, for example, the engine does not run above 5000 RPM. In this case, you would only be using 20% of the available RPM sites (ie, RPM 1, RPM 2 and part of RPM3 only) for mapping the advance curve.

RPM site adjustments

The first of these settings is the Minimum RPM. This sets the RPM for the RPM 1 LOAD site. The display will show SET MIN RPM X00 RPM, where the X represents a number from 0-255. Typically, this is set at the idle speed for the car, but it may be set differently depending on how you want the ignition curve to operate (more on this in a later article). The settings can be changed from 0 RPM through to 25,500 RPM in 100 RPM steps.

In practice, you would use the DIAG (diagnostic) setting mentioned earlier to determine the minimum and maximum engine RPM range. Alternatively, you can use the idle and red-line specifications for your engine.

The second setting is for the Maximum RPM. This value of RPM is indirectly set by the value of the RPM per site (RPM/SITE) adjustment, as shown on the top line of the display. It can be set from 0 to 25,500 RPM in 100 RPM steps.

The second display line shows the maximum RPM. This is calculated based on the minimum RPM setting and the RPM/site value. It is shown in the second line of the display as MAX RPM X00 RPM, where X is a number from 0 to 255. An ERROR indication is shown instead of the maximum RPM if the setting would be over 25,500 RPM.

The reason why we adjust the RPM/SITE value rather than the Maximum RPM directly is because the Programmable Ignition requires a discrete number of 100 RPM steps between each RPM site.

In practice, the RPM/SITE value is altered so that the maximum RPM is at or just over the value required. You can also adjust the minimum RPM setting to achieve the best compromise for the adjustment.

An example may help here using the 11 × 11 map. If, say, the minimum RPM is set at 1000 RPM, then the RPM/SITE value can be set to say 400 RPM for a 5000 RPM maximum, or to 500 RPM for a 6000 RPM maximum. Thus, if you had a red line of say 5500 RPM, you could set the RPM/site value to 500 for the 6000 RPM maximum. Alternatively, you could lower the minimum RPM value to say 800 RPM, with the RPM/site set to 500 for a 5800 RPM maximum.

LOAD site adjustments

The third and fourth settings are for the LOAD sites. Again, in practice, you would use the DIAG (diagnostic) mode to determine the minimum and maximum values from the MAP sensor. The maximum load values occur when the car is accelerating up a hill, while minimum load values are present under very light throttle conditions and when the engine is being overrun in low gear downhill.

The Minimum Load adjustment can be set from 0 to 255 in steps of 1. These 0 to 255 values correspond to the 0V to 5V output from the MAP sensor. This value is set to the reading obtained in the DIAG (diagnostic) mode when the engine is being overrun.

By contrast, the Maximum Load is adjusted indirectly by changing the loads per site (LOADS/SITE) setting. This can be changed in steps of 1 from 0 to 255. The second display line shows the calculated maximum load (MAX LOAD) value based on the minimum load and the LOADS/SITE setting. An ERROR indication shows if the calculated maximum LOAD value is over 255.

In practice, the Minimum Load and the LOADS/SITE settings are adjusted so that they cover the range of the MAP sensor output, although they may slightly overlap the required minimum and maximum values.

Other settings that follow these mapping values are:

1) MAPS: here you can select either the two 11×11 maps (Mapα and Mapβ) or the single 15×15 map. Note that any ignition values mapped into an 11×11 map will no longer be correct if the map is subsequently changed to a 15×15 array and vice versa. Instead, you have to re-enter the values.

2) Resolution: this sets the resolution of the advance/retard adjustments and can be either 1° or 0.5°. Once ignition values have been entered into the map on one resolution setting, they will be incorrect if the resolution is changed to the alternative setting.

3) Response to low RPM setting: at low RPM, the engine speed can change quite quickly. Because the calculation for RPM can only occur between each detected firing pulse, the response to RPM changes can be too slow and can lag behind the engine. This can noticeably retard the ignition with increasing RPM.

The 'Response to low RPM' setting is included to improve low RPM response, particularly at starting. The downside of this setting is that there is some slight ignition retardation, but this is less than 1° for typical low RPM settings.

The RPM value can be set from 0 to 25,500 RPM in 100 RPM steps. The low RPM response operates for RPM below the set value (typically just below idle speed). Above this setting, the standard response to RPM occurs. By contrast, the response at higher RPM is satisfactory because there is only a short period between plug firing and the engine speed will not vary much during this time.

Usually, the setting is adjusted so that it operates at engine cranking speed, but stops when the engine reaches idle speed. In other cases, it may be necessary to raise this RPM limit so that the engine can rev correctly from idle.

4) Debounce: the debounce setting affects the trigger input and its resilience to a noisy signal, as can typically occur with points bounce in older car ignition systems. Unless corrected, points bounce can upset the detection of engine RPM and affect the timing.

Typically, you can use the 0.4ms debounce setting, but the alternative 2ms debounce setting, can be selected if the ignition appears to be erratic due to a noisy input sensor signal.

Ignition Timing – A Quick Primer

A typical internal combustion engine has one or more pistons that travel up and down inside cylinders to turn a crankshaft. As a piston rises inside its cylinder during the compression stroke, a mixture of fuel and air is compressed. In petrol and gas engines, this fuel-air mixture is then ignited using a spark to drive the piston as it starts its downward stroke.

This ignition must be timed accurately to ensure maximum power and efficiency. If the mixture is fired too late in the cycle, power will be lost because the piston will have travelled too far down in the cylinder for the burning fuel to have maximum effect. Conversely, if the mixture is ignited too early, it will 'push' against the piston in the wrong direction as it rises towards top dead centre (TDC).

Ideally, each spark plug is fired so that there is just enough time for the ignited fuel to apply maximum force to the piston as it starts its downward power stroke. In practice, the fuel takes a certain amount of time to burn and so the spark plug needs to be fired before the piston reaches the top of its stroke or top dead centre.

At low engine RPM, the spark only needs to occur a few degrees before top dead centre. However, as engine RPM rises, the ignition must be fired progressively earlier in order to give the fuel the same time to fully ignite – ie, the spark timing must be progressively advanced as engine RPM rises.

This timing requirement is called the 'RPM ignition advance curve' and is often around 6° before TDC at idle, rising to about 40° at the engine's recommended maximum RPM (the redline).

As stated, if the spark ignites the fuel far too early, then the piston may be pushed downwards before it reaches top dead centre. However, if the ignition is only early by a small amount, then the engine will exhibit a knocking sound as the piston rattles within the cylinder. This effect is called 'detonation' (also called 'pinking', 'pinging' or 'knocking') and can cause serious engine damage in severe cases.

Engine load is also an important factor when it comes to ignition timing. Under light loads, the advance timing can usually be at the maximum. However, when the engine is heavily loaded, such as when accelerating or powering uphill, the fuel takes less time to ignite because of higher fuel pressures and temperature (and because the mixture is richer). As a consequence, as engine load increases, the ignition timing must be retarded to prevent detonation.

5) Dwell: dwell is the period during which the ignition coil 'charges' before each plug firing. It is alterable from between 0 to 25.3ms in 0.2048ms steps.

We have provided an oscillator feature (see below) that allows the ignition coil to be driven by the Programmable Ignition and the spark produced by the coil to be monitored. The dwell is then progressively adjusted upwards from 0ms until the spark reaches its maximum voltage. The dwell is then increased slightly above the set value to ensure there is more than sufficient spark when the engine runs.

In addition, the dwell is automatically increased when the battery voltage is low – ie, to ×2 for battery voltages between 9V and 12V; to ×3 for voltages between 7.2V and 9V; and to ×4 for voltages below 7.2V.

6) Edge: this sets the ignition to trigger from either a low-going input signal edge or a high-going signal. In most cases, a high-going signal edge must be selected, but some optical, Hall-effect and reluctor outputs will require the low-going edge selection.

7) Knock: this sets the KNOCK retard feature either ON or OFF and sets the LIMIT at either 4000 or 6000 RPM (these settings are all shown on the LCD). Pressing the ▲ and ▼ pushbuttons cycle the selections between these options.

The LIMIT setting sets the RPM value at which knock sensing ceases. This is usually set to 4000 to 6000 RPM because at higher revs, the engine noise drowns out any knocking, and so would either be undetectable or would cause false readings.

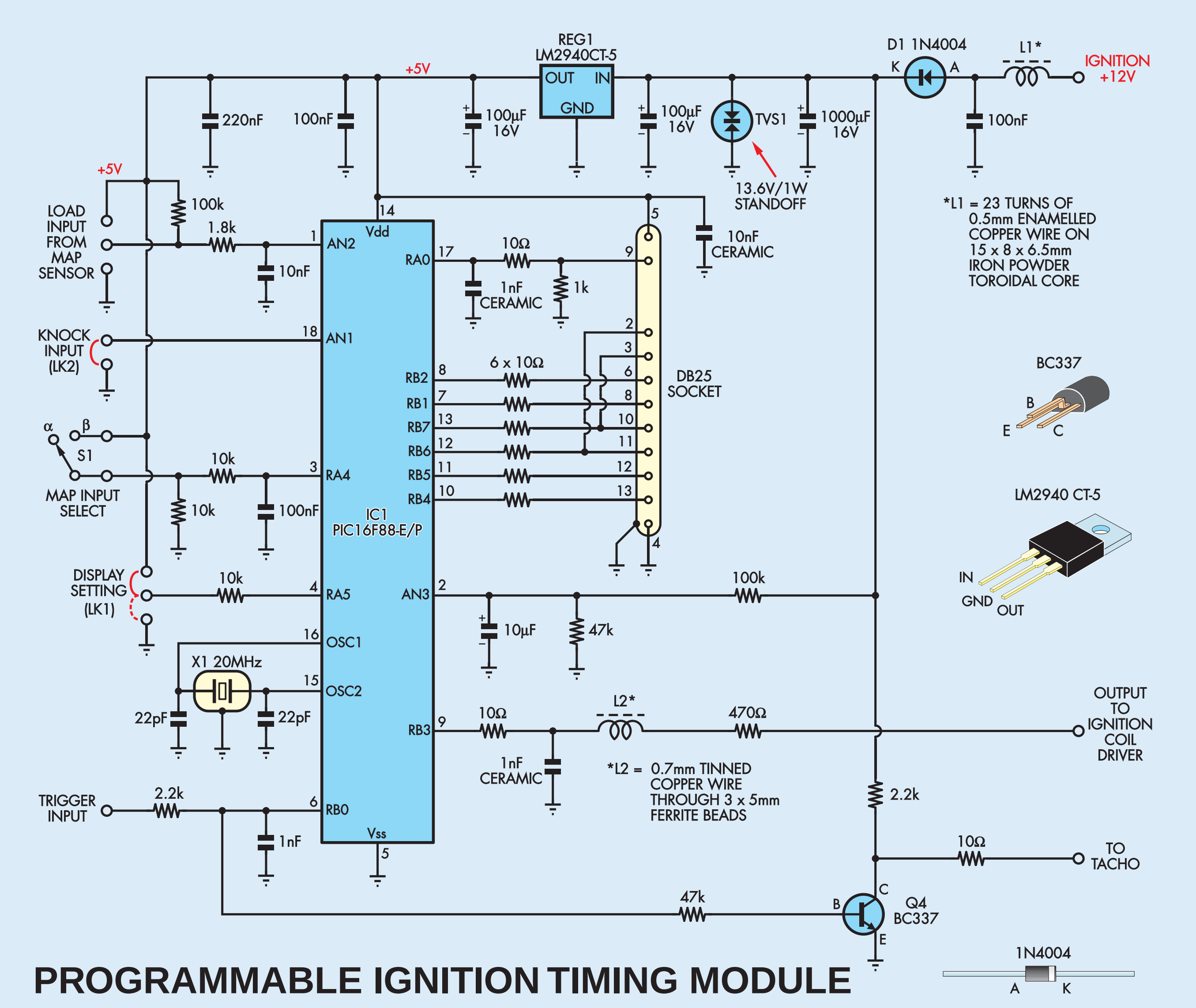


Fig.4: the Ignition Timing Module is based on a PIC16F88-E/P microcontroller. This processes the input trigger, MAP sensor and optional knock sensor signals and provides outputs to drive the Ignition Coil Driver circuit (Fig.5) and a tachometer. It also monitors the Hand Controller's switches and drives the LCD.

Note that knocking will only be detected if the separate knock sensing circuit (to be described) is added and a knock sensor is installed on the vehicle.

8) Diagnostic: this sets the interpolation either ON or OFF. It is normally set to ON and should only be set to OFF when making ignition curve measurements using the Programmable Ignition and a timing light.

9) Oscillator: this sets the internal oscillator ON or OFF. It's normally OFF, but can be set to ON to test the ignition coil spark with varying dwell settings. The oscillation rate is about five times a second (5Hz).

Circuit details

So much for all the fancy features built (or more accurately, programmed) into the unit. Let's now take a look at the circuit details.

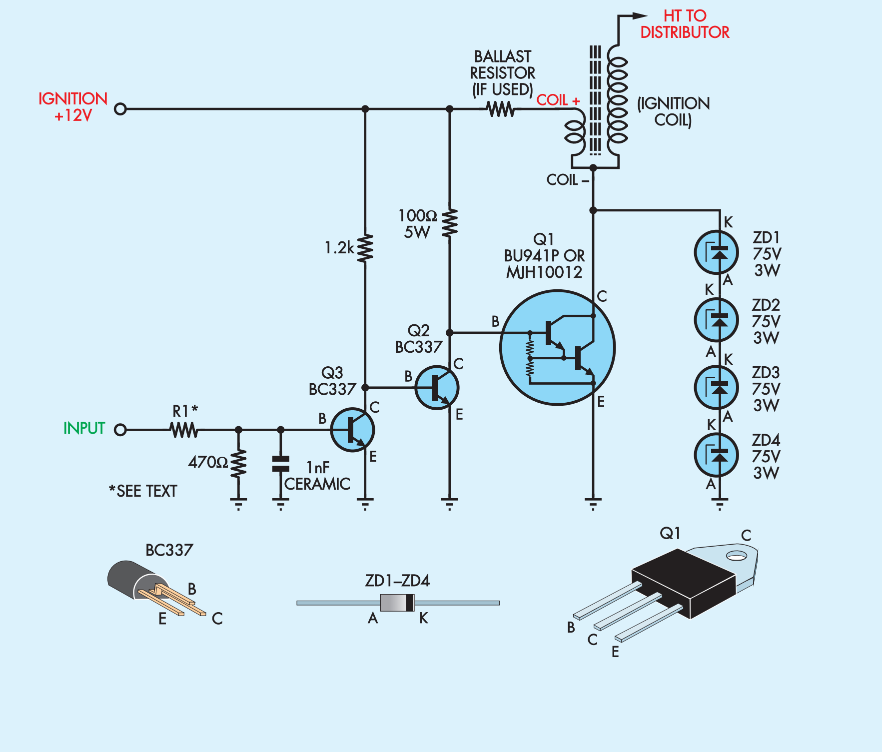
The circuit for the Programmable Ignition can be split into three sections. First, there is the Programmable Ignition Timing circuit, as shown in Fig.4. To this is added an input trigger circuit, depending on the ignition trigger used – see Fig.6. This can be either points, optical, Hall effect or reluctor, or can be taken from the engine management unit (EMU).

Finally, a separate circuit, controlled by the Programmable Ignition Timing circuit, drives the ignition coil – see Fig.5.

The LCD Hand Controller, to be described in Part 2, is a completely separate unit, which connects to the Programmable Ignition Timing module via a DB25 cable. As stated, it's used only during the setting-up procedure, after which it is no longer required unless you wish to reprogram the system (eg, to alter the timing map).

Ignition timing circuit

The main Programmable Ignition Timing circuit (Fig.4) is based on IC1, which is a PIC16F88-E/P high-temperature microcontroller. This micro processes the input trigger and MAP



IGNITION COIL DRIVER (PROGRAMMABLE IGNITION)

Fig.5: the Ignition Coil Driver is based on transistors Q1-Q3. Darlington transistor Q1 switches the ignition coil, while the four series Zener diodes across Q1 protect it against voltage spikes when the transistor turns off.

sensor signals and provides an output to drive the Ignition Coil Driver circuit. It also drives the LCD module in the Hand Controller and monitors its switches.

Timing signals for IC1 are provided by crystal X1. This sets the internal oscillator to run at 20MHz, which enables the software programmed into IC1 to run as fast as possible.

In operation, IC1 accepts the ignition trigger signal at its RB0 input (pin 6) and drives its RB3 output to switch the ignition coil (via the driver circuit) accordingly. As shown, the RB0 input is protected from excess voltages by a series 2.2kΩ resistor, which prevents excessive current flow in IC1's internal clamping diodes. Clamping occurs when the voltage goes below 0V or if it goes above the +5V supply (ie, the input is clamped to –0.6V or +5.6V).

The 1nF capacitor at the RB0 input shunts transient voltages and high-frequency signals, to filter false timing signals.

Transistor Q4 is also driven from the trigger input. The transistor is used to provide a tachometer output at its collector (C). In operation, Q4's collector is normally held high via a 2.2kΩ pull-up resistor, but switches low each time the transistor turns on (ie, when the trigger input is high).

Q4's collector output can be used to drive most modern tachometers. However, an impulse tachometer (now very rare) requires a different connection and this type should operate when connected to the ignition coil's negative terminal.

MAP sensor

The MAP sensor signal is applied to the analogue AN2 input of IC1 (pin 1) via a 1.8kΩ resistor. A 10nF capacitor filters out unwanted high-frequency signals to prevent false readings.

In operation, the AN2 input measures an input voltage ranging from 0 to 5V and converts this to a digital value ranging from 0 to 255. This is the value that's read from the DIAG (diagnostic) display.

Note that +5V supply and ground rails are provided for the sensor. If the Sensym sensor is used, it can be directly mounted on the PC board used for the Programmable Ignition Timing Module.

The optional knock sensor signal is applied to IC1's analogue AN1 input (pin 18). As before, this input accepts signal voltages from 0 to 5V and converts them to digital values.

Conversely, if the knock sensing circuit is not used, this input must be tied to ground using jumper link LK2 to disable the knock sensing function.

The third analogue input at AN3 (pin 2) is used to monitor the +12V ignition supply. As shown in Fig.4, this supply voltage is divided down using 100kΩ and 47kΩ resistors and filtered using a 10µF electrolytic capacitor, before being applied to the AN3 input. This divider effectively converts the supply voltage to a 0 to 5V signal, which is then used to determine if the dwell period should be increased to compensate for a low supply voltage.

Note that the voltage across diode D1 is accounted for in this measurement.

Link LK1 selects either the timing map display or the settings display. In the settings position, the RA5 input is tied to ground via a 10kΩ resistor. Conversely, when LK1 is in the timing position, RA5 is tied to 5V via the 10kΩ resistor.

Note that the RA5 input differs from the other inputs in that it cannot be directly tied to one of the supply rails, otherwise the micro could latch up. The 10kΩ input resistor eliminates this problem.

Switch S1 is used to select between the two 11×11 timing maps. When S1 is open, RA4 is pulled low via the 10kΩ resistors and Mapα is selected. Conversely, when S1 is closed, RA4 is pulled to +5V and Mapβ is selected.

Note that this switch operates only when the 11×11 maps are selected using the LCD Hand Controller. It has no effect if a 15×15 map is selected.

Driving the LCD

Pins 7, 8 and 10 to 13 of the microcontroller are used to drive the LCD module in the Hand Controller (via a DB25 connector). The 10Ω resistors in series with these outputs act as stoppers to keep RF signals out of IC1.

In addition, the RA0 input at pin 17 monitors the switches from the Hand Controller. The associated 1kΩ resistor pulls the input voltage to 0V unless a switch is closed, at which point the

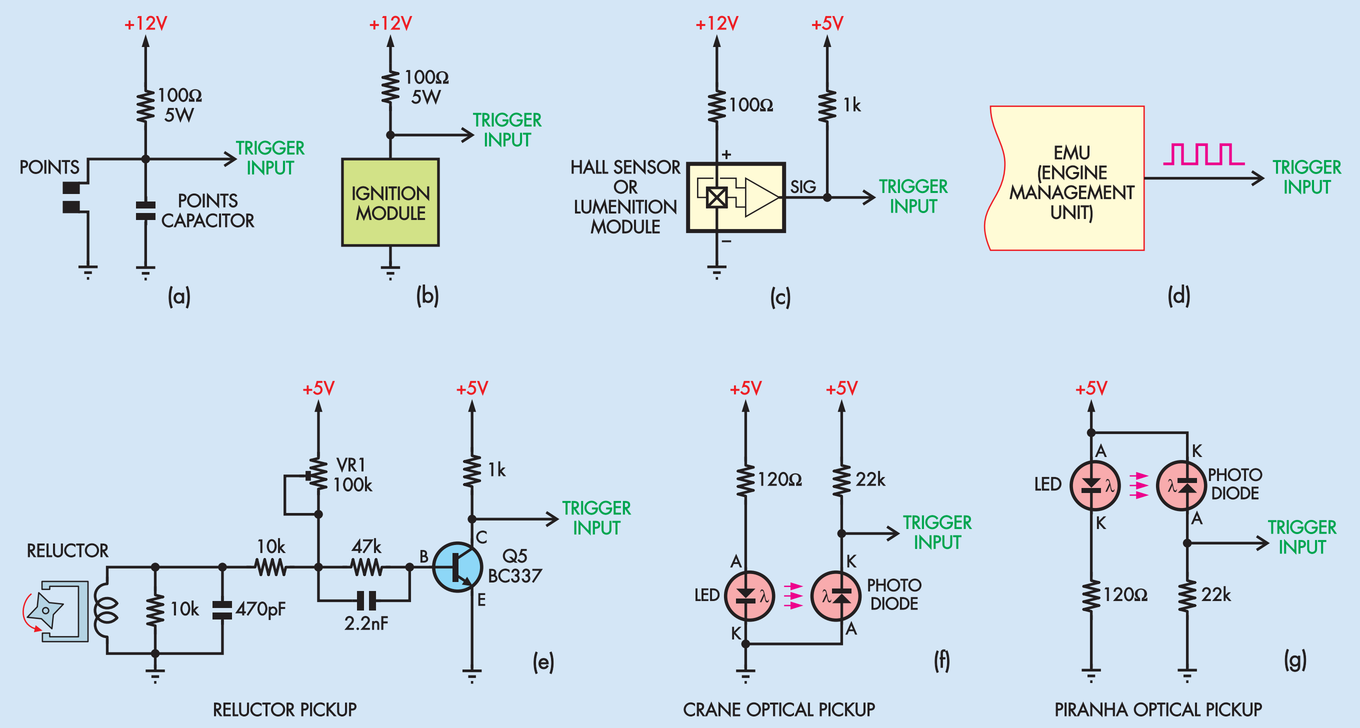


Fig.6: the seven input trigger circuits: (a) points triggering; (b) ignition module (see text); (c) Hall effect and Lumenition triggering; (d) triggering from an engine management module; (e) reluctor pickup; (f) Crane optical pickup; and (g) Piranha optical pickup.

line is pulled high to +5V. The 1nF capacitor filters out any RF signals.

Power supply

Power for the circuit is derived via the vehicle's ignition switch. This supply is then filtered using inductor L1 and the 100nF capacitor. Diode D1 provides reverse polarity protection, after which the supply is decoupled using a 1000µF capacitor.

As a further precaution, the circuit is protected from voltage spikes using transient voltage suppressor TVS1. This clamps any high voltages that may otherwise damage following components.

Following TVS1, the supply is regulated to +5V using regulator REG1. This is a low-dropout device and is used here to ensure that a regulated +5V supply is maintained during starting when the battery voltage can drop well below 12V.

A 100µF capacitor decouples the regulator's output, while a 100nF capacitor (located close to pin 14 of IC1) shunts high frequencies to ground.

Ignition coil driver

Fig.5 shows the Ignition Coil Driver circuit. It's fairly straightforward and is based on transistors Q1 to Q3.

Q1 is a Darlington transistor specifically made for ignition systems. It's capable of handling currents in excess of 10A and voltages exceeding 400V. As shown, four 75V Zener diodes (ZD1 to ZD4) are connected in series between its collector and emitter terminals. These protect the transistor from excess voltages by clamping Q1's collector (C) at 300V, which is well within its rating.

The circuit works like this: when the input signal is low (or there is no signal), transistor Q3 is off, Q2 is on (due to base current through the 1.2kΩ resistor) and Q1 is off. Conversely, when the input subsequently switches high, Q3 turns on and switches Q2 off by pulling its base to ground. As a result, Q1 turns on and current flows through the primary winding of the ignition coil.

The ignition input signal now subsequently switches low again and so Q3 immediately turns off due to the 470Ω resistor between its base terminal and ground. When that happens, Q2 switches on and Q1 switches off, interrupting the current through the ignition coil.

As a result, the coil's magnetic flux rapidly collapses and this generates a high voltage in the secondary to fire one of the spark plugs. The 1nF capacitor on Q3's base is there to suppress any RF signals that may otherwise be injected when the current through the ignition coil is interrupted (ie, when Q1 switches off).

Resistor R1 is included to make the module more versatile. In our application, R1 is not used and is replaced with a wire link. For other applications, where a separate ignition coil driver is required, R1 will be required. Typically, a 470Ω resistor would be used for a 5V drive signal, while a 1.2kΩ resistor would be used for a 12V drive signal.

Finally, the module can also be configured to drive transistor Q1 when the input signal switches low. In this case, Q3 is left out of circuit and a link installed between the pads on the PC board for its base (B) and collector (C) leads. The 1.2kΩ resistor pull-up is also removed from circuit.

Trigger inputs

The Programmable Electronic Ignition is configured for the appropriate trigger input during construction. The seven possible input circuits are shown in Fig.6.

Points trigger

The points trigger is shown in Fig.6(a) and includes a 100Ω 5W wire-wound resistor connected to the 12V supply. This resistor provides a 'wetting' current for the points to ensure there is a good contact between the two mating faces when they are closed. The wetting current is sufficient to keep the contacts clean, but not so high as to damage them.

Ignition trigger

The ignition module version is shown in Fig.6(b). This is essentially the same as the points input, except that a transistor inside the ignition module switches the input to ground instead.

This type of input has been included because some electronic ignition systems do not provide access to the actual trigger (usually a reluctor) and the only output is the ignition coil driver transistor. In this case, the coil is replaced with the 100Ω resistor to provide the necessary pull-up to +12V when the transistor is off.

Hall trigger

Fig.6(c) shows the Hall effect trigger. It uses a 100Ω current-limiting resistor to feed the Hall sensor, while the 1kΩ resistor pulls the output voltage to +5V when the internal open-collector transistor is off. Conversely, the output signal is pulled to 0V when the internal transistor is on.

Note that the same circuit is used for the Lumenition optical module.

EMU trigger

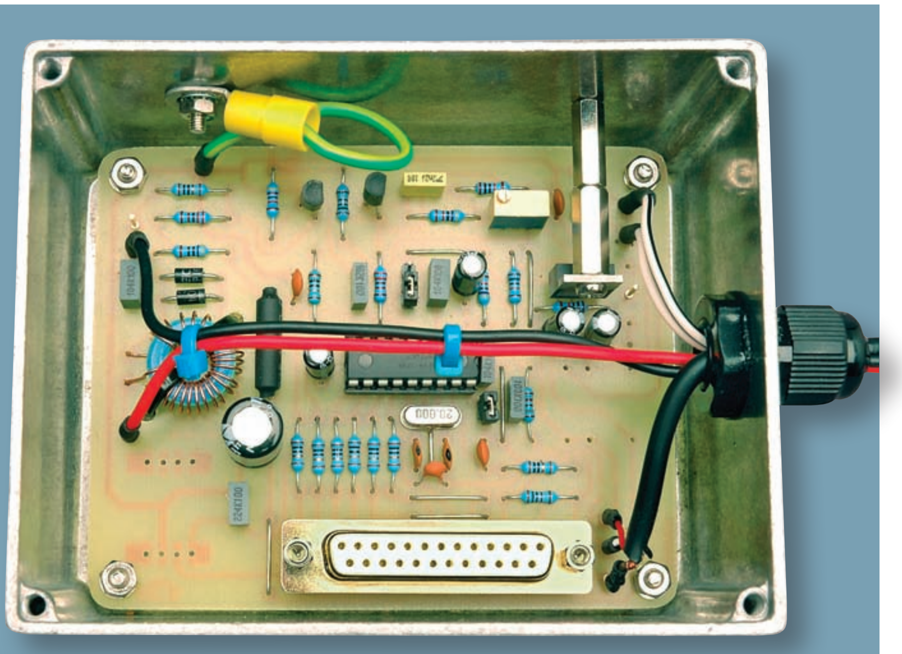
The engine management input circuit is shown in Fig.6(d) and is quite simple. Its 0V to 5V output signal connects to the trigger section of the main circuit in Fig.4.

Reluctor sensors

Reluctor sensors are catered for using the circuit in Fig.6(e). These produce an AC signal and so require a more complex input circuit.

In this case, transistor Q5 switches on or off, depending on whether the reluctor voltage is positive or negative. It works as follows: initially, with no reluctor voltage, Q5 is switched on via current through VR1 and a 47kΩ resistor. The voltage applied to Q5's base depends on the 10kΩ resistor across the reluctor coil and the internal resistance of the reluctor.

Trimpot VR1 is included to provide for a wide range of reluctor types. In practice, VR1 is adjusted so that Q5 is just switched on when there is no signal from the reluctor. The 10kΩ resistor provides a load for the reluctor, while the 470pF capacitor filters any RF signals that may have been induced.



This inside view shows the assembled PC board for the Ignition Timing Module but without the optional Sensym MAP sensor fitted. The full assembly details will be in Part 2 next month.

The 2.2nF capacitor ensures that Q5 quickly switches off when the reluctor signal goes negative.

Optical pickup

Finally, Fig.6(f) and Fig.6(g) show two different optical pickup circuits. Fig.6(f) is for a module that has a common 0V supply connection (eg, Crane), while Fig.6(g) is for a module that has a common positive supply (eg, Piranha). In each case, current for the LED is supplied via a 120Ω resistor, while the photodiode current is supplied via a 22kΩ resistor.

Software

The software for the Programmable Ignition is probably the largest and most complex to date. In all, the final assembler code totals some 6020 lines to perform all the necessary functions, including monitoring the ignition trigger and pressure sensor signals and providing an output based on the ignition timing map.

Basically, the software includes several multiply and divide routines (some 24-bit) to calculate the timing, based on the RPM and load site. These routines are also used to calculate engine RPM and the interpolated advance/retard values and must be performed constantly to maintain the correct timing as engine RPM and load vary.

We managed to perform all the required calculations in under 1ms – fast enough for high revving engines.

A significant part of the software has also been devoted to the many functions accessible via the Hand Controller and to allow the Hand Controller to be used while the engine is running.

In the end, we used all the data memory space of the PIC16F88 to store the ignition timing maps and the adjustable parameters, along with some 97% of the program memory.

Next month: Details of the LCD Hand Controller module and assembly of the Programmable Ignition module – there are six versions to choose from.

Thanks for the Ramory

TechnoTalk

Mark Nelson

For computers at least, memory has never been cheaper. Memory can be somewhat volatile (like human grey cells!), which is why manufacturers are developing and improving several new types of memory that don't fade (or vanish when you turn the power off). Non-volatile memory has a promising future in several forms, as Mark Nelson reports here.

EMPLOYING memory for data storage has always involved a compromise between size, cost and functionality. If you ever owned a Sinclair ZX-81 computer, you almost certainly suffered the problems of the wobbly add-on RAM pack, with the consequent loss of hours of programming. The blame for this could not be laid at the memory, however; it was just the result of an insecure mechanical connection, in other words lousy engineering.

Today's memory products are fantastic by comparison, both in performance and affordability. It's hard to believe how deep a hole that a 16kB RAM pack made in the pocket back in 1981 (£49.95 to be precise, equivalent to £212 based on average earnings). We have it so much better now.

Nevertheless, even the best solid-state memory of today has disadvantages. Flash memory, for instance, has a limited number of erase-write cycles before the memory capacity begins to deteriorate. Memory cards and 'sticks' are not recommended for long-term data storage, and the current generation of sold-state drives (SSDs) have lower storage density and slower writer speeds than hard disk drives.

Dynamic RAM (DRAM)-based SSDs require more power than hard disks and they still use power when the rest of the computer is turned off, whereas hard disks do not. Little wonder then that hardware manufacturers are still looking for the perfect memory storage device.

Chips with everything

It goes more or less without saying that the ideal storage medium for memory is chips. We already have memory chips in desktop and portable computers, in MP3 players and digital cameras, also in bank cards, swipe cards and 'lobster' cards for travel. Memory chips contain no moving parts (making them more reliable than disk drives) and are far more durable than magnetic tape. The disadvantages of solid-state memory for mass data storage mentioned above will probably disappear before long.

When we look what's under development there's some new vocabulary to learn. The acronym RAM is of course familiar. It stands for random access memory, so called because the elements of stored data can be written and read in any order (at random in other words, regardless of its physical location in the storage medium). We all know the difference between static RAM (SRAM), which stays where it is put (until the power goes off) and dynamic RAM (DRAM), which offers faster data access, but needs refreshing every few milliseconds. Both SRAM and DRAM are 'volatile', meaning that the stored data will be lost the moment the power is cut. Non-volatile RAM, such as flash RAM, preserves the data while powered down.

New kids on the block

It's time now to meet the new RAMs: FRAM, MRAM, RRAM and EcoRAM. Each has its own particular advantages and applications.

FRAM (or FeRAM) stands for Ferroelectric RAM, a non-volatile form of memory that is similar in construction to DRAM, but uses a ferroelectric (instead of dielectric) layer to achieve non-volatility. It is very much a niche product, competitive in applications where its operating characteristics give it an advantage over Flash memory. It works by applying an electric field across a ferroelectric crystal, the central atom moves in the direction of the applied field and the polarity of this atom remains the same when the electric field is removed.

Serial FRAMs are compatible with serial EEPROMs, while parallel FRAMs are compatible with parallel SRAMs. FRAM has the advantage of no-delay write speed, ability to withstand 100 trillion read-write cycles and requiring far less power to write and erase.

Magnetoresistive Random Access Memory (MRAM) also occupies only a niche position in the overall memory market, mainly because Flash RAM and DRAM offer greater density. Nevertheless, its proponents believe that MRAM's advantages are so overwhelming that eventually it will become the dominant memory type for all applications.

The M in MRAM underlines its fundamental difference from conventional RAM technologies. Magnetic storage elements store data without using electric charges or current flows. Ferromagnetic plates, separated by a thin insulating layer, hold the magnetic field in which one of the two plates is a permanent magnet and the other's field changes according to an external field. Data is read by measuring the electrical resistance of the cell.

Meteoric matter

RRAM (resistive RAM) aims to supplant Flash RAM by taking advantage of controllable resistance changes in thin-oxide films. Potentially, this could provide greater density, lower power usage, greater speed and lower cost than Flash memory. Dozens of patent applications have been made around the world already for a process in which an electrical pulse induces a change in the resistance of the conduction path through films of nickel or perovskite oxide. The process is reversible. Perovskite, by the way, is a kind of calcium titanium oxide composed of calcium titanate. The mineral occurs in several places around the world, in some meteorites and in the debris ejected by Mount Vesuvius.

EcoRAM is designed specifically for use in server farms, where low power consumption is more important than speed. Internet data centre power requirements are said to be rising by 20% a year, consuming globally as much energy as a country the size of Sweden or Mexico.

Earlier this year, the *Guardian* newspaper reported that US data centres used 61 billon kilowatt-hours of energy in 2006 – enough to supply the whole of the UK for two months, and 1.5 per cent of the entire electricity usage of the USA. According to Intel, memory consumes more power than processors in large server farms, so memory power consumption has to be reduced.

Solid-state, but not as we know it

Finally, it's worth recalling some older (and bulkier) types of data memory that were also solid-state, but in a different way.

At a radio rally around 1980, I bought a Raytheon video data entry terminal that combined a keyboard with a dual scan video monitor. Rather like some of the video game machines found at the time in pubs and amusement arcades, the CRT monitor was scanned simultaneously both horizontally and vertically (in a system known as quadradiddle). I never got it working, far less fathomed out how it functioned, but I do remember the seller telling me that it was from an aircraft radar system and used delay line memory (put this phrase into Wikipedia to read a very informative article).

Delay lines are solid-state (even the ones using mercury, if you consider mercury a solid liquid), as are core stores. In fact, core stores are ferromagnetic (see 'magnetic core memory' in Wikipedia) and as the article explains, this uses small magnetic ferroceramic rings that store information by means of the polarity of the magnetic field they contain. Core stores were used in computers of course, but also in television test pattern generators (to produce the circular design elements) and in telephone exchanges to translate dialling codes into the actual control or routing codes used within the switching apparatus.

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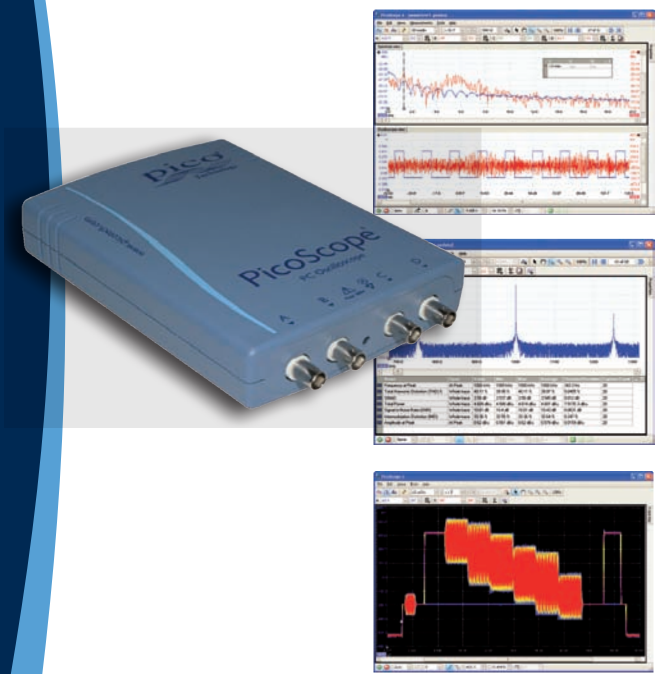

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SP156	3 x Stripboard, 14 strips x 27 holes
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SP161	10 x 2N3906 transistors
SP164	2 x C106D thyristors
SP165	2 x LF351 Op Amps
SP166	20 x 1N4003 diodes
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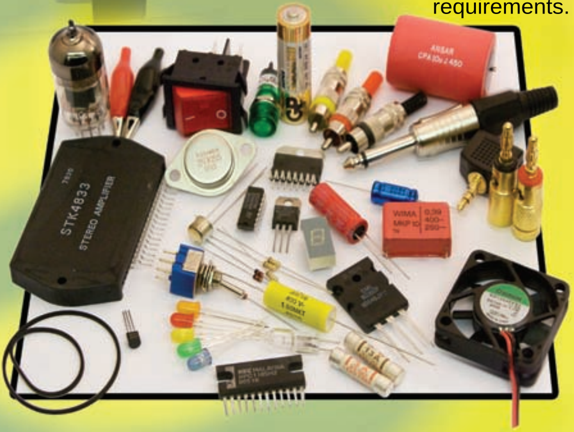

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Rolling Code Keyless Entry System

Versatile IR unit also functions as an alarm

Part.2: By JOHN CLARKE

Last month, we described the circuitry and gave the PC board assembly details for our Rolling Code Keyless Entry System. This month, we cover the installation and setting-up procedures and describe an optional SOIC adaptor board, so that you can program the PIC micro out of circuit.

HAVING completed the receiver board assembly, as described last month, it can be housed in a UB3-sized plastic box. As shown in the photo last month, it simply clips into place, but first you will need to drill a hole in one end for IRD1, plus a hole in the other end for the external wiring.

You will also have to drill matching holes in the lid for the Ack/Power and Arm LEDs (LED1 and LED2).

Now for the initial set-up. First, install a jumper link in the minus (–) position for LK2. This will set the Strike2 output to toggle mode (note: LK2 must always have a jumper connection, either to the '+' or '–' position). Leave jumpers LK1, LK3 and LK4 out for now.

Next, set trimpots VR1 and VR2 to mid-range. These trimpots are later used to set the various time periods.

Transmitter set-up

At this stage, the transmitter is already partially set up because its identity is selected during construction. If the transmitter's PIC microcontroller has not been programmed, then program it now via the ICSP connection. This connection can be made by soldering five leads to the transmitter's ICSP pins and then connecting the other ends of these leads to a 5-way ICSP socket to plug into the PIC programmer.

After the IC has been programmed, clip in the 12V battery and check that the green acknowledge LED lights when a switch is pressed.

Of course, if you buy a complete kit, the PIC microcontroller (and the PIC in the receiver) will be supplied pre-programmed, so you won't have to worry about that last step.

Testing the receiver

The receiver can now be tested. First, with IC1 out of its socket, connect a 12V power source that can supply at least 60mA. That done, switch on and check that there is 5V between pins 14 and 5

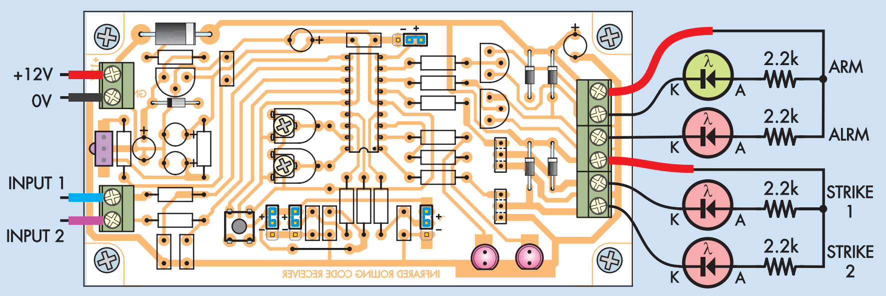


Fig.6: the test LEDs are connected to the receiver as shown here. Follow the procedure in the text to synchronise the transmitters and test the receiver.

of the IC socket. If this is within 10% of 5V (4.5V to 5.5V), switch off and plug IC1 into its socket, making sure that it is correctly orientated.

Next, wire up the test LEDs as shown in Fig.6. These are all wired in series with 2.2kΩ current-limiting resistors. Once the LEDs are wired up, apply power and check that the receiver's power LED flashes briefly at about once per second. If it does, then so far so good.

The transmitter must now be randomised and then synchronised with the receiver. Let's now take a look at these two procedures.

Randomising

Randomisation of the transmitter ensures that it uses a unique set of parameters to calculate the rolling code. This procedure is important because the original parameters programmed in are the same for every transmitter.

Basically, you need to personalise the parameters to prevent another transmitter that has the same identity from operating your receiver. If randomisation is not done, there is the real risk that someone else's transmitter that has also not been randomised will operate your receiver.

To randomise a transmitter, simply connect pins 3 and 5 of its ICSP connector together and then press switch S2. The transmit LED will flash at a one-second rate for the duration. Release the switch when you are ready (after between several seconds and several minutes).

The parameters are all altered every 40µs (that's 25,000 times a second), so they will be different for each transmitter after even short presses.

Synchronising

After randomising, the transmitter must then be synchronised with the receiver. To do this, disconnect pins 3 and 5 of the ICSP header and connect pins 3 and 4 together instead. That done, press and hold down S1 on the receiver and then press one of the switches on the transmitter.

The transmit LED will now flash twice momentarily and the receiver's acknowledge LED will flash on and off at a one-second rate until switch S1 on the receiver is released.

Rolling Code Protection: Keeping It Secret

As previously noted, the Rolling Code Keyless Entry System provides a high level of security because the transmitted code changes each time it is sent. However, to further improve security, we have also included code protection for both the transmitter and receiver.

Basically, code protection prevents the program and data within the PIC microcontrollers from being read by a PIC programmer. As a result, the parameters used to calculate successive rolling codes are kept safe within the microcontrollers. In particular, this effectively prevents a transmitter from being 'interrogated', in order to make a duplicate transmitter that will operate the door lock.

So, while the hex files can be used to program the microcontrollers, they cannot be read back once programming has been verified. The parameters used for calculating the rolling code are then randomised in the transmitter using the set-up procedure already described. It is these parameter and the rolling code seed values that are hidden by the code protection.

Now remove the link between pins 3 and 4 on the transmitter's ICSP header. Once that's done, you should now find that the transmitter operates the receiver. If it doesn't, try synchronising again and make sure that the IR receiver has a clear 'view' of the transmitting LED.

The above randomisation and synchronisation procedures must be done for each new transmitter. Note that a transmitter that has not been synchronised will not be able to operate its receiver, even if their rolling codes are the same. Note also that synchronising a new transmitter prevents the use of a previously synchronised transmitter that has the same identity.

Next, press the main switch on the transmitter and check that the receiver's Strike1 LED lights for about five seconds. The external Arm LED should also light, while the receiver's on-board Arm LED should flash with an even on-off duty cycle. This flashing shows the exit delay.

After about 20s, the exit delay should expire and the Arm LED should then flash briefly once per second.

Now check the operation of the second (smaller) switch which is on the transmitter. This switch should toggle the Strike2 LED on and off with successive pressings.

Testing the alarm

To test the alarm, arm the unit and short Input1 on the receiver to ground (0V) using a clip lead. The external alarm (ALRM) LED should light after 20s and should then stay on for 60s.

You can check the operation of the delayed exit by arming the unit and momentarily shorting Input1 or Input2 to 0V during the exit period. The alarm LED should not light after the exit period has expired.

Receiver options

The receiver can be powered from a 12V DC plugpack or a 12V battery. When powered by a plugpack, make sure it can supply the necessary current for the electric striker and an alarm siren if fitted. Many electric strikes draw around 800mA, so a 1A plugpack will be required.

Note that the armed status is stored in case the power goes off; the armed or disarmed mode will be returned when power is reconnected. So, if the receiver was armed when power was lost, then the armed mode will be restored when power is returned.

Table 1: Strike1 operation (LK1)			
LK1	+	–	Open
Strike1 operates on	Arm Only	Disarm Only	Arm and Disarm

Table 2: Strike2 operation (LK2)			
LK2	+	–	Open
Strike2 operation	Momentary	Toggle	Not valid

Table 3: LK3, VR1 and VR2 settings			
LK3	+	–	Open
Operates when S1 pressed	VR1 sets Strike1 period VR2 sets Strike2 period	VR1 sets Input1 delay VR2 sets Input2 delay	VR1 sets alarm period
Notes	5V sets 64s 2.5V sets 32s 1.25V sets 16s 0.625V sets 8s 0.313V sets 4s 0.156Vsets 2s	5V sets 64s 2.5V sets 32s 1.25V sets 16s 0.625V sets 8s 0.313V sets 4s 0.156Vsets 2s	5V sets 128s 2.5V sets 64s 1.25V sets 32s 0.625V sets 18s 0.313V sets 8s 0.156Vsets 4s

When powering from a 12V battery, a charger should also be connected to maintain battery charge – see Fig.7. A 12V 350mA charger for sealed lead-acid batteries would be suitable. These chargers are fully automatic – they charge the battery when required and maintain full charge with a trickle current.

Depending on your application, Strike1 can be optioned to operate on arming, on disarming or on both arming and disarming. These options are selected using link LK1. Table 1 shows what each link connection does. You may also wish to place a small buzzer across the door strike connection to give an audible indication of door strike operation.

The Strike2 output can be momentarily activated whenever the secondary switch on the transmitter is pressed. Alternatively, it can be toggled on or off with each switch pressing. Link LK2 selects these options.

Receiver time periods

Trimpots VR1 and VR2 are used to set the time periods for Strike1 and Strike2, the exit and entry delays for Input1 and Input2, and the alarm period. Link LK3 provides the means to set each time period – see Table 3.

With LK3 in the '+' position, VR1 and VR2 set the strike period for Strike1 and Strike2 respectively. Table 3 shows the various voltages that VR1 and VR2 can provide to set the strike periods. These voltages can be measured at TP1 for VR1 and at TP2 for VR2.

To set the strike periods, simply adjust VR1 and VR2 to the voltage settings required and press the synchronise switch (S1) on the receiver board.

The delayed inputs (ie, the entry delays for Input1 and Input2) are set when LK3 is in the '–' position. Once again, it's simply a matter of setting the voltages at TP1 and TP2 and pressing S1 to set the values.

Finally, when LK3 is out, VR1 sets the alarm period (VR2's setting is ignored). Just set the required voltage at TP1 and press S1 to program the period in.

Note that because pressing switch S1 programs in the timing adjustments, synchronisation will also alter the timing. This means that if you synchronise a transmitter to the receiver at a later date, you will have to make sure that VR1 and VR2 are in the correct positions for the LK3 option selected before pressing S1.

In practice, this just means leaving VR1, VR2 and LK3 in their final positions after you finish the timing adjustments. That way, if you synchronise a transmitter later on, the last set timing values are simply reset to the same values.

Arm output option

Link LK4 sets the arm output option – see Table 4. When LK4 is in the '+' position, the Arm output is low on arm and open on disarm. Conversely, when LK4 is in the '–' position, the Arm output is open on arm and low on disarm. It all depends on how you intend to use this output as to which option you choose.

Receiver lockout

Any transmitter that has been synchronised can later be locked out from operating the receiver. This is done by setting links LK1, LK2, LK3 and LK4 in the receiver and pressing switch S1 during power up.

Table 5 shows the link options for each transmitter identity. Note that these link settings correspond exactly to the links used in the transmitter to set the transmitter identity

When lockout is performed, the power LED flashes the identity number to indicate that the procedure has been successfully completed. So, for example, if you lock-out an identity 3 transmitter, the power LED will flash three times at a nominal 1s rate before a 4s break until S1 is released.

When S1 is released, the receiver then operates normally, but with the selected transmitter now locked out.

If S1 is held closed, the cycle of LED flashing continues. At the end of the third cycle, all identities will be locked out and the power LED will stay lit until S1 is released. This feature is included as a short cut to locking out all identities.

If one transmitter is locked out and a second one also needs to be locked out, then the power will have to be switched off and links LK1-LK4 repositioned for that transmitter identity. The power must then be re-applied with S1 pressed.

Once the lockout procedure has been completed, you must relocate links LK1-LK4 to their correct positions for the receiver functions that you wish to select. It is then best to test that everything is correct by pressing the switches on another (non-locked-out) transmitter and verifying that the receiver operates as expected.

Where To Get The Bits

Suitable reed switch assemblies, door strikes and sirens are available from Jaycar electronics. They can also supply kits for this project.

The parts available from Jaycar include: (1) the LA-5072 normally closed (NC) reed switch magnet assembly; (2) the LA-5078 door strike; and (3) the LA-5255 and LA-5256 piezo sirens.

Above right: door strike available from Jaycar.

Calculating The Rolling Code

The rolling code for the infrared transmitter comprises four start bits, a 48-bit code and four stop bits.

A calculation comprising a multiplier and an increment value is used to generate the 48-bit code. First, you start with a number (called the seed), then you multiply this seed by the multiplier and then add the increment. The result becomes the next value for random code.

Normally, if the calculation is continued, the random code will become larger and larger as we multiply and then add the increment value. However, this is prevented by limiting the seed value used in the calculation to a certain width; 32 bits in this case.

In practice then, the 24-bit multiplier multiplies the 32-bit seed. The 8-bit increment value is then added and the result is limited to 48-bits by eliminating the more significant bits. This resulting 48-bit code is the code used for the rolling code transmission. In addition, the order of transmission for these bits is jumbled using an 8-bit scramble code with 32 possible combinations.

The calculations do not necessarily produce random numbers, but they do produce variations from one transmission to the next. However, in some cases, the result could converge to settle at the same value, so it is important to check this and make sure the calculations do give diverging values each time.

To do this, the result of each calculation is compared to the last value to ensure it is not repeated. If the result is the same as before, the duplicate code is not transmitted and a new calculation is made after incrementing the result. Subsequent calculations will then begin to diverge again.

Randomisation

To avoid conflict, each transmitter must have a unique set of parameters for making the rolling code calculations. As a result, we have included a 'randomisation' function, whereby the multiplier value, the increment value, the scramble value and the seed value are all changed in a relatively random way.

There are 16.7 million multipliers available and 54 possible increment values. Together with the 32 scramble variations, these provide 29 billion different combinations. In addition, the minimum multiplier value is 8192 to ensure a significant change in value with each calculation.

Even if two transmitters do end up with the same parameter values, the fact that the seed value is a part of the calculation means that you need to be within 200 values of the correct value in order to unlock someone else's lock. The probability of this is 2^{24} divided by 200, or one in 83,000. This is in addition to the one in 29 billion chance of having the same parameter values!

There are up to 16 different transmitters that can be used with the one receiver, and each transmitter uses a different set of seed, multiplier, increment and scramble values. The transmitter sends out its identification code that is embedded in the rolling code, so the receiver knows which set of values it must use in the calculation for each transmitter.

When the transmitter is sending synchronising code to the receiver, it sends the 8-bit identifier, the 24-bit seed, the 24-bit multiplier, the 8-bit increment value and the 8-bit scramble values. The identifier value is also stored, so that the receiver knows that this identity has been synchronised. An identity that has not been synchronised will not operate the receiver.

Once the receiver has these parameters, the transmitter and receiver will remain in lock because they use the same calculation values.

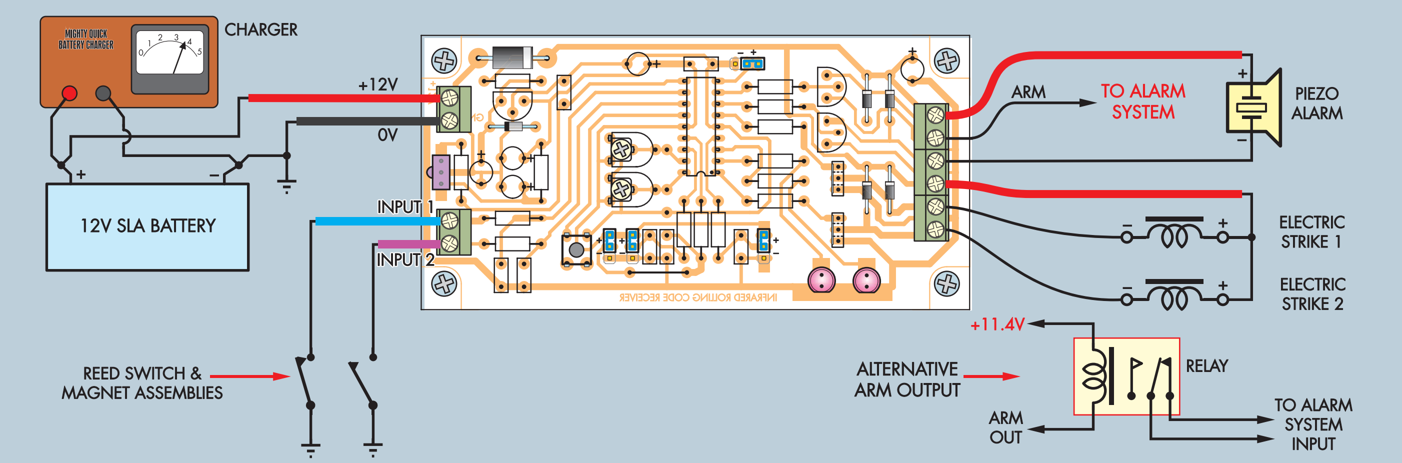


Fig.7: here's how to connect the receiver in a typical installation. Note that you can use both NO (normally open) and NC (normally closed) sensors on the alarm inputs (Input1 and Input2). The battery charger keeps the battery topped up.

Undoing lockout

It's easy to get a locked out transmitter to operate the receiver again (ie, to unlock it). Just synchronise the transmitter with the receiver and all will be back to normal.

Installation

The Rolling Code Keyless Entry System is suitable for use in homes, factories and cars. Fig.7 shows how to wire the unit for a typical installation. **Note that IRD1 must be shielded from direct sunlight, otherwise the reception range will be severely affected.**

In some cases, it may be necessary to connect the infrared receiver (IRD1) via extended leads using twin-core

Table 4: Arm output (LK4)		
LK4	+	–
	Arm output low on arm, open on disarm	Arm output open on arm, low on disarm

Table 5: Receiver lockout selections				
Lockout Identity	LK1	LK2	LK3	LK4
1	+	+	+	+
2	+	+	+	–
3	+	+	–	+
4	+	+	–	–
5	+	–	+	+
6	+	–	+	-
7	+	–	–	+
8	+	–	–	–
9	–	+	+	+
10	–	+	+	–
11	–	+	–	+
12	–	+	–	–
13	–	–	+	+
14	–	–	+	–
15	–	–	–	+
16	–	–	–	–

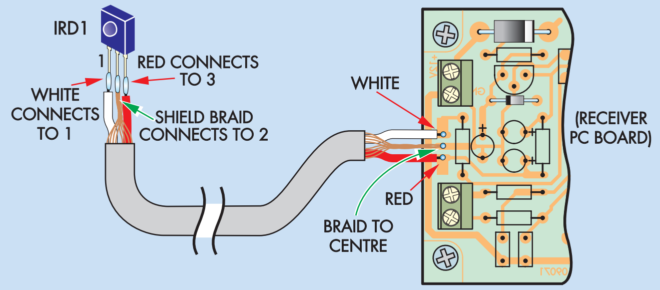
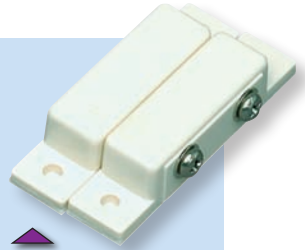


Fig.8: the IR receiver (IRD1) can be connected via twin-core shielded cable as shown here.



Above: you can buy both NO and NC reed switch assemblies.

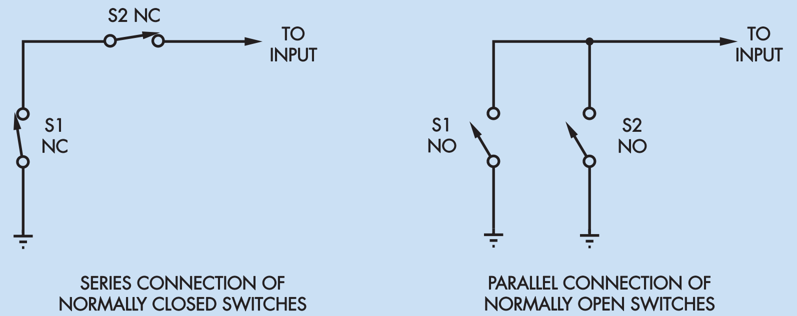


Fig.9: here's how to wire the two different sensor types (NO and NC) to the alarm inputs on the receiver board.

shielded cable (eg, if the receiver is mounted on one side of a wall, but infrared reception is needed on the other side). Fig.8 shows how this is done.

The two alarm inputs (Input1 and Input2) can be used in conjunction with reed switch magnet assemblies that change state when a door or window is opened or closed. You can use either normally closed (NC) or normally open (NO) types. (See last month's weather station project for the lowdown on reed switches.)

As shown in Fig.9, NC types are connected in series, while NO types are connected in parallel. However, for best security, use only one sensor per input.

Alternatively, you can use a PIR detector or a glass breakage detector on one or both of the inputs. *EPE*

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EPE EXCLUSIVE

PIC Programmer SOIC Converter

Programming 18-lead surface-mount SOIC PIC microcontrollers can be quite difficult, because access to the tiny leads is tricky. This adaptor PC board accepts 18-pin SOIC PIC microcontrollers and plugs directly into a conventional PIC programmer.

Most people will probably consider buying a kit for the *Rolling Code Keyless Entry System* project, and the PIC micros used in the transmitter and receiver will come pre-programmed. But what if you want to program them yourself?

One way of programming the SOIC (surface-mount) PIC16F628A–20/SO used in the transmitter is to use the In-Circuit Serial Programming (ICSP) header on the PC board. Basically, you have to connect the Vdd, Vss, $\overline{\text{MCLR}}$, RB6 and RB7 pins on the processor to the +5V, 0V, Vpp, clock and data ICSP connections on a PIC programmer. However, this technique is only good for assembled PC boards (assuming ICSP connections are available on the PIC programmer).

Converter board

If you want to program an SOIC PIC out of circuit (eg, for production runs) some other method is needed. This simple SOIC Converter board solves the problem. It provides a means to connect the pins on the SOIC PIC to a standard 18-pin DIP socket on a PIC programmer.

Parts List

1 PC board, code 723, available from the *EPE PCB Service*, size 29mm × 48mm
1 100nF monolithic ceramic capacitor (code 104 or 100n)
2 9-way header strips with 2.54mm spacing
1 80mm length of 0.7mm tinned copper wire

In use, the SOIC PIC is positioned on the converter board and held in place using a spring-loaded clip (eg, a clothes peg or a bulldog clip). The SOIC Converter then plugs into the PIC programmer, after which programming is carried out in the normal manner.

Circuit details

Fig.1 shows the circuit for the SOIC Converter. There's not much to it – just two 9-pin SIL headers and a 100nF capacitor. The SIL header pins connect to the Vss, Vdd, Vpp, RB6 and RB7 pins of the SOIC device.

No provision has been made for low voltage programming (LVP) because the LVP pin varies between different processors. The 100nF capacitor bypasses the 5V supply.

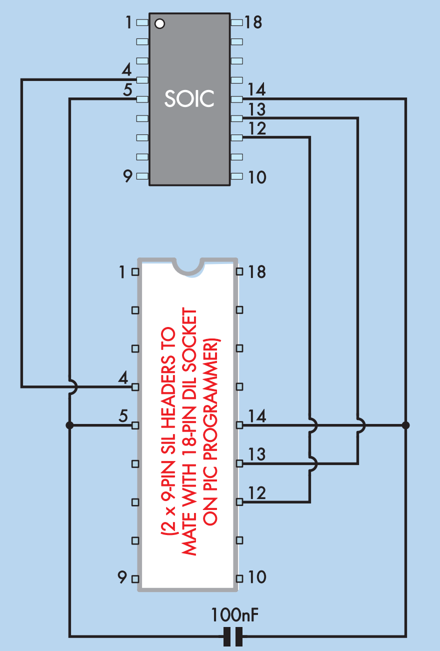


Fig.1: the SOIC Converter uses just two 9-pin SIL headers and a 100nF capacitor.

The PC board (code 723 and measuring 29mm × 48mm) is assembled by first installing the three links on the non-copper side of the PC board – see Fig.2. The two 9-way header strips are then installed and soldered in place.

Finally, the 100nF capacitor is mounted on the copper side of the board – see photo.

Note that power must always be off when mounting the SOIC device or removing it from the board. *EPE*

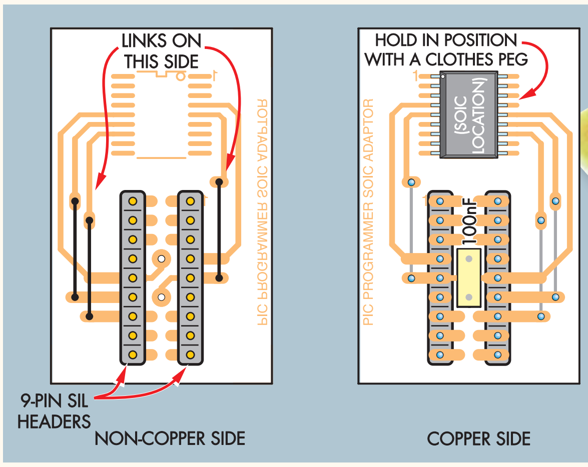
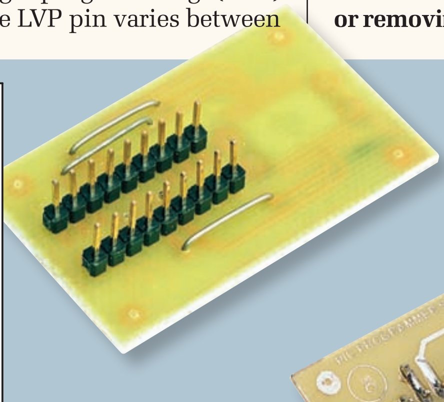
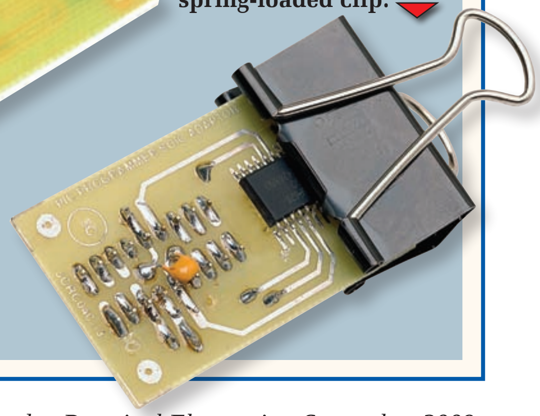


Fig.2: assemble the SOIC Converter as shown here.





Below: the SOIC device is held in place for programming using a spring-loaded clip.

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Reviewing Summit Electronics' QuickBuilder 2 software tool

QUICKBUILDER 2 is a software tool that can aid the development of projects based on a wide range of PIC16*** and PIC18*** series microcontrollers, plus a few others. A large list of compatible devices is available at the QuickBuilder website.

This program was originally available as normal commercial software, but it has been re-launched as a free download with no time limits or other restrictions. The hardware requirements for running the program are not very demanding, and are given as a PC with Pentium class processor running Windows95/98/NT/2000/XP, and having 4MB hard disk space.

Practically any PC should have the wherewithal to run QuickBuilder 2, but there is a potential problem for some users in that it is not guaranteed to be compatible with Windows Vista. It does seem to run under Vista without any obvious problems, but it is necessary to download an add-on from the Microsoft website in order to use the built-in Help system and its old style HLP files. As with any program that is largely graphics oriented, a reasonably high screen resolution is preferable, but it is not essential in this case.

C how it works

When first running and experimenting with QuickBuilder 2, you get the impression that it is a program for beginners, where you develop projects by assembling on-screen building blocks to build up the circuit, then set the appropriate parameters, and finally get the program to produce the PIC code. However, this is not quite the way that it works, and it is not a program for beginners at all. Its purpose is to help experienced PIC project developers work more efficiently.

You do actually start by building up circuits from predefined building blocks, or 'sub-circuits' as they are called in QuickBuilder parlance, and there is software linked to each building block. The Build function is used to produce the code for the circuit, which is in the C programming language. Therefore, a C compiler is needed, in order to produce the assembly language that is used to program the PIC chip.

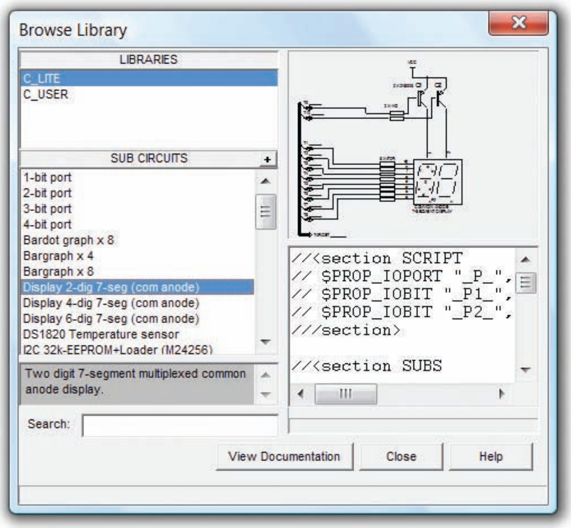


Fig.1. The required sub-circuits are added to the palette by double-clicking their entries in this list

The output of QuickBuilder 2 is designed for use with a CCS C compiler, and a limited demonstration version of this program is available as a free download. Unfortunately, the output of QuickBuilder 2 is not compatible with the popular Hi-Tech PIC C compiler.

Although it is not necessary to produce any code for each sub-circuit, the user does have to add the software that integrates everything into a working application before compiling the program. The code linked to each sub-circuit sets up the lines of the PIC chip in the appropriate fashion, and provides the appropriate support where necessary, but it is up to the user to bring everything together and make it all work in the appropriate fashion. This obviously requires a reasonable knowledge of the C programming language, and preferably the CCS version of PIC C.

In use

The download is quite small, just 1.2 megabytes, so it is a practical proposition if only a dial-up connection is available. Installing the program is very easy and proceeds in normal Windows fashion. The program itself has a conventional layout with the usual menu bar at the top, a small toolbar immediately beneath, and most of the main screen area available for the circuit.

However, the right-hand section of the screen provides a dynamic map that makes it easy to navigate the drawing area, and this section of the screen is also used for a palette of sub-circuits that can be added to the circuit. One slight peculiarity is that the program insists on running in widescreen format, even if a monitor having a normal aspect ratio is used. When set to run in full-screen mode this can result in an unused band along the bottom of the screen, which can be a bit distracting.

On target

With the program 'up and running', the first task is to select the target PIC chip using a menu accessed via the toolbar. Then one or more sub-circuits are added to the drawing area, or design sheet as it is termed in the QuickBuilder documentation.

In order to populate the design sheet with sub-circuits, it is first a matter of adding them to the palette. Right-clicking the palette and selecting the Add option from the pop-up menu produces a small window (Fig.1) where the required sub-circuits are added by double-clicking their entries in the list.

The sub-circuits are then added to the design sheet, and this is just a matter of left-clicking an entry in the palette in order to select it, and then left-clicking again on the design sheet. When two or more sub-circuits of the same type are required, simply left-click on the design sheet for each copy that is needed.

A reasonable range of predefined sub-circuits are supplied, ranging from simple ports, switches, and LED indicators, through to more complex types, such as multiplexed LED displays, a dot matrix LCD, EEPROMs, and a QWERTY keypad. The supplied sub-circuits should suffice to get started with QuickBuilder 2, but I suppose that with this type of thing there will never be enough pre-defined circuits to satisfy every requirement. Ultimately, it will be necessary to delve deeper into the program and modify the supplied sub-circuits or design your own.

Once in place, the sub-circuits can be repositioned by dragging them around the screen, or erased by right-clicking and selecting the delete option from the pop-up menu. The design sheet is large enough to accommodate a fair number of sub-circuits, but even with a high resolution screen it is not possible to display the entire sheet. With larger circuits it is necessary to resort to the Pan panel in order to display the required section of the circuit. No zoom facility is available.

Getting connected

With the sub-circuits in place, the next step is to allocate an input/output line of the PIC chip to each input/output terminal of every sub-circuit. This is achieved by right-clicking the first sub-circuit and selecting Properties from the pop-up menu. A small pop-up window is then used to allocate each input output terminal of the sub-circuit (Fig.2).

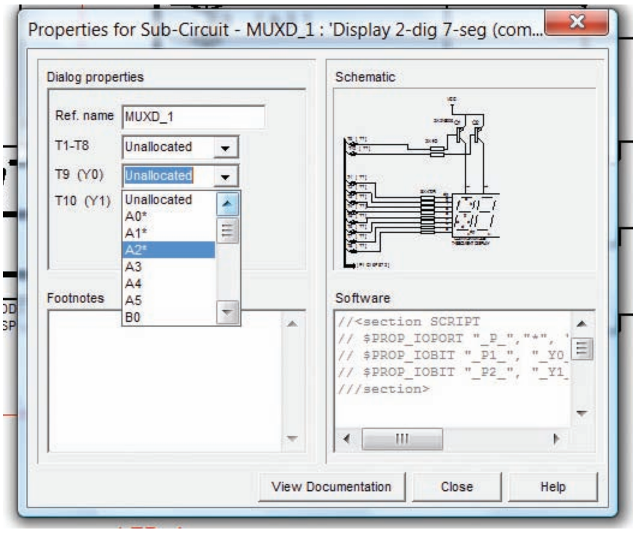


Fig.2. This window is used to allocate each input/output terminal of the sub-circuit to a pin of the PIC chip. Pins that are already allocated are marked with an asterisk

Any lines of the PIC chip that have been allocated already are marked with an asterisk, which should help to avoid incorrectly allocating the same line to more than one function. A full list of input/output allocations is available, see the View menu.

A footnote can be added using the textbox provided in the Properties window. This text appears on the design sheet in a yellow box beneath the sub-circuit. It is also possible to add notes for the entire project by selecting Notes from the Project menu or using the appropriate button on the toolbar. The required text is then entered into the pop-up window. This text does not appear on the design sheet, and is only accessed via the pop-up text editor.

Once the input/output terminals of the first sub-circuit have been allocated, the process is repeated for the remaining sub-circuits, and the circuit is then complete. The end result is something like Fig.3, which is the circuit for a remote terminal, and is one of the demonstration circuits supplied with the program. The program has the usual Print facility that can be used to provide hard copy of the design sheet using any Windows-compatible printer.

Having given everything a final check, it is then time to produce the C code by selecting the Build option from the Project menu or operating the Build button on the toolbar. A pop-up window reports on the progress of the build process, and if

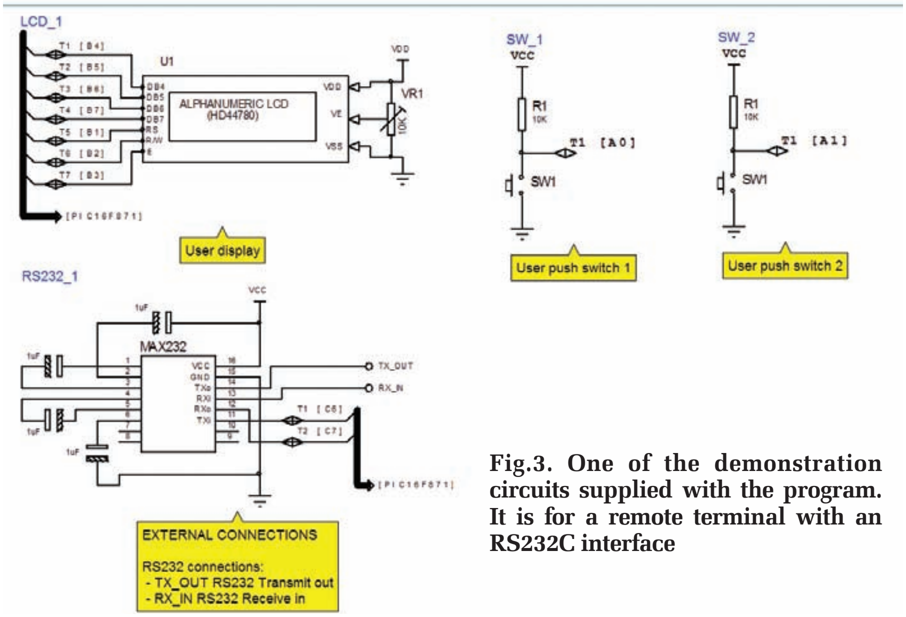


Fig.3. One of the demonstration circuits supplied with the program. It is for a remote terminal with an RS232C interface

all is well it will almost immediately report that the build was successful.

If required, the output of the program can then be viewed from within QuickBuilder 2 (Fig.4) by operating the View Output button. The destination folder for the output text file can be specified using the options window available from the Project menu. With the output code generated, QuickBuilder 2 has completed its part of the development process, and it is then up to you to complete the process and get everything working correctly.

Conclusion

As pointed out previously, it is a mistake to think of QuickBuilder 2 as a program for beginners. It makes it quick and easy to produce a range of PIC-based circuits and the basic PIC C code to go with them.

However, in order to utilize the program it is essential to already have an understanding of the circuits and the techniques used, such as display multiplexing and RS232C interfacing. It is also necessary to have a reasonable knowledge of PIC C programming in order to turn the output of QuickBuilder 2 into the finished product. QuickBuilder 2 is responsible for much of the 'donkey work', leaving the project developer to get on with the clever stuff.

I think it is fair to say that this software is more to do with reusing circuit and software blocks than with the production of instant PIC circuits. Probably every PIC project developer reuses their favourite circuits and supporting software anyway, but QuickBuilder 2 provides a proper framework to work within, putting everything in a neat and easily accessible form. Whether the QuickBuilder approach to things suits you is very much a matter of personal preference. The same is true of the PIC C programming language.

When producing a review, it is not possible to exhaustively test every aspect of the program, but running under Windows XP, QuickBuilder 2 proved to be totally stable and error-free during the test period. As explained previously, it also ran perfectly well under Windows Vista, even though it is not guaranteed to do so.

When using the program with Vista, it is important to download the Help add-on from the Microsoft website so that the built-in Help system becomes active, since this is the only documentation provided. There is no separate instruction manual.

On the face of it, value for money is not an issue since QuickBuilder 2 is now completely free. Bear in mind though, that there is no free version of the CCS compiler other than a time-limited demonstration version that also has a 2k file size limit. You can try the program for nothing, but unless you already own a suitable C compiler it will be necessary to buy one (at 150 US dollars) in order to go on using QuickBuilder 2. This was of less importance when the original QuickBuilder software was a commercial product, but is clearly of more significance now it is available as a freebie. If you are already into PIC C programming, or are considering an entry into this type of PIC programming, then it is certainly worth trying QuickBuilder 2, but keep in mind the true cost of using this program.

Further details of QuickBuilder 2 and the free download are available at: **www.quickbuilder.co.uk**

Further information about the CCS PIC C compiler can be obtained at: **ww.ccsinfo.com/** ***EPE***

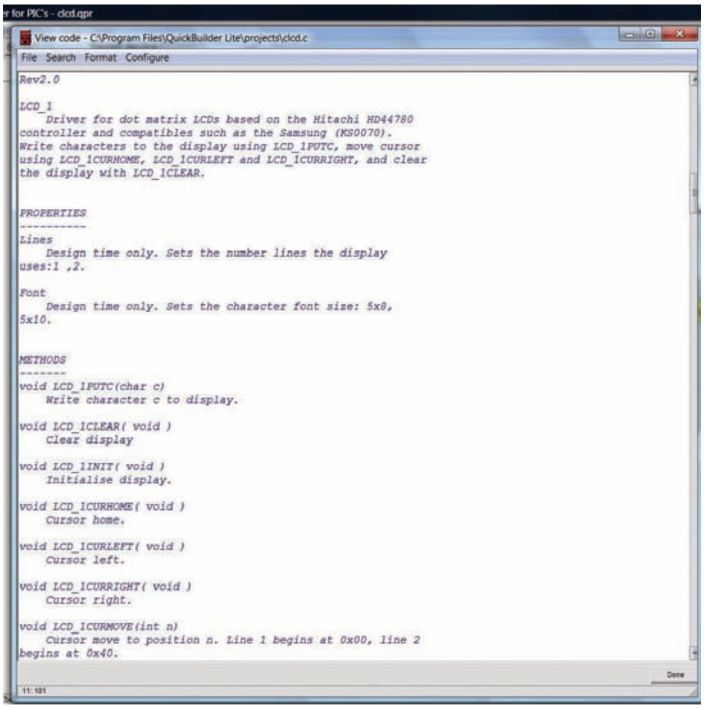
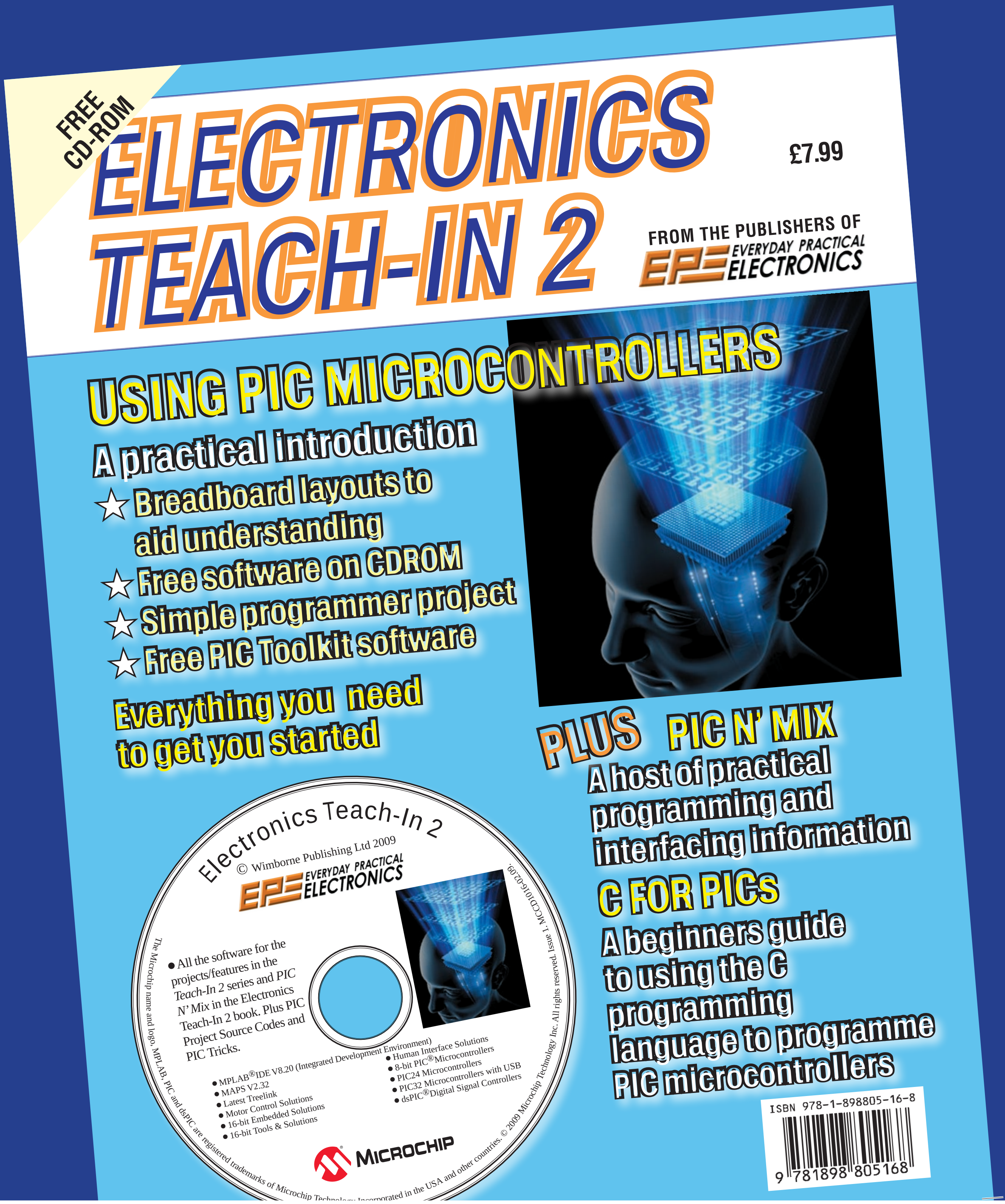


Fig.4. The output of the program can be viewed from within QuickBuilder 2. At this stage, the program has completed its part of the process, and it is up to the user to complete the project



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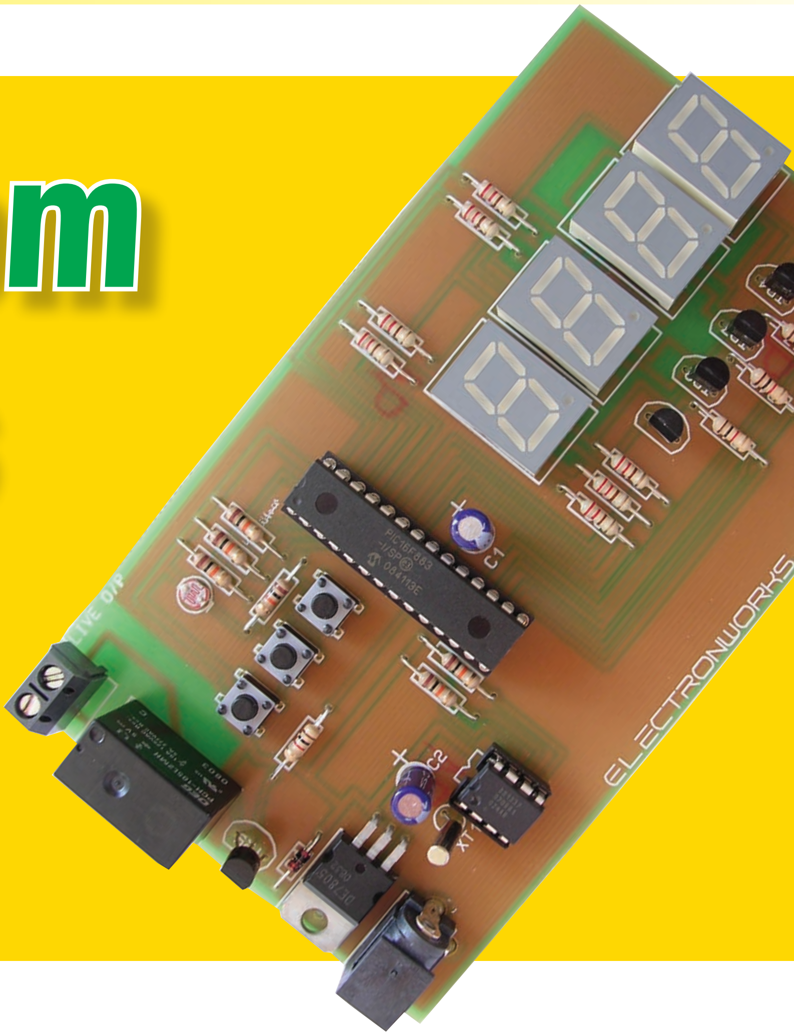
Random Mains Timer

By BILL NAYLOR



Effectively simulates a house being occupied when it is empty!

This article describes the design of a mains timer with a level of randomness to the switching times to more effectively simulate a house being occupied when it is empty. It also has a light sensor to prematurely activate a lamp if the ambient light level is unusually low.

Introduction

Today, home security is more important than ever before. The average home is kitted out with a feast of electronic gadgets that a thief would love to get his hands on. Moreover, these items are portable, easy to steal and easy to sell – ideal food for the hungry burglar.

Unfortunately, some thieves watch their victims' premises before they strike. Many home owners activate a light timer to make their house look occupied, but if the light just switches on early in the evening and off at the end of the evening, the house can indeed look like it is being lit with just a timer-controlled light.

A level of randomness is needed that automatically switches a light on and off throughout the evening at 'random' times to more effectively simulate a property that is occupied. In addition, a light sensor is needed in case of low light levels in the early evening when an occupied house would have its lights on.

Circuit details

The Random Mains Timer does exactly that, and the full circuit diagram is shown in Fig.1. At the heart of the circuit is a PIC16F883 microcontroller. This drives a four digit, 7-segment LED display that shows the current time and, at the press of a button, the time for the light sequence to start, thus it doubles up as a handy clock too. The power supply to the circuit was provided by a 9V DC plug-in mains adaptor regulated to 5V by a 7805 linear regulator.

The 7-segment display pinout details are shown in Fig.2. Segments 'a' to 'g' are wired with a common cathode, connected to pins 3 and 8. The circuit uses four such LED displays, and to save port pins, the 7-segment displays are multiplexed. Thus, the four 'a' segments are wired together and driven from a common port pin. The same with the four 'b' pins … etc.

Each of the four digits is then activated by driving the common cathode pin. So at any one time, the anodes of the LEDs may have a voltage applied to them, but they only light when the corresponding cathode is driven too. If the anode voltage is applied, then the cathode is pulled low for approximately 10ms, each LED digit can be shown in turn.

An LCD display was considered for the design, but a 7-segment display is much cheaper and easier to read from a distance, despite having a more complex driving method.

Time clock

The time is maintained by a DS1337 real time clock (RTC) chip, from Maxim. The pinout and internal function information is included on the circuit diagram Fig.1 – see IC2.

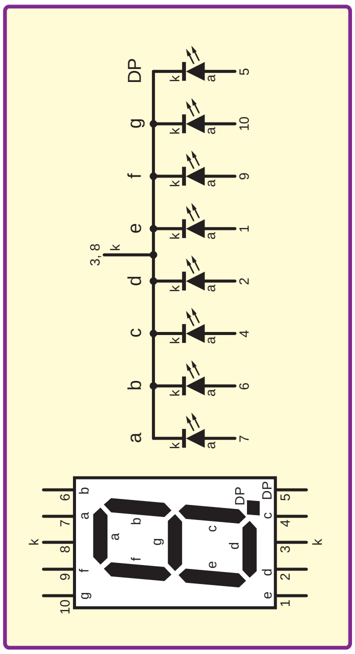


Fig.2. The 7-segment display, common cathode, pinout and segment details

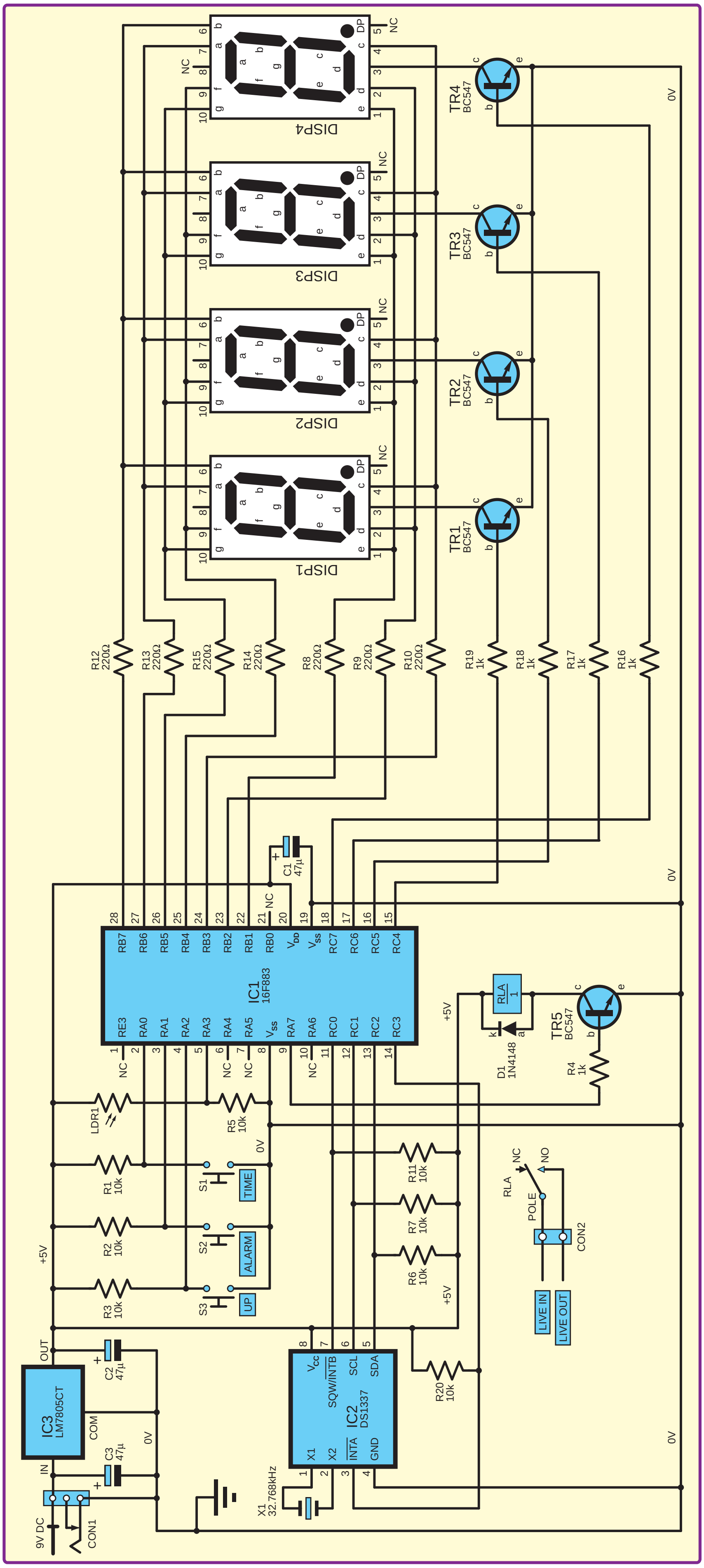


Fig.1. Full circuit diagram for the Random Mains Timer, with 'built-in' light sensor for sensing low light conditions during the day

These devices are simple, yet take such a headache away from the software designer. This RTC consists of three banks of registers, with each bank storing hours, minutes, seconds, day, date, year etc. One bank keeps the time and the other two banks store two alarm settings, Alarm A and Alarm B.

The device (IC2) also has a 32.768kHz oscillator that increments the registers every second, thus keeping track of time. Most crystal-based circuits need external capacitors (approx 30pF), but the DS1337 works perfectly well without them and keeps good time.

Maintaining such registers inside a microcontroller and then incrementing them every second and checking for an alarm condition makes the software quite complex. The addition of an RTC removes this headache.

The DS1337 constantly compares the current time with the values in the alarm registers. If the values match, the corresponding $\overline{\text{INTA}}$ or $\overline{\text{INTB}}$ pins (3, 7) on the RTC are pulled low signalling to the microcontroller to respond to the alarm condition.

When the circuit is first powered, the RTC is initialised and the Time register is loaded with 00:00 (midnight). Alarm Register A is loaded with 1500 hours (3pm). Alarm Register B is set equal to Alarm Register A, then incremented by a 'random' time stored in memory. The 'time' values are stored in a look-up table in software, and can be as short as one minute.

As time progresses, Alarm Register B is incremented with random times and the Alarm B interrupt (INTB) is monitored. When an alarm occurs, INTB goes low, the relay is toggled, the Alarm 2 register is incremented, the RTC interrupt is cleared and the microprocessor waits for the next INTB pulse.

The RTC is interfaced to the microcontroller using an I²C interface. This serial two-wire bus is a bit clunky to write in software, but it provides a neat interface solution while only using two microcontroller pins.

Some microcontrollers have a dedicated I²C bus implemented in their hardware, but on this occasion it was decided to write a software I²C routine. Thus, if the project is revised in future to use a lower functionality micro, the designer's choice is not limited to those with dedicated I²C hardware on chip.

It is worth pointing out that the clock and data lines are open collector, so they need a 10k pull-up resistor connected to them. In this circuit, although only $\overline{\text{INTB}}$ is used, a pull-up resistor (R20) was added to $\overline{\text{INTA}}$ in case of further software revisions.

Light sensor

A light sensor is connected to one of the inputs of the PIC's analogue-to-digital converter (ADC). The resistance of the light sensor increases with decreasing light level, thus pulling the input of the ADC down. When this input falls below 1.1V, the relay is activated and the light switches on.

The light sensor looks at the light level only before the lighting sequence has started. Once the microcontroller starts switching the light on and off, the light sensor is ignored.

Likewise, once the switching routine has finished (at midnight for example) the light sensor is also ignored to avoid the light coming back on again and staying on all night. The light sensor is ignored until noon the following day.

Writing and debugging the software

The software code was the most complex part of the design and is indeed the heart of the system. The software initialises the microcontroller, configures the ports and sets up the RTC.

Since the light timer is only used on a day-by-day basis, it was decided to ignore the day, date and year registers and just set the interrupts to occur when the hours and minutes registers matched. With very little code change, this circuit could be configured to come on at any date in the next century, which just goes to demonstrate the usefulness of an RTC!

The anodes of the 7-segment LED displays were driven by setting/clearing the port pins of Port B. The 220Ω resistors limit the current through each LED to about 15mA. Transistors TR1 to TR4 are then turned on in sequence to activate each LED digit. Each digit is displayed for approximately 10ms before the next LED digit is activated. By persistence of vision, all four digits appear to be displayed together.

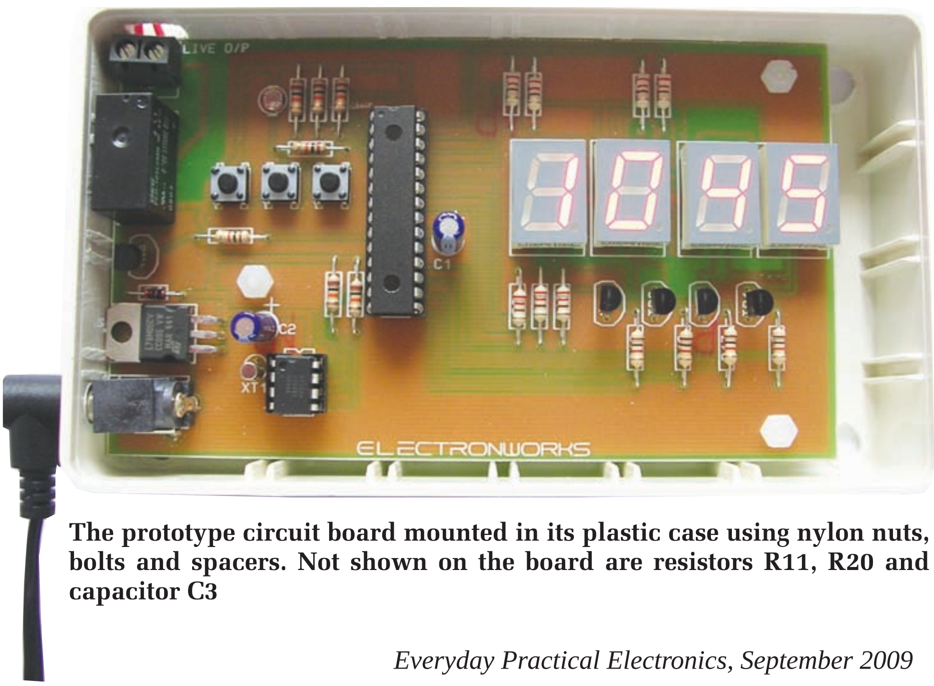
Parts List – Random Mains Timer

1 PC board, code 724, available from the *EPE PCB Service*, size 127mm × 74mm
1 ABS plastic box, size 150mm × 80mm × 50mm approx.
1 5V relay, with 230V AC mains changeover contacts (RLA)
1 2.5mm DC power socket, with matching plug (CON1)
1 2-way screw terminal block, 5mm (CON2)
3 tactile, click effect switches (S1 to S3)
3 nylon PCB standoff bushes, or nylon nuts and bolts
1 8-pin DIL IC socket
1 28-pin 'skinny' DIL socket
Mains cable, length as required

Semiconductors
1 PIC16F883-I/SP microcontroller, preprogrammed (IC1)
1 DS1337 real time clock (IC2)
1 LM7805 +5V 1A voltage regulator (IC3)
5 BC547 *NPN* transistors (TR1 to TR5)
1 1N4148 signal diode (D1)
4 7-segment displays, common cathode (DISP1 to DISP4)
1 32.768kHz crystal (X1)

Capacitors
3 47µF radial electrolytic, 16V (C1 to C3)

Resistors (All 0.25W, 5% carbon film)
8 10kΩ (R1 to R3, R5 to R7, R11, R20)
5 1kΩ (R4, R16 to R19)
7 220Ω (R8 to R10, R12 to R15)
1 light dependent resistor (20kΩ to 100kΩ at 10lux, and 5kΩ at 100lux) (LDR1)



The prototype circuit board mounted in its plastic case using nylon nuts, bolts and spacers. Not shown on the board are resistors R11, R20 and capacitor C3

A brief overview of I²C

MOST serial communication protocols consist of a clock signal and a data signal, and these two signals are sent to all devices on the bus. However, if two or more devices occupy the bus, a way is needed to individually address each device and avoid data being sent to all the devices.

The Serial Peripheral Interface (SPI) has a separate Chip Select (CS) signal for each device on the bus, so although all the data lines are common and all the clock lines are common, each chip only responds to the clock and data when its CS line is pulled low. The problem with this interface is that you need an extra signal line (and port pin) for each device on the bus.

The I²C bus overcomes this by embedding an address in the data it sends. Thus, the bus can interface many devices, but only use two port pins. Fig.3 shows an extract from the DS1337 datasheet.

Data line

The data line, SDA, can only change state when the clock line is low. If it changes when the clock line is high, this represents either a Start or Stop condition, as shown.

Once a Start condition has been sent, the microprocessor holds the clock line low (to allow the data to change state if needed), the data is presented on the line by the microcontroller (MSB first), then the clock line is set high. This clocks one bit of data into the DS1337.

The clock line is then taken low, the next bit is applied to the data line and the clock line is taken high again. Thus, after eight clock cycles, eight bits of data have been sent to the slave device (the DS1337). The eighth bit (the LSB) dictates whether data is about to be read from

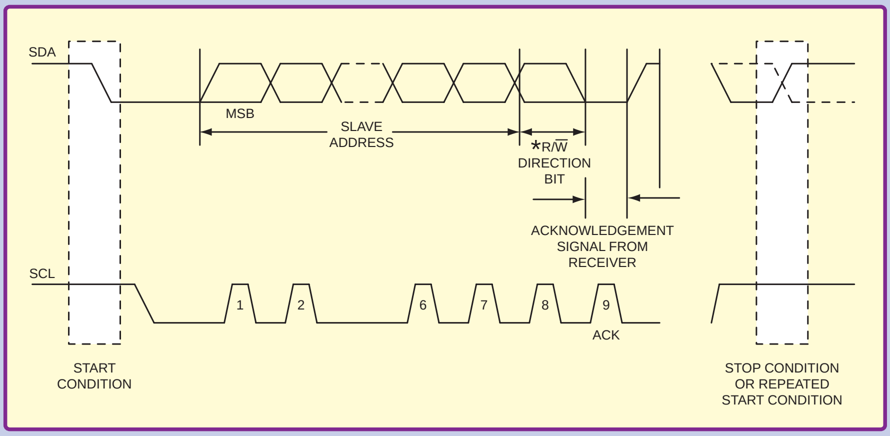


Fig.3. An extract from the Maxim DS1337 real time clock datasheet

the DS1337 (if it is logic 1) or written to it (if it is logic 0). The port pin on the microcontroller that issues the data signal is then changed from an output to an input. A ninth clock pulse is applied to the bus and the slave sends an Acknowledge (ACK) back to the microcontroller, telling it that the byte has been received.

Time line

So, to program the DS1337 with the correct time, the slave address is sent (the device address of the DS1337 is 1101 000) the LSB is cleared (to indicate we are writing to the device). Next, the word address is sent (indicating which register we need to program), then the data is sent (representing the time). This process is repeated for hours, minutes, seconds etc. – see Fig.4.

To read from the DS1337, the device address is sent, the LSB is set (indicating we want to read from the slave) and the word address is sent (to indicate what register we want to read). The device address is then resent and the data port pin changed from an output to an input to receive the incoming data. Thereafter, the data can be read from the slave DS1337. This is detailed in Fig.5.

Finally, to terminate a transmission, a Stop signal has to be sent to the DS1337. This is sent by taking the clock line high, then taking the data line high, as shown in Fig.3.

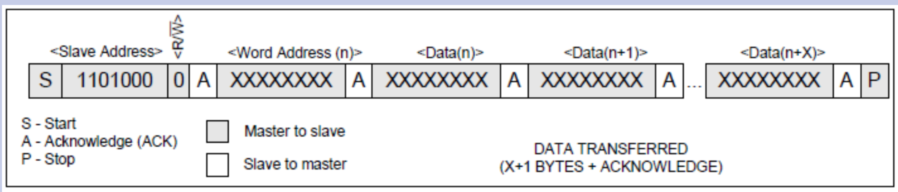


Fig.4. Data write to slave sequence (Source Maxim DS1337 datasheet)

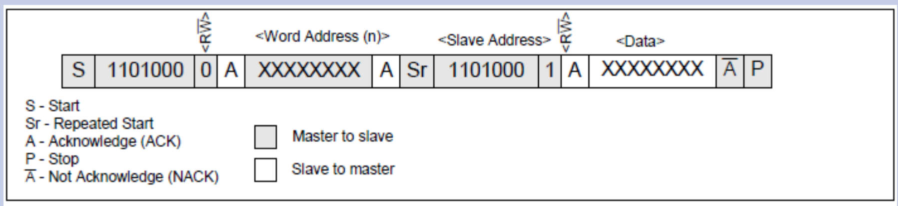


Fig.5. Data read sequence (Source Maxim DS1337 datasheet)

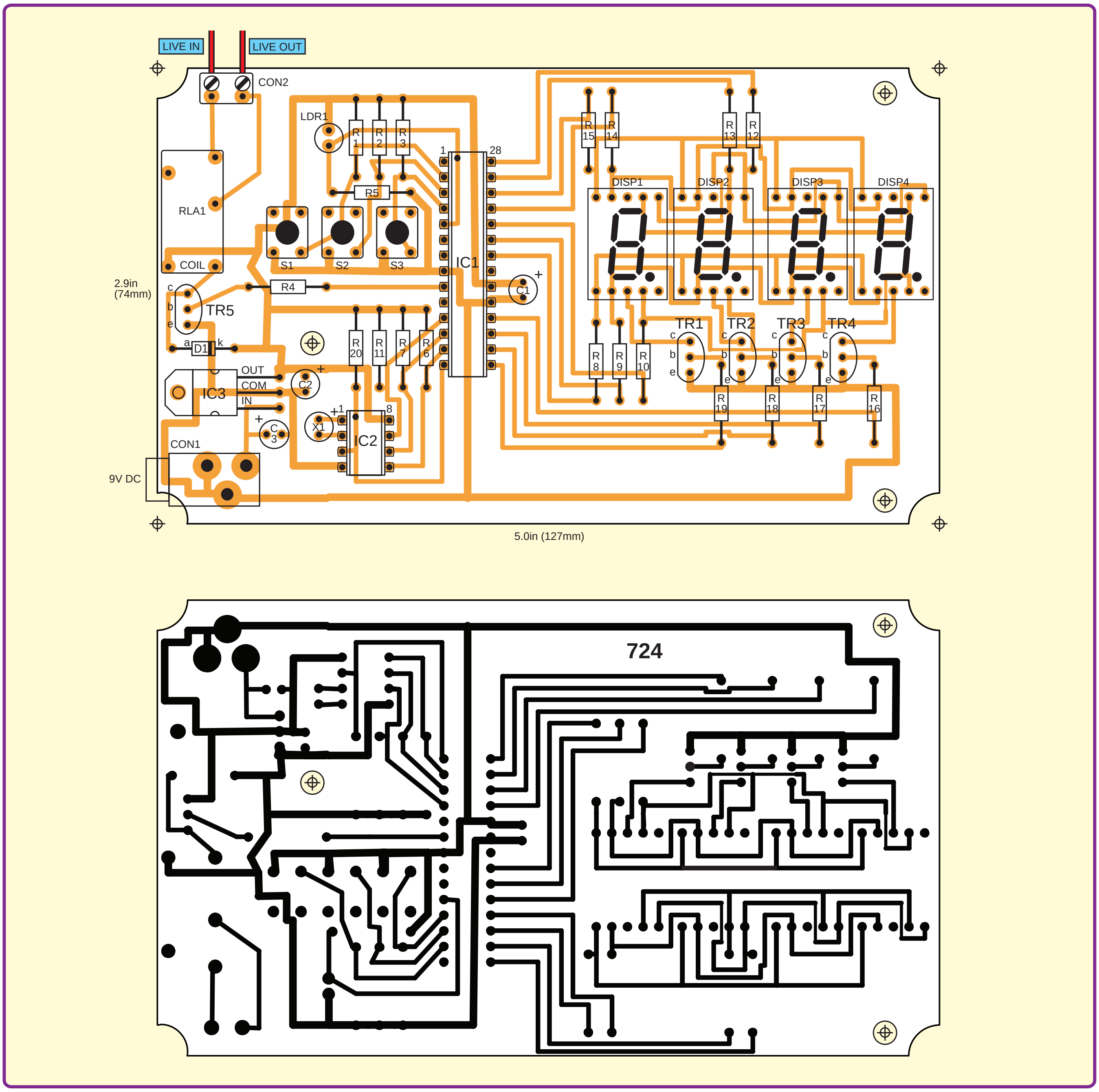


Fig.6. Topside printed circuit board component layout and full-size copper foil master for the Random Mains Timer. Note: the mains relay contacts must be suitably rated to control the appliance being used

The main program is a loop that just reads the RTC, updates the display, scans the input keys and responds to interrupts from the RTC. The RTC issues an interrupt on $\overline{\text{INTB}}$, indicating that the first alarm time has been reached. The relay is activated and the next random value is loaded into the alarm register. The main program loop then continues.

During the light sequence, a flag is set to disable the light detector. Once the sequence has finished, the first light sequence (say 3pm) is loaded back into the alarm register. The light sensor is only activated once the first light sequence has been reached. This will prevent the light sensor activating the relay once the light sequence has finished and burning bright throughout the night.

Software

The software files will be available via the EPE Library site, acess via **www.epemag.com**. Pre-programmed PICs will be available from the author, Bill Naylor – see the end of this article.

Construction

The Random Mains Timer is built on a single-sided printed circuit board (PCB) measuring 127mm × 74mm. This board is available from the *EPE PCB Service*, code 724. The PCB component layout and full size copper foil master is shown in Fig.6.

The design of the PCB was fairly straight forward.

Since the microcontroller (IC1) has to provide large surges of current to the LED display, it is important that a large value capacitor (C1) is placed close to its Vcc pins to stop any ripple on this pin. Good grounding is also important for the same reason.

The crystal (X1) of the RTC needs to be kept away from any electrical noise in order to maintain its accuracy. Therefore, it was mounted close to IC2, the DS1337, far away from any switching lines and surrounded by the PCB ground plane. Likewise, the input to the microcontroller from the light sensor (LDR1) was routed away from any switching signals.

Finally, the mains relay was mounted in the corner of the board, as far from the other circuitry as possible. An area free from PCB copper was placed around the relay to further reduce the likelihood of the mains reaching the low voltage. The relay can obviously be used to switch low voltages, but is rated to handle mains voltages.

Given that this PCB has mains electricity on it, it is extremely important that the PCB is NEVER handled when the mains is connected. It is essential that the PCB be mounted in a plastic box on nylon stand-off pillars and secured to the case using nylon nuts and bolts.

The relay contacts MUST be able to withstand the rating of the appliance being controlled.

Initial tests and fine tuning

The PCB has a 2.5mm input jack to provide power to the board. It is recommended to apply 7V to 9V DC to this connector. The 7805 (IC3) regulates the voltage down to 5V and this is routed to the rest of the circuit.

The terminal block in the opposite corner of the PCB carries the mains. Connect the Live IN to the port nearest the corner of the PCB, with the Live OUT coming out of the port labelled LIVE O/P.

First run

The circuit was bread-boarded before the PCB was designed. Therefore, on first power up (always a nervous occasion) the board worked perfectly. Slight software modifications were made to reduce the LED display flicker. The circuit was put on a soak test for 24 hours and the time from the RTC was still accurate, indicating that our cautions about the layout around the RTC crystal were justified.

The software was then modified to give an 88:88 output with the relay coil energised. The current consumption was measured at 65mA. With the relay unenergised, the current fell to 43mA. Thus, with a 9V plug-in mains adaptor input, the 5V linear regulator only dissipates a maximum of 250mW so, although it runs warm, it will not overheat.

The circuit powered up showing the contents of the Time register (00:00). To set the clock, press the far left button and then press the far right button. This will increment the time.

To set the time when the light sequence needs to start, press the middle button. This will start with the preset time of 15:00 hours. Pushing the far right button increments the alarm time.

If the alarm time is set to, say, 8pm, the light sequence will start at 8pm, then go through 31 preset on/off times, each about 20 minutes in length. If the ambient light level is unusually low, the relay will trip switching on the light, the timer will wait until 8pm, then start its sequence as normal.

Once the sequence has completed the light will switch off and the light sensor will be ignored until noon the following day.

Further developments

The project was designed to be low cost, so the entire circuit fits onto one PCB. However, it would be better if the LED displays and switches were to be mounted on a separate board, so that they can be fitted to the top of the box.

For safety, the mains circuitry could be mounted on a separate PCB too, with wires linking the PCB to the relay coil. For added safety, a double-pole relay would also isolate the Neutral instead of just switching the Live supply lead.

All of the components for this kit, including the PCB and programmed microcontroller can be purchased from Bill at: **www.electronworks.co.uk** *EPE*

Max's Cool Beans

By Max The Magnificent

THERE'S a funny image that's been bouncing around the Internet for years and years. It shows a piece of electronic equipment that is supposed to illustrate the difference between men and women. In the case of the 'Men' portion of the machine, we have a single on/off switch and a corresponding light. By comparison, the 'Women' area comprises the most baffling collection of switches, knobs, and dials augmented with meaningless annotations.

I've seen this little scamp many, many times over the years, and it always brings a wry chuckle, but I never thought to take things further, until... a few months ago when I ran across this image once again, and I said to myself: "It would be fun to make something like this!" (I find I'm talking to myself a lot these days.)

However, I certainly don't want to simply make a copy of something that's been done before... where would be the fun in that? No! I want to create something incredibly clever and cunning that makes anyone who sees it gasp aloud and say, "Ooooh Shiny!"

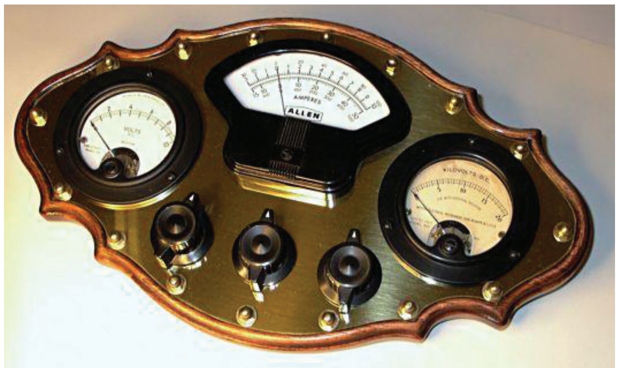
Steampunk

Have you heard of 'Steampunk'? This means different things to different people. For some, it's a sub-genre of fantasy and speculative fiction that came into prominence in the 1980s and early 1990s. For others, Steampunk refers to creating modern artifacts (like computers) that appear as though they were created in Victorian times.

One guy whose work I think is absolutely fantastic is, 'Hieronymus Isambard 'Jake' von Slatt – Proprietor' as he bills himself on his Steampunk Workshop website (**www.steampunkworkshop.com**). Hmmm, I wish I had a cool name like that instead of being stuck with 'Max The Magnificent' ... oh well...

I also have a friend called Douglas who ives in California. Douglas is constructing a Steampunk version of a *Dr. Who* TARDIS Control Console (**http://douglas442.livejournal.com**). I really like the look-and-feel Douglas has achieved using a mixture of wood and brass, coupled with antique switches and meters.

I tell you... I really didn't appreciate all of the things that would be involved when I commenced this project. For example, consider the antique knobs and switches and meters (oh my!). Where does one go to find these little scamps? Well, I had some luck on eBay with regard to the knobs and switches, but the meters proved somewhat harder. Douglas gave me a really nice 4½in. diameter meter to start my collection; another friend called Martin, who restores antique audio equipment located a few more; and I also found some nice ones in scrapped test equipment at my local technology recycling centre.



In the case of controlling 'The Beast', which currently goes by the moniker 'Max the Magnificent's Man versus Woman Display-O-Meter' for short (you have to admire the way this rolls off the tongue), I decided to use a PICAXE microcontroller to read the values on the switches and dials and to control the output displays in the form of meters and LEDs.

And what about a cabinet? Truth to tell, this was a bit of a stumper until I saw the Steampunk Guitar Amplifier project on Jake's website. Jake told me that this was originally a radio cabinet his friend had saved from the scrapheap. So I searched around on the web for folks who restore antique radios, and quickly found a great guy called John in Indiana who had an Atwater Kent console circa 1929/1930 sitting in his garage. The radio itself was broken, but that was OK because I only wanted the cabinet, which is now sitting in front of me in my office (it is in perfect condition and it's absolutely gorgeous!).

So things are really starting to come together. This is proving to be a 'Cool Beans' project and I will certainly keep you informed as to my progress. Until next time, have a good one!

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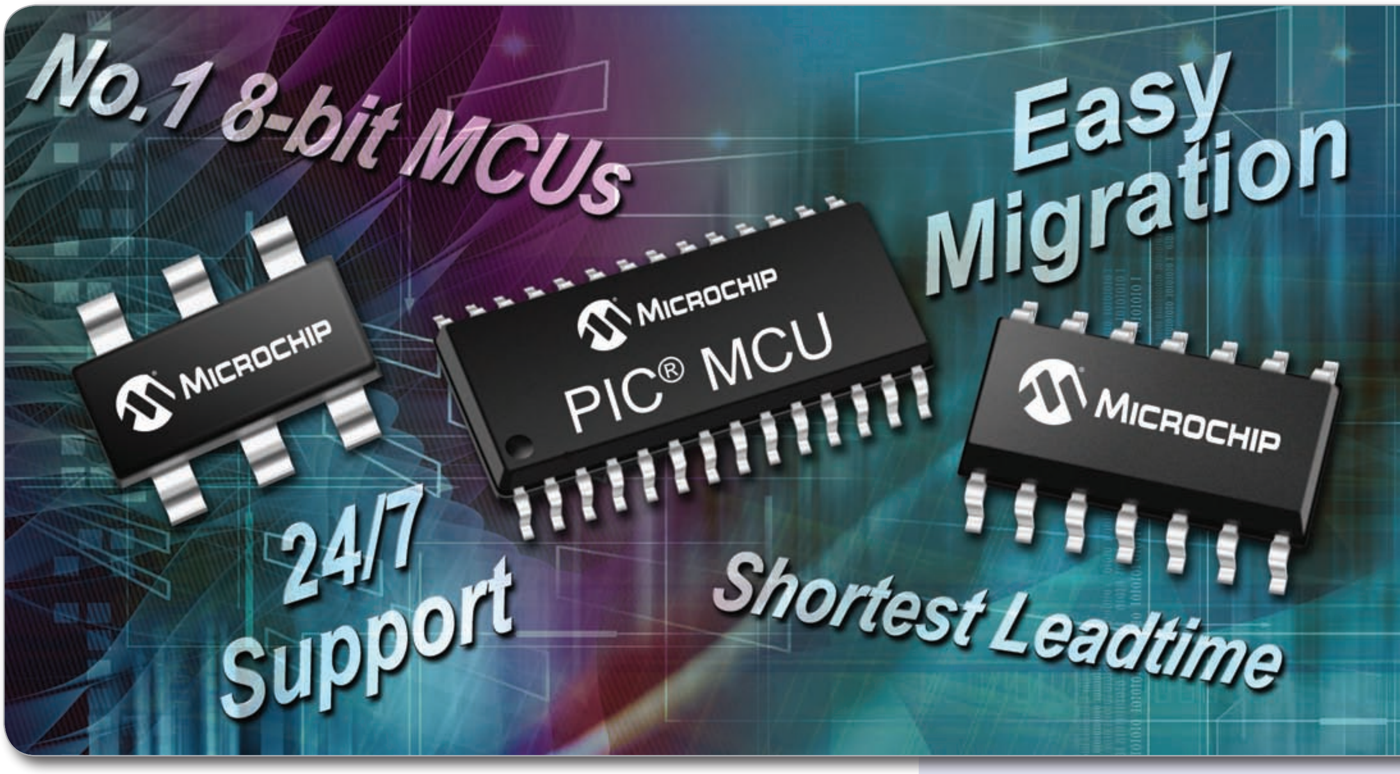

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Recycle It!

BY JULIAN EDGAR

Salvaging the good bits from cordless drills – and putting them to work

Cordless drills are now probably the most frequently discarded power tools. Whether it's at the local tip, at garage sales or even in kerbside rubbish skips, there are always plenty of defective battery-powered (cordless) drills available.

WITH the incredibly low price of new cordless drills, it's really not worthwhile repairing a defective one – especially when they're usually discarded because the battery pack is defunct. For the price of a new battery pack (or even less), you can buy a complete new drill.

What about in your own garage? Likely as not, you've got one or more broken cordless drills tucked away at the back of the workbench. If not, there are lots of cordless drills that can be picked up for nothing. And there are several useful items that can be made from the components inside them!

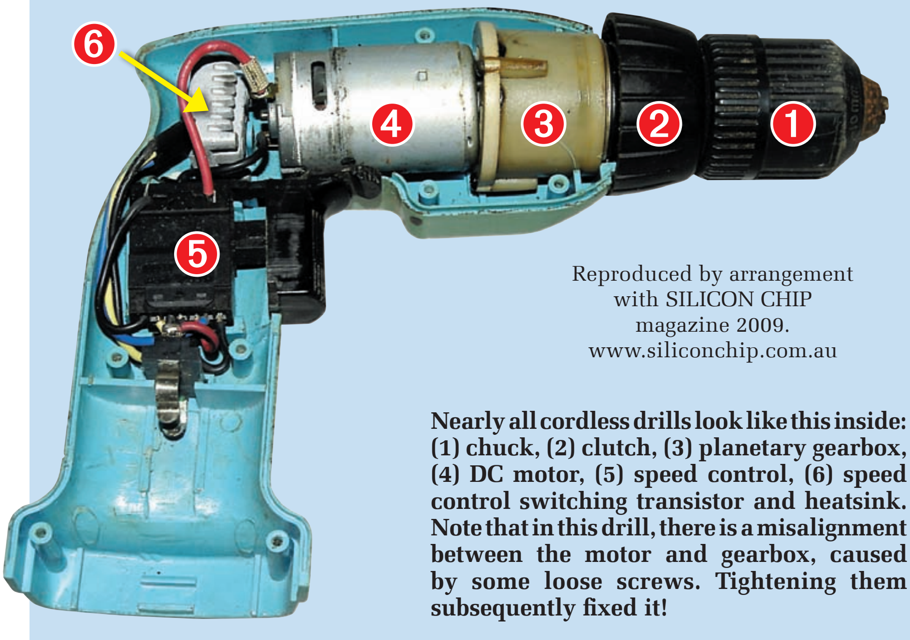
It just takes a little salvage work to retrieve those bits.

Internals

Cordless drill chucks usually have a maximum rotational speed of 1000 rpm or less. However, the motor speed is much higher than this. To reduce the speed of the DC electric motor (and to increase the torque), a planetary gearbox is used. In fact, there are usually two planetary gear sets back-to-back – rather like the gear systems used in automotive automatic transmissions. And like auto transmissions, some cordless drills let you select between ratios – more on this in a moment.

For their size, planetary gears are very strong and, especially when two sets are used, allow high reduction ratios to be achieved in small volumes. Considering their size and torque capacity, these are really nice little gearboxes.

The torque multiplication might be achieved by the gearbox, but if you want to quickly drill holes or drive screws, you need real motor power. This is provided by a high-current, brushed DC motor. Typically, the 'motor-stalled' DC current is around 10A at 12V, and considering that the motors are about the size of a 'D' cell, that makes for quite a powerful (and useful) motor – especially since it hasn't cost anything!

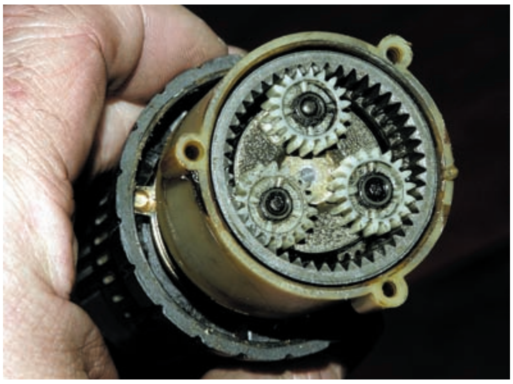


Nearly all cordless drills look like this inside: (1) chuck, (2) clutch, (3) planetary gearbox, (4) DC motor, (5) speed control, (6) speed control switching transistor and heatsink. Note that in this drill, there is a misalignment between the motor and gearbox, caused by some loose screws. Tightening them subsequently fixed it!

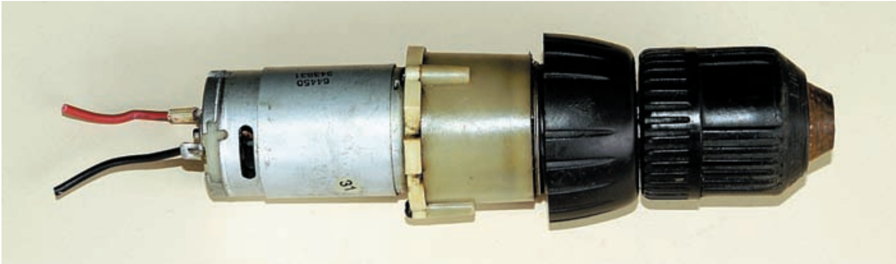
Up to speed

Many cordless drills have an electronic variable speed function, achieved by pulse-width modulating the power fed to the motor via a switching transistor. This transistor is usually mounted on a separate interior heatsink, and the rest of the control electronics are integrated into a housing with the trigger switch.

A reversing switch is also often mounted directly above the speed control. So even if you salvage just these parts, you have a handy high-current electric motor speed control (or, for example, a 12V DC light dimmer).



Cordless drills use planetary gearboxes to reduce the chuck speed and increase torque. Usually two back-to-back geartrains are used – this view shows the motor input side. These gearboxes are compact, have a high reduction ratio and are strong for their size.



A discarded cordless drill can provide a compact and powerful drive assembly for nothing! The motor/gearbox/clutch/chuck combination can be used to drive robots, power small winches – or even be a portable drill for use on car power.

One of the easiest uses of the innards of a discarded cordless electric drill is as a hand-cranked DC generator. In this application, the gearbox steps-up the rotational speed of the chuck, allowing up to 0.5A at 5V to be generated with ease – quite good for such a small generator!

Finally, most of these drills have an adjustable slipping clutch that allows the peak torque to be set before drive ceases.

Using the parts

There are plenty of uses for these bits and pieces. One of the easiest is to simply pull the body of the drill apart (because they are low voltage devices, tamper-proof screws aren't fitted, making it really easy) and cut the supply wires at the motor. Bend a piece of steel rod into a crank-shaped handle and lock one end in the chuck. Turn the handle and – hey presto! – you have a pretty 'grunty' small DC electric generator.

How grunty? Well, on one unit I measured, it was quite easy to run a half-amp load at 5V – that's 2.5W! And 2.5W is plenty to run a torch bulb or two high-efficiency Luxeon LEDs. It's also quite enough to charge two 1.2V rechargeable cells or a mobile phone battery.

If you pick a drill that has two user-selectable gear ratios, it works even better. In one ratio, turning the handle is easy, but the amount of power generated is lower (that's the 'topping up' setting, if you like). Alternatively, you can slide over the gear selection lever and have around twice the power output at the same rotational speed – but it's much harder to turn the handle.

To protect it and allow it to be easily held, the generator/gearbox/clutch/chuck assembly is best squeezed inside a length of PVC pipe (again picked up for nothing, this time from the rubbish pile of a building site). If it needs to be semi-weatherproof, just add PVC end caps with appropriate holes drilled for the crank handle and power wire exits.

Mechanical drive

The motor/gearbox/clutch/chuck assembly can also be used wherever

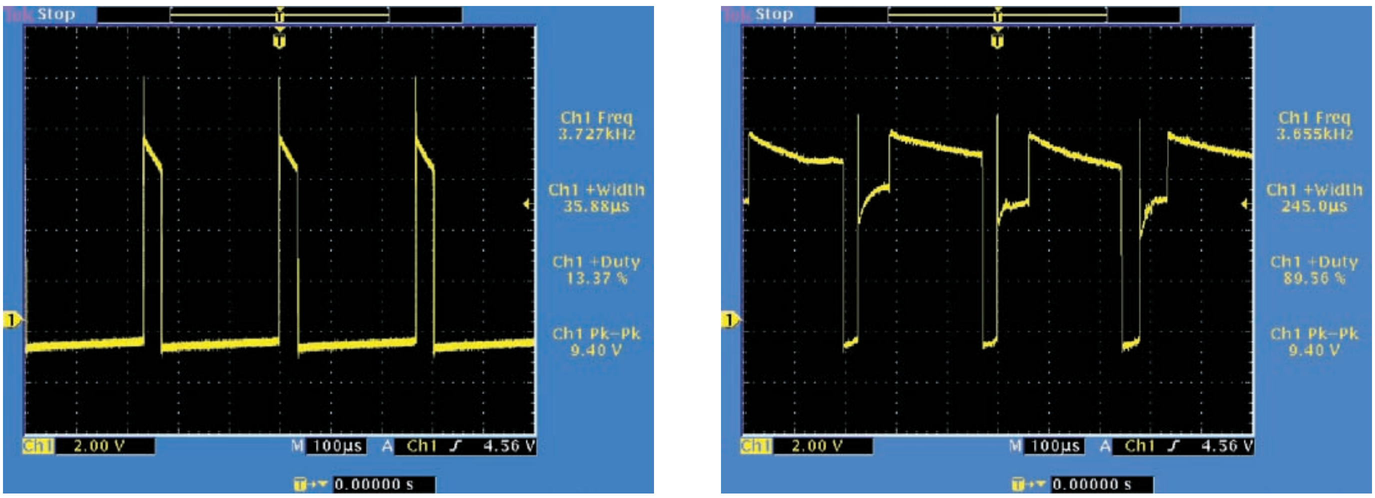
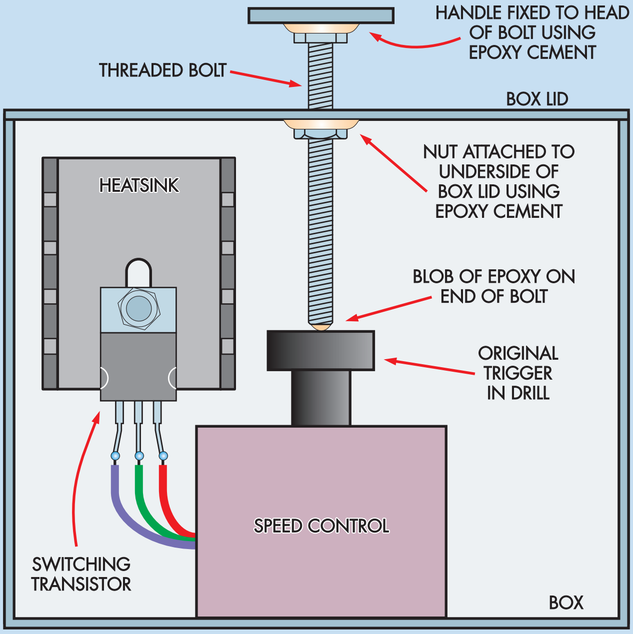


Fig.1: these scope shots show a typical speed control output for low PWM (left) and high PWM (right) duty cycle settings.



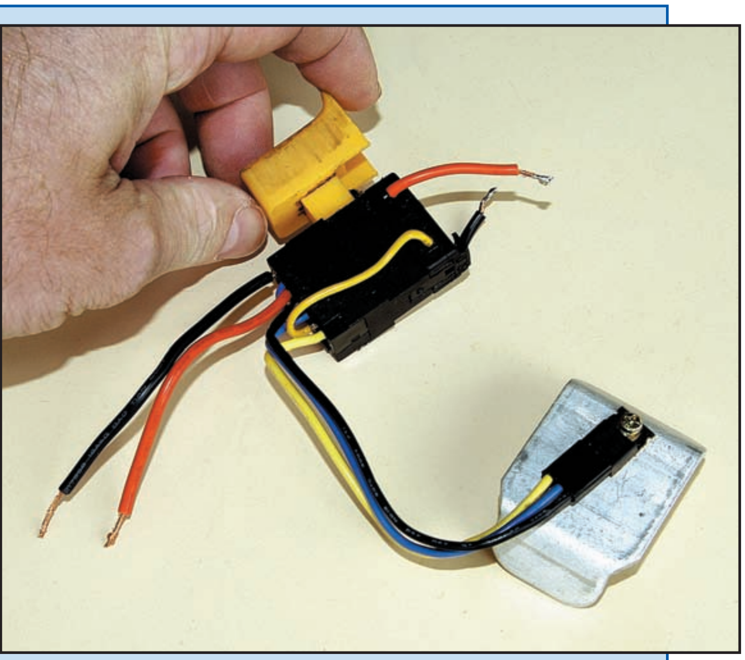


Fig.2: here's how to adapt the control unit to allow low-voltage light dimming or speed control of DC motors. The threaded bolt goes through a captive nut and is turned to smoothly deflect the speed control trigger. Above right is a typical pulse-width modulated (PWM) control unit, complete with its heatsink-mounted switching transistor.

a high-torque output, low-voltage mechanical drive is needed. For example, two of these assemblies can easily be combined to form the individual wheel traction motors for a small robot (or you can use four for the ultimate in manoeuvrability!). Another possibility is to use one of these assemblies to drive a small winch – eg, to hoist a model railway baseboard up near the ceiling when it isn't being used.

In these applications, the inbuilt slipping clutch is a real asset, as it stops the motor from being overloaded when the output is stalled.

Since nearly all these motors will happily work for short periods on 12V (even when the nominal battery voltage of the drill might be only 9.6V), the salvaged cordless drill is easily equipped with a long cable with some battery clips to allow it to be powered by a car battery.

Variable speed controller

The variable speed controller is a mixed blessing. While it is capable of handling high currents (very high for short periods), the physical layout of the module lends itself only to those applications where a squeeze or push trigger is needed. Unless you have lots of spare units to play with, don't pull the module apart in an attempt to substitute a rotary potentiometer for the slide type – once it's apart, it can be very hard to put back together.

A better approach is to build a mechanical system that can vary and maintain the trigger movement needed in the application. For example, by using a coarse-threaded bolt and a fixed nut, the original trigger can be progressively moved by rotating the bolt – see Fig.2. The unit can then be used wherever low-voltage DC motor speed control (eg, for a miniature 12V lathe) or filament light dimming is required.

Finally, the electric motor itself is ideal for driving a fan. Small fan blade assemblies can be salvaged for nothing from microwave ovens.

Be careful with microwave ovens though – they can pack a lethal punch, even with the power switched off. Make absolutely certain that all high-voltage capacitors inside the oven have been discharged before attempting to salvage any parts. Don't think of even opening up a microwave oven if you don't know what you are doing.

Conclusion

When you see a cordless drill, salvage it and strip it back to the internals. The resulting bits take up very little storage room and can be used to make a hand-cranked generator or as a powerful low-voltage motor/gearbox unit with variable speed control. ***EPE***

Rat It Before You Chuck It!

Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up but you get the idea . . .)

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Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

HAVING completed the circuit board and produced the required cut-outs and holes in the case, a project is getting close to completion. With most projects there is still some way to go though.

The next step is to fit the circuit board into the case, but ideally the board should be tested *before* it is fitted into the case. If there should happen to be an error on the circuit board, it is highly unlikely that it will be possible to fix the problem without disconnecting the board and removing it from its case.

This can be time consuming, and the process of dismantling and rebuilding a project entails a slight risk of damaging something in the process. It is much better if any mistakes can be found and rectified prior to installing the circuit board in its case. Also, should a problem occur with the finished project, having pretested the circuit board you will know that it is almost certainly some other part of the unit that is at fault.

Pretesting

Testing the circuit board of a mains-powered project is a highly dangerous undertaking and MUST not be attempted by a beginner/novice. However, it is fairly straightforward with most battery-powered projects. It is basically just a matter of wiring the board to the battery, and any other essential off-board components, such as potentiometers and switches.

There is no need to make the 'test' wiring look pretty. On the other hand, it does have to be right, so it should be given the same degree of care that is used when fitting the 'real' wiring.

Leads fitted with the smallest size crocodile clips are useful for making 'solderless' temporary connections, but fitting a large number of leads in this way is probably not practical. You're likely to accidentally disconnect something each time you add a new lead!

It is necessary to take a realistic attitude with this situation, and with some projects there will be so many hard-wired connections that it would be impossible to justify the time and effort involved in pretesting the circuit board. However, it is a practical proposition with most small and medium sized projects. It might still be worth it with larger projects where the pretesting would be time consuming, but not nearly as time consuming as removing a faulty circuit board and installing it again.

Mounting tension

The circuit board must be fitted into the case in such a way that there is no significant risk of it coming adrift. There are several common methods of holding a board in place, including the obvious one of simply bolting it in place.

This method is slightly less straightforward than it might seem at first. It is clearly essential to have the underside of the board held clear of the case if it is of metal construction, or if it is one that has a metal chassis that is used when mounting the circuit board. It is otherwise a certainty that some of the connections on the underside of the board will short-circuit through the case.

The easy solution is to use some spacers between the board and the case, as in Fig.1. The spacers are just metal tubes of a suitable diameter for the mounting bolts used, and they are typically between about 6mm and 25mm long.

The threaded type is probably easier to use when mounting large boards that require several mounting bolts. With threaded spacers you can fix them all onto the mounting bolts, add the board, and then fit the fixing nuts.

The problem when using plain spacers is the need to hold the bolts and spacers in place while the board and fixing nuts are added. It can be done, but this task is often quite awkward to achieve. Using Blu-Tack or plasticine to temporarily hold things in place can make the job much easier.

It is essential that the mounting holes in the case are drilled accurately, since any error in their positioning tends to place stresses on both the case and circuit board. Any significant errors when using threaded spacers will make it impossible to fit the circuit board onto the mounting bolts. Using a needle file to suitably elongate the mounting holes in the case will usually be sufficient to get the board in place.

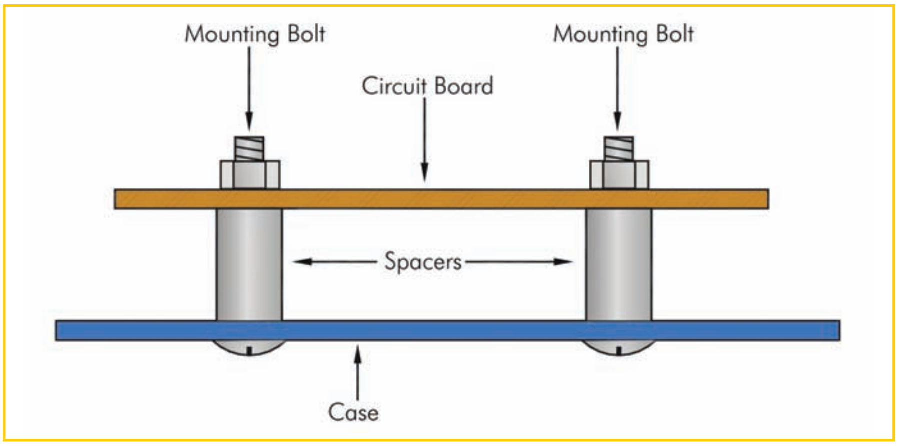


Fig.1. Spacers are used over the mounting bolts to hold the underside of the board clear of the case. Spacers about 6mm long are usually sufficient

On the face of it, using a case or chassis made from a non-metallic material removes the need for spacers. However, the spacers are still required, regardless of material used for the case or chassis. They are required because of the soldered connections that protrude on the underside of the board making it impossible for the board to fit flat against the case.

Without the spacers, the board inevitably becomes distorted as the mounting nuts are tightened, and the areas of the board around them are forced right down onto the case surface. At best, this will impose unnecessary stresses on both the board and the case. At worst it will result in serious damage to the circuit board and (or) the case.

Even a short spacer about 6mm long used over each of the mounting bolts should be sufficient to keep the connections on the underside of the board slightly clear of the case, thus avoiding short-circuits and stresses on the board. Spacers are available in plain and threaded versions, with the later having a screw thread cut on the inside, and running the full length of the tube. It does not really matter too much which type is used.

Minor adjustments of this type are often needed, but anything other than minute errors are best avoided. Apart from producing some scrappy looking results, too much of this type of thing could result in the board being fixed in an unreliable fashion.

It's a stand-off

Various types of plastic stand-offs provide the main alternative to mounting bolts and spacers. The simplest type of stand-off clip into holes of the appropriate diameter drilled through the case and the circuit board. While this method makes it quick and easy to fit and remove the circuit board, in practice it is not always entirely satisfactory. Unless the mounting holes are drilled accurately and cleanly it will probably be impossible to fit the stand-offs into the holes, or they will fit into the holes but will not lock into place reliably.

With some stand-offs, it does not seem to matter how accurately the mounting holes are drilled. They never provide a reliable means of mounting the circuit board. Some of these stand-offs are probably designed to be used in conjunction with mounting bolts rather than as the only means of mounting the board. The motherboards in PCs are often mounted on the case using a mixture of bolts and some extremely basic stand-offs, as are many very large boards.

Stand-offs that snap in and out of position are hardly ever satisfactory when used with stripboard. The likely cause of this problem is that the matrix of pre-drilled holes in the board makes it impossible to produce really neat mounting holes. Drilling out one of the existing holes tends to make it merge with four of the other pre-drilled holes. This produces a rather odd shaped mounting hole that prevents the stand-off from snapping into place properly.

This type of stand-off is only suitable for use where the circuit board will be mounted on a chassis within the case, rather than directly on the outer casing. Obviously, it is physically possible to use this type of stand-off with most cases, but the clips would protrude a few millimetres from the surface of the case, which would not provide a neat finish. Also, there would probably be a tendency for the clips to get knocked out of position, leaving the circuit board detached from the case.

Fig.3. Plastic cases often have guide-rails moulded into the interior, permitting boards to be fitted horizontally or vertically

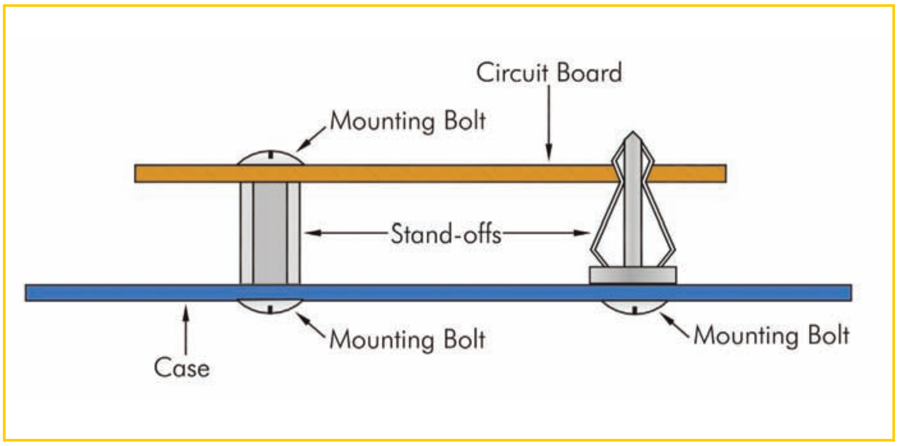


Fig.2. Some stand-offs use mounting bolts at both ends (left), and are much the same as threaded spacers. A variation on this (right) is to have the stand-off bolted to the case with the circuit board just clipped into place

Mounting bolts are a much better choice with stripboard, although the type of stand-off shown on the left in Fig.2 is a good choice for stripboard. These usually take the form of a plastic outer section with a metal insert that has the screw threads. They differ from threaded spacers in that there are only a few millimetres of screw thread at each end, rather than having the thread running the whole length of the spacer. A threaded spacer could be used, but this type of stand-off cannot be used as a threaded spacer. Due to the limited length of the screw thread, it is essential to use very short (about 5mm or 6mm) mounting bolts with this type of stand-off.

There is another type of stand-off that is a cross between screw fixing and snap-on varieties. One end is fixed to the case using a short bolt, but the circuit board clips in place at the other end. This type of stand-off is shown on the right in Fig.2. This is probably the most popular type, and it works well provided the board will clip into position securely.

There is a further variation that has the stand-off secured to the case by a self-adhesive pad. Getting this type positioned accurately on the case or chassis can be tricky, but there is an easy way. Fit all the stand-offs onto the circuit board, and then press this assembly down into place in the case, making sure that it is in a suitable position before finally pressing it into place. The soft plastics used for some project cases defy most types of glue, but with this type of stand-off it is usually very difficult to remove it once it has been fixed to the case.

Some cases have built-in mounting pillars, but these are rarely of any practical value. The obvious problem with this type is that the circuit board has to be designed to suit the positioning of the mounting pillars. In the present context, this is unlikely to be the case, and any built-in mounting pillars are more likely to be a hindrance than a help. In fact, they can get in the way to such an extent that it becomes necessary to drill them down. Use a drill bit that is slightly larger in diameter than the mounting pillar.

Off the rails

There is a similar problem with the guide rails (Fig.3) that are moulded into a fair proportion of plastic project cases. As in this example, there are usually two sets of rails so that circuit boards can be fitted horizontally or vertically. This is a very simple but effective method, where the board just slides into place, and there are no unsightly mounting bolts showing on the exterior of the case. Provided it is just the right size, the circuit board is normally held in place very securely when the case lid is fitted.

Like built-in mounting pillars though, guide rails are only usable with boards that are specifically designed for that particular case. It might be possible to produce an oversize board that accurately fits the guide-rails if you make your own printed circuit boards or use stripboard. Simply cut a board of the correct size and leave blank areas at each end where it will fit into the guide-rails.

Unfortunately, in most cases, any built-in guide rails will be unusable. Some guide rails border on being unusable simply because they are minute and the circuit board can easily come ‘off the rails’. It is probably best not to use this method unless the rails are fairly substantial.

A further problem with guide rails is that with most cases it is only possible to use quite small circuit boards. Larger boards could be accommodated if it was possible to mount the boards parallel to the front and rear panels instead of perpendicular to them.

With some cases this can be achieved with the aid of plastic clips that are fitted to the board. The clip and board assembly is then slotted into the guide rails. An indirect method such as this inevitably provides a less secure method of mounting compared to simply fitting the board straight into the guide rails, but it usually works well enough.

Filters circuits Part 3

THIS month we conclude our three-part article on active filters prompted by a question posted by ***Paul Goodson*** on the *EPE Chat Zone* (**chatzones.co.uk**). Paul was interested in bandpass filters for audio signals, but was struggling with the apparently dissimilar information on filters he had read from different sources.

In the first article we provided an overview of filter basics and terminology. Then, last month, we discussed some of the different types of filter response and showed that basic filter design seems at least to be reasonably straightforward with the help of suitable software. In fact, it is not quite as simple as just typing a few values into a program, as the quality of the components used can have a big impact on filter performance.

This month, we will take a look at some practical aspects of filter circuit design, in particular how to choose components for filters, including capacitors, resistors and op amps. But first, we will take a look at bandpass filters, starting with a few extra basics and definitions.

Bandpass filters

The generalised frequency response of a bandpass filter is shown in Fig.1. The bandwidth is BW = $f_H - f_L$. For example, if f_L = 2kHz and f_H = 4kHz then BW = 2kHz. The centre frequency, f_C , is given by:

$$f_C = \sqrt{f_H\, f_L}$$

Note that because we are using a log scale, the centre is the geometric mean of f_L and f_H, not a point arithmetically half way between f_L and f_H . For example, if f_L = 2kHz and f_H = 4kHz then f_C is 2.828kHz, not 3kHz.

The fractional bandwidth is the bandwidth divided by the centre frequency:

$$Fractional\ Bandwidth = \frac{BW}{f_C} = \frac{f_H - f_L}{\sqrt{f_H\, f_L}}$$

This is often expressed as a percentage, the percentage bandwidth. For example, if f_L = 2kHz and f_H = 4kHz then the fractional bandwidth is 0.71 or 71%.

The inverse of fractional bandwidth is the Q factor of the bandpass filter:

$$Q = \frac{f_C}{f_H - f_L}$$

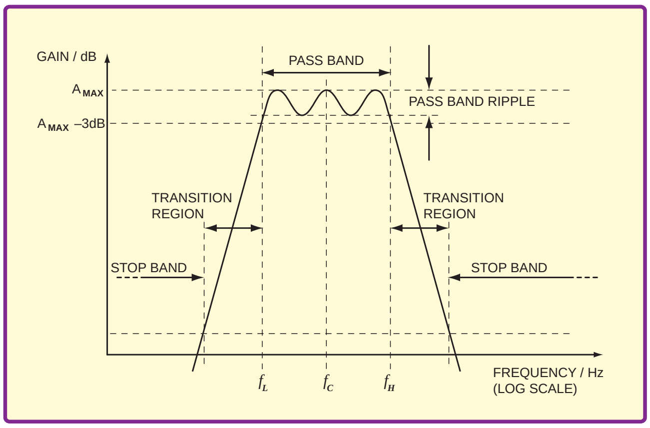


Fig.1. (left) Band-pass filter frequency response

Large values of Q (small fractional bandwidths) imply very narrow passbands and place higher demands on the circuit's components (op amp performance and component tolerance).

If the fraction bandwidth is large, say over 100%, then the bandpass filter can be made from a simple series combination of a low pass filter with a cutoff of f_H and a high pass filter with a cutoff of f_H. For smaller fractional bandwidths, a specific bandpass filter circuit must be used.

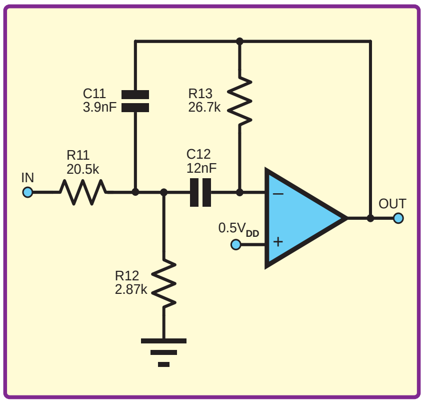


Fig.2. (below). A synthesised 2kHz to 4kHz MFB bandpass filter using Microchip's FilterLab

Multiple feedback

The multiple feedback (MFB), or Rauch, filter circuit uses a single op amp and is a

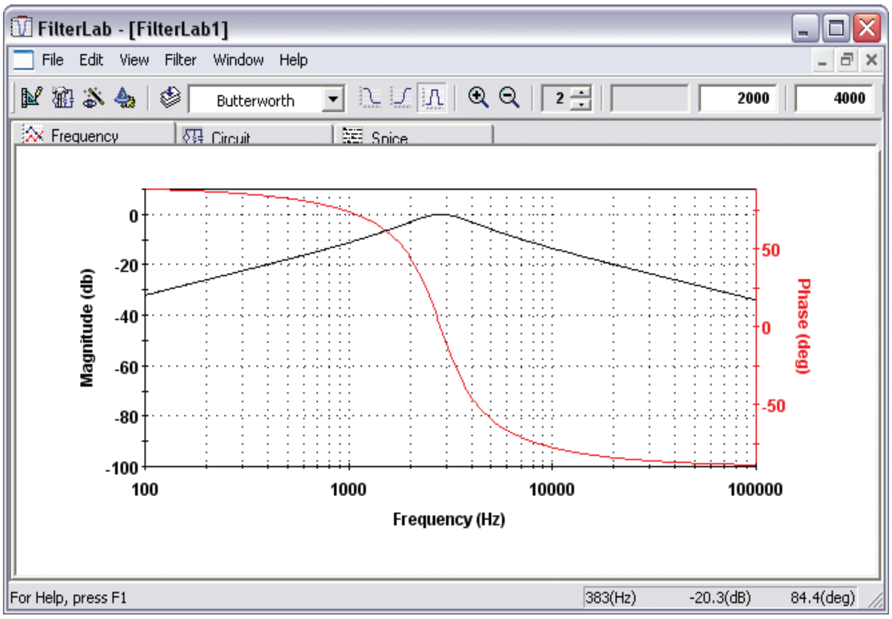


Fig.3. Screen shot of Microchip's FilterLab software displaying the frequency response plot for Fig.2

useful and simple means of creating relatively low Q bandpass circuits (Q less than 20 and ideally less than 5). An op amp with a high gain-bandwidth product is required for this circuit, particularly for higher Q values. One op amp gives you a second-order stage and these can be cascaded for higher-order filters.

An example of an MFB second-order bandpass filter is shown Fig.2. This has f_L = 2kHz and f_H = 4kHz. This was synthesised using the FilterLab 2.0 software from Microchip. The software is available free from **www.microchip.com/filterlab** (or search for 'filterlab' on the Microchip home page). FilterLab can create filters up to eighth-order, using both MFB and Sallen and Key stages.

FilterLab will plot the filter's response for you. A screenshot of FilterLab displaying the response of the circuit in Fig.2 is shown in Fig.3. Readers will recall that last month we looked at another useful filter synthesis program, Filter Free. It is worth downloading and trying out more than one filter design program as they provide different options for filter design.

The MFB filter is economic, in that a second-order bandpass stage only uses one op amp. However, it has quite severe limitations in terms of the Q factors it can achieve and is sensitive to the op amp's gain-bandwidth product. The state variable filter (SVF) delivers higher performance and lower component sensitivity, but a second-order stage uses three or four op amps, depending on the version employed.

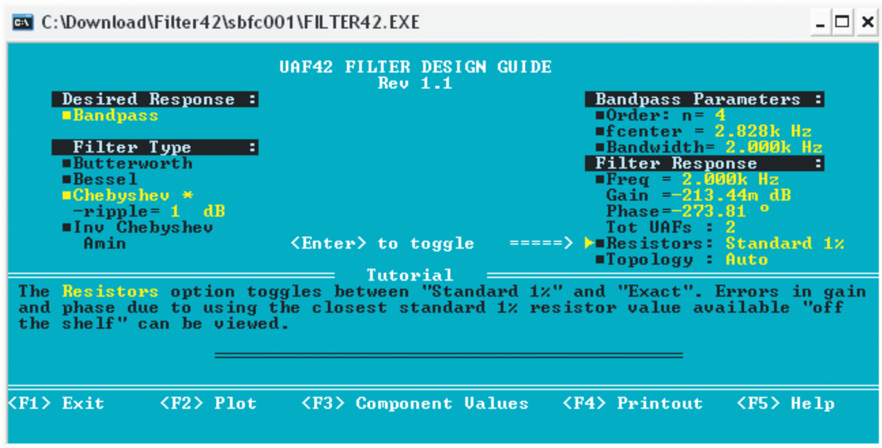


Fig.6. Screen shot of Filter42 software, which is used to design state variable filters (SVFs) using Texas Instruments UAF42 universal active filter chip

from Texas Instruments (originally it was a Burr Brown device) is such a device. This implements a second order SVF, similar to Fig.4, but with all three responses (high, low and bandpass) available.

Its integrators already have 0.5% accurate 1000pF (1nF) on-chip capacitors, meaning that many filters do not require additional external capacitors. The chip also contains an uncommitted op amp of the same type as the others. The UAF42 is available in 14-pin DIP and SOIC-16 surface-mount packages. The bulletin, which are required. It also shows you how the various stages should be connected together.

In this case, we need two 'PP1' stages, as shown in Fig.7. The required component values are as follows (1% resistors):

Stage 1: R_{F1} = 41.2kΩ R_{F2} = 41.2kΩ
R_Q = 14.7kΩ

Stage 2: R_{F1} = 76.8kΩ R_{F2} = 76.8kΩ
R_Q = 14.7kΩ

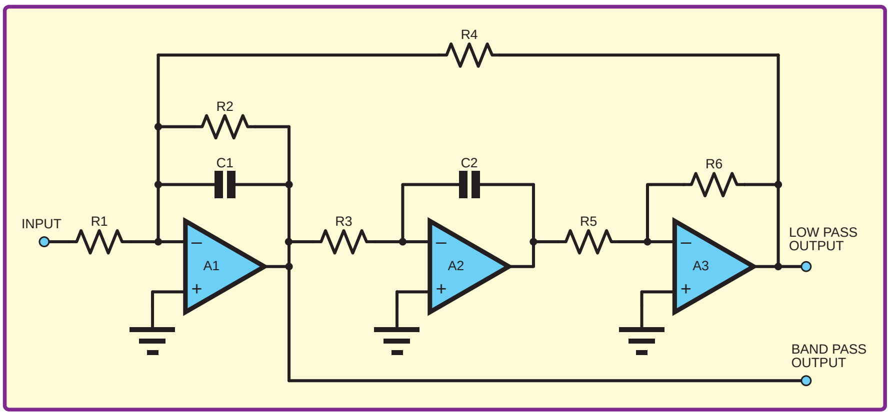


Fig.4. A Tow-Thomas biquadratic filter, which provides low-pass and high-pass outputs. It comprises integrator circuits, op amps A1 and A2, and an inverting amplifier, A3

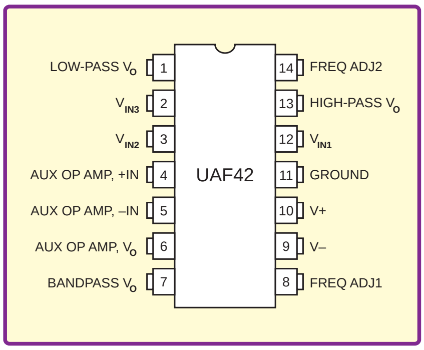


Fig.5. Pinout connections for the UAF42 universal filter IC from Texas Instruments

Universal filters

The SVF is called a universal filter because it can simultaneously provide low-pass, high-pass and bandpass outputs, although not all versions provide all three. A further advantage over MFB and Sallen and Key filters is that it is possible to independently adjust gain, frequency and Q factor with SVFs, making them easily tuneable, although not all variants allow all three properties to be independently tuned. As usual, multiple SVF stages can be cascaded to achieve higher-order filters.

As we have indicated, there are a number of ways of implementing SVFs, and we do not have space to look at all the possibilities here. A popular version is the Tow-Thomas Biquadratic Filter (see Fig.4), which provides low-pass and high-pass outputs. The filter comprises two integrator circuits using op amps A1 and A2, and an inverting amplifier using A3. Input and feedback signals are summed at the input of A1

The large number of op amps required for implementing SVFs may be a disadvantage, but the problem can be overcome by using a dedicated chip. The UAF42 universal filter pin connections of the 14-pin DIP device are shown in Fig.5.

Filter42

Again, design software comes to our aid. This time it is called Filter42, and it is specifically designed to calculate component values for the UAF42 universal filter chip.

Full details of all the various circuit configurations and software options are provided in the document 'Filter Design Program for the UAF42 Universal Active Filter' (currently available from TI at **http://focus.ti.com/lit/an/sbfa002/sbfa002.pdf**). The programme is DOS-based, but runs fine in Windows-XP. If you are using this chip you should also read the datasheet, currently available at **http://focus.ti.com/lit/ds/symlink/uaf42.pdf**.

A screen shot of the programme ready to calculate the component values for a fourth-order 1dB ripple Chebyshev filter, with a 2kHz to 4kHz pass band, is shown in Fig.6. Pressing F2 displays the component values for whichever of the six or so circuit configurations, detailed in the application

The Bandpass V_O output pin (pin 7) (BP Out on Fig.7) of the first stage is connected to the V_{IN3} (pin 2) input pin of the second stage (V_{IN} on Fig.7). The filter attenuates the signal by one quarter in the pass band and has a maximum input voltage of 10V on a ±15V supply.

Performance

The performance of filter circuits is often sensitive to component value variations and imperfections of the resistors and capacitors used; as well as certain key op amp specifications, such as the gain-bandwidth product. This sensitivity is typically worse for small fractional bandwidths (large Q factors).

Using inadequate components may, for example, cause your filter's cut-off frequencies to be incorrect, for the level of attenuation in the stop band to be much less than expected, or for the signal to be distorted. Filters responses depend on the combination of *R* and *C* values rather than absolute values, so you can choose relatively high or low resistor or capacitor values for the same filter and this has an impact on filter performance. Filter software gives varying degrees of control over this.

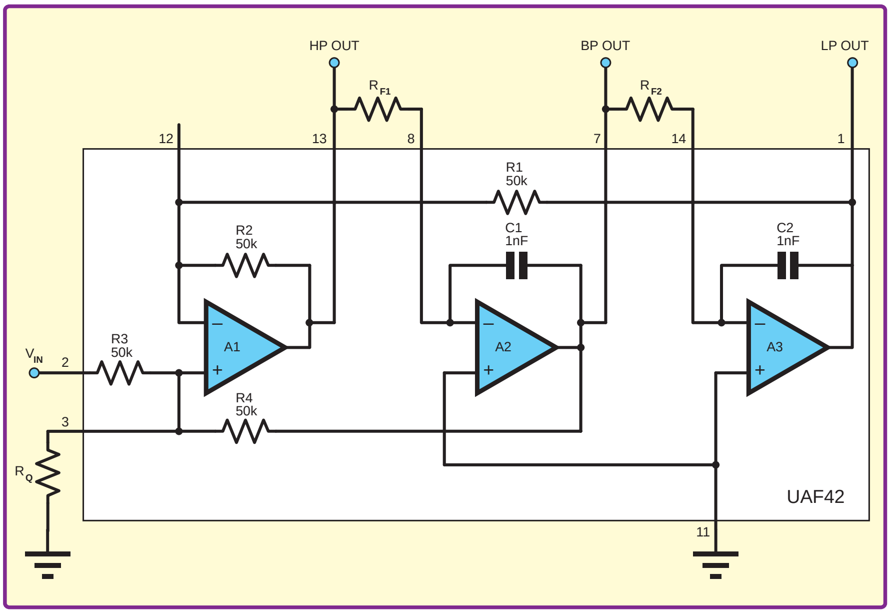


Fig.7. A UAF42 circuit required for a fourth-order Chebyshev 2kHz to 4kHz bandpass filter. Two of these stages are required (see text)

Resistors

Large resistors reduce loading on the op amps outputs and allow you to use smaller (cheaper) capacitor values, but the capacitors should not be too small (see below). Large resistors will also tend to reduce the power consumed by the filter, but increase noise in the circuit.

Some filters are affected by op amp offsets, reducing the value of resistors through which op amp input bias currents flow will reduce offsets, as will using a low offset op amp and one with low bias currents. Some high speed op amps (which may be required in some filters) need relatively low resistor values to perform well.

Capacitors

The capacitors used in active filters should not be too small (less than 100pF), otherwise other capacitances, such as the op amp's input capacitance (for some filters) may have to be taken into account. The op amp's input capacitance should be a known quantity, but stray capacitances from the circuit board and wiring, which may affect any filter with small capacitors, will be hard to quantify.

High-order filters are sensitive to component values, which is a worse problem with capacitors than resistors, because high tolerance capacitors are rare and more expensive than their resistor counterparts. If your filter design software allows you to enter capacitor values (so it sets the resistors) you may be able to use measured capacitor values for a one-off circuit.

Non-ideal behaviour of capacitors may have a significant impact if you are trying to build a high performance filter, in particular losses in the capacitors result in errors in filter behaviour.

Capacitors suffer from dielectric adsorption (DA), which is the tendency of a capacitor to recharge itself after being discharged. At first this might seem to be a low frequency effect, but detailed analysis of dielectric absorption shows that it affects the behaviour of the capacitor over its entire usable frequency range. Mylar and Hi-K ceramic capacitors have high DA values and should be avoided.

A capacitor's 'equivalent series resistance (ESR)' is the effective resistance in series with the capacitor; the higher the ESR the more losses in the capacitor. Capacitors also have inductance, again resulting in non-ideal behaviour. The effect of both ESR and inductance is included in the dispersion factor (DF) often quoted on capacitor datasheets. A large DF means more losses and worse filter performance. Sometimes, the inverse of DF, Q-factor is quoted. The lower a capacitor's Q factor the higher the losses.

Ceramic capacitors, except NP0 types, and particularly those with high dielectric constants (high-k ceramics) should be avoided in filter circuits. General good choices for filters are NP0 ceramic, silver mica, metalized polycarbonate, polypropylene and polystyrene.

Op amps

Op amps have very high open loop gains (hundreds of thousands or millions) at low frequencies, but their gain is deliberately made to fall off as frequency increases to prevent instability. Op amps are usually used with large amounts of negative feedback, resulting in low (often units or tens) closed-loop gain.

If the closed-loop gain is much smaller than the open-loop gain, the circuit's gain depends almost entirely on the feedback components and is largely independent of the op amp's gain. That is why you can set the gain of an op amp amplifier with two resistors without knowing the gain of the op amp.

Given that the op amp's gain falls with frequency, it follows that as frequency is increased we will reach a point at which the op amp's (open loop) gain falls to a value close to that of the circuit. At this point, the design equations (eg, gain = R1/R2) no longer hold and the circuit gain will start decreasing too.

The larger the closed-loop gain the lower the frequency at which this will occur. So, for a higher circuit gain, the circuit bandwidth will be smaller. In fact, for closed-loop op amp amplifiers we have:

$$\textit{Gain} \times \textit{Bandwidth} = \textit{Constant}$$

This constant is called the 'gain bandwidth product' (variously abbreviated GB GBW, GBP and GBWP).

If the GBP is 5MHz, the open loop gain falls to unity at 5MHz. If such an op amp is used in closed loop with a gain of 10, then the circuit will work more or less up to 500kHz (as 10 × 500kHz = 5MHz). Similarly, if a bandwidth of 100kHz is required, the circuit gain cannot be more than 50 (50 × 100kHz = 5MHz).

Gain bandwidth product is important for op amps in MFB and Sallen and Key filter stages. The formula for required GBP varies depending on how the filter is configured and specified, but for an MFB bandpass filter Microchip state GBP = K × Q × 100 × f_H, where K is the stage's gain.

For Fig.2, this is roughly GBP = 1 × 1.4 × 100 × 4000 or 0.56MHz, which is not particularly demanding and is probably within the specification of the popular 741 op amp. However, it does not take much to make this requirement more difficult though. For example, shifting the 2kHz bandwidth up to 8kHz to 10kHz to give a Q of 4.47, we get GBP = 1 × 4.47 × 100 × 10000 or 4.47MHz, which is beyond the limit of a few common general purpose op amps, although easily covered by faster devices.

Output impedance

Op amp output impedance is also affected by frequency, because the output impedance in closed loop is the open-loop output impedance divided by the gain. At high frequencies, as the op amp gain decreases, the effective output impedance also increases. Once this impedance becomes similar to the impedances of the components in the feedback network it will start influencing the filter's response. The filter gain may, therefore, not continue to behave (eg, fall off continuously) at high frequencies, as would be expected from the idealised response curves.

If the filter is handling reasonably large voltages (a few volts rather than a few millivolts), then the op amps slew rate is likely to be important. Slew rate is a measure of how fast an op amp's output can change and limits the device's ability to accurately reproduce input waveforms, particularly for larger signals and high frequencies.

For a signal peak of V_P volts and a maximum in-band frequency of *f*, the op amp's slew rate should be at least $2\pi f V_P$V/s. For example, a 50kHz filter with a 10V peak-to-peak (V_P = 5V) signal requires a slew rate of 1.6MV/s or 1.6V/μs. Note that the popular 741 can only manage about 0.5V/μs and would therefore cause distortion in this application.

PLEASE TAKE NOTE

Lightning Detector – Breadboarding Projects *June '09*

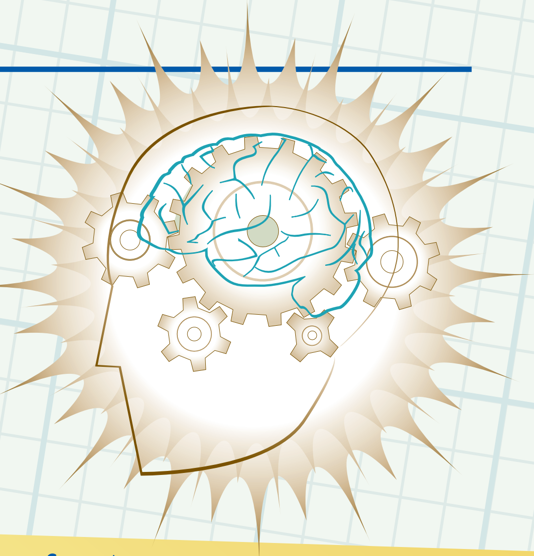
Page 49, Fig 9.1. The type number for op amp IC2 should be a 7611 device.

Heating Oil Storage Tank Burglar Alarm *July '09*

Page 55, Fig.2. Transistor TR1 should be a type BFY51, not as shown.

Ingenuity Unlimited

Our regular round-up of readers' own circuits



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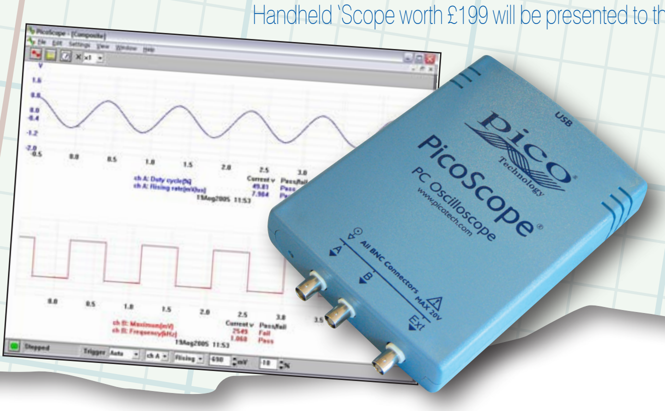

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The circuits shown have NOT been proven by us. **Ingenuity Unlimited** is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and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

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Battery Tester for SLAs – *Health check*

Rechargeable sealed lead-acid batteries (SLAs) don't last forever, and eventually have to be thrown out, but, although you might suspect the capacity is down, it would be useful to know exactly how far down; is it 80% or only 20%? Without this information it isn't possible to make a rational decision on whether or not to keep one.

The only meaningful way of deciding whether to keep it is to do a proper 'drop test' in which you apply a realistic load to the battery and watch the fall of the terminal voltage over a time-frame that will be anywhere from five to 10 hours. This used to be done with a chart-recorder, but nowadays you'd use your computer. Normally, you would also need a data-logger to execute the analogue-to-digital conversion required.

Data-loggers are high-tech gadgets, but this level of sophistication is wholly inappropriate here. Remember, all we want is a rough visual guide as to the health of the SLA. In any case, few hobbyists could justify the expense. The circuit diagram in Fig.1 shows a method of achieving our aim, and one which should cost you next to nothing.

The trick is to recall that most computers already has an analogue-to-digital converter: there is one incorporated in the audio chip. All we need is a computer, some audio-recorder software (plenty free on the internet) and the circuit described here.

You will need to load the battery with a high-wattage resistor that will drain the battery in about five hours. The rest of the circuit is simply an inexpensive CMOS chip configured to oscillate at some arbitrary rate (I chose 1kHz). The output of this oscillator is virtually rail-to-rail, and so its amplitude closely reflects the battery's terminal voltage (we aren't after precision here, only a trend). The resistive divider picks off a small signal which goes to the computer (I used the Line-in, which requires around 200mV).

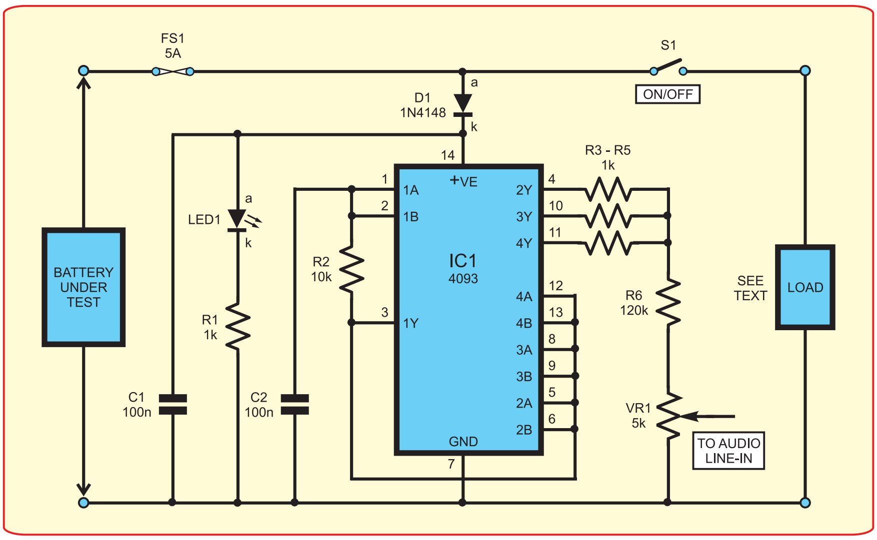

Fig.1. Circuit diagram for the sealed lead-acid battery tester

It is interesting to compare the charts of various SLAs and to see the different failure modes. A good battery will stay above 10V until it is drained, and then quickly fall away. With an older one, only a single cell might be down. Or the entire voltage may rapidly collapse to virtually nothing under load. This sort of detailed information will help you better decide whether to keep it or bin it.

Bruce Clothier, Oadby

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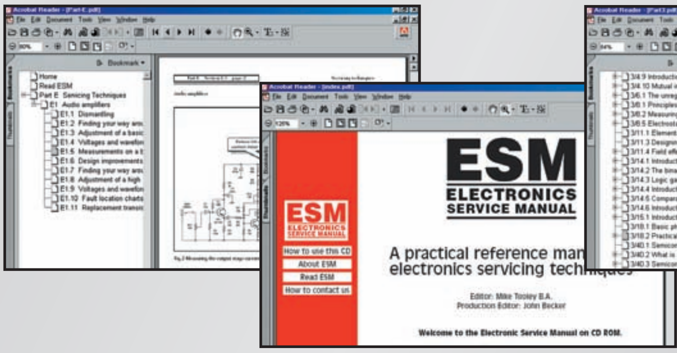

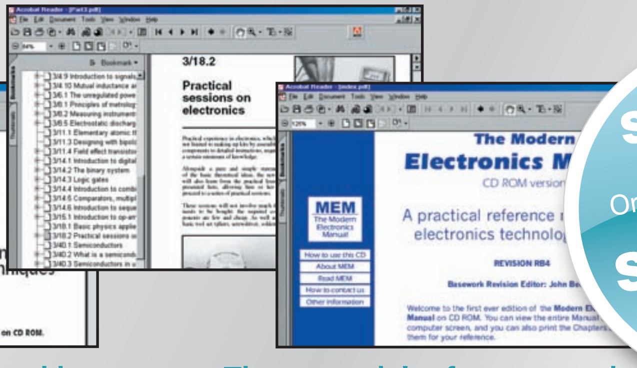

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PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Debugging – an art not science

One of the hardest, yet most interesting challenges that we have to deal with when designing software is debugging. Debugging is the art – yes it's an art not a science – of how you solve problems with the way your software and circuit operates.

Loosely speaking, there are three categories of errors in software, and each has a different debugging approach:

Syntax Errors – The compiler or assembler is unable to convert your text into an actual program

Incorrect Behavior – Your program operates, but it doesn't do what you intended

Erratic Behavior – Your program operates correctly, most of the time, but sometimes goes wrong at unpredictable times.

Syntax errors are easy to solve because the compiler or assembler will display a helpful message saying exactly what the problem is, and on what line number, to the extent that you sometimes wonder why the compiler didn't fix the problem in the source code itself!

Incorrect behavior is the kind of error that we are most familiar with. Maybe the software flashes an LED at the wrong rate, or sends too many bits out to a serial memory device.

These problems are relatively easy to track down because they always occur whenever you run the program – you simply need to track down which part of the software is doing it, and fix it. OK, perhaps it's not always that simple, but we will discuss the techniques in a minute.

The final category, *erratic behavior*, is the bane of all software engineers. Your software appears to work perfectly, except that once in a while it does something unexpected – a corrupted message over a serial port, freezing for an unusual amount of time, a sudden crash.

For a professional engineer these issues are a nightmare – your boss, who is used to project plans and estimates that are probably accurate to within 20% asks "when will it be fixed" and your only answer is "when it's done". Problems like these can take a day, or several months to solve. You just can't say.

So how do software engineers debug problems within software?

Emulators

In the old days, the only option available for debugging was to use a processor emulator, custom hardware that implemented the normal functionality of the processor, but also provided access to the address and data lines of the CPU, which were not available on the standard IC. This hardware was very expensive, costing thousands of pounds, and was very difficult to get hold of due to limited production runs.

With an emulator and the debugger software that came with it (often on a custom computer) you could set 'breakpoints' – instructions to the debugger to freeze operation of the processor if a particular address was reached. Once the debugger detected an access to this address it stopped the program and allowed the user to inspect the registers of the processor. It was possible to set complicated scenarios, under which these breakpoints would occur, such as 'break if this address is reached and the accumulator has a value of 0x12 and this is the second time you have been at this address'.

Emulators are very powerful tools, but way beyond the reach of hobbyists, and even small companies.

Crash and burn

There are other more primitive techniques available that don't require expensive hardware, but instead rely on the hardware of the target circuit itself. Toggling an LED, displaying text on an LCD or even transmitting information over a serial port as the program reaches a critical point in the code are all popular alternatives, and sometimes the only practical solution.

Debugging under these conditions is known as 'crash and burn', from the days when programs were held on EPROM memory. You would write your test code, burn it into an EPROM and then run it. When it crashes, you hopefully have learned enough about the problem to write some new test code, and the cycle repeats.

As EPROMs used to take 20 minutes to erase under a UV lamp it was normal for each developer to have a stack of EPROMs erased and ready to be programmed, and they would make frequent trips to the UV eraser to clear a bunch of chips at a time. In large organisations it was not unusual for arguments to occur over who was next in line for the eraser!

Engineers with a little foresight, and with target hardware that had enough spare RAM, would write a 'debug monitor' to assist with the debugging process. A monitor is a small program that is programmed into EPROM or Flash memory, and that can itself transfer programs from a PC via a serial link directly into RAM.

The monitor allows you to start the program, manually halt it and even run the program a single instruction at a time, allowing the processor registers to be displayed between each execution. These monitors are small, simple and crude, but offer a significant timesaving over the crash and burn technique – so long as your target can support it.

What monitors cannot do is allow your program to run at full speed while providing breakpoints – that still requires an expensive emulator.

BDM

At some point, probably due to pressure from the large number of small and relatively cash-poor software companies that sprang up in the 1980s, the microprocessor manufacturers woke up to the problem of debugging software. They realised that with the addition of a small amount of silicon space on their processors they could provide a 'halfway house' between full emulation and simple monitor debugging.

Often referred to as 'background debug mode' or BDM, it allows a simple low-cost external system to control the operation of the processor – and crucially, allow the placement of one or more breakpoints within the target application. As the mechanisms improved over the years, we have now reached the stage where a powerful debug tool can be created for a processor that retails for less than thirty pounds – the Microchip PicKit2 for example.

While the PicKit2 (and its replacement, the PicKit3) are most frequently used for programming microprocessors, they are, in fact, also powerful debugging interfaces. The software to drive this interface is wrapped up within MPLAB. You can view your assembly or C source code and step through it, line by line if you wish, while it executes on the circuit board. When the processor halts, you can view the content of variables and all processor registers.

It *significantly* reduces the time required to fix bugs in the software, and turns the debugging experience from an act of frustration into an interesting adventure. There is something quite magical about seeing your normally lifeless source code come to life, exercising the circuit as you step line by line through the program!

To gain access to the benefits of in-circuit debugging, you only need to reserve two pins on the processor for use by the external debugger. These are normally called PGD and PGC, and along with power and the RESET pin are the only connections required. The author automatically adds these signals to a small standard six-pin header with every new design right from the start of the design process, ready to be plugged directly into a PicKit2 once the circuit has been built.

Simulators

While some form of hardware debugging is essential for solving problems with your software design, there are other techniques available that can help avoid having the problem in the first place – unit testing and simulation.

Simulation is where you run your microprocessor software in a program on a PC that implements a 'virtual' microprocessor. This program allows full, complex control over your code, and is limited only by the complexity of the simulator software. The simulator cannot run your code at full speed (although modern PCs simulating the slower PIC processors get very close) and, of course, it cannot interface to the hardware of your circuit, although it may be able to simulate peripherals such as the serial port.

Simulators are highly useful tools because they enable you to develop software before your circuit has been produced. By carefully writing your code so that the portion of it that interfaces to hardware is cleanly isolated from the rest, you can develop and fully test much of your code in the simulator, even before you have designed your hardware. Testing this way means that you can create rock-solid, bug-free code that can be reused elsewhere.

The term 'unit testing' refers to testing these individual, isolated pieces of code. Writing code that is independent of other parts of the software so that it is reusable means that you can write it once, test it once and use it with confidence many times, in different projects, never needing to worry about it again. That's the theory anyway, but it's a good goal for us all to aspire to!

As a final thought, it's also a good idea, where possible, to keep the processor hardware similar, so that you can first download a previously tested debugging program to verify the basic operation. The author tries wherever possible to use a standard processor design, including an RS232 interface, even if the project doesn't call for one. This allows for the use of a standard bootloader application (covered in a previous *PIC n' Mix* article) which allows for:

Verifying that the hardware works, or works at least enough to run software

Providing a standard, quick way to load software

The use of a standard, well tested and proven set of startup code – so you can think about your application, not how to get the CPU up and running.

The author has several standard bootloaders for different processor families – 18F, 24H and PIC32. Generally, they either work 'out of the box' or are modified slightly to suit the hardware requirements of the project in hand. This approach is particularly helpful if you find yourself jumping from one processor type to another – it's very easy to forget the peculiarities of each type, and to make mistakes in the basic startup sequence that can leave you spending hours looking for wiring errors when it fact it is nothing more than a missing line of code!

More on video

For those of you who have been following our articles on video generation and seen the review of the commercial XGS PIC game development system (*EPE* July '09), you might be interested in the *Uzebox*, an 'open source' game system developed by BeLogic. It's a low-cost circuit consisting of just two ICs – an Atmel ATmega644 processor and an RGB to composite video converter.

Being open source, the circuit and software are freely available, so you can build your own or purchase a fully assembled development system. The support for the platform is fantastic, and not only are there a number of games freely available for it, but also the development team have managed to play videos on it – a real accomplishment for an 8-bit processor running at just 28MHz.The commercial version is available through Sparkfun Electronics, and the project website is at **http://belogic.com/uzebox/**

For those of you who are wondering, then yes, we will be covering colour video generation on the PIC24 later!

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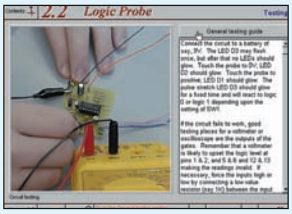

Logic Probe testing

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.

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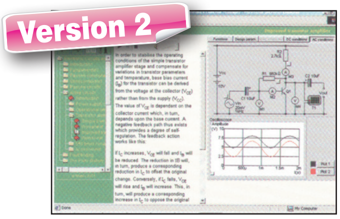

Circuit simulation screen

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

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

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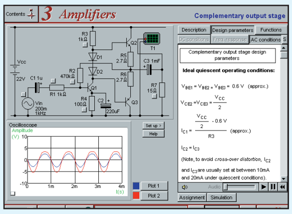

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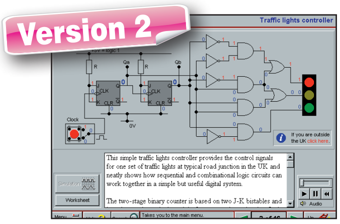

Virtual laboratory - Traffic Lights

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

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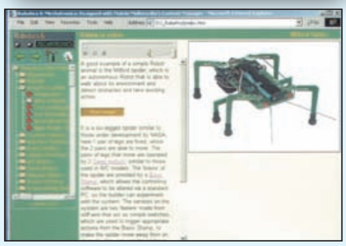

Case study of the Milford Instruments Spider

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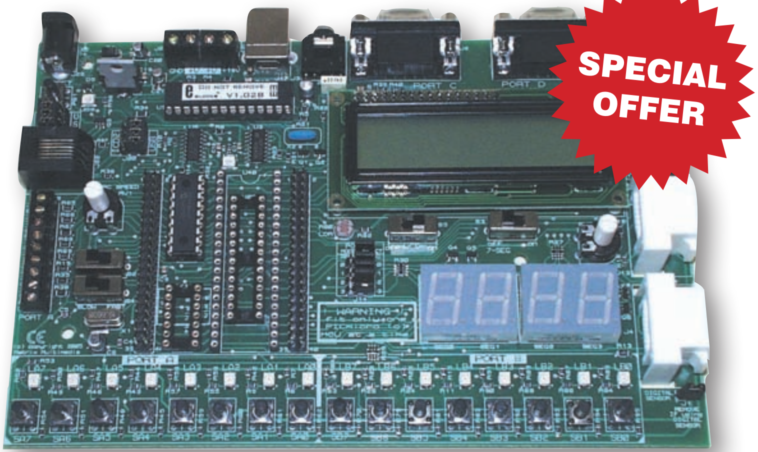

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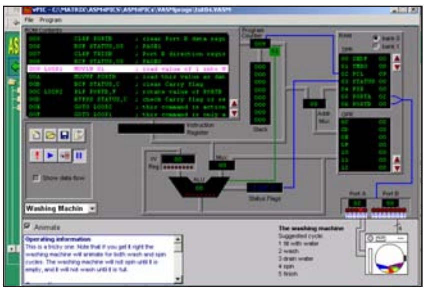
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

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

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

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

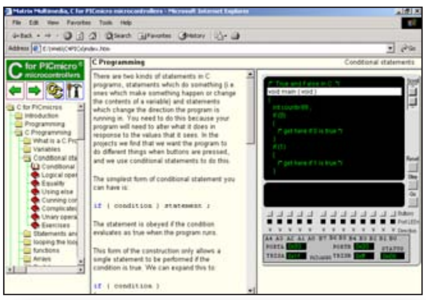


'C' FOR 16 Series PICmicro Version 4

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

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

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



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

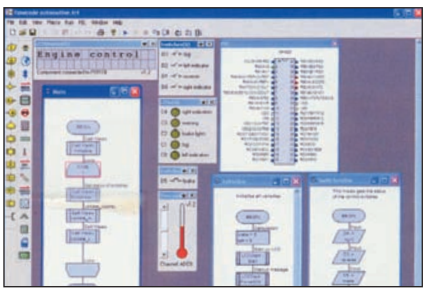
FLOWCODE FOR PICmicro V3

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

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

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

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



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

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

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

SPECIAL PACKAGE OFFER

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

£50.00 inc. VAT and p&p

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

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

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

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

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

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

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

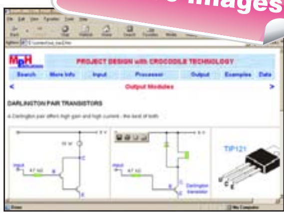
Get TINA + Flowcode for a total of just £50, including VAT and postage.

PROJECT DESIGN WITH CROCODILE TECHNOLOGY

An Interactive Guide to Circuit Design

Over 150 pages
Over 600 images

An interactive CD-ROM to guide you through the process of circuit design. Choose from an extensive range of input, process and output modules, including CMOS Logic, Op-Amps, PIC/PICAXE, Remote Control Modules (IR and Radio), Transistors, Thyristors, Relays and much more.
Click Data for a complete guide to the pin layouts of i.c.s, transistors etc. Click More Information for detailed background information with many animated diagrams.
Nearly all the circuits can be instantly simulated in Crocodile Technology (not included on the CD-ROM) and you can customise the designs as required.*

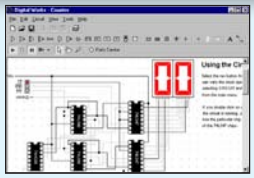


WHAT'S INCLUDED
Light Modules, Temperature Modules, Sound Modules, Moisture Modules, Switch Modules, Astables including 555, Remote Control (IR & Radio), Transistor Amplifiers, Thyristor, Relay, Op-Amp Modules, Logic Modules, 555 Timer, PIC/PICAXE, Output Devices, Transistor Drivers, Relay Motor Direction & Speed Control, 7 Segment Displays.Data sections with pinouts etc., Example Projects, Full Search Facility, Further Background Information and Animated Diagrams.
Runs in Microsoft Internet Explorer
All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

Single User £39.00 inc. VAT.
Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.
(UK and EU customers add VAT at 15% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

Hobbyist/Student £44 inc. VAT.
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Institutional 10 user £249 plus VAT.
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ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 jpg images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).

Now contains Irfan View image software for Windows, with quick-start notes included.

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☐ 'C' for 16 Series PICmicro V4
☐ Flowcode V3 for PICmicro
☐ Digital Works 3.0

Version required:
☐ Hobbyist/Student
☐ Institutional
☐ Institutional/Professional 10 user
☐ Site licence

☐ PICmicro Development Board V3 (hardware)

☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
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Note: The software on each version is the same, only the licence for use varies.

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Net Work

Alan Winstanley

Welcome to this month's *Net Work*, the column specially written to help readers get more out of the Internet. We start with a timely reminder of our own services available to readers via the web. Regular readers will know that, over the past twelve months or so, we have redeveloped our Internet presence to focus more on the online downloadable version. We believe we were the first UK magazine to offer both a hardcopy on the newsstands as well as supplying a downloadable PDF as an option. By visiting **www.epemag3.com** you can buy a year's subscription to *EPE* Online for the remarkably low price of just US $18.99 for twelve issues.

We try hard to accommodate every visitor, but the *EPE* website is optimised for IE7 and Firefox, and despite our best efforts, some browsers may not be fully compatible with some features. Our website is hosted by our USA-based co-partners – a number of readers will have communicated in the past with Max, Alvin or Dean – and the 'Library' link along the top of the home page is your first port of call to access source codes and PCB foil downloads.

Each month's source codes and PCBs are compressed together into zip files, accessible by month/year. More recently, we have added a Free Project Archive in the Library, containing nearly 100 constructional projects, available as free PDF downloads. They are categorised under various headings, including games, PIC projects, lab equipment, radio and audio projects.

Sometimes, you may have to substitute parts and you should check availability of key components prior to commencing construction. Although we cannot feasibly provide technical support for legacy projects, the *EPE Chat Zone* forum at **www.chatzones.co.uk** is as lively as ever and is a good place to exchange hints and tips with like-minded readers. Why not download some of our free projects now, and if you know anyone keen to get started in hobby electronics, then spread the word!

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If you wish to purchase any of our merchandise, *EPE* offers e-commerce facilities, and we deliver to most countries in the world. In the top menu of our home page readers will see links for 'UK Store' and 'US Store'. Due to the way our online presence has evolved, the two systems are different, but they sell a selected range of common products, as well as having their own unique items. Readers may choose which site to purchase from: our US store accepts US dollars and sells subscriptions to *EPE Online*, *Radio Bygones*, books and technical CDs, and also accepts subscriptions for the hard copy.

Microsoft Family Safety is a free tool to help protect younger users against inappropriate websites or other online resources

Our UK store is run from the head offices here in Wimborne, UK, and accepts credit card payments in Pounds Sterling only. Again, we deliver worldwide and you can buy electronics books, CDs and subscribe to the hard copy from the UK, and also order back issues or reprints. Basically, readers can choose whichever site they prefer to deal with. UK telephone orders can also be placed by calling 01202 873 872 (International: +44 1202 873 872). Our Email address for enquiries is **orders@epemag.wimborne.co.uk**.

One web user berated the writer somewhat for allegedly failing to cater for Apple internet users, but being an electronics magazine dedicated to the PC means that we cannot realistically hope to cover every option. Rightly or wrongly, the PC is the choice of the mass market, with Internet Explorer 7/8 or Firefox being the mainstream browsers in use today.

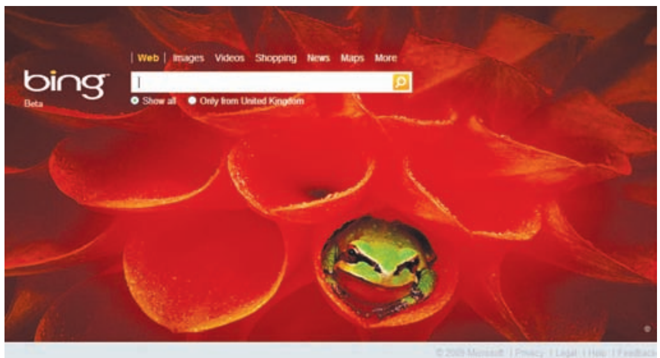
First aid

Microsoft has had a busy time recently, starting with the delivery of Internet Explorer 8 for XP, Vista or Windows Server (see **www.microsoft.com/windows/internet-explorer/worldwide-sites.aspx**). Another interesting free product is Microsoft Family Safety, which is part of the current Microsoft Live suite, and it attempts to protect against accessing inappropriate sites. The filtering settings can be controlled from any computer and usage reports can be viewed online as well. If you have youngsters sharing your web feed, then this filtering product is worth a try and it won't cost you a penny. More details from **http://www.microsoft.com/protect/products/family/onecarefamilysafety.mspx**.

Microsoft's paid-for 'Windows Live OneCare' PC healthcare package is gradually being wound down during Summer 2009, primarily because it has not kept pace with the explosive growth of online threats. Coming soon will be a new antivirus package called 'Microsoft Security Essentials' available for free in the second half of 2009. It claims to guard against viruses, Trojans, malware and many other threats, all in one 'lightweight' package, which hopefully will not bring a moderate PC to its knees, as some security packages tend to do. A restricted beta is available (not UK) from **http://www.microsoft.com/security_essentials/market.aspx**

I'll be keeping a close eye on Microsoft Security Essentials, but the big news this month is the launch, in beta phase, of Bing (**www.bing.com**), Microsoft's attempt to oust Google from pole position. Bing holds the promise of a friendlier and more focussed search engine, presented in a clean minimalist style. Particularly useful is the flyout pop-up window available on the right hand of a search entry, which offers a little more information about that link.

I'll take a look at Bing in a bonus *EPE* Online article at **www.epemag3.com** – see you there! You can email me at **alan@epemag.demon.co.uk**.



Bing goes your web search – the face of Microsoft's new search engine that plans to go head-to-head with Google

DIRECT BOOK SERVICE

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

FOR A FURTHER SELECTION OF BOOKS SEE THE NEXT TWO ISSUES OF *EPE*

3

All prices include UK postage

Electronics Teach-In + FREE CD-ROM

Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. Plus 15 easy-to-build projects. The 152 page A4 book comes with a free CD-ROM containing the whole Teach-In 2006 series (originally published in *EPE*) in PDF form, interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the Teach-In series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

The Teach-In series covers everything from Electric Current through to Microprocessors and Microcontrollers and each part includes demonstration circuits to build on breadboards or to simulate on your PC.

In addition to the Teach-In series, the book includes 15 CMOS-based simple projects from the Back-To-Basics series by Bart Trepak, these are: Fridge/Freezer Alarm, Water Level Detector, Burglar Alarm, Scarecrow, Digital Lock, Doorchime, Electronic Dice, Kitchen Timer, Room Thermometer, Daily Reminder, Whistle Switch, Parking Radar, Telephone Switch, Noughts and Crosses Enigma and a Weather Vane. There is also a MW/LW Radio project in the Teach-In series.

152 pages + CD-ROM **Order code ETI** **£8.50**

ROBOTICS

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

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

Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages - large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

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

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

198 pages **Order code BP902** **£14.99**

ANDROIDS, ROBOTS AND ANIMATRONS
Second Edition – John Iovine

Build your own working robot or android using both off-the-shelf and workshop constructed materials and devices. Computer control gives these robots and androids two types of artificial intelligence (an expert system and a neural network). A lifelike android hand can be built and programmed to function doing repetitive tasks. A fully animated robot or android can also be built and programmed to perform a wide variety of functions.

The contents include an Overview of State-of-the-Art Robots; Robotic Locomotion; Motors and Power Controllers; All Types of Sensors; Tilt; Bump; Road and Wall Detection; Light; Speech and Sound Recognition; Robotic Intelligence (Expert Type) Using a Single-Board Computer Programmed in BASIC; Robotic Intelligence (Neutral Type) Using Simple Neural Networks (Insect Intelligence); Making a Lifelike Android Hand; A Computer-Controlled Robotic Insect Programmed in BASIC; Telepresence Robots With Actual Arcade and Virtual Reality Applications; A Computer-Controlled Robotic Arm; Animated Robots and Androids; Real-World Robotic Applications.

224 pages **Order code MGH1** **£16.99**

RADIO

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£20.00**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the last century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

COMPUTERS AND COMPUTING

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s. Uses only clear and easy-to-understand language. Larger type size for easy reading. Provides basic knowledge to give you confidence to join the local computer class.

This book explains how to use your PC on the Internet and covers amongst other things: Choosing and setting up your computer for the Internet. Getting connected to the Internet. Sending and receiving emails, photographs, etc., so that you can keep in touch with family and friends all over the world. Searching for and saving information on any subject. On-line shopping and home banking. Setting up your own simple web site.

228 pages **Order code BP600** **£8.99**

BUILD YOUR OWN PC – Fourth Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. The author goes 'under the hood' and shows step-by-step how to create a Pentium 4 computer or an Athlon 64 or Athlon 64FX, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows XP. The few existing books on this subject, although outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are looking for.

224 pages - large format **Order code MGH2** **£16.99**

THE PIC MICROCONTROLLER
YOUR PERSONAL INTRODUCTORY COURSE – THIRD EDITION
John Morton

Discover the potential of the PIC microcontroller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised third edition covers the popular reprogrammable Flash PICs: 16F54/16F84 as well as the 12F508 and 12F675.

270 pages **Order code NE36** **£20.99**

PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C – LEARNING TO FLY THE PIC24
Lucio Di Jasio (Application Segments Manager, Microchip, USA)

FREE CD-ROM

A Microchip insider tells all. Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compliler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that changed with the introduction of the 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

Experienced PIC users and newcomers alike will benefit from the text's many thorough examples, which demonstrate how to nimbly side-step common obstacles and take full advantage of all the 16-bit features.

496 pages +CD-ROM **Order code NE45** **£32.99**

THEORY AND REFERENCE

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
Third Edition
Mike Tooley

A comprehensive reference text and practical electronics handbook in one volume – at an affordable price!

New chapter on PIC microcontrollers – the most popular chip family for use in project work by hobbyists and in colleges and universities.

New companion website: spreadsheet design tools to simplify circuit calculations; circuit models and templates to enable virtual simulation; a bank of on-line questions for lecturers to set as assignments, and on-line self-test multiple choice questions for each chapter with automatic marking, to enable students to continually monitor their progress and understanding.

The book's content is matched to the latest pre-degree level courses, making this an invaluable reference for all study levels, and its broad coverage is combined with practical case studies, based in real-world engineering contexts throughout the text.

The unique combination of a comprehensive reference text, incorporating a primary focus on practical applications, ensures this text will prove a vital guide for students and also for industry-based engineers, who are either new to the field of electronics, or who wish to refresh their knowledge.

400 pages **Order code NE43** **£23.99**

BEBOP TO THE BOOLEAN BOOGIE
Third Edition
Clive (Max) Maxfield

BOOK + CD-ROM

This book gives the "big picture" of digital electronics. This indepth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

500 pages **Order code BEB1** **£32.95**

BEBOP BYTES BACK (and the Beboputer Computer Simulator) CD-ROM
Clive (Max) Maxfield and Alvin Brown

CD-ROM

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. if you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

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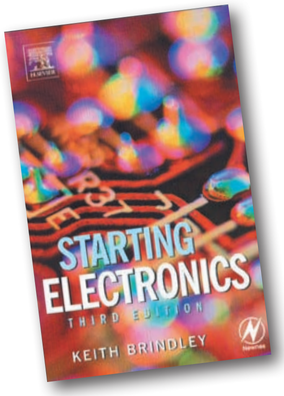

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Keith brindley

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Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

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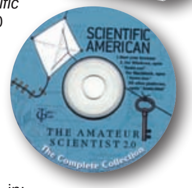

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eBay presents an opportunity for everyone, the trick is to master it. This book shows you how to start trading on eBay UK. It also offers advice on getting organised and tips to put you ahead.

The book has been developed from Cherry's popular hands-on course "Buying and Selling on eBay for Technological Simpletons". In addition to fully explaining eBay and how to trade on it there are sections on Paypal, producing pictures of your sale items, fees and accounts, safety and security, including what to do when things go wrong and what protection is provided.

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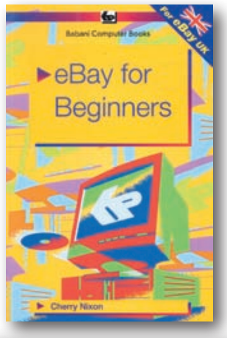

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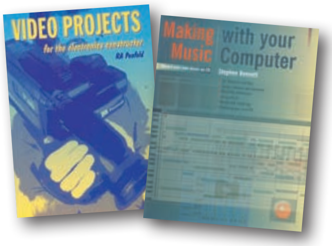

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Ian Waugh

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VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

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There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

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DATA AND DESIGN

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Owen Bishop

This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

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88 pages **Order code BP299** **£5.49**

DIGITAL LOGIC GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explaination of microprocessor techniques as applied to digital logic.

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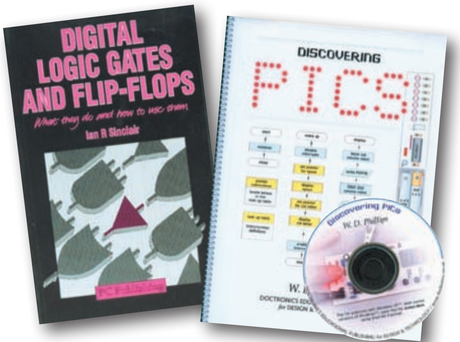

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold

This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

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MICROCONTROLLER COOKBOOK
Mike James

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For details see the shop on our UK web site at www.epemag.com or contact us for a list of *Radio Bygones* books.

PROJECT BUILDING AND TESTING

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

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ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

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The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

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PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

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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.

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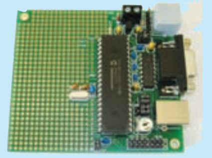

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EVERYDAY PRACTICAL ELECTRONICS

NEXT MONTH

1PPS DRIVER FOR QUARTZ CLOCKS

Remember our *GPS-Based Frequency Reference* project from April/May '09 issues? Well, we've produced a fantastic add-on module for it. Using the 1Hz pulses available at the rear of the unit enables you to drive the escapement coil of a low-cost quartz clock movement – thus providing super accurate time keeping, but with an analogue face!

MINISPOT 455kHz MODULATED OSCILLATOR

This is a great little project for radio fans. The circuit produces a 455kHz carrier waveform, amplitude-modulated with a 500Hz tone. Use it to align the intermediate frequency (IF) stages of any AM broadcast or shortwave radio.

PROGRAMMABLE IGNITION – PART 2

In next month's instalment, we'll look at the circuit for the system's LCD Hand Controller module, including all the assembly details. We'll also cover the six possible versions of the Programmable Ignition System – so just about every possible automotive scenario is covered.

RECYCLE IT! – SPEAKER MODS

We've all seen bargain loudspeakers at car boot sales – but are they any good? Well, for the ones going for a few pounds it hardly matters and even if they are not top-of-the range hifi there are plenty of effective, and cheap and easy modifications you can try out, courtesy of our scavenging guru, Julian Edgar.

OCTOBER '09 ISSUE
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Published on approximately the second Thursday of each month by Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Printed in England by Acorn Web Offset Ltd., Normanton, WF6 1TW. Distributed by Seymour, 86 Newman St., London W1T 3EX. Subscriptions INLAND: £19.95 (6 months); £37.90 (12 months); £70.50 (2 years). OVERSEAS: standard air service, £23.00 (6 months); £44.00 (12 months); £83.00 (2 years). Express airmail, £32.00 (6 months); £62.00 (12 months); £119.00 (2 years). Payments payable to "Everyday Practical Electronics", Subs Dept, Wimborne Publishing Ltd. Email: subs@epemag.wimborne.co.uk. EVERYDAY PRACTICAL ELECTRONICS is sold subject to the following conditions, namely that it shall not, without the written consent of the Publishers first having been given, be lent, resold, hired out or otherwise disposed of by way of Trade at more than the recommended selling price shown on the cover, and that it shall not be lent, resold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.