THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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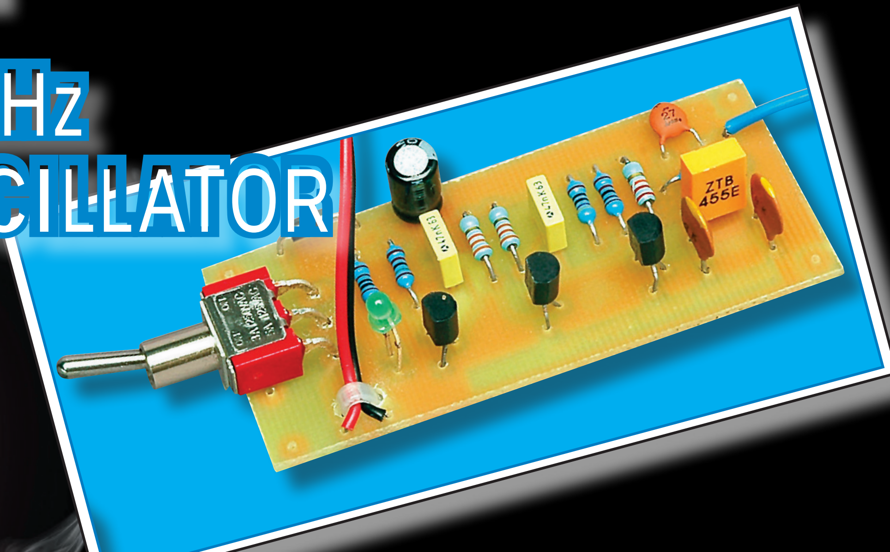
MINISPOT 455kHz MODULATED OSCILLATOR

For IF alignment of AM and shortwave radios



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Improving the sound of salvaged loudspeaker systems

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OCT 2009 PRINTED IN THE UK

ISSN 0262 3617

• PROJECTS • THEORY •
• NEWS • COMMENT •
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VOL. 38. No 10 October 2009

EPE EVERYDAY PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS TODAY INTERNATIONAL

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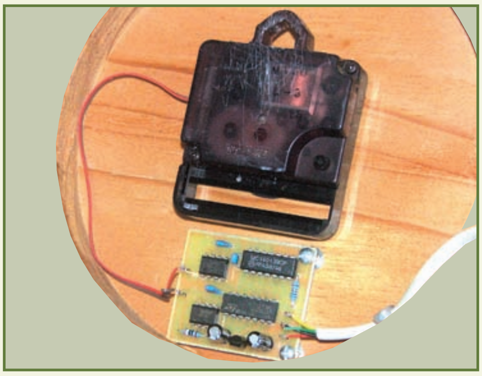

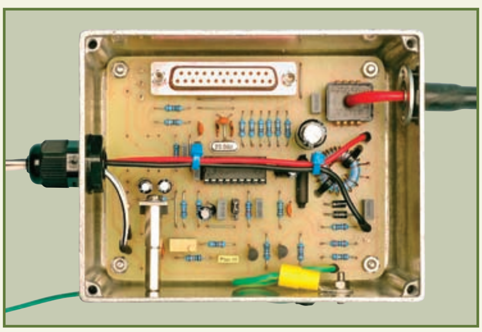

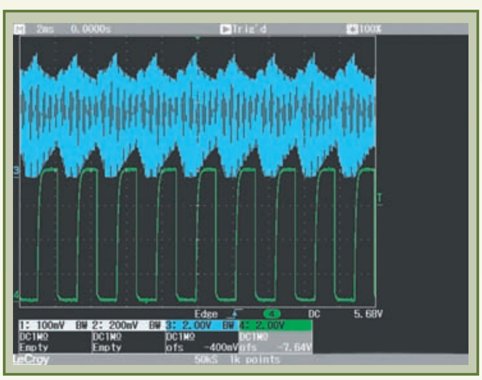

Our November 2009 issue will be published on Thursday 8 October 2009, see page 72 for details.

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

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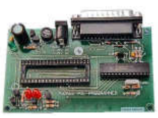
NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. See website for PICs supported. ZIF Socket and USB lead extra. 18Vdc.
Kit Order Code: 3149KT - **£49.95**
Assembled Order Code: AS3149 - **£59.95**

NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows XP Software. ZIF Socket and USB lead not incl.
Assembled Order Code: AS3128 - **£49.95**
Assembled with ZIF socket Order Code: AS3128ZIF - **£64.95**

'PICALL' ISP PIC Programmer



Will program virtually all 8 to 40 pin *serial-mode* AND *parallel-mode* (PIC15C family) PIC microcontrollers. Free Windows software. Blank chip auto detect for super fast bulk programming. Optional ZIF socket.
Assembled Order Code: AS3117 - **£29.95**
Assembled with ZIF socket Order Code: AS3117ZIF - **£44.95**

ATMEL 89xxxx Programmer

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets not included. Supply: 16Vdc.
Kit Order Code: 3123KT - **£27.95**
Assembled Order Code: AS3123 - **£37.95**

Introduction to PIC Programming

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

PIC Programmer Board

Low cost PIC programmer board supporting a wide range of Microchip® PIC™ microcontrollers. Requires PC serial port. Windows interface supplied.
Kit Order Code: K8076KT - **£39.95**

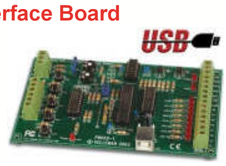
PIC Programmer & Experimenter Board

The PIC Programmer & Experimenter Board with test buttons and LED indicators to carry out educational experiments, such as the supplied programming examples. Includes a 16F627 Flash Microcontroller that can be reprogrammed up to 1000 times for experimenting at will. Software to compile and program your source code is included.
Kit Order Code: K8048KT - **£39.95**
Assembled Order Code: VM111 - **£59.95**

Controllers & Loggers

Here are just a few of the controller and data acquisition and control units we have. See website for full details. 12Vdc PSU for all units: Order Code PSU445 £7.95

USB Experiment Interface Board



5 digital input channels and 8 digital output channels plus two analogue inputs and two analogue outputs with 8 bit resolution.
Kit Order Code: K8055KT - **£38.95**
Assembled Order Code: VM110 - **£64.95**

Rolling Code 4-Channel UHF Remote

State-of-the-Art. High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). 4 indicator LED 's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two & *Ten Channel versions also available.*
Kit Order Code: 3180KT - **£49.95**
Assembled Order Code: AS3180 - **£59.95**

Computer Temperature Data Logger

Serial port 4-channel temperature logger. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£19.95**
Assembled Order Code: AS3145 - **£26.95**
Additional DS1820 Sensors - **£3.95 each**

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

4-Ch DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 130 x 110 x 30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£74.95**
Assembled Order Code: AS3140 - **£89.95**

8-Ch Serial Port Isolated I/O Relay Module

Computer controlled 8 channel relay board. 5A mains rated relay outputs and 4 opto-isolated digital inputs (for monitoring switch states, etc). Useful in a variety of control and sensing applications. Programmed via serial port (use our new Windows interface, terminal emulator or batch files). Serial cable can be up to 35m long. Includes plastic case 130x100x30mm. Power: 12Vdc/500mA.
Kit Order Code: 3108KT - **£64.95**
Assembled Order Code: AS3108 - **£79.95**

Infrared RC 12–Channel Relay Board

Control 12 onboard relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112 x 122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£59.95**
Assembled Order Code: AS3142 - **£69.95**

Audio DTMF Decoder and Display

Detect DTMF tones from tape recorders, receivers, two-way radios, etc using the built-in mic *or* direct from the phone line. Characters are displayed on a 16 character display as they are received and up to 32 numbers can be displayed by scrolling the display. All data written to the LCD is also sent to a serial output for connection to a computer. Supply: 9-12V DC (Order Code PSU445). Main PCB: 55x95mm.
Kit Order Code: 3153KT - **£34.95**
Assembled Order Code: AS3153 - **£44.95**

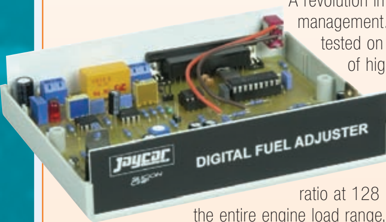
Telephone Call Logger

Stores over 2,500 x 11 digit DTMF numbers with time and date. Records all buttons pressed during a call. No need for any connection to computer during operation but logged data can be downloaded into a PC via a serial port and saved to disk. Includes a plastic case 130x100x30mm. Supply: 9-12V DC (Order Code PSU445).
Kit Order Code: 3164KT - **£54.95**
Assembled Order Code: AS3164 - **£69.95**

AUTOMOTIVE KITS FOR ELECTRONIC ENTHUSIASTS

DIGITAL FUEL ADJUSTER

KC-5385 £24.75 plus postage & packing



A revolution in budget engine management. Extensively tested on a wide range of high performance cars, this unit gives you complete control of the air/fuel ratio at 128 points across the entire engine load range, providing incredible mapping resolution and brilliant drivability. Supports both static and real-time mapping. Kit supplied with a quality solder masked PCB with overlay, machined case with processed panels, programmed micro and all electronic components.

Requires Handheld Digital Controller KC-5386 (below) - no need for a laptop!

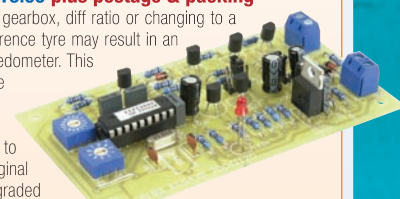
DIGITAL TACHOMETER

KC-5290 £19.75 plus postage & packing

A clear 4-digit LED tachometer showing up to 9,900rpm in 100rpm increments. Housed neatly in a small jiffy box (83 x 54 x 31mm) to mount nicely on your dashboard, it features 10 LED bargraph with optional dot or bar mode (showing 8-independent rpm thresholds), calibration options for 1- 12 cylinder 4-stroke or 1- 6 cylinder 2-stroke engines, anti-flickering and automatic night-time display dimming. This kit can also be combined with our rev limiter KC-5265, to perform engine limiting. Kit includes case with silk-screened panel, PCBs, pre-programmed PIC micro, 7-segment displays, red acrylic, hook-up wire and all electronic components.

SPEEDO CORRECTOR MKII

KC-5435 £16.00 plus postage & packing



Modifying your gearbox, diff ratio or changing to a larger circumference tyre may result in an inaccurate speedometer. This kit readjusts the speedometer signal up or down from 0% to 99% of the original signal. This upgraded model enables automatic input setup selection and indicates when the input signal is being received. Kit supplied with PCB with overlay and all electronic components.

Recommended box UB5 use HB-6013 £1.25

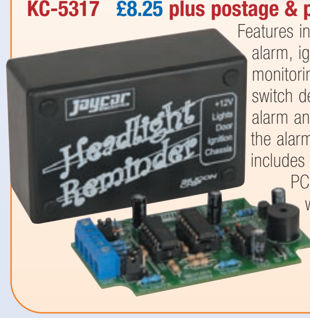
HANDHELD DIGITAL CONTROLLER

KC-5386 £19.75 plus postage & packing

Used for the mapping/programming of the digital fuel adjuster kit (above), it features a two line LCD and easy to use push buttons. Both an interface and display - use it to program the adjuster or leave it permanently connected to display the adjuster's operation. Kit supplied with silkscreened and machined case, PCB, LCD, and all electronic components.

CAR HEADLIGHT REMINDER

KC-5317 £8.25 plus postage & packing



Features include a modulated alarm, ignition and lights monitoring, optional door switch detection, time-out alarm and a short delay before the alarm sounds. 12VDC kit includes quality solder masked PCB with overlay, case with screen printed lid and all electronic components.

HIGH PERFORMANCE TIMER

KC-5379 £12.50 plus postage & packing

A sophisticated timer adaptable for two types of uses. The first is 'one shot' operation, which can be used to keep electric windows active, or a thermo fan running for a period after ignition is switched off etc. The second is a 'pulse' type operation, which can be used to squirt water spray for 1 second every 9 seconds. The uses are endless, with time adjustable from 0.1 sec to 16.5 mins. Kit supplied with PCB and all electronic components.

CAR BATTERY MONITOR

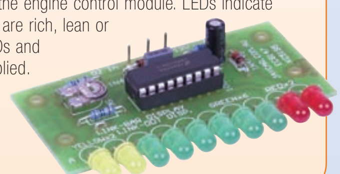
KA-1683 £5.25 plus postage & packing

Don't get caught with a flat battery! This simple electronic voltmeter indicates the condition of your car's battery so you can act in advance and avoid getting stranded. Kit includes PC board and all components.

MIXTURE DISPLAY FOR FUEL INJECTED CARS

KC-5195 £5.00 plus postage & packing

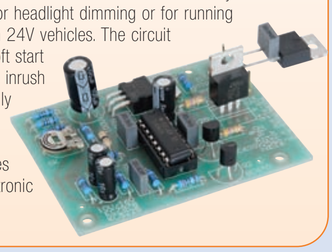
Also known as an EGO (exhaust, gas, oxygen) monitor, this simple kit allows you to monitor your car's fuel mixtures. Use it as a tuning tool to help in vehicle modification or simply to see the behaviour of the engine control module. LEDs indicate whether mixtures are rich, lean or normal. PCB, LEDs and components supplied. Thousands sold!



10A 12VDC MOTOR SPEED CONTROLLER

KC-5225 £7.25 plus postage & packing

Ideal for controlling 12VDC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. Use it for headlight dimming or for running 12VDC motors in 24V vehicles. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps. Kit includes PCB and all electronic components.



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EPE – anywhere, anytime

At the time of writing this Editorial, it's early August; the seagulls are screeching (I live by the sea in Brighton) and just for once it's a pleasantly hot day with small boats on the Channel and a bright sun in the sky. Yes, it's holiday season, and many of you will also be down by the sea, or perhaps further abroad.

Now, picture this – you're sat on the beach and you realise that you've left your favourite magazine at home, or the next issue is out and it will be ten days till you get to see it. What to do? Well, this light-hearted example is just one of many situations when it would be nice to be able to download a copy of EPE to your laptop, the hotel computer or even a PDA. A year's worth of EPE costs less than a pound an issue, and you'll never forget to visit the newsagent or leave it on the train. So, if you are planning a late holiday, why not leave the paper copy at home and travel light, knowing that for just a few pounds you can have global access to the very best in hobby electronics publishing.

...and send us a postcard!

It doesn't have to be a donkey on Blackpool beach, but do keep writing to us at EPE! We really do like to hear what you enjoy in EPE, where we could improve and the successes and occasional frustrations you have with our projects. We are continually impressed with the resourcefulness of EPE readers, so don't hide your talent and ideas – share them with fellow readers through the letters page or the Ingenuity Unlimited section.

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

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

Touch And Go

Touch screen beverage dispensers – are they your cup of tea? Barry Fox investigates.

MAKING small, thin screens respond to touch is now routine, says UK company Zytronic, and the market is crowded with cut-throat competition. But making large, thick TV panels or rear-projection shop windows touch sensitive is much more difficult. Zytronic has recently won contracts from Samsung and the Coca-Cola Company to put large touch displays using Zytronic's Projected Capacitive Technology (PCT) into beverage dispensing machines, soon to be tested in restaurants in Georgia and California.

At a briefing in London held to announce the deal and demonstrate PCT, Dr Andrew Morrison, technical director, reminded that there have been four ways to make screens touch sensitive, with over 80 manufacturers competing to produce them.

The first systems were resistive, dating back to 1977. A sandwich of plates, made conductive by coating with indium tin oxide, make local contact when pressed. The system works well for satnav graphics, but not for video because the coating adds optical haze.

Surface acoustic wave systems bounce sound waves over the surface, and a finger breaks the beam. There is no optical haze but rain disrupts. Infra red surface beams work in similar fashion, and are upset by sunlight.

Surface capacitance relies on an indium tin coating on the front surface to draw current from electrodes at the screen corners and create a voltage drop when a finger touches it. The front surface is prone to wear and scratching.

Zytronic has been developing Projected Capacitance Technology for nearly ten years. Although the company is reluctant to discuss it, the core technology was patented by a UK inventor and licensed to Zytronic.

The system is now scalable from five-inch to 100-inch screens. The sensors are on the rear of the panel, so protected from wear. A web of very fine copper wires (around 10 microns wide or one sixth the size of a human hair) is deposited on the glass surface, and sealed with plastic.

A signal of around 1MHz is fed through the mesh and touching the front surface of the glass causes tiny (picofarad) changes of capacitance that shift the frequency by a few hundreds of Hz – much as electronic musical instruments like the Theremin change note with human proximity. The PCT pitch change is tracked by sensitive electronics at the screen edge to pinpoint the touch.

The glass will usually be 6mm or 12mm thick for windows, but can be 20mm to 30mm thick for table tops, and some signals can be detected through 50mm sheets. The wires can be deposited on flexible roll-up sheeting for sticking to shop windows, to give touch control to a rear-projected picture.

Although the wires are skewed to minimize optical effects, there is still some optical hazing. So the system is best suited for large panel graphics, gaming and vending control. Zytronic says it is now working on five-micron wires for video screens. The mesh will be printed rather than deposited.

The technology has been used by Diebold/NCR for ATMs, by Ecast for 40-inch juke box panels, by Aristocrat for the Norwegian State Lottery, and now by Samsung and Coca Cola for 15.1-inch moulded polycarbonate screens in vending machines.

3D TV RESEARCH

Films made in 3D could soon pack more of a punch thanks to work being carried out by a De Montfort University Leicester researcher. Dr Cristian Serdean is exploring an alternative way of creating high quality 3D from 2D stereoscopic images – stereoscopic images are created by filming two sets of footage of the same subject, but from slightly different angles, corresponding to the viewer's left and right eye.

Dr Serdean has been awarded a £182,693 grant under the Engineering and Physical Sciences Research Council's First Grant Scheme to fund the work.

Traditionally, the 3D effect is achieved by shooting stereoscopic images and then merging them for display purposes. The resulting film is seen in 3D with the aid of special glasses designed to pass the correct image to each eye, which the brain then processes into 3D information. This method is often inefficient, expensive and inconvenient because it involves having to store and transmit two sets of footage and also requires the viewer to wear special glasses.

Dr Serdean is hoping to perfect a different method of representing 3D data, which is created using a single set of footage containing the 2D view, plus information about the depth of each pixel in the scene. This 3D data can then be viewed on auto-stereoscopic displays, which allow people to see the 3D effect without special glasses. The research will look at how to improve the complex process of extracting depth information from 2D stereoscopic video frames, a key step in the production of this type of 3D film.

Pixels are first turned into frequency coefficients using a mathematical function known as a transform (see *Ciruit Surgery*). The coefficients are then used to find corresponding points between the two sets of footage in order to estimate the correct depth for each pixel. Dr Serdean will look at whether a particular type of mathematical transform, known as a 'multiwavelet', will find the correspondence points between the two sets of footage to a greater degree of accuracy. He said: "After HDTV, the next big revolution in home cinema is going to be 3D television, where accurate stereo to 3D conversion is an important enabling technology.

Satellite Internet

A new partnership between Beyond DSL, Ten Haaft GmbH and Conrad-Anderson is set to revolutionise mobile satellite broadband internet in the UK. Using Ten Haaft's 'Oyster' automatic satellite system and the Astra2Connect satellite internet service, UK distributors and vehicle electronics specialists Conrad-Anderson can provide mobile broadband for any vehicle throughout northern or central Europe.

In light of the *Digital Britain* report, it is becoming increasingly important for us all to have broadband coverage. The Oyster Internet is a perfect mobile solution for those areas with poor access from cable broadband and/or mobile phone signal. This makes it a viable solution for many consumers and systems-critical businesses across the UK; mobile banks, mobile post offices and racing teams to name a few.

Having been sold successfully in Germany for two years, the Oyster Internet is now available in the UK.

Two-way satellite internet is the only way to guarantee a broadband connection in any location in the UK and northern and central Europe. The technology of the Oyster Internet provides connectivity at a vastly reduced cost compared with any existing systems, both in terms of the cost of the hardware and the monthly data charges.

The system offers uninterrupted and guaranteed broadband speeds, without worrying about lack of signal or signal quality. This is because the coverage is distributed through a geostationary satellite – similar to satellite TV, so as long as the dish has line of sight to the satellite it will provide connectivity.

The features and benefits of Oyster Internet include: automatic search with one-click deployment; will work anywhere in central and northern Europe (without extra charges); perfect for motorhomes, caravans, exhibition trucks/trailers and mobile control centres, ie any mobile application; receive TV and Internet from the same satellite dish (one at a time); no degradation of signal due to geographical location (barring obstruction of satellite); lowest cost mobile satellite internet available

The Oyster Internet hardware (motorised dish, control box and satellite modem) costs £3499; fitting costs £300; monthly charges – from £17.49 to £69.99; one-off connection charge – £50.

For more information please follow this link: **http://www.conrad-anderson.co.uk/satelliteinternet/mobile-satellite-internet.htm.**

THE GEEK ATLAS HELPS BLETCHLEY PARK

O'Reilly Media, publishers of the new resource, *The Geek Atlas: 128 Places Where Science & Technology Come Alive* by John Graham-Cumming, has announced that they will donate 50 pence to the Bletchley Park Trust Fund for each copy sold in the UK.

The history of science is all around us, if you know where to look. And if you're a traveller who loves science, you'll definitely want to check out *The Geek Atlas*. This unique travellers' guide covers 128 destinations around the globe where major breakthroughs in science, mathematics, or technology occurred – or are happening now.

"Unfortunately, finding great scientific places to visit isn't as easy as finding homes of long-dead poets, painters, or writers," notes Graham-Cumming, a self-described wandering programmer. "This is a pity, because if there's one thing that makes science stand apart, it's the willingness of scientists to freely share what they do."

Unlike many travel books, this one is written for scientists. "In the technical descriptions, I've tried to simplify the science without dumbing it down to the point of using analogies and metaphors instead of actually describing ideas," he says.

"So as you flip through the book, you'll see the sorts of pictures you'd find in a travel guide, but also a lot of diagrams and equations." (Any reader who doesn't want to deal with the equations can safely read the first part of each chapter.)

Each site in *The Geek Atlas* focuses on discoveries or inventions and includes information about the people and the science behind them. Full of interesting photos and illustrations, the book is organised geographically by country and comes complete with latitudes and longitudes for GPS devices.

The destinations covered include: Bletchley Park in the UK, where the Enigma code was broken; the Alan Turing Memorial in Manchester, England; the Horn Antenna in New Jersey, USA, where the Big Bang theory was confirmed; the National Cryptologic Museum in Fort Meade, Maryland; the Trinity Test Site in New Mexico, where the first atomic bomb was exploded; the Joint Genome Institute in Walnut Creek, California.

Every site in this book has genuine scientific, mathematical, or technological interest – places guaranteed to make every geek's heart beat a little faster.

"One thing that I've been asked by reviewers again and again is to recommend one single must-see place. Picking one place is next to impossible – there's just so much great science out there – but I will admit to shedding a tear every time I see the Difference Engine at the Science Museum in London (Chapter 77)," writes Graham-Cumming. "It's mathematics in motion and arithmetic in action."

John is a wandering programmer who's lived in the UK, California, New York and France. Along the way he's worked for a succession of technology start-ups, written the award-winning open source POPFile email programme and churned out articles for publications such as *The Guardian* newspaper, *Dr Dobbs*, and *Linux Magazine*. He is the proud owner of a three-letter domain name, where he hosts his website: **http://www.jgc.org**.

For more information about the book, including table of contents, index, author bios, and cover graphic, see: **http://www.oreilly.com/catalog/9780596523206**.

The Geek Atlas, John Graham-Cumming. ISBN: 9780596523206, 542 pages. Book price: £22.99

By JOHN CLARKE

Programmable Ignition System For Cars Part 2

Six versions to build to suit your car's trigger input!

This month, we describe the circuit for the LCD Hand Controller module and provide all the assembly details for the Programmable Ignition – there are six versions to build.

LAST MONTH, we published the circuit details for the Programmable Ignition Timing Module and its companion Ignition Coil Driver Module, and covered their operation in some detail. The various input trigger circuits (points, reluctor, Hall sensor, optical) were also described.

LCD Hand Controller

That just leaves the LCD Hand Controller Module. Its circuit diagram is shown in Fig.7. It comprises an LCD module, a 4017 decade counter (IC1), a DB25 socket and several pushbutton switches. This unit connects to the main circuit via a standard DB25 RS-232 cable.

Signals from the microcontroller in the Programmable Ignition Timing Module drive both the LCD module and IC1. IC1 has 10 outputs, and each output independently goes high in sequence as it is clocked at its pin 14 input. A high at the reset (MR, pin 15) sets the '0' output at pin 3 high.

Each output connects to a switch (S1 to S10). When a switch is closed, it pulls pin 9 of the DB25 socket high whenever its corresponding output on IC1 is high. This allows the microcontroller (in the Ignition Timing Module) to recognise which switch is closed.

The LCD is driven using data lines DB7 to DB4. The display readings are entered via the data lines and are controlled via the EN and RS (Enable and Register Select) inputs.

Note that the data lines and the EN and RS lines are all connected to ground (0V) via 330Ω resistors. These resistors allow the LCD module to be driven without the signals being corrupted by interference from the car's ignition.

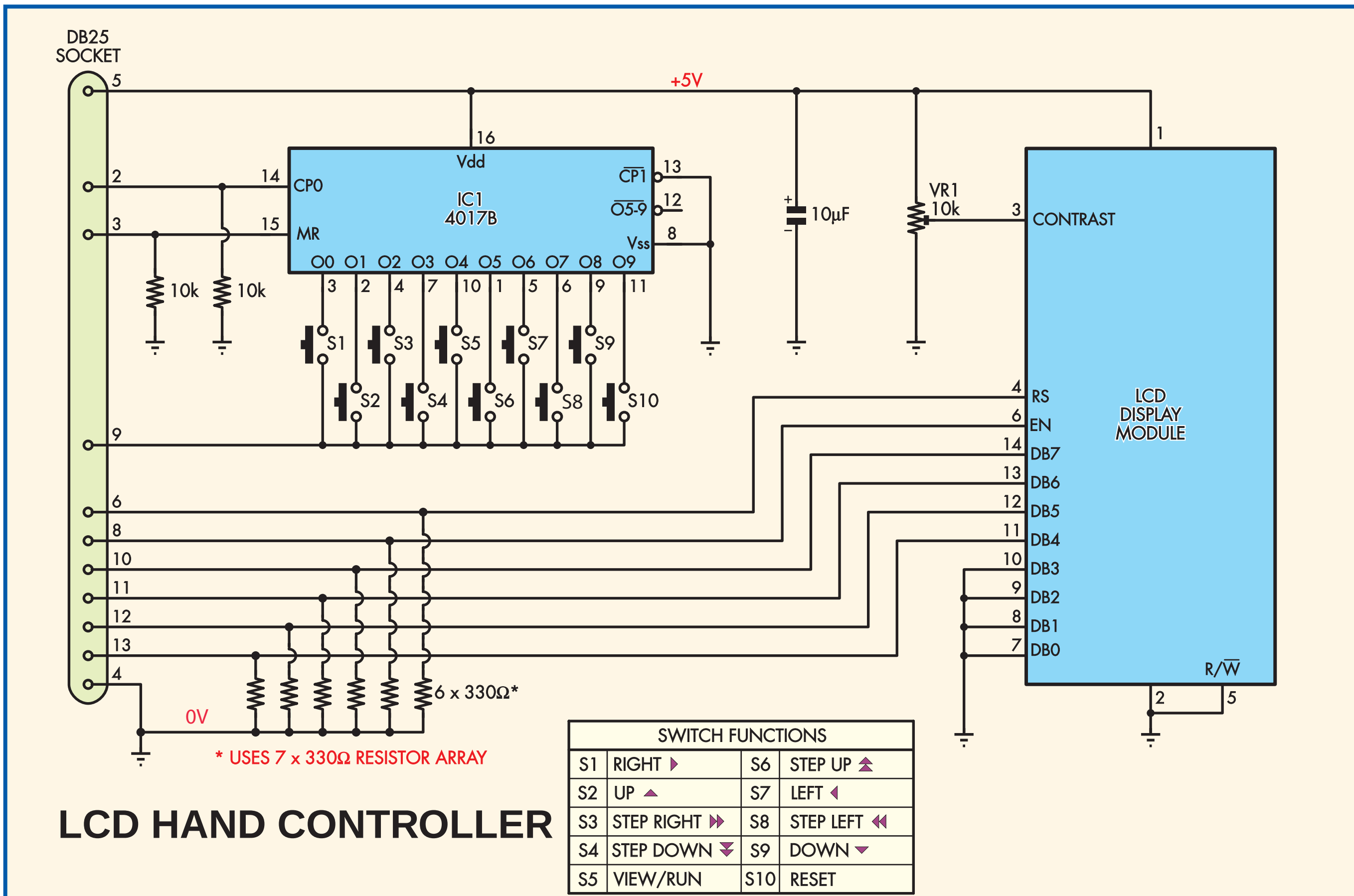
Finally, trimpot VR1 is used to adjust the display contrast.

Assembly

OK, that completes the circuit description. Let's now build all the modules for the system.

As shown in the accompanying diagrams, the Programmable Ignition System is built on three PC boards – one for the Programmable Ignition Timing Module (code 727, size 103 × 82mm); one for the Ignition Coil Driver Module (code 728, size 40 x 39mm); and one for the LCD Hand Controller (code 729, size 115 × 65mm). All these printed circuit boards are available from the *EPE PCB Service*.

The Programmable Ignition Timing Module board is housed in a diecast



SWITCH FUNCTIONS			
S1	RIGHT ▶	S6	STEP UP ⏫
S2	UP ▲	S7	LEFT ◀
S3	STEP RIGHT ⏩	S8	STEP LEFT ⏪
S4	STEP DOWN ⏬	S9	DOWN ▼
S5	VIEW/RUN	S10	RESET

Fig.7: the circuit for the LCD Hand Controller is quite simple. It uses 10 switches, an LCD module, a 4017 counter (IC1), a DB25 socket, a 10μF capacitor and a few resistors. Trimpot VR1 sets the display contrast.

aluminium case measuring 119 x 93 x 57mm, while the Ignition Coil Driver board goes into a much smaller diecast box measuring 51 × 51 × 32mm.

The LCD Hand Controller board goes into a 120 × 70 × 30mm plastic case with a clear lid.

Before installing any components, check each PC board for copper track etching defects. Check also that all the holes have been drilled and that the hole sizes for the larger parts are correct.

Ignition timing module

There are six different component layouts for the Programmable Ignition Timing Module board, one for each different trigger input. It's just a matter of choosing the one that's applicable to your car.

For example, if your car has a reluctor distributor, follow the reluctor version component overlay diagram – see Fig.10. Similarly, if it has a Hall effect or Lumenition pickup module, use the layout of Fig.11, and so on.

It's not difficult to recognise the different sensor types. Reluctor distributors have a coil and a magnetic ring that has as many points (or protrusions) as the number of engine cylinders. By contrast, Hall effect distributors include a metal vane that passes through a gap in the Hall sensor itself. Lumenition triggers are similar to Hall effect sensors and so the overlay diagrams for these trigger types are the same – see Fig.11.

Construction

Having decided which PCB your vehicle needs, start construction by installing PC stakes at the external wiring points, then solder in all the wire links. That done, install the resistors, using Table 1 as a guide to select the values. In addition, it's also a good idea to check each resistor using a digital multimeter (DMM) to make sure you have the correct resistor value for each position.

Next, install the IC socket for the microcontroller, making sure that it's oriented with its notch at the lefthand end, as shown. Don't install the microcontroller (IC1) at this stage though – that step comes later.

Diode D1 and transient suppressor TVS1 are next on the list. Note that D1 must be oriented as shown, while TVS1 can be installed either way around. Follow these with the transistor(s) and REG1, taking care to ensure that these parts are oriented correctly.

If you are building the reluctor version (Fig.10), trimpot VR1 should now be installed. It should be oriented with its adjusting screw to the left.

The link headers for LK1 and LK2 can be installed now. LK1 is a 3-way header, while LK2 is a 2-way header. Place a jumper shunt over two of the three pins for LK1 and another jumper shunt onto both pins for LK2.

Now for the capacitors. Several types are used on the board: ceramic, MKT and electrolytic. **The ceramic capacitors are all shown on the overlays in yellow, so that you don't get them confused with the MKT types.** Be sure

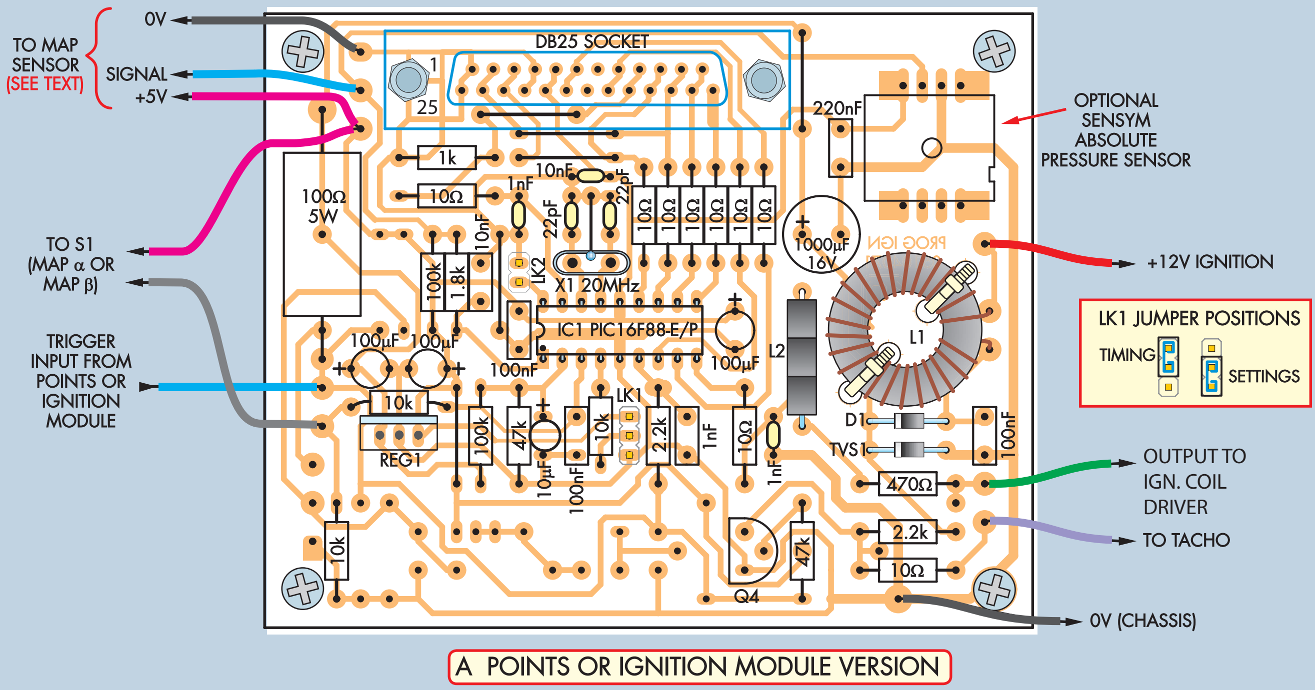


Fig.8: this is the points version. Secure all wiring leads to the board using cable ties and cover the connections to the PC stakes with heatshrink tubing or silicone, to prevent them coming loose.

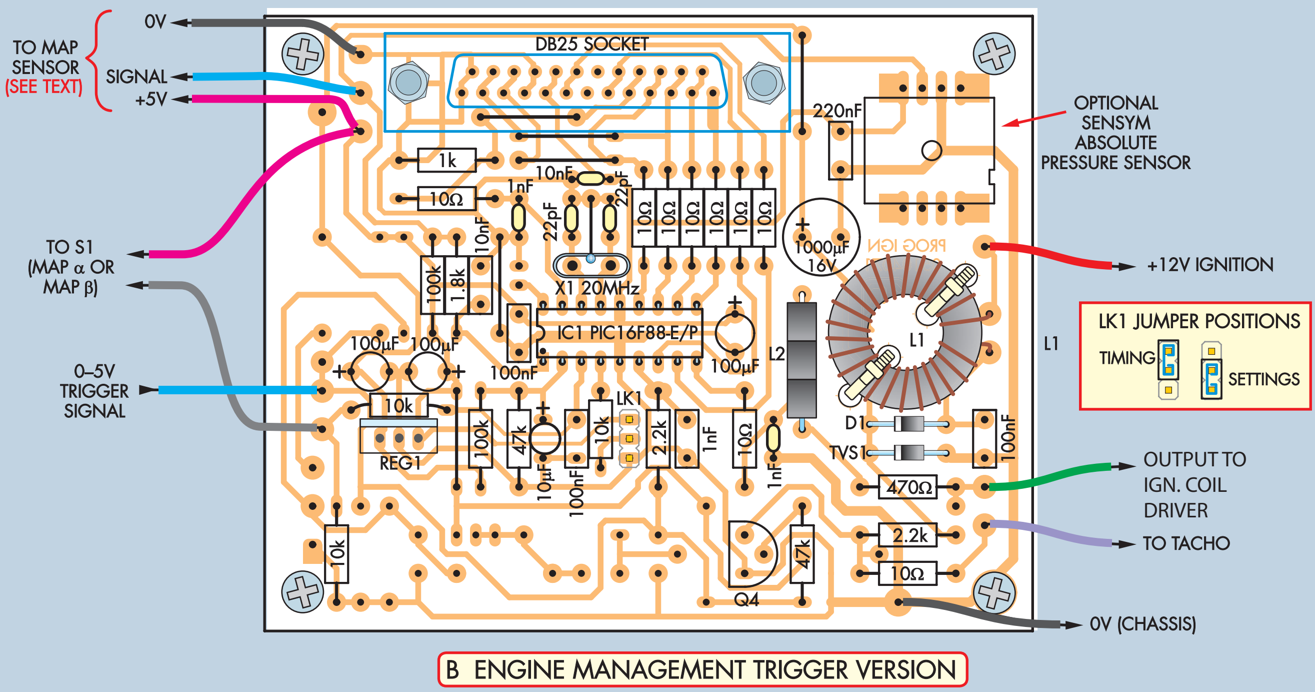


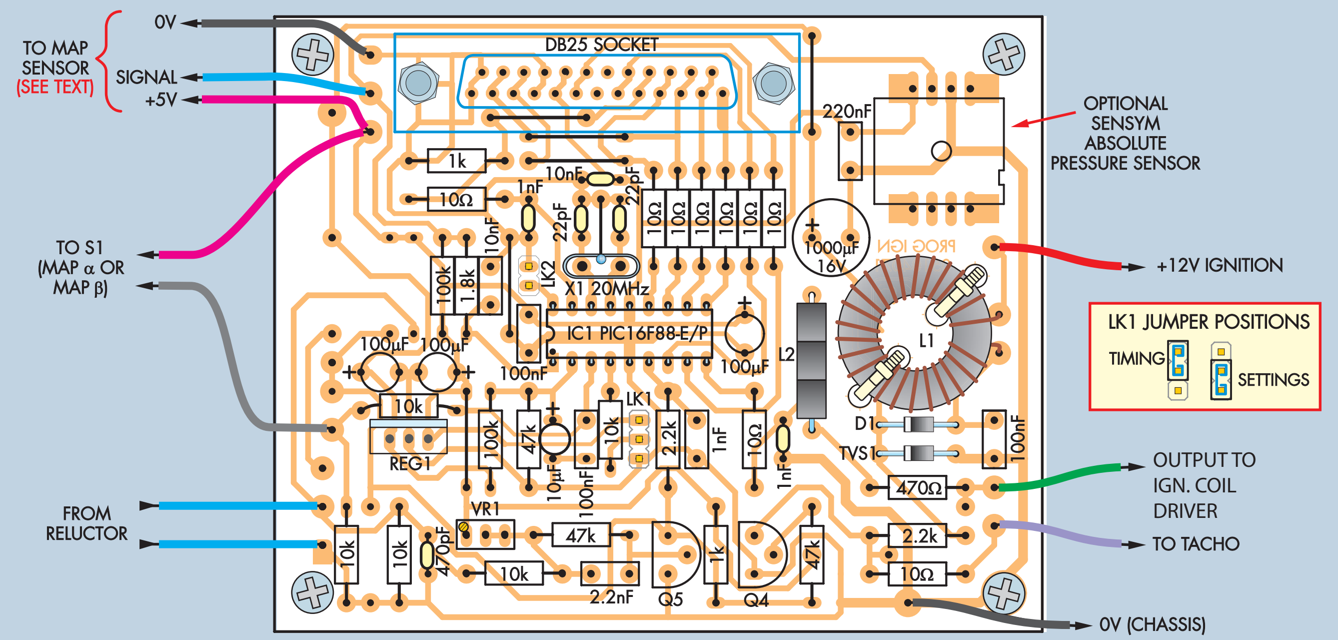
Fig.9: the engine management trigger version requires no additional input conditioning circuitry. In this case, the ECU trigger signal goes straight to pin 6 of IC1 via a 2.2kΩ resistor.

to orient each electrolytic capacitor with the polarity shown.

Once the capacitors are all in, install the crystal (X1). Note that the crystal's metal case is earthed (0V) using a short wire link. This link is soldered to its case and runs to a pad on the PC board between the two 22pF ceramic capacitors.

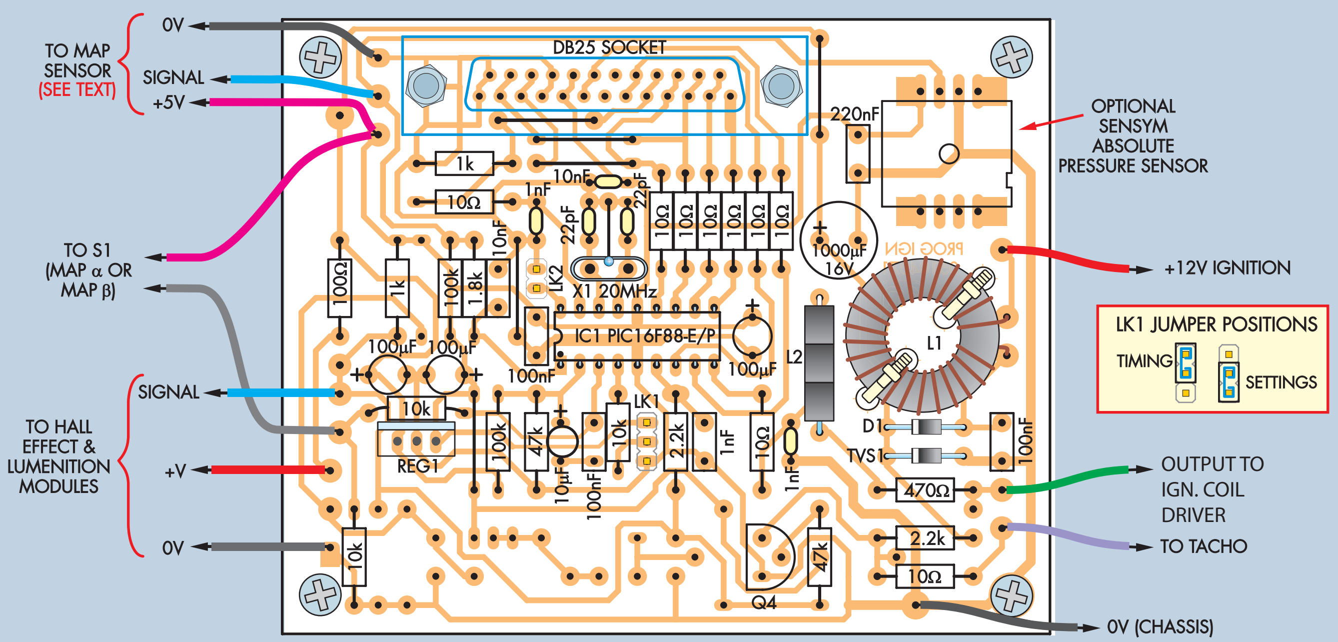
Sensym pressure sensor

If you are using the Sensym absolute pressure sensor (eg, if you car doesn't already have a MAP sensor or you are not using a secondhand MAP sensor), then this can be installed now. Note the sensor's orientation notch – this goes towards the righthand edge of the PC board. If you get the sensor's orientation wrong, it will not be powered but no damage will result from doing this.



C RELUCTOR VERSION

Fig.10: follow this parts layout diagram if your car's distributor has a reluctor pickup. The Sensym pressure sensor is used only if there is no external MAP sensor (applies to all versions).



D HALL EFFECT/LUMENITION VERSION

Fig.11: this is the layout to follow if the distributor uses a Hall effect device or a Lumenition module. Take care with component orientation during assembly.

Inductors

Inductors L1 and L2 are next on the list. First, L2 is made by passing a 0.7mm tinned copper wire link through three ferrite beads. A length of the 4mm heatshrink tubing is then slid over the three cores and shrunk down to hold everything in place, after which the assembly can be soldered to the board.

Inductor L1 is much larger. It's made by winding 23 turns of 0.5mm enamelled copper wire through a 15 × 8mm × 6.5mm powdered-iron toroidal core. **These turns should be evenly spaced around the core, as shown on the overlays.** That done, the wire ends are stripped of insulation and soldered to their PC pads. The toroid is then secured to the board using two plastic cable ties.

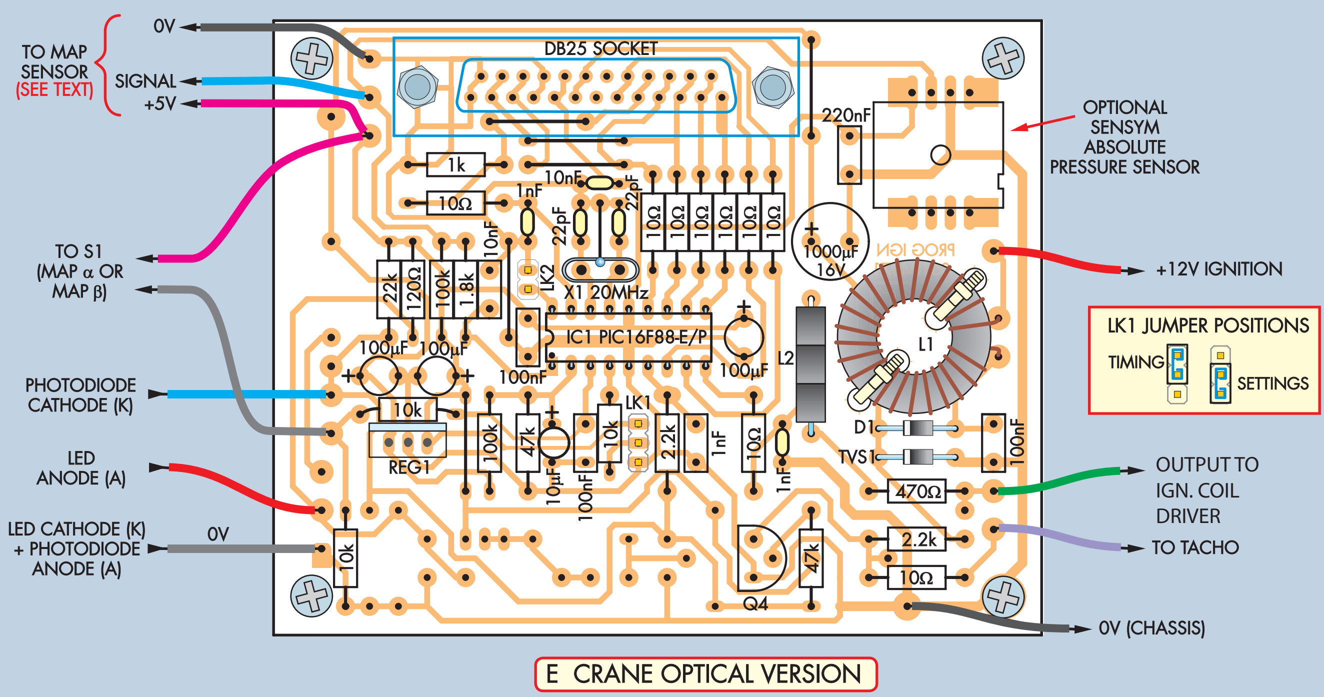


Fig.12: build this version if your distributor has been fitted with a Crane optical pickup. Make sure that inductor L1 is firmly secured, to ensure reliability (all versions).

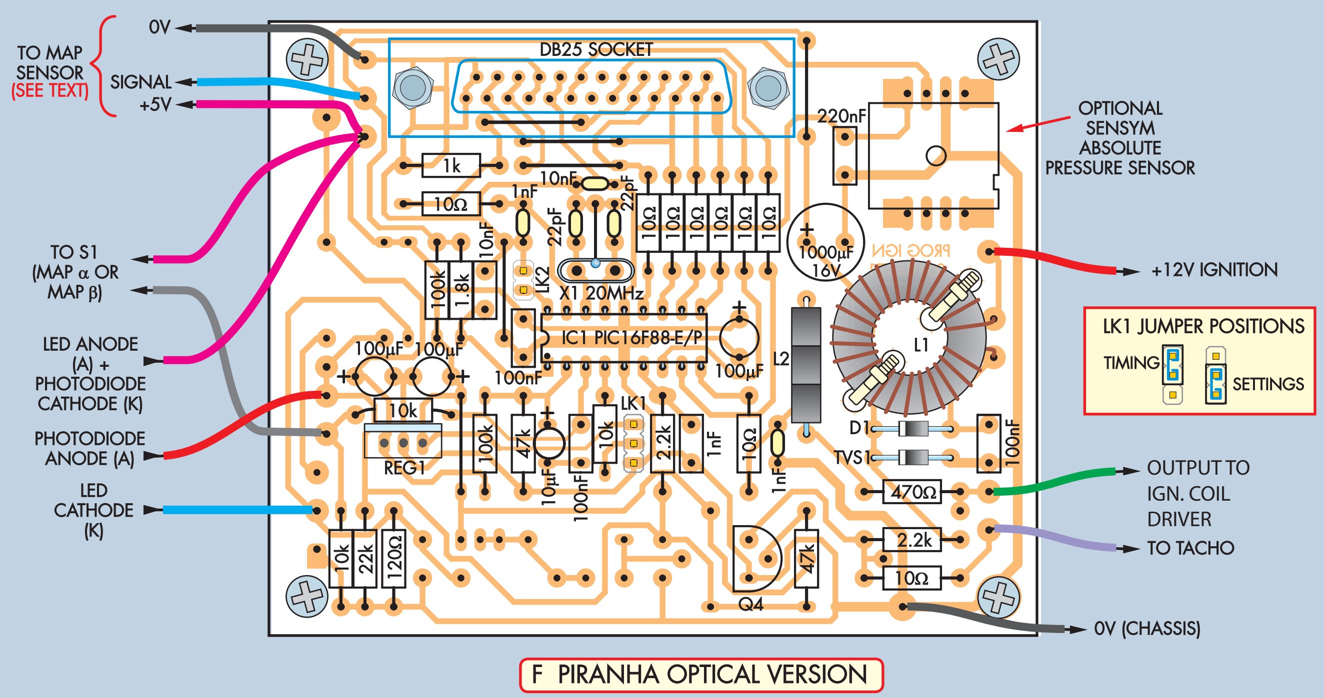


Fig.13: the Piranha optical pickup version is almost identical to the Crane version, but note the different locations for the 22kΩ and 120Ω resistors.

DB25 socket

Finally, the DB25 socket can be installed in position. Before doing this though, two D-connector nut extenders must to be attached to the PC board. These are simply passed through their two mounting holes and secured using spring washers and nuts on the underside of the board. **In addition, the righthand extender is fitted with a nylon washer to prevent the spring washer and nut from shorting to nearby copper tracks. Don't leave this washer out!**

By contrast, the lefthand extender makes contact with the ground track on the PC board, so that the shell of the socket is earthed when it is installed. That way, when the DB25 lead is connected, its shield will also be earthed.

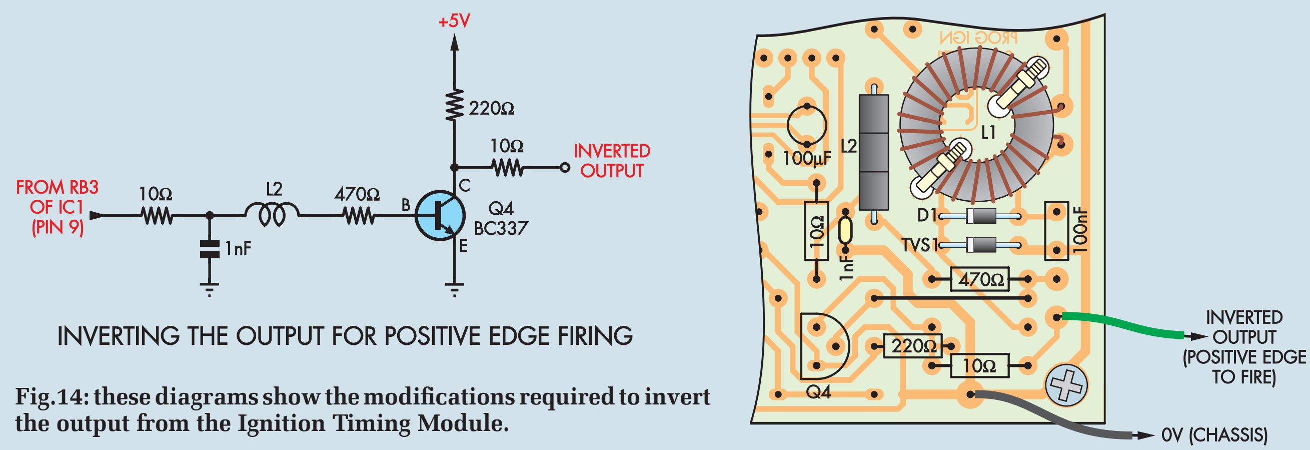


Fig.14: these diagrams show the modifications required to invert the output from the Ignition Timing Module.

The DB25 socket can now be secured in place on the board using a second set of nut extenders, and its pins soldered to the PC pads. Note that you may need to cut down the extender threads so that the nuts sit flush with the socket's mounting flange.

Inverting the output

In normal operation, the RB3 output (Fig.4, Pt.1) from the Programmable Ignition Timer Module goes high in order to turn on transistor Q1 (via Q3 and Q2) in the Ignition Coil Driver. This in turn allows current to flow through the primary of the igition coil.

Conversely, when RB3 goes low, Q1 switches off, the current through the coil is interrupted and the coil 'fires' the relevant spark plug. So, a low-going signal at the Ignition Timing Module's output normally causes the Ignition Coil Driver to fire a plug via the coil.

However, there may be some applications where the output from the Programmable Ignition Timing Module needs to be inverted, so that a low output 'charges' the coil and a high-going output causes the plug to fire. This may be the case if you connect the Programmable Ignition Timing Module to a different ignition coil driver.

In this case, an inverted output can be provided using the tachometer driver transistor (Q4). The necessary changes to the circuit and to the PC board layout are shown in Fig.14. The only extra parts required are a 220Ω resistor and some tinned copper wire for the link.

Housing

Having completed the board assembly, the next step is to install it in its metal diecast case. Fig.15 shows the assembly details.

The first step is to position the board inside the case and mark out its four mounting holes. That done, remove the PC board and drill the mounting holes to 3mm. Deburr each hole using an oversize drill bit, then secure a 6mm-long tapped spacer to each mounting point using an M3 x 15mm screw inserted from the outside of the case.

You will also have to drill a hole in one end of the box to accept a cable gland for the various external leads (ie, +12V lead, trigger signal leads and signal output lead). An additional hole for a second cable gland will also

Table 2: Capacitor Codes

Value	µF code	IEC Code	EIA Code
220nF	0.22µF	220n	224
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
2.2nF	0.0022µF	2n2	222
1nF	0.001µF	1n0	102
470pF	NA	470p	471
22pF	NA	22p	22

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	3	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	7	10kΩ	brown black orange brown	brown black black red brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.8kΩ	brown grey red brown	brown grey black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	2	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	120Ω	brown red brown brown	brown red black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	9	10Ω	brown black black brown	brown black black gold brown

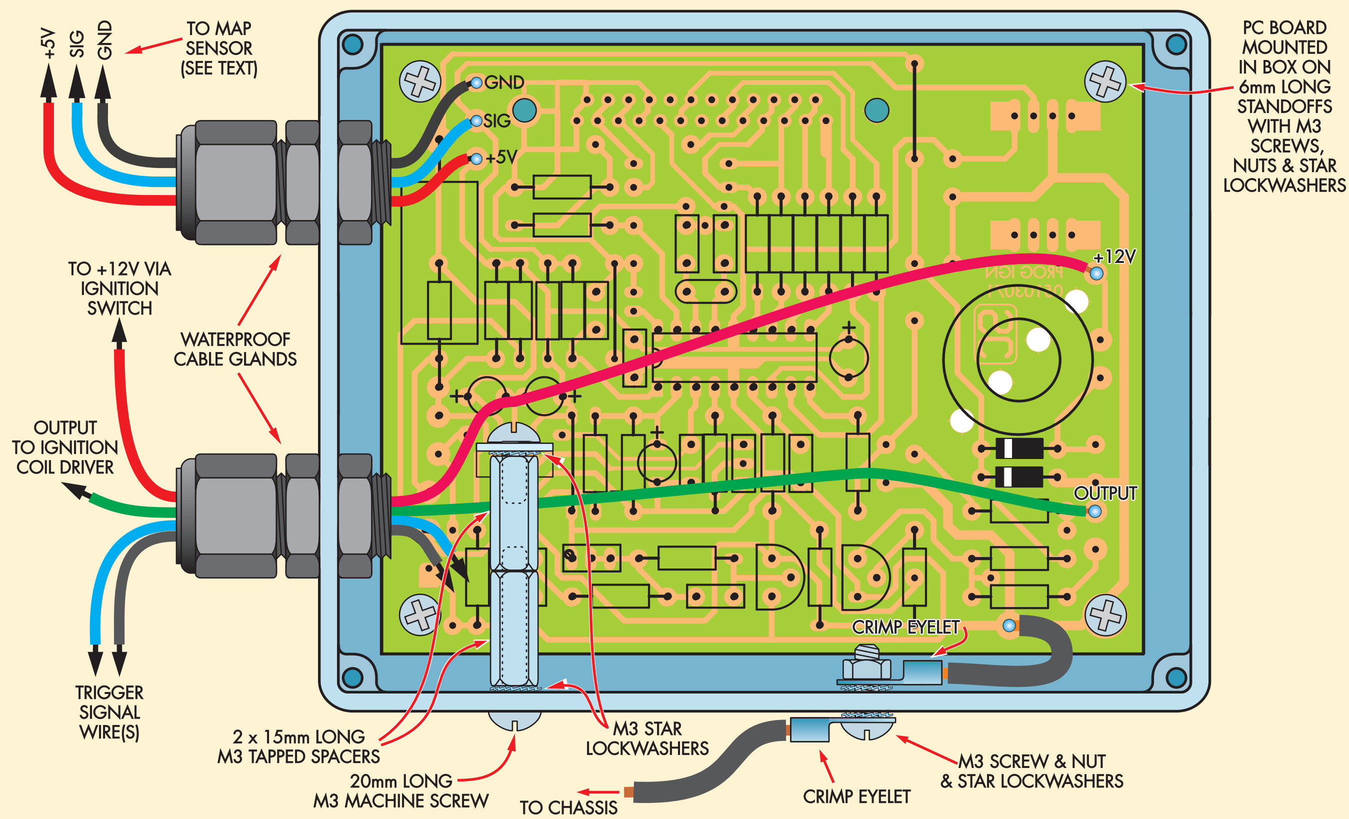
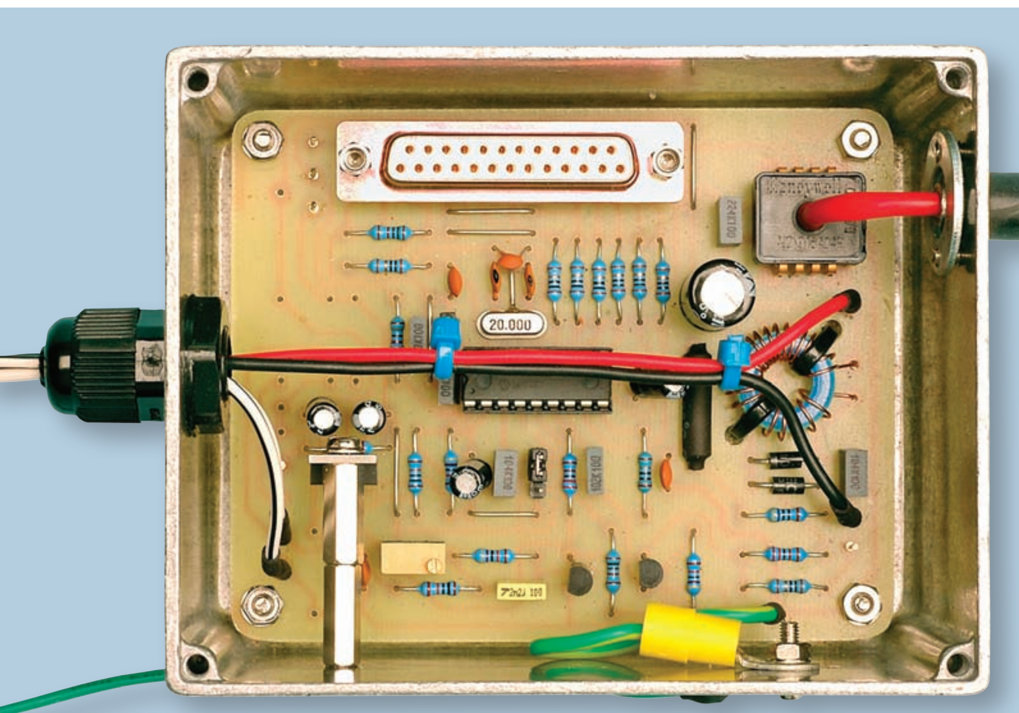


Fig.15: this diagram shows the final assembly and external wiring details for the Ignition Timing Module. Note how the 0V (ground) rail on the PC board is connected to one side of the metal case, with a lead then run from this point to the vehicle's chassis. Use cable ties to help secure the leads, both inside and outside the case.



This view shows the assembled PC board for the Ignition Timing Module with the optional internal Sensym MAP sensor fitted (ie, when there is no existing external MAP sensor or you are not using a secondhand MAP sensor). Make sure that the unit is ruggedly built, so that no leads can come adrift.

be required if you are using an external MAP sensor (see Fig.15).

Next, a 3mm hole must be drilled through the side of the box adjacent to the GND (0V)/chassis PC stake. This mounting hole is used to terminate an 'earth' wire from the PC board via a crimped eyelet connector. A second wire terminated in an eyelet connector is also attached to the outside of the case to make the chassis connection. The entire assembly is secured using a M3 x 9mm screw, nut and star washer – see Fig.15.

Another 3mm hole is drilled to allow the metal tab of regulator REG1 to be secured to the metal case using two M3 × 15mm tapped metal spacers. This arrangement serves a dual purpose: 1) it mechanically secures the regulator to prevent it from breaking; and 2) it provides heatsinking for the regulator tab.

The two spacers are secured to REG1's tab using an M3 × 9mm screw, while an M3 × 20mm screw secures the spacers to the side of the case.

Note that star washers must be used under each screw head, to prevent the assembly from shaking loose.

Manifold pressure sensor options

IN ORDER TO utilise the vacuum advance feature provided by the Programmable Ignition System, some means of monitoring manifold pressure is required.

There are several options available here. The simplest option is to use the MAP (manifold air pressure) sensor that's already installed on your car (if it has one). This sensor would normally be used to detect manifold pressure for the car's own Engine Management Unit, to control the timing.

If your car does not have a MAP sensor, then you can easily obtain one to do the job. There are different sensors to suit normally aspirated engines and to suit turbocharged engines.

Normally aspirated engines do not boost the air pressure for the fuel mixture and so a 1 bar (one atmosphere, 100kPa or 15psi) sensor is all that is required. These sensors measure the air pressure compared to a vacuum and output a voltage close to 4V for atmospheric pressures and close to 0V for a vacuum.

Turbo engines boost the air pressure above atmospheric and consequently a one-bar sensor is inadequate. This is because the output from a 1 bar sensor would not change for pressures above 1 bar. There is also a possibility that the sensor could be damaged if the pressure went too far beyond its rating.

In this case, a two-bar sensor should be adequate for most applications. However, if the boost is greater than 2 bar, a 3 bar sensor will, of course, be required instead.

One option is to use an on-board Sensym sensor that covers from 0 to 1 bar or from 0 to 2 bar, as specified in the parts list. This device is best used at temperatures ranging from 0-85°C and so the Programmable Ignition Timing Module should be mounted inside the cabin rather than in the engine bay.

Alternatively, most automotive breakers can sell you a MAP sensor quite cheaply. These are available from various models of Vauxhall, Honda, Toyota, Subaru and others. Details of the Vauxhall type 1 bar, 2 bar and 3 bar MAP sensors and the Motorola 2.5 bar MAP sensor are available at this web site: http://web.archive.org/web/20050906201309/www.pgmfi.org/twiki/bin/view/Library/MapSensor

Typically, the 1 bar Vauxhall sensors are designated with a 039, 460 or 883 code. 2 bar sensors have an 886, 012, 539 or 609 code and 3-bar sensors have a 749 code. The A, B and C labels refer to the positioning of the ground, signal and +5V terminals.

Hose adapter

If you are using the on-board Sensym pressure sensor, then a hose connection will be required from the sensor to a chassis-mount flange (or through-piece) on the side of the box. This piece serves as both an anchor point and as a 3mm-to-5mm adapter.

This is necessary because the sensor's hose connection is 3mm in diameter, while a standard automotive vacuum tube requires (at least) a 5mm fitting to enable it to stay in place without air leaks.

A 15mm round brass spacer is used as the adapter. The 3mm-diameter hose from the sensor is pushed inside the spacer at one end (ie, the end inside the case), while the external vacuum tube is fitted over the spacer at the other end (outside the case).

Note that it will be necessary to slightly enlarge the hole at one end of the spacer to accept the 3mm (ID) hose. Silicone sealant can be used later, when fitting the hoses, to ensure air-tight connections.

Fig.16 shows how the adapter is fitted. First, a brass nut is soldered to one end of the adapter, after which the adapter is pushed through a 5mm hole in the side of the case. It is then clamped in position using a 20mm OD washer and a couple of M3 x 6mm machine screws that go into tapped holes in the washer (or you could use M2 × 10mm screws and nuts).

Alternatively, you can do away with the adapter altogether and pack the

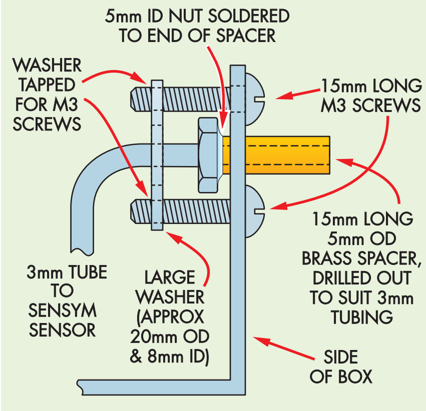


Fig.16: a simple adapter made from a brass spacer can be used to connect the 3mm outlet on the Sensym pressure sensor to a standard 5mm vacuum hose.

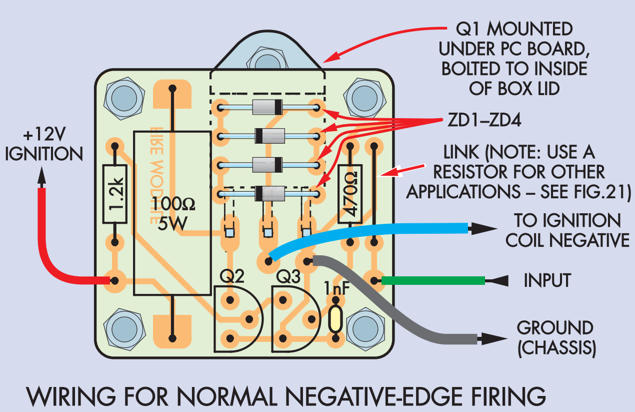
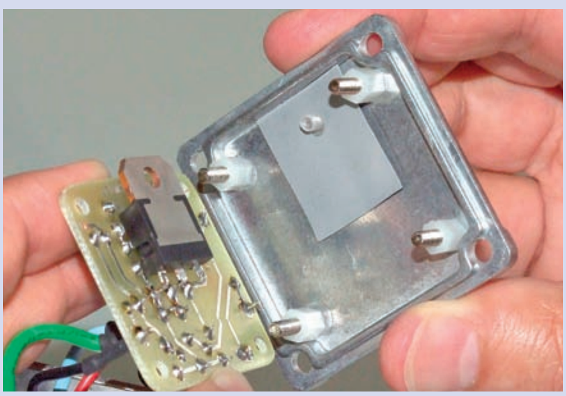


Fig.17: this is the parts layout for the Ignition Trigger Module. Note the different orientations for Zener diodes ZD1-ZD4.



The metal tab of the Darlington transistor (Q1) must be insulated from the case using a TO-218 insulating washer and a nylon screw and nut.

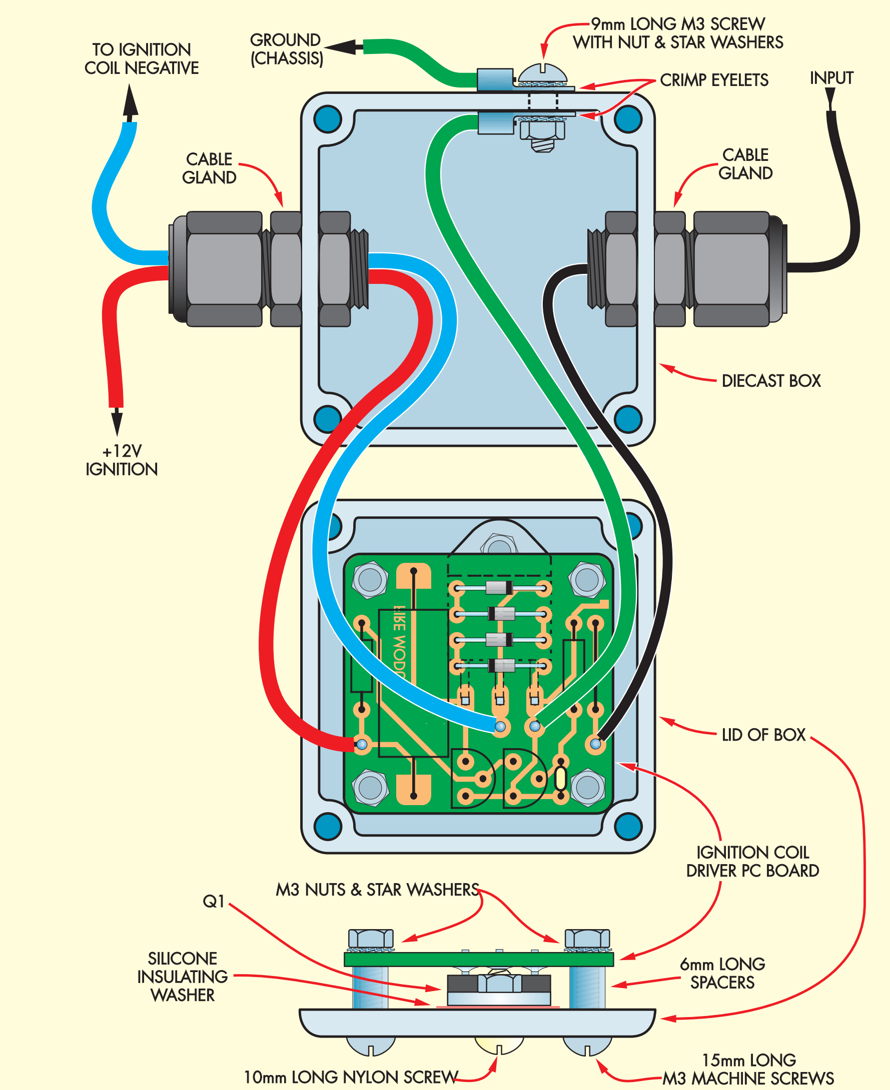
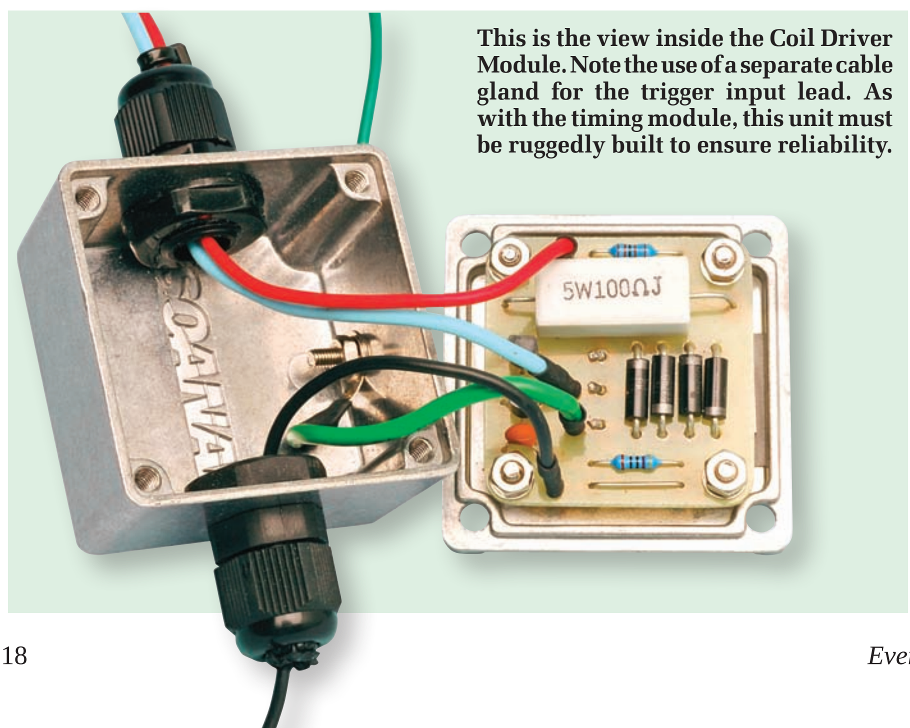


Fig.18: final assembly and external wiring details for the Ignition Coil Driver. After assembly, use a multimeter (set to a low ohms range) to confirm that the metal tab of Darlington transistor Q1 is properly isolated – it must not be shorted to the case.



This is the view inside the Coil Driver Module. Note the use of a separate cable gland for the trigger input lead. As with the timing module, this unit must be ruggedly built to ensure reliability.

inlet on the Sensym sensor out with several layers of heatshrink tubing so that the 5mm hose is a tight fit. That way, the 5mm (ID) vacuum hose that runs to the engine manifold can simply pass through a hole in the case and go straight to the Sensym pressure sensor.

As before, silicone sealant can be used to ensure an airtight fit, but be careful not to block the sensor inlet with the sealant.

Once all the holes have been drilled in the case, the PC board can be fitted and the assembly completed, as shown in Fig.15. *Be sure to use automotive wiring for all external connections*. These leads should all be secured using cable ties and the connections to the PC stakes covered with heatshrink tubing. This is necessary to prevent the leads from vibrating and coming adrift.

Wiring the pressure sensor

There are three options when it comes to wiring the pressure sensor:

1) If you are using an existing MAP sensor, connect the signal lead only. **DO NOT connect the +5V and 0V supply leads** (the sensor will already have supply connections).
2) If you are using an external (eg, secondhand) MAP sensor that you've added to the vehicle, connect all three leads (ie, signal, +5V and 0V).
3) If you are using the on-board Sensym sensor, do not make any external connections (the second cable gland can be deleted).

Ignition coil driver

Fig.17 shows the assembly details for the small Ignition Coil Driver PC board.

Begin construction by installing the wire link, then install the 1.2kΩ and 470Ω resistors. The 100Ω 5W resistor can then go in (if needed) – it should be mounted all the way down onto the PC board, so that it cannot vibrate and break its leads.

Zener diodes ZD1 to ZD4 are next on the list. Be sure to orient them as shown (two face in one direction and two in the other, so take care here). Follow these with transistors Q2 and Q3 and the 1nF ceramic capacitor.

Darlington transistor Q1 is mounted on the underside of the PC board. This device is installed with its leads bent up through 90°, so that they go through matching holes in the PC board from the copper track side (ie, the metal

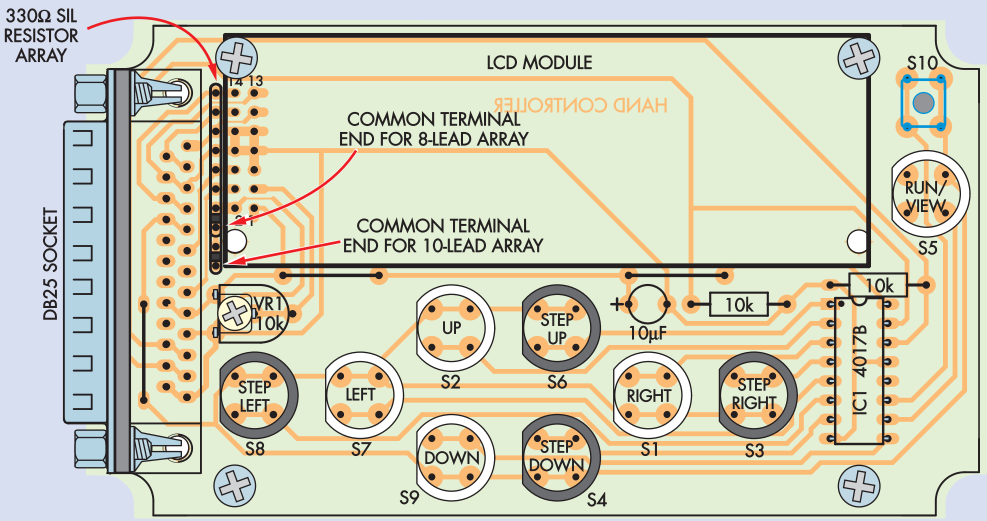


Fig.19: the LCD Hand Controller PC board is easy to assemble. Install the three links first and note that the switches, IC and 10µF electrolytic capacitor are polarised. The LCD is connected via a 14-way DIL pin header.

The PC board mounts inside the case on four M3 × 12mm spacers and is secured using M3 screws, nuts and flat washers – see Fig.19. Note how the 10µF capacitor is mounted on its side, so that it clears the front panel.

tab of the device faces away from the board – see photo next to Fig.17.).

Push the leads through their holes until Q1's metal tab is exactly 6mm below the underside of the PC board, then lightly solder one of the leads. This will allow you to make any adjustments as necessary before completing the soldering.

Finally, complete the board assembly by installing PC stakes at the four external wiring points.

Once completed, the Ignition Coil Driver PC board can be installed in its diecast box – see Fig.18. As shown, the board is mounted on the lid of the box on 6mm tapped spacers and secured using M3 × 15mm screws, nuts and star washers. Transistor Q1 (on the underside of the board) is fastened to the lid for heatsinking.

The first step is to mark out all the mounting holes on the lid. Drill these holes to 3mm, then carefully deburr them using an oversize drill. In particular, make sure that Q1's mounting hole is perfectly smooth and free of any metal swarf that could puncture its insulating washer.

Note too, that Q1's mounting hole should be chamfered (use an oversize drill bit). This is necessary to avoid sharp edges around the circumference of the hole, to prevent arcing through the insulating washer (due to the high voltages present on the transistor's tab).

Once the holes have been 'cleaned up', fit the four tapped spacers to the board mounting positions and secure them using the M3 × 15mm screws. That done, install transistor Q1's nylon mounting screw and insulating washer (see photo), then slip the board into position and secure it using M3 nuts and star washers.

Don't leave the star washers out – they are necessary to ensure that the nuts don't shake loose due to vibration.

Transistor Q1 can now be secured by installing its nut and tightening the

Parts List – Programmable Ignition System

Programmable Ignition Unit

*1 PC board, code 727, size 103 × 82mm
1 diecast aluminium case, size 119 × 93 × 57mm
2 IP68 waterproof cable glands for 4-8mm cable
1 15 x 8 x 6.5mm powdered-iron toroid (Jaycar LO-1242 or equivalent) (L1)
3 5mm ferrite beads for L2 (Jaycar LF-1250 or equivalent)
1 20MHz crystal (X1)
1 SPDT toggle switch for MAP switching (optional) (S1)
1 18-pin DIL IC socket
1 DB25 female straight pin PC mount socket
4 D-connector nut extenders and two locking nuts and shake-proof washers
1 2-way pin header (LK2)
1 3-way pin header (LK1)
2 jumper pin shorting links
2 crimp eyelets
4 6mm tapped nylon standoffs
1 3mm nylon washer
2 M3 tapped × 15mm brass standoffs
1 M3 × 20mm screw
4 M3 × 15mm screws
2 M3 × 9mm screws
8 M3 star washers
5 M3 nuts
10 PC stakes
1 60mm length of 4mm ID heatshrink tubing
4 100mm cable ties
1 2m length red automotive wire
1 2m length black automotive wire
1 2m length green automotive wire
1 2m length brown automotive wire
1 2m length yellow automotive wire
1 150mm length of 0.7mm tinned copper wire
1 600mm length of 0.5mm enamelled copper wire

Semiconductors
1 PIC16F88-E/P microcontroller programmed with ignprgm.hex (IC1)
1 LM2940CT-5 low-dropout 5V regulator (REG1)
1 BC337 *NPN* transistor (Q4)
1 1N4004 1A diode (D1)
1 1W transient voltage suppressor (TVS1) 13.6V standoff voltage (Jaycar ZR 1162 or equivalent)

Capacitors
1 1000µF 16V PC electrolytic
3 100µF 16V PC electrolytics
1 10µF 16V PC electrolytic
1 220nF MKT polyester
3 100nF MKT polyester
1 10nF MKT polyester
1 10nF ceramic
1 1nF MKT polyester
2 1nF ceramic
2 22pF ceramic
1 10µF 16V PC electrolytic

Resistors (All 0.25W, 1% metal film)

2 100kΩ	1 1.8kΩ
2 47kΩ	1 1kΩ
3 10kΩ	1 470Ω
2 2.2kΩ	9 10Ω

Points and ignition module version
1 100Ω 5W resistor

Reluctor version
1 BC337 *NPN* transistor (Q5)
1 2.2nF MKT polyester capacitor
1 470pF ceramic capacitor
1 100kΩ top-adjust multi-turn trimpot (VR1)
1 47kΩ 0.25W 1% resistor
2 10kΩ 0.25W 1% resistors
1 1kΩ 0.25W 1% resistor
1 PC stake

Hall effect version
1 1kΩ 0.25W 1% resistor
1 100Ω 0.25W 1% resistor
2 PC stakes

Optical pickup version
1 22kΩ 0.25W 1% resistor
1 120Ω 0.25W 1% resistor
2 PC stakes

Manifold pressure sensor alternatives (see text)
1 ASDX015A24R Sensym (0-15PSI, 0-1bar) absolute pressure transducer (RS Components Cat No. 2508593055) (Farnell Cat. No. 419-7586); or
1 ASDX030A24R Sensym (0-30PSI, 0-2 bar) absolute pressure transducer (RS Components Cat No. 2508593077); or
1 Manifold absolute pressure (MAP) sensor – available from an automotive breakers. MAP sensors are available from most Vauxhall, Honda, Toyota and Subaru models and others that have an engine management computer. Try to obtain the wiring connector with the sensor.

Miscellaneous
Angle brackets for mounting units, automotive connectors, self-tapping screws etc.

Programming Code
Note: the programming code (ignprgm.hex) for the PIC16F88-E/P microprocessor featured in this project will not be released or be made available on our website. Authorised kit sellers will supply programmed microcontrollers as part of their kits.

For people who do not wish to build the project from a kit, programmed micros are available from Silicon Chip (www.siliconchip.com.au) for $30.00 by airmail.

Ignition Coil Driver

*1 Ignition Coil Driver PC board, coded 728, size 40 × 39mm
1 diecast aluminium box 50.8 × 50.8 × 31.8mm (Jaycar HB-6050)
1 TO-218 insulating washer rated at 3kV
2 IP68 waterproof cable glands for 4-8mm cable
4 M3 tapped x 6mm nylon standoffs
4 M3 × 15 screws
1 M3 × 10mm screw
1 M3 × 6mm nylon screw
5 M3 nuts
6 3mm star washers
4 PC stakes
1 2m length red automotive wire
1 2m length black automotive wire
1 2m length green automotive wire
1 2m length brown automotive wire
1 60mm length of 0.7mm tinned copper wire
1 40mm length of 4mm heatshrink tubing

Semiconductors
1 MJH10012, BU941P TO-218 high-voltage Darlington transistor (Q1)

2 BC337 *NPN* transistors (Q2,Q3)
4 75V 3W Zener diodes (ZD1-ZD4)

Capacitors
1 1nF ceramic

Resistors (All 0.25W, 1% metal film)
1 1.2kΩ
1 470Ω
1 100Ω 5W wirewound

LCD Hand Controller

*1 PC board, code 729, size 115 × 65mm
1 front panel label (or screen printed lid) for case
1 plastic case, size 120 × 70 × 30mm, with clear lid (Jaycar HB 6082 or equivalent)
1 4017 decade counter (IC1)
1 LCD module (Jaycar QP 5515 or backlit QP 5516)
5 white click-action switches (S1,S2,S5,S7,S9)
4 black click-action switches (S3,S4,S6,S8)
1 SPST micro tactile switch (S10)
1 DIL 14-way pin header
1 DB25 PC mount right-angle socket
1 DB25-pin male to DB25-pin male 1.8m RS-232 connecting lead (all pins connected) (Jaycar WC 7502)
4 12mm long M3 tapped plastic spacers
4 M3 x 6mm CSK screws
2 M3 x 6mm screws
2 M3 x 12mm plastic screws
2 2.5mm thick plastic washers
1 100mm length of 0.7mm tinned copper wire
1 10µF 16V PC electrolytic capacitor
2 10kΩ 0.25W 1% resistors
1 7-way, 8-way or 9-way 330Ω terminating resistor array (8-10 leads). Note: six resistors are used in the circuit, and one end of each resistor connects to the pin 1 common
1 10kΩ horizontal trimpot (code 103) (VR1)

* All PC boards are available from the *EPE PCB Service.*

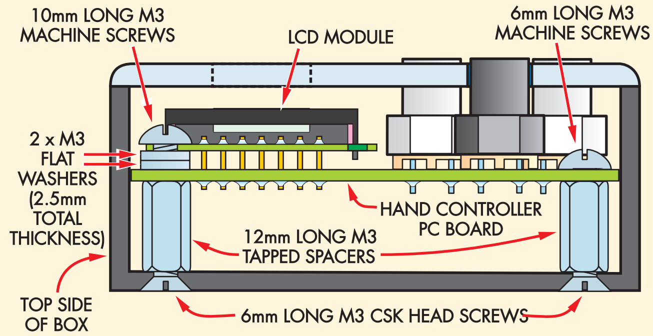


Fig.20: this cross-sectional diagram shows how the PC board for the LCD Hand Controller is mounted in the case. Note how the top edge of the LCD module is supported on two M3 flat washers.

Nylon screw (use a pair of needle-nose pliers to hold the nut in position while you 'start' the screw). **Finally, use your multimeter (set to a low ohms range) to confirm that Q1's metal tab is indeed electrically isolated from the case lid (you should get an open-circuit reading).**

The earth/chassis supply lead goes to a crimp eyelet, and this is secured to the inside of the case using an M3 × 10mm screw, star washers and nut. This screw secures a similar eyelet and earth wire arrangement on the outside of the case (this wire goes to the vehicle chassis).

As shown in Fig.18, the remaining wires exit via the cable glands. Cover these leads with heatshrink tubing at the exit points and note that the signal lead *must* pass through its own *separate* gland, while the ignition coil (–) lead and the +12V lead pass through a second gland.

Note that, in addition to the heatshrink, these leads may require packing out with tubing so that they are tightly clamped by the glands. **The signal lead must at all times be kept clear of the ignition coil (–) wire to prevent retriggering as the coil fires. Be sure to take it out through its own cable gland and route it well away from the ignition coil wire – see Fig.18.**

Hand Controller

The LCD Hand Controller assembly is shown in Fig.19.

Start construction by installing the three wire links, including the one under the DB25 socket. That done, solder in the dual-in-line 14-pin header for the LCD module, taking care to avoid solder bridges between adjacent pins.

The SIL resistor array is next. This will have a pin 1 indication at one end (usually a dot) and this end must go towards trimpot VR1. **Note that all the top seven holes must be used, leaving some free adjacent to VR1 if the array does not have 10 pins.**

IC1 can now be installed, taking care to ensure it is correctly oriented. That done, install the two 10kΩ resistors, trimpot VR1 and switches S1 to S9. Note that each of these switches must go in with its flat side to the left – see Fig.19. We used white and black switches – as indicated on the overlay. S10 is a smaller pushbutton 'tactile' switch that will only fit with the correct orientation.

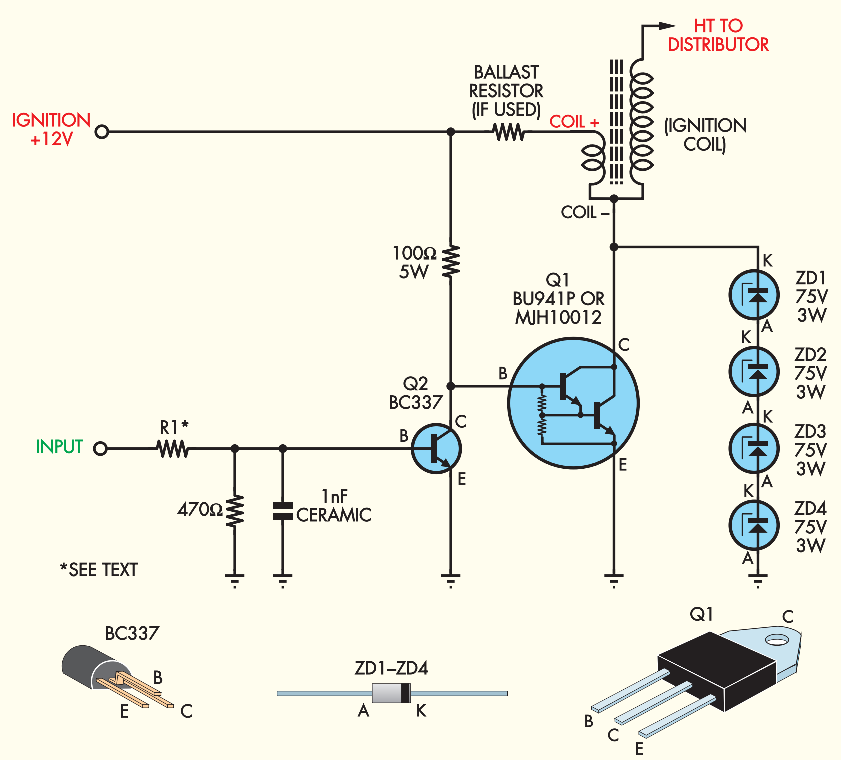
The 10µF capacitor is next on the list. **This must be mounted on its side to provide clearance when the lid is on (see photo).** Take care with the polarity of this capacitor.

The DB25 right-angle socket can now go in. Make sure it is seated flat against the board and take care to avoid solder bridges between the pins.

Finally, the LCD module can be installed by pushing it down onto its 14-pin DIL header. Push it all the way down until it is correctly seated against the header, then solder the header pins to the top of the module's PC board.

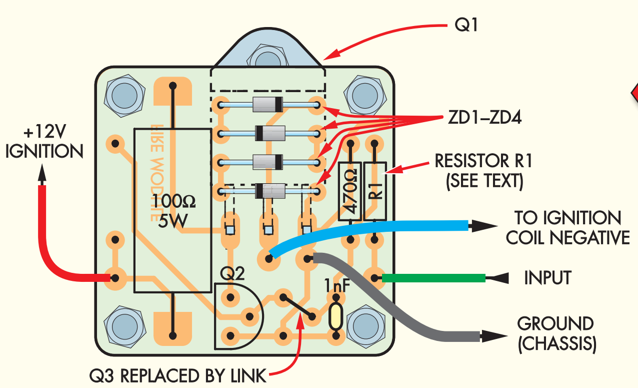
Fig.20 shows how the PC board is mounted in its case. If you are building a kit, the case will be supplied pre-drilled and with a screen-printed front panel. If not, then holes will need to be drilled in the base of the case for the four board mounting holes and a cut-out made to accommodate the DB25 socket in the side of the case. In addition, the lid will require holes for the switches and a clearance slot for the DB25 socket.

Inverting The Firing Sense Of The Ignition Coil Driver



MODIFIED IGNITION COIL DRIVER (TO INVERT THE FIRING SENSE)

Fig.21: this modified Ignition Coil Driver circuit can be used to 'fire' a plug when the input signal goes high.



MODIFIED WIRING FOR POSITIVE-EDGE FIRING

Fig.22: this is the modified parts layout. Use a 470Ω resistor for R1 for a 5V input signal and a 1.2kΩ resistor for a 12V input signal.

THE IGNITION COIL DRIVER can be used on its own for other applications; eg, as a replacement coil driver in an existing system. However, in some cases, it may be necessary to change the 'trigger sense' of the circuit.

The standard set-up has the coil 'charging' when the input signal is high and then 'firing' a plug on a negative-edge input signal. To invert this level sense, transistor Q3 and the 1.2kΩ resistor are deleted and a link installed between the pads normally used for Q3's base (B) and collector (C) leads.

This effectively bypasses Q3 and the input now drives Q2 via a base resistor (R1) – see Fig.21. Fig.22 shows the revised parts layout for the PC board. Use a 470Ω resistor for R1 when it is driven by a 5V input signal and a 1.2kΩ resistor when driven from a 12V signal.

With this arrangement, the coil 'charges' when the input signal is low and 'fires' a plug when the signal goes high.

Note that switch S10's hole should only be about 3mm in diameter – ie, just sufficient for a small probe to actuate the switch.

Testing

OK, now for the 'smoke' test, starting with the Programmable Ignition Timing Module.

First, apply +12V to the supply input and connect the case to the 0V rail. That done, use your multimeter to check that there is 5V (±0.1V) between pins 14 and 5 of IC1's socket. If this is correct, switch off and install IC1, making sure it is correctly oriented.

Next, connect the RS-232 DB25 lead between the Programmable Ignition Timing Module and the LCD Hand Controller and apply power. You should be greeted with some characters on the LCD. If there are none, or if the display is faint or the contrast is poor, adjust VR1 on the LCD Hand Controller board for best results.

If there is still no display, recheck the parts placement on both PC board assemblies. Check also that the DB25 cable is correct – each pin should be connected through to the same socket pin on the opposite end of the lead.

Assuming all is well, the display shown on the LCD will depend on the position of jumper shunt LK1. Remember that the Settings position will show the settings mode (used when changing parameters), while the Timing position will show the RPM and Load site values against the timing values.

The initial timing values are all set to 0° advance. Check that you can change the values using the switches on the LCD Hand Controller.

Converting your distributor

Finally, note that if you have a distributor with points, you can convert it to a Hall effect pick-up instead, to make it maintenance-free. The details on how to do this will be included in a seperate modification panel in Part 3, next month.

Next month: We will describe how the unit is set up and installed in a car.

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Something Old, Something New

Mark Nelson

If this column has a recurring theme, it's identifying new and disruptive technologies before they become mainstream. We don't always check back on how these new concepts are progressing, so this month we'll revisit some ideas discussed previously and also examine some completely new developments. Mark Nelson reports.

EXACTLY a year ago we looked at energy harvesting – the notion of generating electricity from human footfall and other 'coincidental' movement. 'Free' power is a very appealing concept, although making it a reality and collecting usable amounts of electricity in an economic manner is a significant challenge to researchers.

Proving it's feasible is Sainsbury's new superstore at Gloucester Docks, which opened a couple of months ago. Proudly described as the retailer's first customer-powered store, the building has been designed to respect its environment and minimise its impact through the careful management of energy use and harnessing the power of natural resources such as wind, rain and sun.

European first

What makes this a genuine first in Europe is the revolutionary installation that creates green energy every time customers drive into the car park to do their shopping. 'Kinetic road plates' deflected by passing cars generate electrical energy that would otherwise go unharvested.

The plates are expected to produce 30kW of green energy an hour, more than enough to power the store's checkouts, saving power that would otherwise be taken from the national grid. The system, pioneered for Sainsbury's by Peter Hughes of Highway Energy Systems, does not affect the car or fuel efficiency, and drivers feel no disturbance as they drive over the plates.

Alison Austin, Sainsbury's environment manager, explains that the plates placed in the road surface of the car park are rounded, so it does not matter which direction you travel over the ramp. The weight of vehicles driving over the plates pushes them down, creating a rocking motion below the road surface to operate generators that create energy used as power for the checkouts and for other purposes.

Other environmental features of the new store include rainwater harvesting, to flush all of the toilets, plus reducing electrical demand by using 40 sun pipes in the roof to make maximum use of natural daylight and automatic light dimmers on brighter days.

Wireless world

Wireless network nodes are another area in which energy scavenging techniques are now being put to good use. Jennic, a Sheffield-based semiconductor manufacturer specialising in microcontrollers for wireless networking, has unveiled a demonstration system that harvests all kinds of energy – thermal, solar, radio frequency (RF) and vibrational.

Jimi Simpson, product marketing manager, explains: "Harvesting energy from sustainable sources presents designers with the ultimate power challenge: the energy supplied is available at relatively low levels and not necessarily continuously. This means that every element of the design, from the sensor to the microcontroller, must be considered and managed to achieve the highest levels of power efficiency."

Jennic solves this problem by using a 2-bit RISC processor in the wireless microcontrollers to implement a software-controlled charge-and-fire energy management process, in which the microcontroller periodically wakes up to assess energy levels, and then collects and transmits data when sufficient energy is available. The 'sleep' current is less than one microamp, while in active mode, transmission current is just 15mA and receive current is 18mA.

To awake the sensor, make a reading, transmit this data and revert to sleep mode takes around 200 microjoules of energy. Harvesting this amount of energy indoors from photocells would take several hours, but is almost instantaneous when powered by vibration.

In Simpson's view, this wireless microcontroller undoubtedly sets the benchmark for energy harvesting in wireless networking. The ultra-low current consumption enables the JN5148 to utilise very compact energy storage devices, including super capacitors and rechargeable cells.

It is claimed that the diverse range of energy harvesting technologies catered for in this solution matches the broad spectrum of applications for networked wireless sensors, which include energy and air conditioning management, process control, logistics and asset tracking.

On the home front

Back in March, we predicted that 2009 might turn out to be the year of the femtocell, a new breed of low-power wireless access points, justified by the fact that 60 per cent or so of mobile usage takes place indoors (either in the home, out shopping or at work). The idea is to persuade offices, shops and 'switched-on' households to install their own mini base stations that link into the mobile network using standard broadband connections (phoneline or cable). At the time, it looked as if France would lead the race. However, the first commercial femtocell offering in Europe has been launched here in the UK by Vodafone.

The company's Access Gateway is similar in size to a router, and is intended for domestic use. It plugs straight into any home broadband line to bring customers improved and more reliable coverage indoors. Quick and easy to install, the Gateway works with all 3G handsets and can support up to four voice calls at any one time. Users will no longer need to worry about missed calls on their mobiles due to inconsistent indoor coverage.

Available now, the Gateway is available free as part of an inclusive price plan starting from £15 a month, or else as a one-off purchase for £160. In case you're wondering whether you could latch on to other people's femtocells, the answer is no; only mobile numbers registered by the subscriber can use the Gateway.

Health risk?

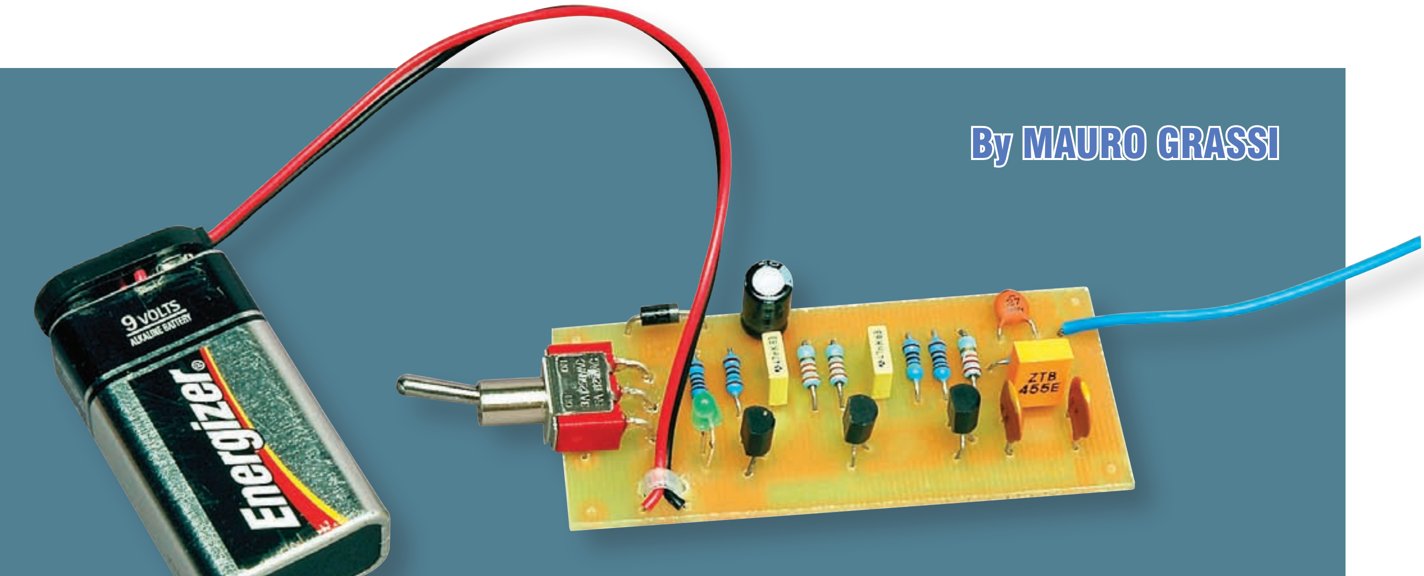
Given the widespread opposition to mobile base stations close to schools and housing, it may seem perverse to install a source of radio frequency (RF) energy right inside the home. All the same, the European Commission's snappily-named Scientific Committee on Emerging and Newly Identified Health Risks reported earlier this year that exposure to RF fields is unlikely to lead to an increase in cancer in humans. It conceded, however, that further studies are required to identify whether considerably longer-term (well beyond ten years) human exposure to such phones might pose some cancer risk.

The World Health Organization also takes the view that negative health effects are not likely to be caused by mobile phones or their base stations, and will be making recommendations along these lines later this year. It notes, however, that authorities in Austria, France, Germany, and Sweden advise reducing people's exposure to mobile phones. Recommendations include, using hands-free technology to minimise the radiation to users' heads and not to use mobile phones in a car, without an outside antenna.

Dirty electricity

A far more potent source of RF radiation, according to one pressure group, is the compact fluorescent lamp or CFL. Unlike incandescent bulbs, these emit RF radiation in the frequency range of 25kHz to 100kHz and measurements by an independent French research centre, confirmed by the Flemish Institute for Technological Research, show that CFLs generate powerful electromagnetic fields (EMF) up to one metre distance.

It is further claimed that over and above the direct radiation, 'hash' from CFLs can travel along domestic electrical wiring and expose people to so-called 'dirty electricity' throughout the house. For this reason, some groups are arguing that more research should be done before incandescent lamps are banned.



By MAURO GRASSI

Minispot 455kHz modulated oscillator

The Minispot produces a 455kHz carrier waveform, which is amplitude-modulated with a 500Hz tone. You can use it to align the intermediate frequency (IF) stages of any AM broadcast or shortwave radio.

THIS project generates an amplitude-modulated 455kHz RF signal. It can be used to accurately align the intermediate frequency (IF) stages of heterodyne AM receivers.

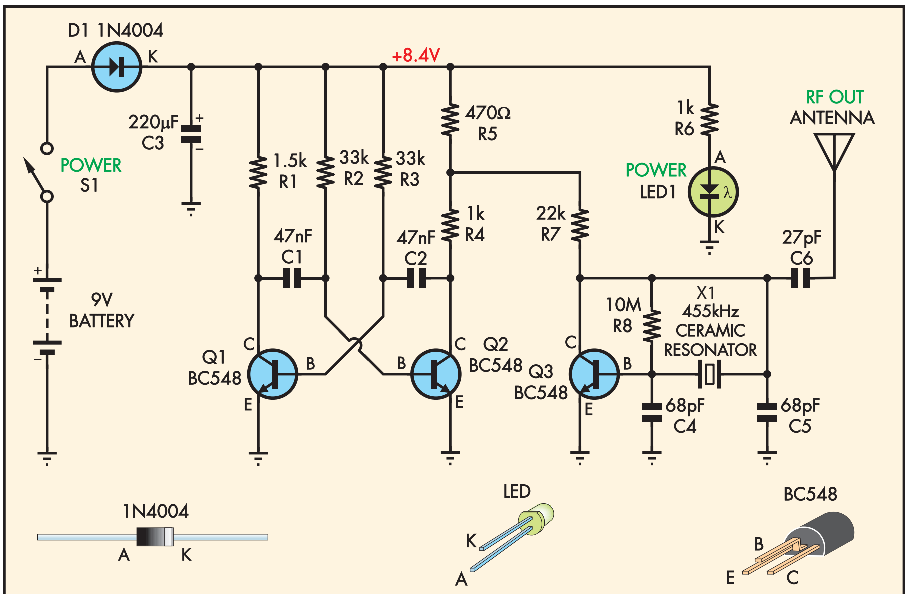
If you are involved in restoring vintage radios, you will want this Minispot 455kHz modulated oscillator to accurately align the IF stages.

Tuning in

The objectives of IF alignment are to ensure that all tuned circuits in the IF stages are tuned to the same frequency and that this frequency is the correct frequency, usually 455kHz.

If various parts of the IF stages are tuned to different frequencies, the sensitivity of the receiver will be poor. It may also be plagued with unwanted audible whistles appearing in the audio output. Therefore, correct IF alignment is essential for good performance.

There are various ways in which IF alignment can be achieved. The



MINISPOT MODULATED OSCILLATOR

Fig.1: the circuit consists of a multivibrator (transistors Q1 and Q2) running at 500Hz and this modulates a 455kHz oscillator based on transistor Q3 and ceramic resonator X1.

simplest is to align your receiver 'by ear'. This involves tuning to a broadcast signal and adjusting the IF stages until the maximum output from the loudspeaker is obtained. However, this method will almost certainly not give the best results.

Not only is it likely to result in having all stages aligned to the wrong frequency, but there is also the difficulty of judging at what point the maximum output is obtained.

The ideal method is to use an RF signal generator, set precisely to 455kHz, and fed into the first IF stage (ie, after the mixer). As the alignment proceeds and the sensitivity improves, the output from the signal generator can be progressively reduced, to avoid activating the AGC (automatic gain control) circuit of the radio (which would otherwise act to reduce the receiver's sensitivity).

Ah, you say, "I don't have an RF signal generator". This is where this 455kHz modulated oscillator comes into play. It will do the same job, but costs only a few pounds.

Circuit description

The circuit of Fig.1 can be divided into two parts. The first part consists of a two-transistor multivibrator (Q1 and Q2) which generates a square wave at around 500Hz. The second part is a phase-shift oscillator (Q3) with a 455kHz ceramic resonator (X1) connected between the collector (C) and base (B) of the transistor. This would normally be referred to as a 'Pierce oscillator'.

We use the multivibrator to 'modulate' the 455kHz oscillator by varying its supply voltage. This is done simply by connecting R7, the 22kΩ collector load resistor for Q3, to the voltage divider resistors driven by Q2 (R4 and R5). But wait, we are getting a long way ahead of ourselves in describing how the circuit works. Let's just back-track a bit and describe the operation of Q1 and Q2, the astable (free-running) multivibrator.

In essence, the multivibrator consists of two transistors which alternately switch on and off. In fact, the way that the transistors are biased ensures that only one transistor can be on at any time. The frequency of the alternate switching is determined by resistors R2 and R3 and capacitors C1 and C2.

To describe the operation, suppose transistor Q1 is initially on while Q2 is off. Since Q1 is on, the collector end of capacitor C1 is near ground (0V) and so is the collector end of resistor R1. Now C1 begins to charge through resistor R2 to 0.6V, eventually turning on Q2.

When Q2 turns on, its collector goes to 0V, pulling C2 down with it, causing the base of Q1 to be pulled below ground. So Q1 turns off. Now C2 is charged via R3 to 0.6V, which then turns off Q2 and Q1 is turned back on.

This process repeats continually, and the resulting output at the collector of either Q1 or Q2 is a square wave, with a frequency dependent on the *RC* time constant formed by C1 and R2 or equivalently, C2 and R3.

Frequency

The frequency of the square wave produced is given by the equation:

***f* = 1/(0.693(R2C1 + R3C2)) (approx.) = 1/(2 x 0.693R2C1)**

With the values used in this project (R2 = R3 = 33kΩ and C1 = C2 = 47nF),

Parts List

- 1 PC board, code 726, available from the *EPE PCB Service*, size 72mm × 32mm
- 1 9V battery, with clip and leads
- 1 cable tie
- 1 SPDT toggle switch
- 1 300mm length of wire for antenna

Semiconductors

- 3 BC548 NPN transistor (Q1-Q3)
- 1 1N4004 400V 1A rectifier diode (D1)
- 1 3mm green LED (LED1)
- 1 ZTB455 455kHz ceramic resonator (X1)

Capacitors

- 1 220µF 16V radial electrolytic (C3)
- 2 47nF MKT polyester (C1, C2)
- 2 68pF ceramic (C4, C5)
- 1 27pF ceramic (C6)

Resistors (All 0.25W, 1% metal film)

- 1 10MΩ (R8)
- 1 1.5kΩ (R1)
- 2 33kΩ (R2, R3)
- 2 1kΩ (R4, R6)
- 1 22kΩ (R7)
- 1 470Ω (R5)

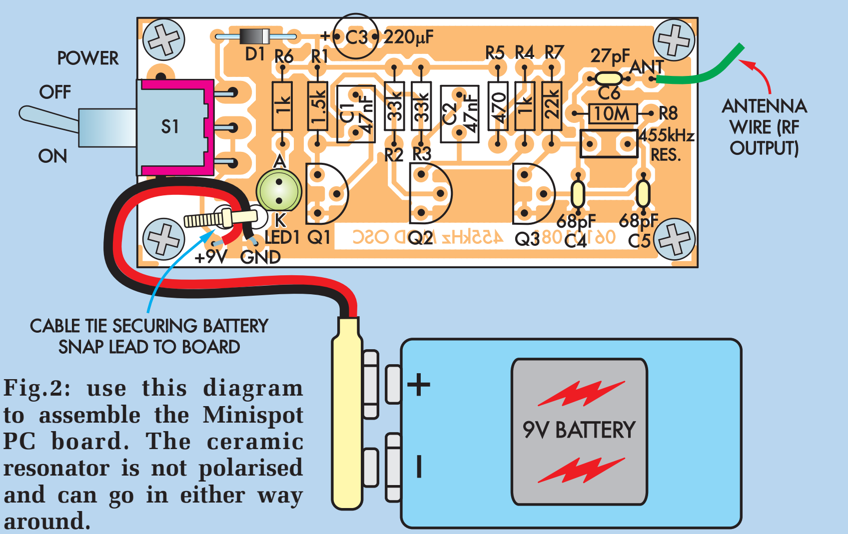
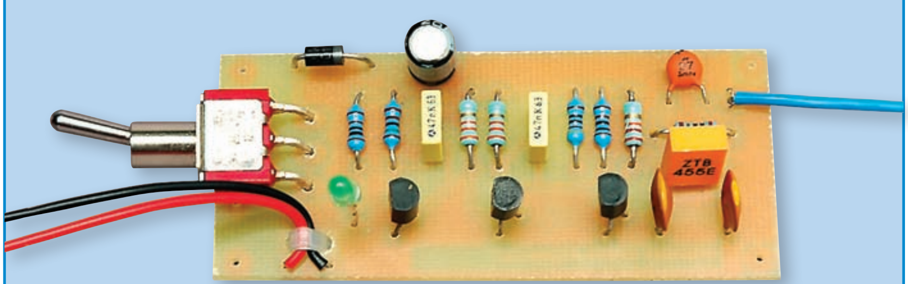


Fig.2: use this diagram to assemble the Minispot PC board. The ceramic resonator is not polarised and can go in either way around.



Compare this fully assembled PC board with the above wiring diagram when installing the parts. The antenna wire should be about 300mm long.

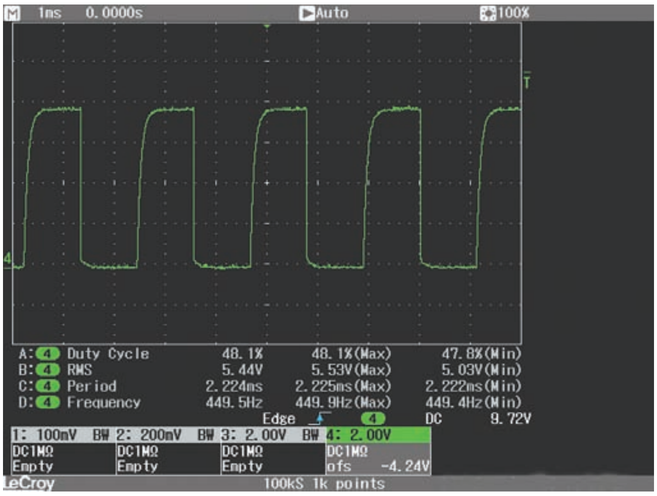


Fig 3: this oscilloscope screen shot shows the signal at the collector of transistor Q1. It is a square wave at 449Hz, with an approximate duty cycle of 50%. Small variations in the values of resistors R2 and R3, and capacitors C1 and C2 account for the small deviations in the duty cycle and frequency from theoretical values.

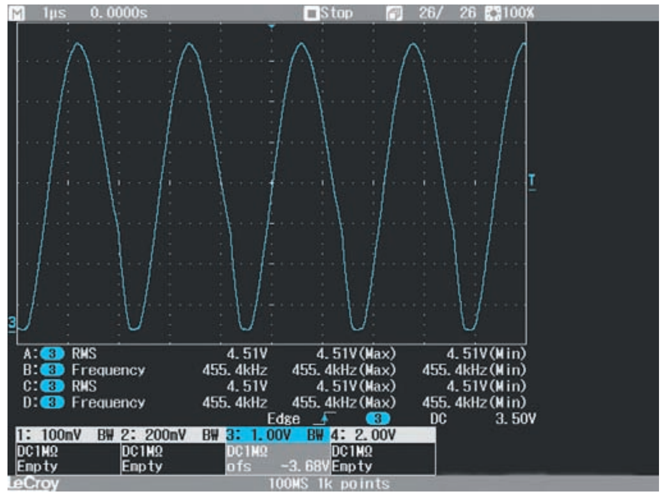


Fig 4: this oscilloscope screen grab shows the signal that appears at the collector of transistor Q3. At the relatively high timebase speed being used, the waveform appears as an approximate sinewave at 455kHz, but slower timebase speeds will in fact show the amplitude as varying – see Fig.5 below.

the expected frequency is approximately 465Hz. This will vary slightly, according to the actual values of R2, R3, C1 and C2. In particular, if R2*C1 and R3*C2 are not exactly equal, then the duty cycle will not be exactly 50%.

As noted earlier, the astable multivibrator is used to power the 455kHz oscillator via resistor R7. As we have seen, the collectors of Q1 and Q2 continually switch high and low. Resistor R7 is fed from the voltage divider formed by resistors R4 and R5, and since the collector of Q2 switches between about +0.2V and +8.4V (nominal), the junction of R4 and R5 will, therefore, be switched between about +8.4V and +5.5V (without allowing for the slight loading effect of R7).

Hence, the supply voltage to the 455kHz oscillator is varied over these limits, and so the amplitude of the output signal from the collector of Q3 will vary in direct proportion to the supply voltage; ie, it will be 'amplitude modulated' at 455kHz.

The modulated output signal is AC-coupled by capacitor C6 to a length of wire, which functions as an antenna.

A 9V battery is used to power the circuit via power switch S1. Diode D1 protects the circuit against reverse battery polarity.

Capacitor Codes

Value	µF Code	IEC Code	EIA Code
47nF	0.047µF	47n	473
68pF	NA	68p	68
27pF	NA	27p	27

Construction

The PC board for this project is coded 726, and measures just 72mm × 31mm. This board is available from the *EPE PCB Service*. The component overlay diagram is shown in Fig.2.

Start construction by soldering in the eight resistors. Make sure that the correct values are used, either by referring to the colour code table – or better still, measuring the resistors with a multimeter before soldering them in place. Diode D1 can then go in, making sure that it is oriented correctly.

The capacitors are next on the list. Only the 220µF electrolytic (C3) is polarised, with its negative terminal connecting to the ground plane. The ceramic resonator can then be installed, followed by the three transistors and the LED.

Make sure that the transistors go in the right way around. The LED is soldered in with its cathode (shorter lead) connected to the ground plane.

Next, connect the battery clip, making sure that the red wire connects to the positive supply terminal, and the black lead connects to the ground plane (0V). Secure the leads of the battery clip with a cable tie. Two holes have been provided on the PC board to do this. You may now solder the toggle switch (S1) in position.

Finally, cut a length of insulated wire about 300mm long. This forms the antenna. Solder one end of the wire to the antenna pad on the PC board. That completes the construction of the Minispot oscillator.

Testing and troubleshooting

Commence testing by applying power and flicking the toggle switch to the on position which should result in the LED lighting up. If it does not,

Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	10MΩ	brown black blue brown	brown black black green brown
❏	2	33kΩ	orange orange orange brown	orange orange black red brown
❏	1	22kΩ	red red orange brown	red red black red brown
❏	1	1.5kΩ	brown green red brown	brown green black brown brown
❏	2	1kΩ	brown black red brown	brown black black brown brown
❏	1	470Ω	yellow violet brown brown	yellow violet black black brown

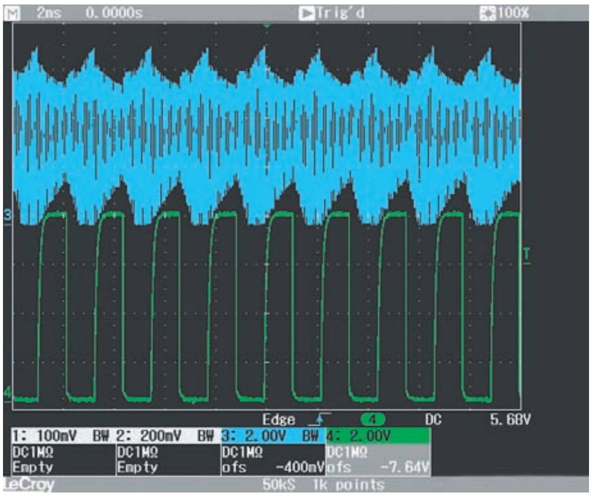


Fig.5: in this screen shot, the lower trace (green) is the audio waveform at the collector of Q1, while the top trace (cyan) is the resulting amplitude modulated 455kHz output at the collector of Q3. As shown, the modulation is not very clean, but it is fine for the intended application.

it's possible that either diode D1 or the LED (or both) is reversed. That's not likely though, because you have carefully followed the preceding assembly instructions, haven't you?

Once power is applied and the LED is lit, the circuit should be producing a modulated 455kHz signal. You should be able to listen to it using an AM radio tuned to either 910kHz or 1365kHz, which are the second and third harmonics of the fundamental frequency. If it is working, you should hear a tone of around 500Hz when the antenna is close to the radio.

If you have an oscilloscope, you can check the waveforms, some of which we have included with this article. The collectors of Q1 and Q2 should have a square wave around 500Hz, as shown in Fig 3. The collector of Q3 should be an approximate sinewave at 455kHz, whose amplitude should fluctuate – see Fig 4.

Conclusion

This simple project is easy-to-build and cost effective. It will greatly aid in the alignment of the IF stages of any AM radio. ***EPE***

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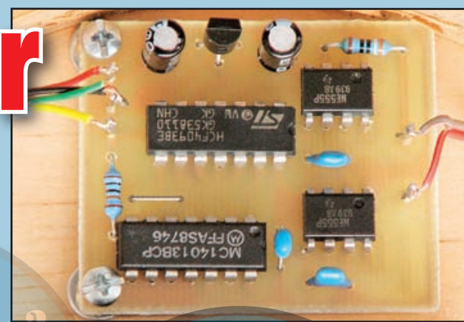
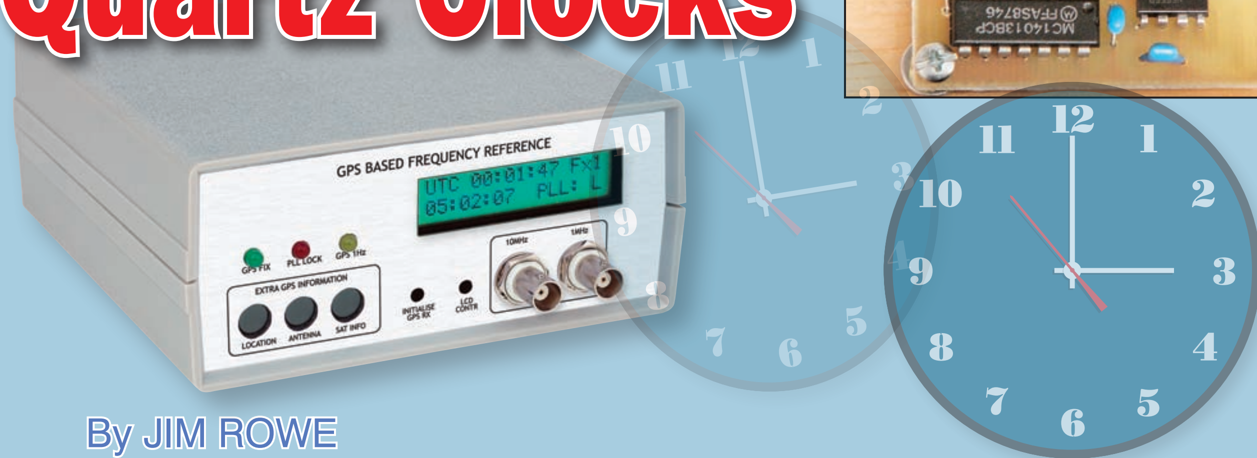
Simple add-on board mates with the GPS Frequency Reference

1pps Driver For Quartz Clocks





By JIM ROWE

This simple add-on module for the GPS-Based Frequency Reference is designed to drive the escapement coil of a low-cost quartz clock movement. It uses the 1Hz GPS pulses available at the rear of the Frequency Reference, so that the clock can display local time with GPS-based accuracy.

IF YOU built the *GPS-Based Frequency Reference* described in the April/May 2009 issues, you'll know that it provides a continuous readout of 'Universal Time Coordinated' (UTC) on its LCD. This time is derived directly from the GPS satellite system, and is therefore very accurate.

In practice, it's not all that difficult to mentally convert UTC into local time. In most cases, you simply add or subtract a certain number of hours, depending on the nominal longitude of your local time zone and, of course, your time of year.

That's all well and good, but most people would find a direct readout of their local time a little more useful. And that's where this project comes in. It uses the 1pps (one pulse per second) output from the GPS system to drive a quartz wall clock. All you have to do is set the display for local time at the start, after which the clock will be accurately controlled via the GPS seconds pulses.

It turns out to be very easy to interface the GPS Frequency Reference to a standard 'analogue' quartz clock movement. First, you have to remove the existing circuitry from the clock (usually just a chip and a crystal on a tiny PC board) and bring out the connections to the clock's escapement coil. That done, the coil can be pulsed by the little driver module described here. This driver module is small enough to fit inside the clock (next to the movement) and gets its power from the GPS Frequency Reference, along with the 1Hz (1pps) pulses.

How it works

If you remove the back from a standard 'analogue' quartz clock movement and take a look inside, you'll find a small PC board with a single IC chip and a tiny quartz crystal (usually 32.768kHz). This drives a simple stepper motor coupled to a multi-stage reduction geartrain.

Inside the IC there's an oscillator stage which uses the crystal to generate the 32.768kHz 'clock' pulses, plus a counter chain, which divides these pulses down to 1Hz (one per second). These 1Hz pulses are then used to drive the movement's stepper motor so that it gives an increment of rotation every second. The geartrain then steps down these increments in the motor spindle's rotation to drive the spindles for the clock's second, minute and hour hands.

The stepper motor is basically the interface between the electronic and mechanical sections of the clock movement. This makes the motor quite interesting, especially as it's surprisingly simple in construction.

In most cases, the motor is similar to the arrangement shown in Fig.1. As can be seen, it has a multi-pole permanent magnet rotor that is free to rotate inside a circular gap in a soft-iron

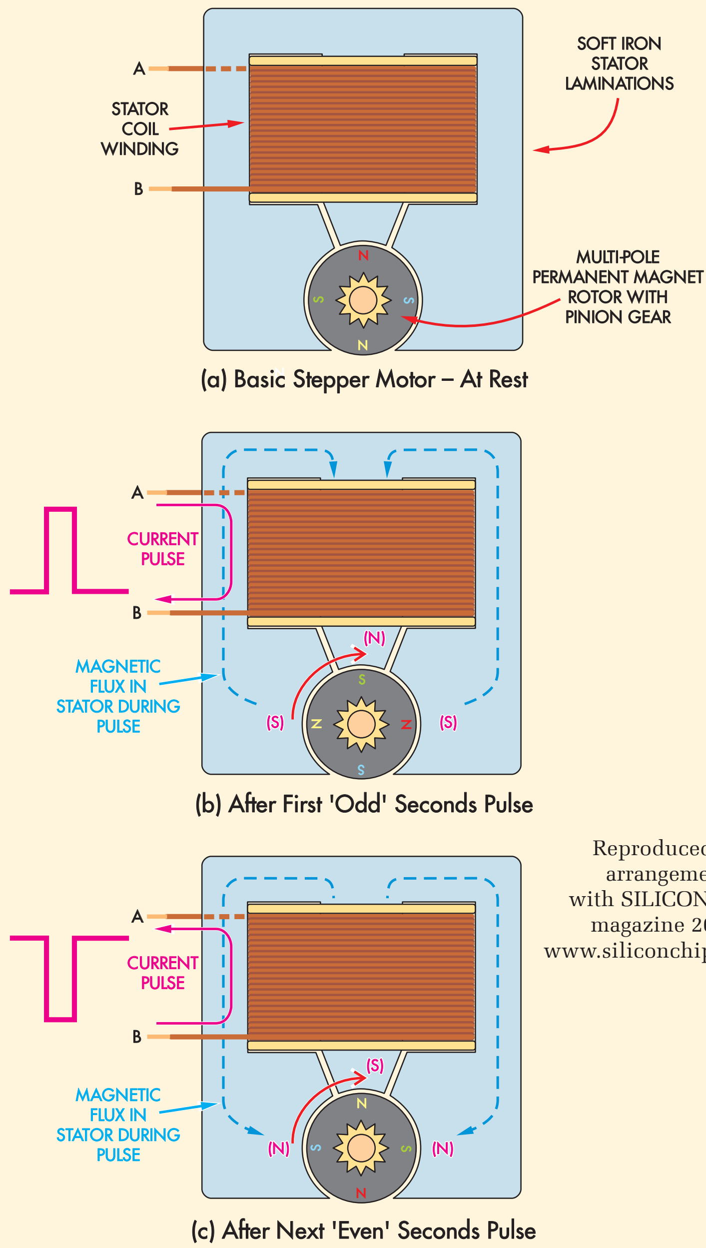


Fig.1: a clock stepper motor uses a multi-pole permanent magnet rotor, which rotates inside a circular gap in a soft-iron stator. It's made to step in the same direction by reversing the polarity of the current pulse at each step.

stator. The latter has two pole pieces which are driven by a single coil.

The trick is to get this very simple motor to rotate in one-second steps, all in the same direction. That's done by applying the pulses to the stator coil with alternate polarity, as shown in Fig.1.

Basically, 'odd' pulses are applied with one polarity, while 'even' pulses are applied with the opposite polarity. As a result, the rotor clicks around through an angle equivalent to the distance between its permanent magnet poles each second – see Fig.1. The geartrain steps down these one-second jumps to drive the clock hands.

This means that using the 1Hz pulses from the GPS Frequency Reference to drive such a clock movement is quite easy. All we have to do is provide a simple driver circuit which accepts the 1Hz GPS pulses and in turn applies brief current pulses to the stepper motor coil in the same alternate-polarity manner as the normal clock electronics. That's exactly what we do in this project.

Circuit details

Refer now to Fig.2 for the complete circuit details. It can basically be divided into two logical sections.

The first section comprises the NAND gates of IC1 and flip-flop IC2a. This section separates the stream of 1Hz pulses coming from the GPS Frequency Reference into two streams of alternating 'odd' and 'even' pulses.

The second section comprises 555 timers IC3 and IC4. These drive the stepper motor coil using the two separated pulse streams.

In greater detail, the incoming 1Hz pulses are first fed through IC1b, which is connected as an inverting input buffer. Note that pin 6 of IC1b is tied to ground via a 100kΩ resistor to prevent it from 'floating high' if the input cable is disconnected from the GPS-Based Frequency Reference.

IC1b's output appears at pin 4 and is fed in two directions – to pin 9 of IC1c and to the clock input (pin 3) of IC2a. IC1c simply re-inverts the signal and its pin 10 output is then fed to pin 12 of IC1d and to pin 1 of IC1a.

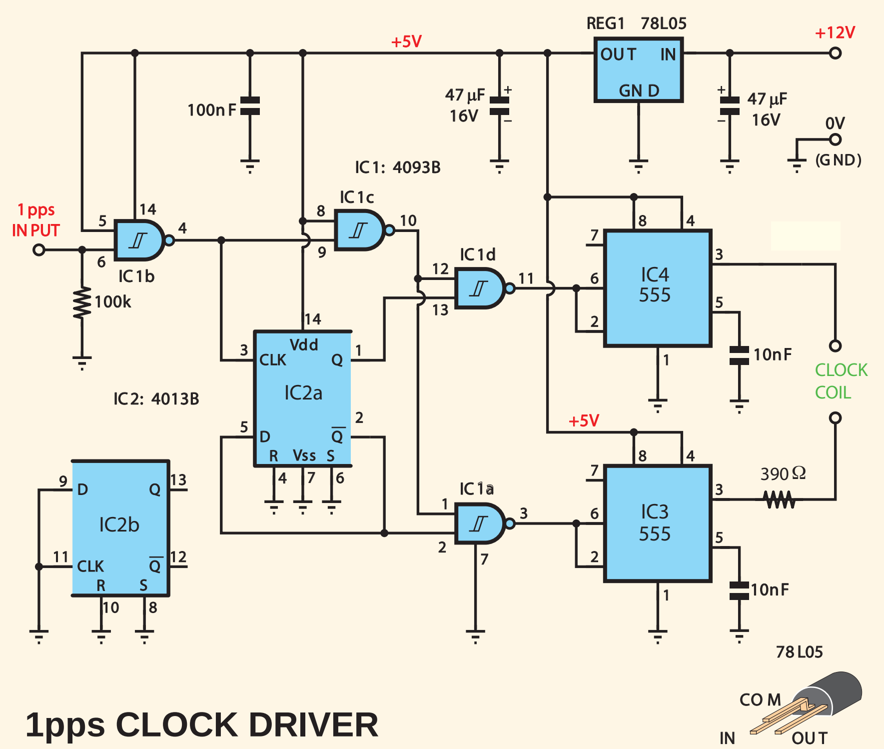
IC2a is one half of a 4013B dual D-type flip-flop (the second flip-flop in the IC is not used here). As shown, its $\overline{Q}$ output is connected back to the D input, so the flip-flop is configured in toggle mode. As a result, its Q and $\overline{Q}$ outputs (pins 1 and 2 respectively) toggle back and forth in complementary fashion, in response to the incoming pulses.

IC2a's Q output is fed to pin 13 of IC1d, while its $\overline{Q}$ output goes to pin 2 of IC1a. As a result, IC1d and IC1a separate the 1Hz pulses into two alternating streams, each controlled by the toggling outputs of IC2a. The 'odd' 1Hz pulses (inverted) emerge from pin 11 of IC1d, while the 'even' pulses (also inverted) emerge from pin 3 of IC1a.

Output drivers

These two separated pulse streams are then used to trigger 555 timers IC3 and IC4, which are used here simply as inverting drivers. As you can see, the clock's stepper motor coil is connected between their two pin 3 outputs via a 390Ω current-limiting resistor.

During the gaps between the pulses, both IC3 and IC4 are in their 'off' state, with their pin 3 outputs both switched low. As a result, no current flows through the stepper motor coil. However, each time a pulse arrives at IC1b's pin 6 input, either pin 11 of IC1d or pin 3 of IC1a will pulse low,



1pps CLOCK DRIVER

Fig.2: the circuit uses NAND gates IC1a to IC1d and D-type flip-flop IC2a to separate the incoming 1Hz pulses into alternating 'odd' and 'even' pulse streams. These pulse streams then drive 555 timers IC3 and IC4, which in turn drive the clock coil.

Parts List – 1pps Clock Driver

1 PC board, code 725, available from the *EPE PCB Service*, size, 46mm x 38mm
5 PC board terminal pins

Semiconductors
1 4093B quad CMOS Schmitt NAND (IC1)
1 4013B dual CMOS flip-flop (IC2)
2 555 timers (IC3,IC4)
1 78L05 low-power 5V regulator (REG1)

Capacitors
2 47µF 16V radial electrolytic
1 100nF monolithic ceramic
2 10nF monolithic ceramic

Resistors (0.25W 1% metal film)
1 100kΩ
1 390Ω

depending on the current state of flip-flop IC2a.

This causes either IC3 or IC4 to trigger, pulsing its output pin to the +5V level for the duration of the pulse (about 100ms) and hence driving a pulse of current through the stepper motor coil in one direction or the other. The next pulse (about 900ms later) then triggers the other 555 output driver, resulting in a current pulse through the stepper motor coil in the opposite direction.

Power for the circuit can be derived from any 12V DC source, including the 12V DC rail used to power the GPS Frequency Reference. This is applied to a low-power regulator (REG1) which delivers a +5V rail to power the circuit.

The two 47µF electrolytic capacitors and the 100nF capacitor provide supply decoupling and filtering.

Building the module

All of the driver module circuitry is mounted on a small PC board, code 725, measuring just 46mm × 38mm. This is small enough to mount in the back of most wall-type quartz clocks, alongside the movement. This board is available from the *EPE PCB Service*.

The component assembly details are shown in Fig.3. No particular order need be followed, but we suggest that you install the wire link first, followed by PC stakes at the five external wiring points. The two resistors and the capacitors can go in next. Take care to ensure that the two 47µF electrolytics are orientated correctly.

That done, you can install regulator REG1 and then complete the assembly by soldering in the four ICs. You can, if you wish, use IC sockets here. Be sure to orientate the ICs as shown on Fig.3 (ie, with pin 1 at lower left) and be careful not to get IC1 (4093B) and IC2 (4013B) mixed up.

The two terminal pins on the far left, marked CC1 and CC2, are used to terminate the leads from the clock's stepper motor coil (see Fig.3). In addition, you have to make three connections to the GPS Frequency Reference – ie, +12V, GND and the 1Hz GPS pulses. A length of 2-pair telephone cable can be used for these connections.

Modifying the movement

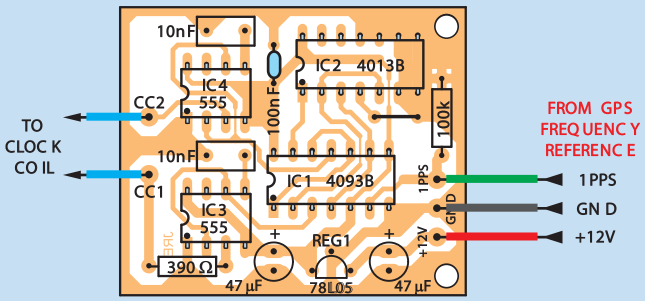
It's not difficult to modify the quartz clock movement so that it can be driven by this module. The first step is to remove the back and then the clock's PC board. The latter usually fits into a slot at one end of the movement's case. If the battery contacts are attached directly to the PC board, these can be removed as well.

As you are removing the PC board, you'll find that there are two fine wires from the stepper motor coil soldered to it. These two wires must be carefully desoldered from the board, after which the board can be discarded.

The next step is to connect a short length of light-duty 2-core cable (eg, a 200mm length of 'rainbow' cable) between the coil wires and the CC1 and CC2 terminals on the driver board. This should be done in such a way that neither the joints nor the coil wires will be strained if the lead wires are accidentally pulled.

The way to do this is as follows. First, cut a small rectangle from an old PC board, making it exactly the same size as the clock PC board (so that it will slide into same case slot). That done, cut a 3mm hole into the side of the movement case near the board slot, then bring the ends of the lead wires in through the hole and solder them to two pads on the new 'termination board'. Finally, solder the motor coil wires to these same pads and refit the back to the clock movement.

The driver module itself can be mounted next to the clock module.



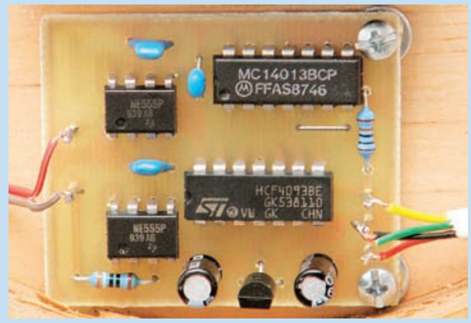


Fig.3: install the parts on the PC board as shown in this layout diagram and the above photo. Take care with component orientation when installing the ICs and the electrolytic capacitors.

In our case, the module was attached to the wooden dial 'plate' using a pair of 6G × 9mm self-tapping screws, with an M3 nut and flat washer under each to act as spacers.

GPS reference connections

As mentioned earlier, a length of 2-pair telephone extension cable is used to connect the driver module to the GPS Frequency Reference. To do this, we suggest fitting an extra DB-9 socket on the rear panel of the GPS Frequency Reference, just above the holes for the GPS 1Hz and phase error pulse outputs – see photo on the right.

That done, use three short lengths of hook-up wire to make the connections inside the unit to three of the pins on this added socket. One lead goes from the socket to the main board ground, another to the +12V line and the third wire to the rear of the 'GPS 1Hz' output socket.

Now fit a matching DB-9 plug to the end of the cable from the clock driver module. Be sure to connect the leads to the correct pins on this plug, to mate with those on the new DB-9 socket.

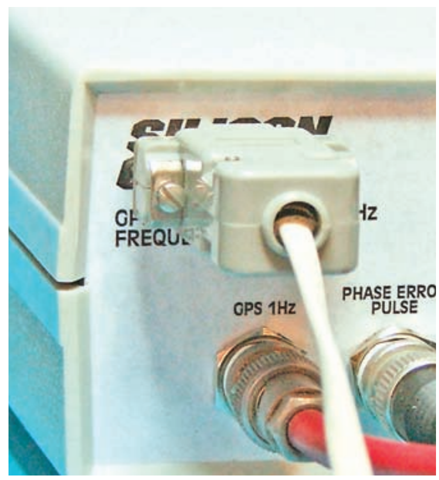
Time-set

It's now just a matter of testing it out. Connect the DB-9 plug to the socket, apply power and check that the clock immediately starts ticking. Its second hand should step in time with the flashes from the 'GPS 1Hz' LED on the front panel of the GPS Frequency Reference.

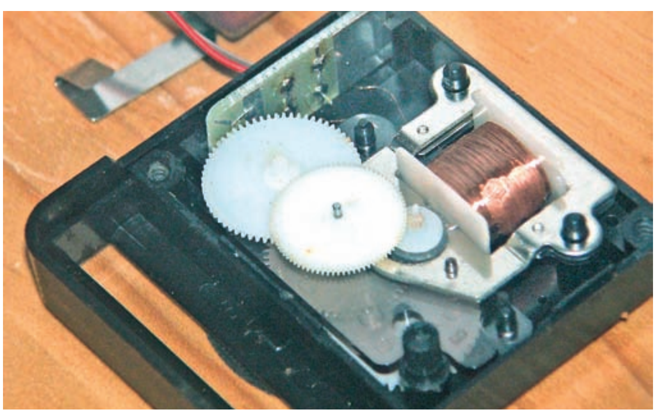
All that remains when you get to this stage is to set the clock movement to the current local time. If you want the second hand to read correctly as well, the easiest way to do this is to first unplug the clock connection from the rear of the GPS Frequency Reference when the seconds hand is in the 12 o'clock position.

That done, set the minutes and hours hands manually for the start of the next minute and then, as soon as the UTC seconds display on the Frequency Reference's LCD reaches '59', plug the connection back in again to restart the clock.

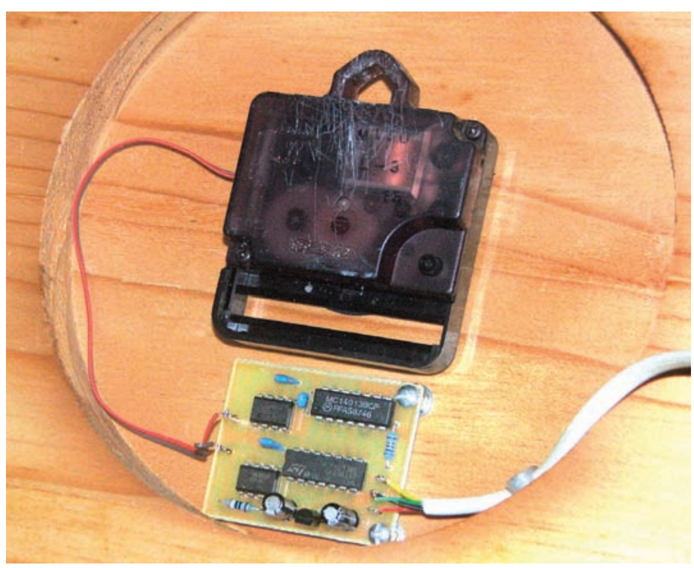
If you time this reconnection correctly, the clock will now display local time accurately (to the second) – and will continue to do so as long as GPS 1Hz pulses keep arriving. ***EPE***



The driver board can be connected to the GPS Frequency Reference via a length of 2-pair telephone cable fitted with a DB-9 plug. This can plug into a matching DB-9 socket mounted on the rear panel, just above the 'GPS 1Hz' output socket.



The leads from the clock coil are soldered to two pads on a piece of scrap PC board, as shown in the above photo (see text). These pads also terminate the leads from the driver board. The photo on the right shows the completed driver module mounted in the back of the clock case.



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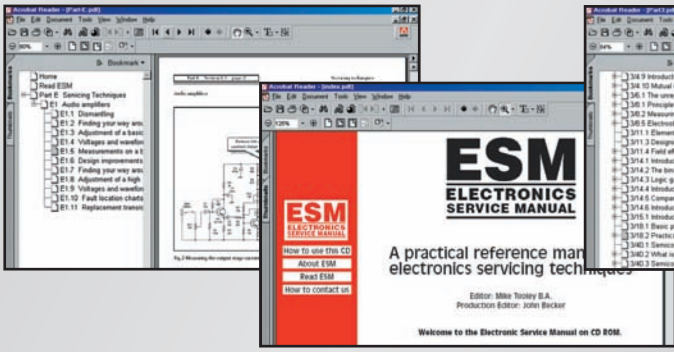

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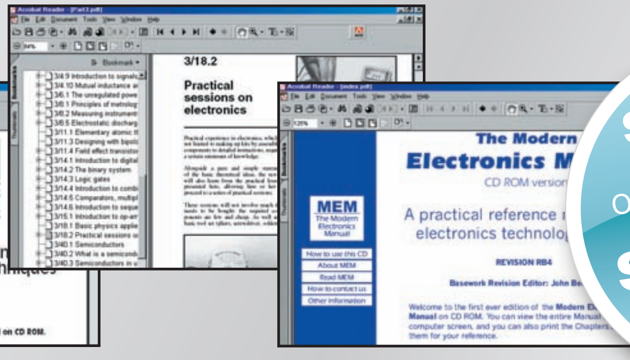

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Guitar-To-MIDI System

By Nigel Gough

Hit the WOW-factor with this low-cost, PIC-based, guitar interface

Within a group of muscians, the electronic keyboard player has the most varied and wonderful range of sounds at their fingertips. With the invention of MIDI (musical instrument digital interface) back in 1983, it became even easier for them to access these sounds at the touch of a button.

These days, with computer-based sequencers and 'soft synths', a musician can compose and produce remarkable recordings in their own home with the minimum of problems. If you are fluent at playing the keyboards, this is a dream come true. But what about the poor old guitar player?

Guitar-to-MIDI interface

Well, they can use a MIDI interface to produce the same sounds as a keyboard. Commercial units are available, but they are quite expensive. Most of these are polyphonic and use an extra six-way pickup, which needs to be attached to the guitar.

The design presented here is monophonic, only one note can be played at a time, but this is still very useful for solo playing. No modification to the guitar is required as it makes use of the existing pickups. So, it will work with any of your favourite guitars. The design uses a PIC microcontroller and a few other components, and is an inexpensive, easy-build, alternative to a commercial unit.

Circuit details

The author's original design used quite a few external components to condition the guitar signal before feeding it to a PIC micro, which in turn measured note frequency and amplitude, before producing MIDI data. The design went through many changes reducing the amount of components and letting the software do more work, until arriving at the final version.

Refering to the circuit diagram shown in Fig.1, the guitar signal is applied to IC1a, a TL072 dual op amp, through capacitor C1 and resistor R1. The feedback resistor R2 gives the op amp a gain of 3.7. It was found that this gave a good output swing when using a single coil type pickup used on Fender-style guitars.

The op amp is biased at half supply voltage by resistors R3 and R4, with capacitor C2 providing AC decoupling to ground (0V). The output of IC1a goes directly to the PIC analogue input.

When the guitar string is plucked, the output voltage of the op amp swings above and below the bias point. However, the TL072 cannot swing as far as 0V, or to the supply voltage. So, to get the best resolution from the analogue-to-digital converter (ADC) within the PIC, its positive and negative reference points need to be the same as the maximum and minimum voltage swing points of the op amp output.

This is realised by resistor chain R7, R8 and R9, which is connected to the ADC reference inputs, configured in the software. The other half of IC1 forms a high impedance buffer, which passes the clean guitar signal to an output socket.

The PIC (IC2) has minimal external components, a few resistors and a couple of LEDs which show MIDI activity and peak audio. The clock for the PIC is internal and seems accurate enough for this purpose.

The MIDI output is provided by the serial port within the PIC. The supply voltage for the whole circuit is provided by a 9V PP3-type battery through a 78L05 5V voltage regulator IC3.

Software

Calculating the frequency of an audio signal may seem, at first, to be a simple problem to solve. By amplifying the signal until severe clipping takes place and connecting this to a digital input of the PIC, would seem to give the PIC a good signal to read.

This is fine if the waveform is clean like a sinewave and has no harmonics. But a plucked guitar string is very rich in harmonics and the resultant

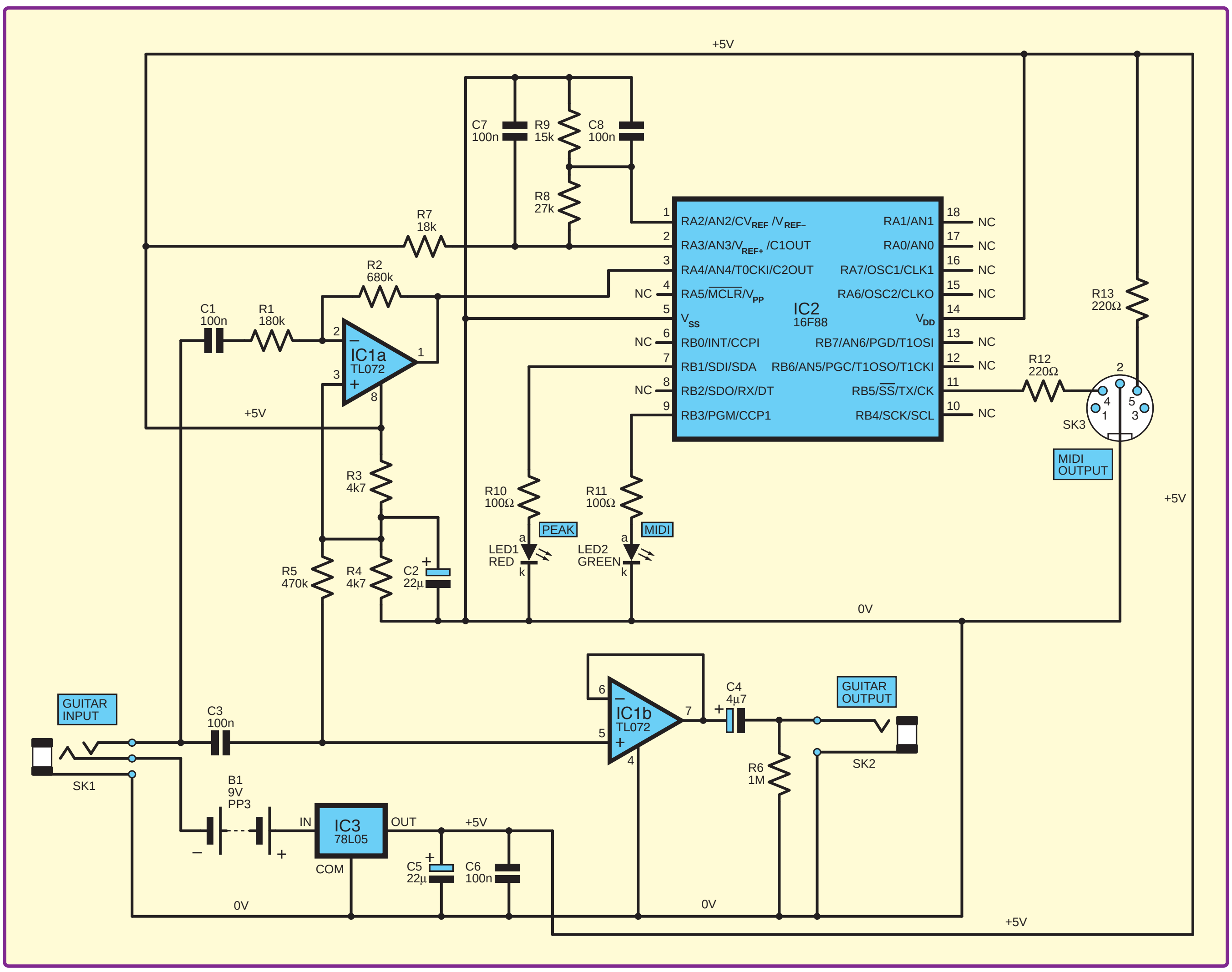


Fig.1. Complete circuit diagram for the Guitar-To-MIDI System

clipped signal switches from supply to ground level more often than the fundamental note and is pretty random too. This makes it almost imposible to control what the PIC will do.

The author first tried filtering the signal to remove the harmonics, but this posed yet another problem. A guitar has a range of notes covering several octaves, so at what frequency should the filter be set?

After a lot of thought, an idea emerged. Many years ago several companies designed guitar effects pedals called 'octave dividers', which provided one or two octaves below the note being played on the guitar. They seem to work very well, so how did they do it?

Luckily, the author had a circuit diagram of such a device and after studying it found the answer. They used two comparators feeding into a CMOS bistable IC. To one input of each comparator was sent a lightly filtered version of the original guitar signal, the other was sent a DC voltage, which tracked the envelope of the guitar signal. One comparator worked for the positive side of the signal, the other for the negative.

Guitar waveform

A guitar string when plucked produces a waveform which has well defined short duration peaks within the signal which are larger than the harmonics. When the positive comparator is triggered by the positive pulse, its output sets the bistable output to a high state.

The bistable remains in this state until the negative comparator is triggered by the negative pulse in the remaining part of the guitar signal, at which point the bistable resets again. This produces a very good square wave signal for the PIC to calculate the note frequency.

When building a similar system and applying it to the PIC, it seemed to work well, although only over a limited range of string volume. Quiet notes were ignored!

By this time the design was getting more complicated and far from perfect, so some radical thinking was needed. The PIC wasn't actually doing very much apart from measuring a pulse frequency and outputting serial data. What a waste of its power!

Parts List – Guitar To Midi System

1 PC board, code 730, available from the *EPE PCB Service*, size 90mm × 58mm
1 small plastic box, size 114mm × 76mm × 38mm
2 6.35mm (¼in.) insulated (plastic body) PCB mounting stereo jack sockets, with plastic panel-mounting fixing nut (SK1, SK2) (SK2 could be replaced with a mono type)
1 5-way 180° type A DIN socket, PCB mounting (SK3)
1 8-pin DIL IC socket
1 18-pin DIL IC socket
1 9V battery, with clip and leads

Semiconductors
1 TL072 dual FET op amp (IC1)
1 PIC16F88-I/P microcontroller, preprogrammed (IC2)
1 78L05 +5V 100mA voltage regulator
1 5mm red light emitting diode (LED1)
1 5mm green light emitting diode (LED2)

Capacitors
5 100nF ceramic (C1, C3, C6 to C8)
2 22µF radial electrolytic, 35V (C2, C5)
1 4.7µF radial electrolytic, 63V (C4)

Resistors (All 0.25W, 5% carbon film)
2 100Ω (R10, R11)
2 220Ω (R12, R13)
2 4.7kΩ (R3, R4)
1 15kΩ (R9)
1 18kΩ (R7)
1 27kΩ (R8)
1 180kΩ (R1)
1 470kΩ (R5)
1 680kΩ (R2)
1 1MΩ (R6)

Analogue to the rescue!

By feeding an unfiltered guitar signal into the PIC's analogue-to-digital input (ADC) and having the PIC analyse it, would be the ideal

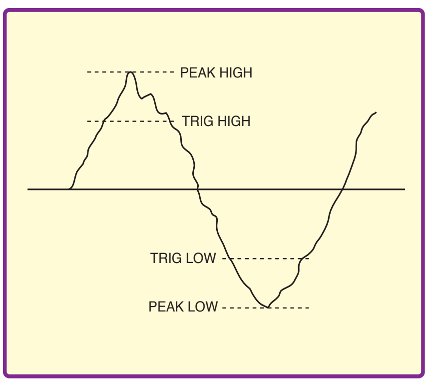


Fig.2. Typical guitar signal waveform shortly after a string has been plucked. It can be seen that there are two peaks and several harmonics present

solution. First, what was needed was a software equivalent of the comparators previously used.

Fig.2 shows a typical guitar signal shortly after a string has been plucked. It can be seen that there are two peaks and several harmonics present.

If the ADC is read continously, the software can start and stop the PICs internal timer when voltages go above and below two preset trigger points. This is similar to the set and reset of the bistable in the hardware version. It was found that a trigger point of half the peak value (positive and negative) seemed adequate at a wide range of signal levels.

So, first of all, the PIC needs to find the peak values in order to calculate the trigger points. The lowest '*E*' note on the guitar has a frequency of approximately 82Hz. To find the peak values, the PIC must sample for the length of time that will capture both peaks at 82Hz; which is 12mS.

This time period is applied to all notes played and the PIC remembers the peaks and calculates the trigger points. Also, by subtracting the negative peak from the positive peak and applying a bit of maths, the MIDI velocity (amplitude) of the note can be calculated too.

Immediately after this, the frequency can be measured using the trigger points as virtual comparator voltage levels. All this happens very quickly after the string has been plucked, so the waveform has not had a chance to alter.

Getting in tune

As you can imagine, measuring the frequency in this way could lead to accuracy problems. But as we are only interested in producing a desired note and not the actual pitch of the string, these errors can be eliminated by the use of a look-up table.

A range of frequencies either side of the required one will produce the same MIDI note, the switch points in the table being halfway between the guitar fret notes. This also, to some degree, compensates for tuning errors in the guitar. Obviously, the best results are achieved when the guitar is perfectly in tune.

Note on – Note off

To play a note on a MIDI sound module, the data must tell it when to start and stop the note, as well as its note value and the velocity (loudness). As mentioned earlier, the velocity is calculated by the peak-to-peak level of the initial plucked note.

To end the note, the software needs to continuously monitor the signal amplitude until it falls below a preset level, then send 'note off' data to the module. This is easily done by the peak level routine used earlier, and is fine if you want to wait for a note to stop before a new one can be played.

But in reality, this is really difficult to control to ensure no notes are missed. So the software also needs to check if a new note has been played and respond accordingly.

To do this, the last set of peak values are remembered and checked against the next set taken. If a string is plucked, the new peak values will be greater than the last, unlike a naturally decaying note where they will be less.

To guard against false triggering, it was decided to only start a new note if the peak values increase by a certain amount above the last read values. This gave a very fast and reliable response to the new plucked note.

Confused?

With all software applications, there is a chance that something in the outside world will not respond in the way that the software expects. In this case, when playing a series of quick notes, the situation can occur when the guitar note suddenly ends while the software is trying to time between two peaks.

The routine would keep waiting for the missing peak and only find it when the next note is played, by which time the calculations would be wrong. Eventually it would correct itself by another similar mistake!

So, it was decided to include a 'time out' option that would make the routine end and wait for a new note if the perceived note wavelength was longer than approximately 20mS (well below the bottom guitar note). This solved the problem.

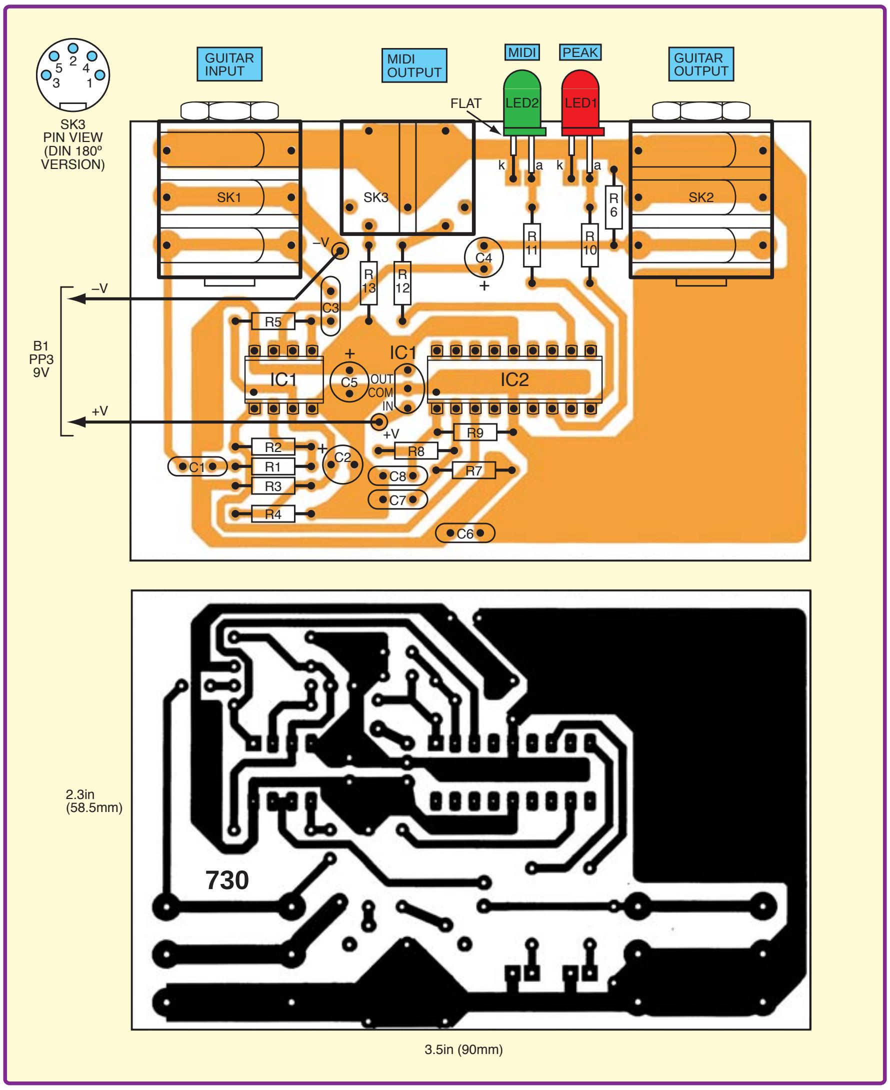


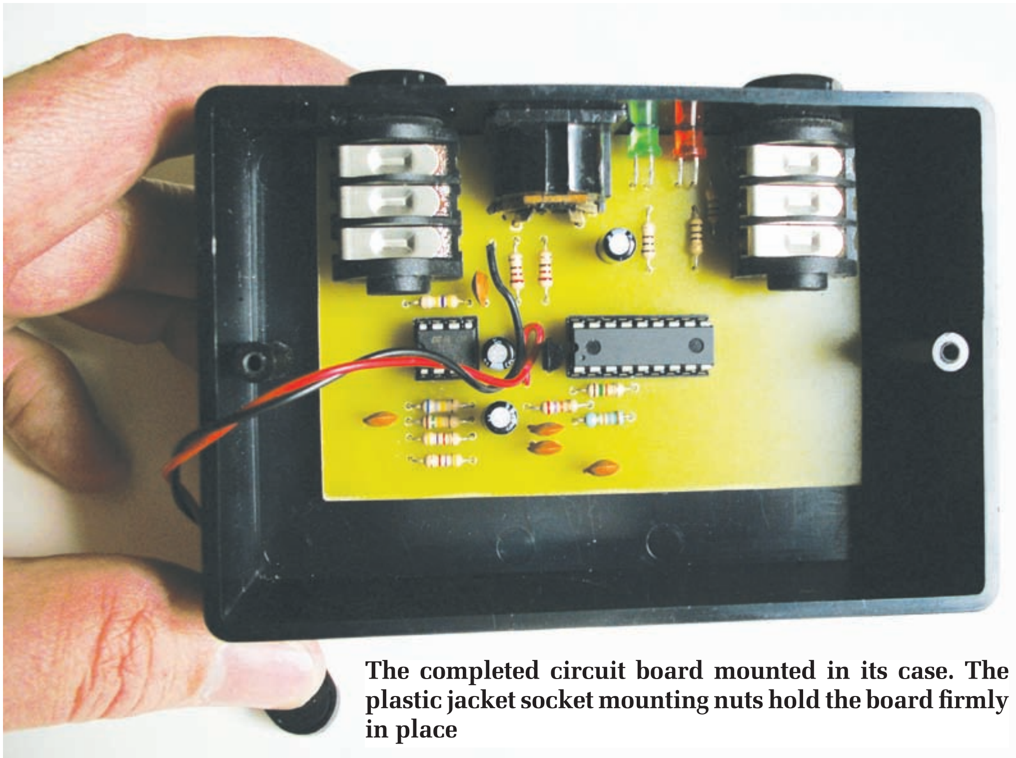
Fig.3. Printed circuit board component layout and full-size underside copper foil master pattern for the Guitar-To-MIDI System

Construction

All components, except the battery, are mounted on a small single-sided printed circuit board (PCB). This board is available from the *EPE PCB Service*, code 730. The topside component layout and full-size underside copper foil master pattern is shown in Fig 3.

Working from the smallest to the largest components, start construction by inserting the resistors and small ceramic capacitors. Follow this with the three radial electrolytic capacitors. Double-check that you have the correct value capacitors, and that their polarities agree with the component overlay (Fig.3), before soldering in position. You could also check your resistor values with your multimeter before inserting them on the PCB.

Your next task is to solder in position the two IC sockets and the voltage regulator, IC3. As they need to be placed the correct way around, you



The completed circuit board mounted in its case. The plastic jacket socket mounting nuts hold the board firmly in place

should refer to Fig.3 for their correct orientation on the board.

Do not insert the ICs in their sockets at this stage – they are 'plugged in' once the final assembly has been checked. In the case of the PIC (IC2), it is essential that a socket is used so that it can be removed for programming purposes.

It is probably a good idea if you insert the voltage regulator (IC3) first, as it makes handling this device easier, without the IC sockets being in the way. The body of the regulator gives the 'key' as to how IC3 is mounted on the PCB, see Fig.3.

Before soldering the two LEDs in position, you need to bend their pins over at 90°, about 5 to 6mm from their bodies. This is to allow their tops to just protrude through their holes in the side of the plastic case – see photos. The cathode (k) of the LEDs is the shorter lead, and is also recognized by being next to a 'flat' on the packaged body. Refer to Fig.3 for soldering details.

We now come to the PCB mounting jack sockets and DIN socket. You may need to enlarge the board holes to take these components – there's plenty of copper area around their holes to enable enlargement.

The input jack plug/socket (SK1) combination turns the unit on when the jack plug is inserted. This is usual for guitar effects pedals. An on/off switch could be inserted in the red (positive) battery lead if you wish.

Casing-up

Before soldering the battery leads to their copper pads, the almost completed PCB should be partly positioned inside its case and the drilling holes for the jack sockets, DIN socket and LEDs carefully marked on one sidewall of the case. You will need to refer to the photographs to get some idea of the drilling details of the plastic case.

Remove the PCB and solder the battery leads to the board. After giving it one final 'wiring' check, put the PCB to one side and concentrate on the plastic case.

You will probably need to drill a series of small holes around the circumference of the socket holes and then 'punch' them out to form the final socket mounting holes. Clean up the now large holes with a small half-round or round file. Note the DIN socket hole needs to be slightly larger than the component itself – to take the DIN plug – see photo.

Once the case drilling has been completed and the holes cleaned up, you can now start mounting the PCB in its case. The two plastic 'chassis' jack socket mounting nuts firmly secure the PCB in the case. Make sure the two LEDs just protrude through their holes.

You can now plug in the two ICs, connect the battery and close the lid of the case ready for 'playing'.

Software

The software files will be available via the *EPE* Library side, accessed via **www.epemag.com**. Pre-programmed PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Playing technique.

Finally, here are a few tips for getting the best out of the unit:

1) Always use a plectrum. This gives good strong peaks for the software to read.

2) Make sure that only one string is making a sound, ie the one you want! Open 'ringing' strings, especially the lower pitch ones will cause frequency beating with the desired string. Muting strings with the palm of your hand, helps to deaden the previous notes.

3) Do not pluck too hard, some high output pickups will overload the op amp and cause the waveform to clip, thus reducing the size of the peaks against the background harmonics. Keep an eye on the 'peak' LED and if it turns on a lot, reduce the guitar volume or pick softer.

It doesn't take much practice to become good at producing reliable MIDI note data, and as a by product, it improves your 'picking' technique. ***EPE***

Ingenuity Unlimited

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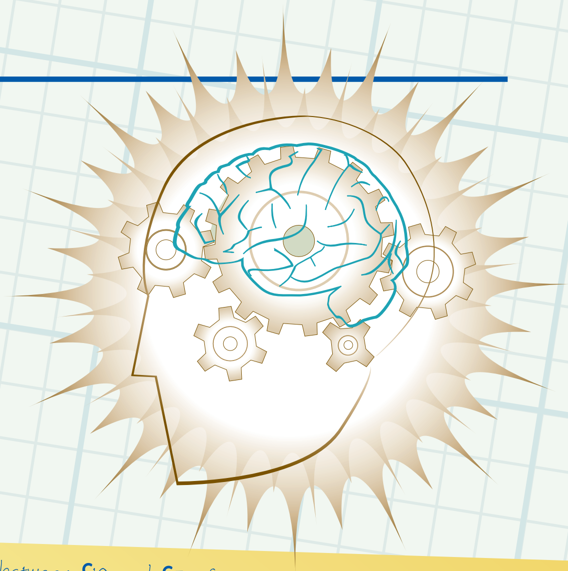

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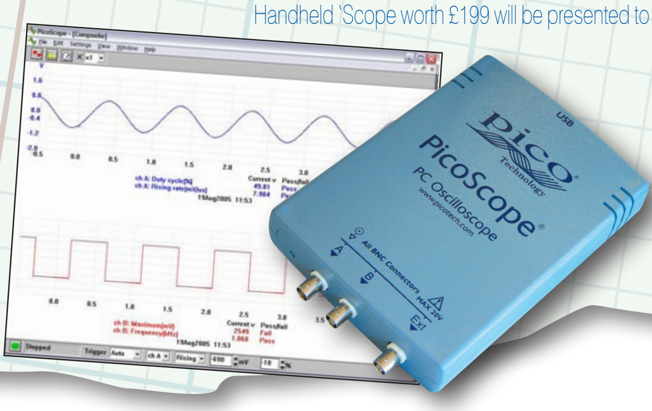

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Simplified Stroboscope – *Illumination*

THIS is a simplified version of the technical stroboscope. It has many uses in model engineering, for example diagnosing unbalanced rotating machinery or aircraft propellers, backlash in fast-moving valve mechanisms or vibration in structures.

The traditional strobe used a specialised gas-discharge lamp, which was expensive and fairly short lived. I get a similar effect by over-driving high-intensity LEDs. Their life might be quite short, but that doesn't matter too much if it gets the required result.

The circuit (Fig.1) is basically the well known 555 'hysteresis' oscillator, rather than the standard form found in the manufacturer's handbook. This allows the 'on' time and 'off' time to be controlled separately by diodes and leaves the discharge pin (7) free to drive the LEDs.

Fine frequency control involves the seldom used CV pin (5) and only affects the 'off' time. As shown, it gives approximately ±8% frequency variation. Because of the way the 555 operates, this percentage variation is the same at all pulse repetition frequencies (PRFs).

I use clusters of four to six parallelled LEDs cannibalised from cheap battery-powered lamps. Several clusters are connected in series

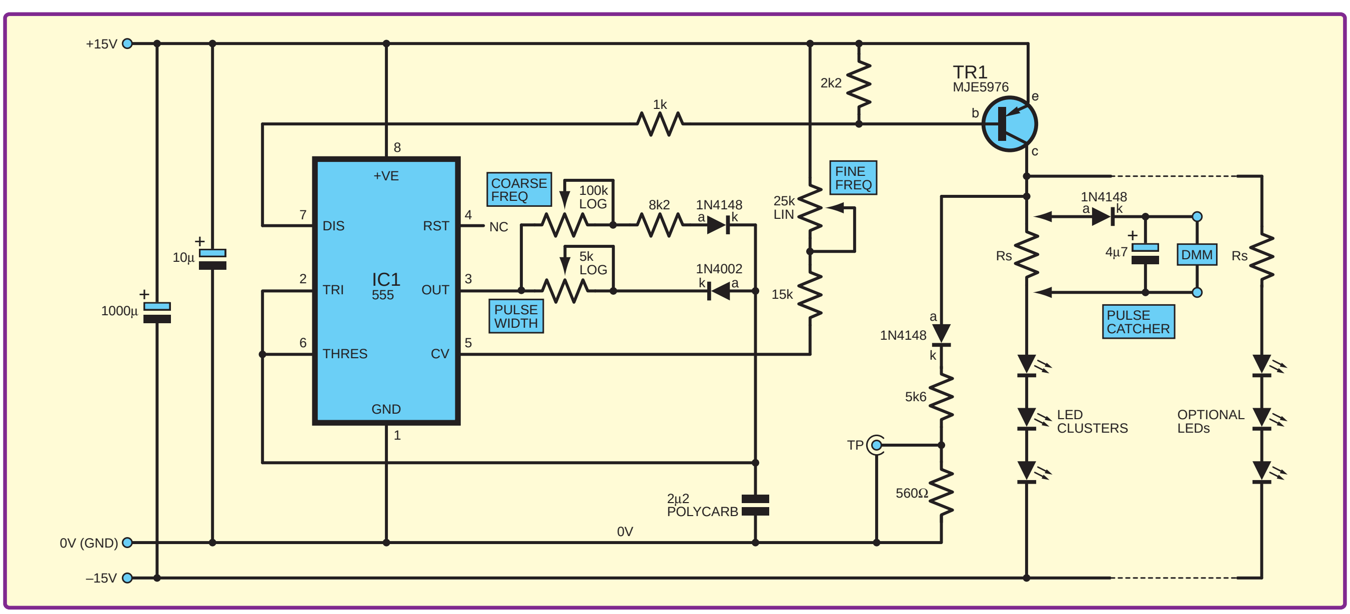


Fig.1. Circuit diagram for the Simple LED Stroboscope

with a current-limiting resistor Rs, chosen to give about 1A, say about 200mA to 250mA per LED. The circuit (inset) shows a 'pulse catcher' that allows you to measure the pulse voltage across Rs with an ordinary DMM.

Current hogging

The cheap LED clusters seem to be well matched, even at 200mA, and will share current happily. The dearer (and more powerful) LEDs tend to die of 'current hogging', when one LED steals all the current and promptly fails.

If this happens, individual LEDs can be connected in series strings, with each string having its own current-limiting resistor. At these power levels, LEDs need to be soldered with the shortest possible lead length onto a PCB with enough copper to carry away the heat. Otherwise, they can die of thermal shock when pulsed at low PRFs.

The *PNP* power transistor TR1 is a Motorola MJE5976 (60V, 10A, 90W) You can substitute any equivalent part with enough current gain (at least 150). No heatsink is needed. I used a +/-15V power supply because this was available. The rail voltages could be derived from batteries.

The shortest pulse width is about 40ms. The 5kΩ potentiometer will stretch this to about 8ms. With the components shown, the inter-pulse period varies from 20ms to 240ms (50Hz to 4Hz). Unless you can find reverse-taper pots, the pots are wired 'backwards', so the frequency is highest at anticlockwise to give a reasonable spread on the frequency scale. The test point (TP) allows you to monitor the pulses and measure the PRF.

There is no interlock to prevent you from over-driving the series resistors. These can have a low power rating, but they will fry if you use long pulses at high PRF, which you don't actually need. For normal strobe work a duty cycle of less than 1% is desirable.

In use

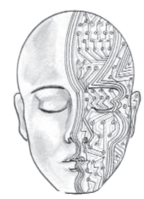
To use the strobe, set the shortest pulse width that still allows you to see the target. You will probably need to reduce the room lighting. Adjust the coarse frequency control to try and 'find' the image and use the fine frequency control to 'freeze' it or to 'phase' it slowly backwards and forwards. If the target is symmetrical then each part of it should be marked so it can be distinguished. Otherwise, you just see a mixture of the parts.

A PRF of 50Hz (3000rpm) is about the most that will be needed for use with machine tools. At this speed, a 40ms pulse gives less than one degree of rotational blur. Model aircraft engines can run at 12000rpm or more. A 50Hz PRF will show every fourth revolution at this speed, though 200Hz would be better. Working at very low PRFs can be quite painful, but it is possible to make good observations down to 2Hz.

Safety

Don't use this circuit if you suffer from epilepsy in any form. You should be familiar with safe working practice for rotating machinery. Always keep enough background lighting so you can see what you are doing. Be aware that working with the strobe may introduce a 'distraction factor' which can cause carelessness.

Walter Gray, Farnborough



Recycle It!

BY JULIAN EDGAR

Improving the sound of salvaged speakers

Looking to buy – or scrounge – a secondhand speaker system? There are plenty of bargains around and you can often improve their performance for very little outlay.

This pair of speakers was picked up at a local Salvation Army shop for £6 – a bargain!

ONE AREA of consumer electronics that hasn't fundamentally changed over the last 30 years is the design and manufacture of speakers. Whether they were originally connected to a record player, tuner, cassette deck or CD player, all boxed speakers use much the same technology. This means that the speakers you can now pick up at car boot/garage sales, the tip or secondhand are still very useful, no matter what music source you're using.

But nothing sounds worse than a really horrible speaker, so why bother sourcing cheap or no-cost discards? There are two main reasons: first, there are some very good speakers out there just waiting to be found; and second, if you have a half-reasonable starting point, it's not hard to make some major improvements for very little extra money.

Buying speakers

In most cases, you won't have a chance to listen to a speaker that you're collecting, so how do you make any judgements about how good it will sound? Here are some buying points:

1) Pick them up and feel their weight. Usually, heavier means better.
2) Detach the grille and inspect the cones. The roll suspensions should be intact and you should be able to manually move the bass driver back and forth without any binding (or interference) between the voice coil and the dust cap. Be wary if you cannot detach the grille.
3) Either a ported or non-ported design is fine, but in the case of ported speakers, the port diameter should be large enough to ensure that whistling or 'chuffing' noises do not occur. In other words, a tiny port diameter with a large diameter woofer isn't a good sign. Very large diameter (but short) ports are also unlikely to be indicative of a good design, as they'll be tuned to a high box resonant frequency.
4) Check the brand and any labelled specifications (eg, impedance and power handling). Often the specifications aren't very trustworthy, but the better the brand, the more the figures can be believed.

Inside each box was a decent small 'woofer' and a cone-type 'tweeter' with a single capacitor crossover.

5) Make sure that you will be able to open up the enclosure, either by unscrewing the drivers or by detaching the back.
6) Assess the condition of the boxes.

Making improvements

Once home, the first step is to listen to your newly acquired purchases. Hmm, sounds pretty bad? But what specifically is bad? Is the treble over-bright? Is the treble dull? Is the bass lacking, or perhaps all one-note?

Try the speakers on voice as well as on different sorts of music. In fact, listening to the human voice is a surprisingly good way of assessing the mid-range response. In addition, PC frequency generator software is freely available on the web and it's well worth downloading a suitable program. This can then be used to drive your amplifier and newly-acquired speakers across a range of input frequencies.

If the speakers sound absolutely awful, just chalk the episode down to experience and go find some more! But if they have potential, there's plenty you can do to improve their performance without much outlay.

Troubleshooting

Here are some of the problems you might find – and what you can do about them.

1) Problem: over-bright treble

Cure: install a resistor in the feed to the tweeter. Experiment with different resistor values and you'll soon get a feel for the changes that can be made. An 8.2Ω 1W resistor is a good place to start.

2) Problem: poor treble

Cure: replace the tweeter. Unless you fluke a direct drop-in replacement, this is often most easily achieved by cutting another hole in the baffle and installing the tweeter in a new spot. The old tweeter can then just be electrically bypassed.

If the grille cloth is dense and the treble improves with the grilles off, replace the cloth with a design that is more open-weave. (Just go to a dressmaking shop and buy black open-weave scrim fabric that's easy to see through when stretched.)

3) Problem: coloured midrange

Cure: in non-ported designs, place a loose fold of quilt wadding (or fibreglass insulation) inside the box. Aim to fill about 75% of the volume.

Alternatively, in ported designs, staple a thin layer of quilt wadding to the internal panels, making sure you don't block the port. As with grille cloth, quilt wadding is available very cheaply at dressmaking supply shops.

4) Problem: poor bass

Cure: in non-ported designs, fill three-quarters of the box with quilt wadding, as described above. Also, when the speakers are working hard, use a moistened finger to check for air leaks, especially around the terminal block and the edges of the woofer.

In ported designs, try changing the length of the port. Place a rolled-up cylinder of thin cardboard in the port and move it back and forth within the port to effectively lengthen the port by different amounts. Use the frequency generator software and your PC and make lots of listening tests.

The aim here is to reduce any bass resonant peaks – say, over the range from 30Hz to 150Hz. In most cases, the port will be too short rather than

The woofer and cone-type tweeter are mounted on a front baffle, which is easily removed. Note the rather odd port design and the large gap around the tweeter!

Another oddity was the internal box fill, which was rolled into a cylinder and placed at one end of the box (in front of the port?).

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 . . .)

If you have some practical ideas, write in and tell us!

A piece of scrap chipboard was used to close off the opening around the tweeter and the port. This was simply screwed and glued into place. The tweeter was then re-installed from the front and the gap around its rear magnet assembly closed off with sealant.

The grille cloth was reinstalled and the baffle glued back into place. And the results? Comparing the modified and unmodified speakers showed a much more natural sound. All that remains is to paint the boxes and then these will be great for the garage, or for the kids.

Some black spray paint concealed the blanking plate and the changed tweeter mounting.

too long. When you have found the right length, glue the cardboard in place.

It's easy to use a spray can to paint the insides of the new port black, so that no-one would ever know! Note that it's no big deal if the port is lengthened so that it protrudes through the front grille – after all, several very well known speakers come like this as standard!

5) Problem: speaker overloads

Cure: if the speaker is easily driven into bass distortion, fit a 200 F non-polarised capacitor in series with it. This will reduce the amount of bass being fed to the speaker, and it's an ideal approach if you have other speakers in the system (eg, a subwoofer) to provide the required 'bottom end'.

This also works well if you're using the newly acquired speakers as extension speakers, but still want the main speakers to be powered at high levels. Check out **www.jaycar.com.au/images_uploaded/crossovr.pdf** for the crossover frequencies that various values capacitors give in systems with different impedances.

6) Problem: cabinet finish

Cure: unless you've got yourself a really high-quality design, it's usually not worthwhile spending hours improving the finish of dilapidated boxes. However, one quick and easy approach is to give the box a quick rub back (or if it's a plastic finish, a wipe over) and then spray-paint the box matt black. It won't come up with a 'piano' finish, but the poor surface will no longer stand out and the 'cabinets' will look quite neat.

Finally, note that the sound that the speaker makes can be dramatically altered by its room placement. If speakers lack bass response, put them in the corners of the room. If the bass is strong and muddy, bring them out from the corners, or even try raising them off the floor on stands. Similarly, if the treble is muted, raise the speakers so that the tweeters are at ear level when you're seated. It's always worth moving speakers around – if you haven't done this before, you'll be amazed at how much you can vary their sound.

Conclusion

You don't have to spend a fortune to get good sound from low-cost secondhand speakers. In fact, with just a little work, you can often get them to outperform many mini and mid-sized off-the-shelf systems. ***EPE***

More internal fill (based on old quilt wadding) was added to supplement the original fill, which was replaced more loosely in the enclosure.

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INTERFACE

By Robert Penfold

VISUAL FREEDOM

Visual BASIC 6.0 is now at least three major versions out-of-date. Even so, many still seem to regard it as the best version of Visual BASIC, and the best programming language for many applications, including the production of software for home-built PC add-ons. There are probably two principal reasons for this, which are that it is the most 'visual' version of this language, and it is based on something very close to a traditional BASIC programming language.

Strangely, later versions became less 'visual' in approach, with the drawing components of version 6.0 being axed in favour of conventional programming methods. Rather than producing shapes on the screen and having the program generate the appropriate programming code, the user has to produce the code using conventional programming commands.

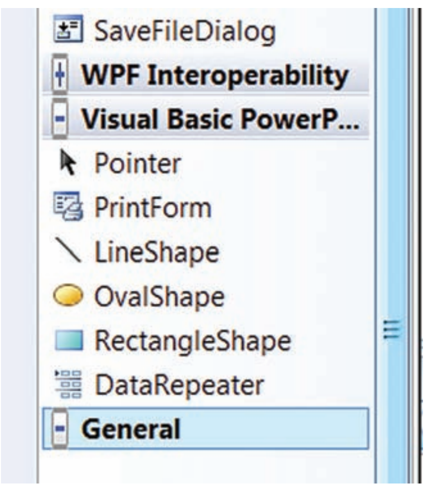


Fig.1. The Power Packs 3 components should be added to the Toolbox. If not, select Tools – Choose Toolbox Items, and then enable them using the dialogue box that appears

This tends to be a very much slower way of achieving the same thing, and it probably results in many programmers simply opting for a more fundamental approach with fewer graphics. The underlying programming language is now more powerful than the 'real' BASIC of version 6.0, but it has become more difficult to learn and use. It has also become somewhat 'over the top' for those producing relatively simple programs.

Free for all

Although Visual BASIC 6.0 has its advantages, and much of the software published in *EPE* has been produced using this product, it has become increasingly out-of-date, lacking full compatibility with later versions of Windows. Although they may be inferior in some respects, there is a huge advantage to the later versions of Visual BASIC, which is that they have been made available as free downloads from the Microsoft website.

The free versions are roughly equivalent to the Standard version of Visual BASIC 6.0 and its predecessors. However, they have a less stringent licensing agreement, which means that it is not limited to personal use. Users are free to distribute their programs, commercially or otherwise. This degree of freedom had previously required the user to purchase the more expensive Professional version.

The current free version of Visual BASIC is Visual BASIC 2008 Express Edition. Actually, the entire Visual Studio suite of programs is available as a free download, but it is not necessary to download and install the complete version. Individual programming languages such as Visual BASIC or Visual C# can be downloaded and installed.

In order to go on using any of them beyond the trial period it is necessary to go through a simple registration process and obtain a product code. Having done so, the program can be used indefinitely. There is no charge of any kind for registering any of the Express Edition programs.

Although drawing components are absent from all the current versions of Visual BASIC, and not just the free version, it is possible to add them using a free add-on. The current version of this freebie is called Power Packs 3, and it actually provides more than some drawing components. However, the improved graphics capabilities are probably the only additions that are of interest in the current context.

The drawing components do not operate in exactly the same way as those in Visual BASIC 6.0, but they are broadly similar. They also seem to be much the same as in the earlier Power Packs.

One important respect in which they differ from the equivalent components in Visual BASIC 6.0 is that they operate with a different coordinate system that uses much lower resolution. The new coordinate system seems to be based on screen pixels, and it is probably something that has been enforced by changes to the Visual BASIC programming language.

Getting into shape

With the Power Packs 3 software installed, the Visual BASIC Toolbox should include a separate section for the new Power Packs components (Fig.1). Only three of these are of interest here, and these are the LineShape, OvalShape, and RectangleShape components.

These provide the basic shapes indicated by their names, but they can actually provide a little more than the basic shapes. The required shape is produced by first selecting the appropriate component and then dragging it onto the form in the normal fashion.

Visual and snap grids can be displayed on the form, and can make it easier to get things correctly sized and aligned from the outset. Neither are used by default, but they can be switched on by selecting Options from the Tools menu, and then going to the Windows Forms Designer section and the General subsection (Fig.2).

Set a suitable grid size (in pixels) and set the LayoutMode to SnapToGrid. The

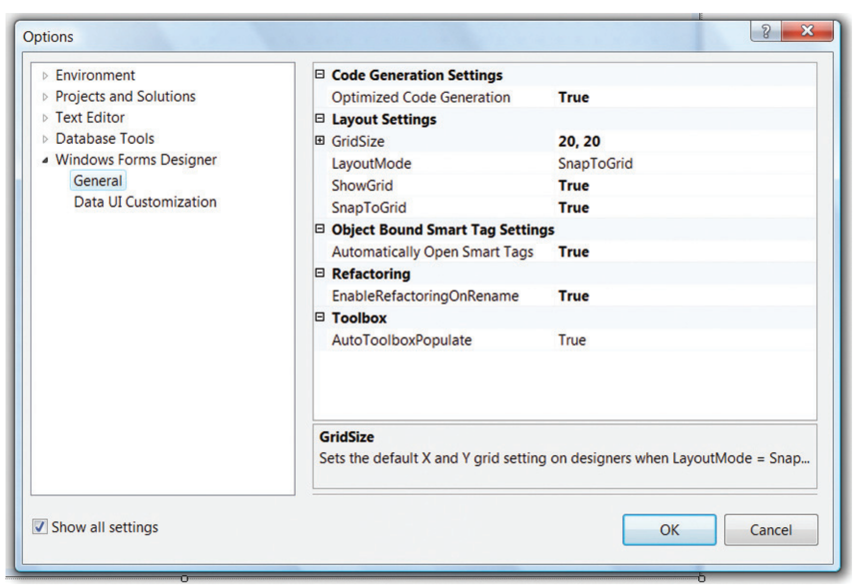


Fig.2. It is possible to switch on a snap grid and a grid of dots on the form. Both can be very useful when adding graphics to a form, and they can also be helpful with other components, such as buttons and text boxes

ShowGrid and SnapToGrid settings should both be set at True. I find it confusing that making these changes will not cause the grid to appear immediately. The form must be closed and reopened, after which the visual grid should appear and the snap grid will become operational.

There are other aids that make it easier to produce the perfect screen layout, including a range of automatic alignment and sizing options under the Format menu or the Layout toolbar. Among other things, these can be used to set groups of objects to the same size, to align them horizontally or vertically, and to increase or decrease the spacing. Last and by no means least, do not forget that the Properties window for an object allows its size and position to be set with one pixel resolution, making it easy to do any necessary 'fine tuning'.

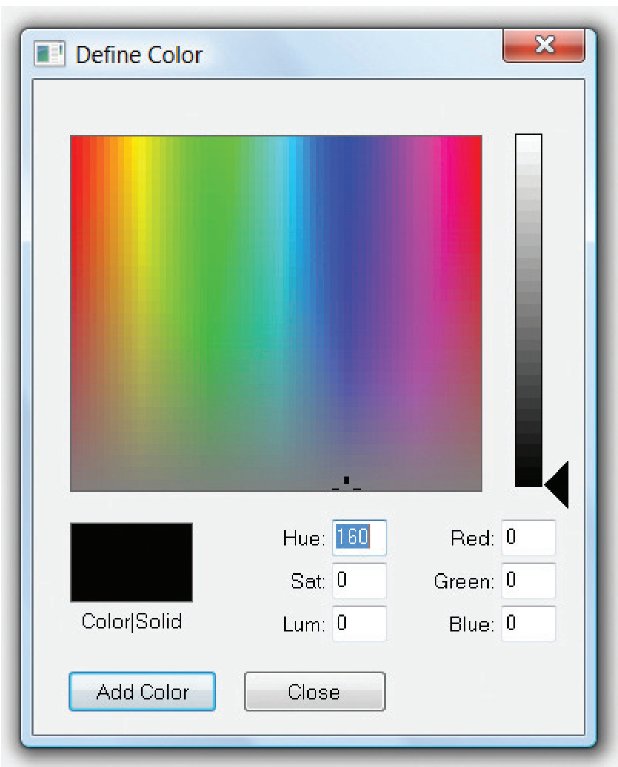


Fig.3. Various preset colours are available, or you can mix your own using the Define Color window

Back to front

With anything more than very simple graphics objects it is necessary to use several shapes, often with them overlapping, or with smaller objects on top of larger ones. It then becomes necessary to get the objects layered in the correct order, or smaller objects will disappear behind larger ones. The Format menu has an Order submenu, and this has Send to Back and Send to Front options that respectively take an object to back or front of a stack of objects. The same options are available from the Layout toolbar.

Of course, the tools for sizing, aligning, and layering objects are not just available for shapes. They can be used with any visible components, and are invaluable for getting neat rows of control buttons, columns of labels, or whatever. Bear in mind that shape objects cannot be used in front of components such as labels and buttons. The shape objects are effectively part of a fancy background, and other types of component will always appear in front of them.

In practice, it is unlikely that it would be necessary to have a shape appear in front of another type of component, so this is probably not a major limitation. Fortunately, the shape components can be used to generate events such as a click event, so it is possible to use them to produce fancy control buttons.

Thrill of the draw

The default settings for shapes give a simple black outline and nothing more, so it is usually necessary to go to the Properties window and do a fair amount of formatting in order to produce something more exciting. At the very least, it will usually be necessary to change the FillStyle from Transparent to Solid, and to set the required FillColor.

For most purposes, the predefined colours will suffice, but it is possible to define your own by going to the custom section and right clicking one of the blank rectangles. This brings up the Define Color window (Fig.3) where any desired colour can be selected.

There is the option of using a gradient fill, and this can be useful for producing things such as more realistic indicator lights, which can give much more professional looking results. An oval shape with the same height and width set in the Size parameter produces the basic circle for a light. The outline is set to the desired width via the BorderWidth parameter.

A black border is used by default, but an alternative can be selected via the BorderColor setting. A dark grey often looks better than the black default colour. The FillGradient and FillStyle should be set to Central and Solid respectively.

Using a Central gradient gives what is more usually termed a 'radial gradient'. The user selects a central colour and any different colour for the outer parts of the shape. A gradual transition from one to the other is then provided.

In the current context, a simple indicator light effect can be obtained by using a bright colour in the centre of the circle and a much darker version of that colour at the perimeter. Different colours can be used, such as green for 'on' and 'red' for off, or the 'off' state can be indicated by using much darker versions of the same colour. Four virtual indicator lights that are switched on are shown in the top row of Fig.4, and their off versions are shown in the bottom row.

A radial fill can be used with the rectangular shape, so you can have square or rectangular lights if preferred. Bear in mind that the FillColor is the one at the edge of the shape and the FillGradient is the one at the centre. This is perhaps the opposite of what one might expect.

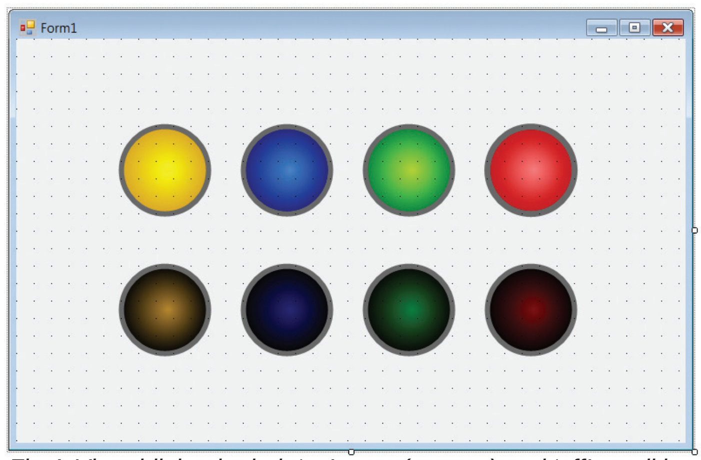


Fig.4. Virtual lights in their 'on' state (top row) and 'off' condition (bottom row). Unlike the real world, virtual blue LEDs do not cost extra

In Control

When dealing with shape components it should be remembered that nearly every parameter can be altered by the program. A change of colour simply requires the program to set a new FillColor, and where appropriate, a new FillGradient as well. This will often involve reading a port, using a bitwise AND instruction to read the appropriate bit, and then using a conditional instruction to set the appropriate colour depending on the state of that bit.

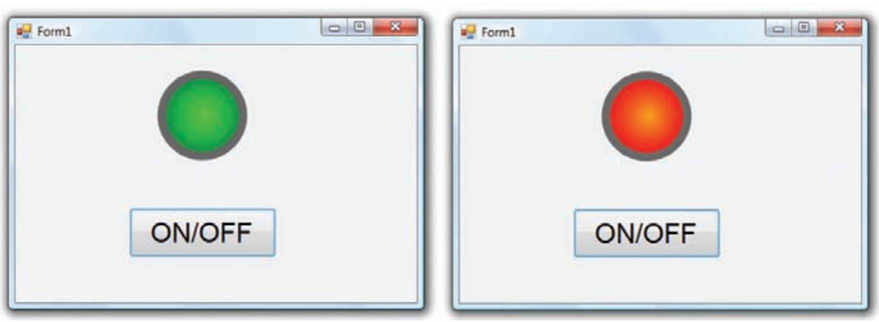


Fig.5. Operating the button toggles the virtual light between red and green states. Practically any aspect of a shape component can be controlled by the program, and the shapes can also be used to generate events

Virtual lights are sometimes used in conjunction with control buttons to indicate the state of the button. In the simple example of Fig.5 (left), the button has been pressed and the light has gone to green. In Fig.5 (right) the button has been pressed again and the light has returned to the red state.

Listing

The simple program of Listing 1 is all that is needed to make the virtual light operate in the required manner. The first If...Then...Else instruction changes the fill colour to green if it is currently red. If it is not currently red, then it must be green, and the Else part of the instruction sets it to red. The second If...Then...Else instruction provides a similar function, but for the gradient colour.

As already pointed out, the shape components themselves can be used to generate events, making it possible to produce things such as buttons with built-in lights, and 'illuminated' analogue displays. As explained in previous *Interface* articles, the LineShape component makes it very easy to produce analogue displays.

Listing 1

```
Public Class Form1

    Private Sub Button1_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button1.Click
        If OvalShape1.FillColor = Color.Red Then OvalShape1.FillColor = Color.Green Else OvalShape1.FillColor = Color.Red
        If OvalShape1.FillGradientColor = Color.Orange Then OvalShape1.FillGradientColor = Color.Lime Else OvalShape1.FillGradientColor = Color.Orange
    End Sub
End Class
```

Obviously, the add-on shape components and the basic editing tools of Visual BASIC fall well short of the facilities provided by an illustration program, but the basic elements and features are there, making it possible to produce some useful screen layouts. However, do not waste time 'reinventing the wheel' by overlooking the built-in components and the various add-ons available for Visual BASIC.

More information and a download link for Visual BASIC 2008 Express edition can be found at:

http://www.microsoft.com/express/vb/Default.aspx

More information about Power Packs 3 and a download link can be found at:

http://msdn.microsoft.com/en-us/vbasic/bb735936.aspx

Poles and Zeros

WE originally intended to conclude the series of articles on filters last month, but we have received some emails asking for more information. So we shall continue to look at some related topics, starting with 'Poles and Zeros' in response to the following email from ***(Sam) Zack*** of Ontario, Canada.

Thanks for the very interesting topic on Filter Circuits in EPE *July '09 issue. I have found something which is not very clear for me about Zeros and Poles.*

*As we know, the gain is defined as the ratio between the output and the input, so as I understand it, at a zero break frequency the gain should reach zero, and at a pole break frequency the gain should become infinity. But the frequency domain response graph (*EPE *July '09, page 57, Fig.3) shows that at a pole (pole 1) the gain decreases and does not increase. Why the opposite response?*

In the previous article, we mentioned poles and zeros because readers will come across these terms when consulting datasheets, application notes or other technical documents relating to filter circuits or filter design software. For the benefit of readers who do not have the previous article to hand, the following paragraph recaps the description which we gave then.

When analysing filters, we find critical frequencies (or break frequencies) at which the response (ie, the gain) of the filter is zero or infinity. These points are called '*zeros*' and '*poles*' respectively. Poles cause the gain of the filter to decrease with increasing frequency, with the eventual rate of decrease being 6dB/octave or 20dB/decade. Zeros cause the gain of the filter to increase with increasing frequency, with the rate of increase being 6dB/octave or 20dB/decade at sufficient distance from the zero. Poles make the phase shift more positive by 90 degrees per pole, and zeros make the phase shift more negative by 90 degrees per pole.

But this is not the whole story. As we pointed out at the time, the zero and infinite gain refer to the response in the *complex frequency domain*, not in 'ordinary' frequencies. Unfortunately, a full treatment of this topic requires some advanced mathematics, which most people would only encounter if they attended a mathematics, engineering or science course at university; and even then it often takes a while to get to grips with it.

Transformation

A rigorous mathematical description of poles and zeros is beyond the scope of *Circuit Surgery*, but this month we will try to give a feel for what is involved. One of the key concepts is the idea of mathematical transforms. With this approach, a problem is shifted from a form in which it is difficult or impossible to solve into a transformed 'domain', solved in that domain and then the solution is transformed back into the original form.

A simple example of transforming a calculation to make it easier is taking logarithms. Tables of logarithms were used extensively before the days of pocket calculators and personal computers. For example, to solve $x=3.7^{2.5}$ with just pen and paper may be quite difficult. But if we transform the problem into the log domain we get:

$\log(x)=\log(3.7^{2.5})=2.5*\log(3.7)=2.5\times 0.568=1.42$

so $x = \text{antilog}(1.42) = 26.3$

We look up log 3.7 in the table, multiply the result by 2.5 and look up the result in the inverse table to get x (26.3). We solve $x=3.7^{2.5}$ by solving the transformed problem 2.5×0.568. When using a slide rule with a log-log scale, the transformation process is in effect 'built-in'.

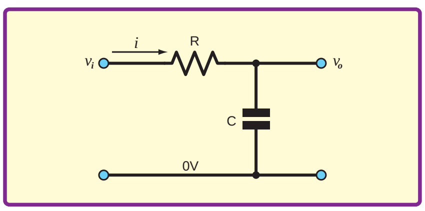


Fig.1. A basic RC low-pass filter

So why do we need transforms in circuit analysis? We can illustrate this with an attempt at mathematical analysis of the circuit in Fig.1, which should be familiar to many readers as a simple RC low-pass filter. Do not worry too much if you don't fully understand the mathematics in the next few paragraphs; the main message is that even simple frequency dependent circuits are described by equations which may be very difficult to solve.

Circuit analysis

To analyse the circuit we will assume that no current flows via the output, so the currents in the capacitor and resistor must be equal (the current i on the schematic).

The current in the resistor is related to the current voltage across it by *Ohms law*, so we have:

$$v_i - v_o = iR$$

For a capacitor, the current is determined by the *rate of change* of voltage across it. This is a more fundamental view of what a capacitor does in a circuit than its impedance – which is probably what you would have used if asked to solve the circuit; but we are going back to basics here.

The rate of change of voltage times the capacitance gives the current into the capacitor. 'Rate of change' can be expressed by the differential term *dV/dt* (spoken as 'dV by dt'). *dV* represents the voltage change in the infinitesimally small amount of time *dt*. So we have:

$$i = C\frac{dv_o}{dt}$$

If we substitute Cdv_o/dt for the i in the first equation we get

$$v_i - v_o = RC\frac{dv_o}{dt}$$

which we can arrange so that all the output V_o terms are one side and all the input V_i terms are on the other, to give us an equation relating the input voltage to the output voltage (ie, a version of the transfer function).

$$v_o + RC\frac{dv_o}{dt} = v_i$$

This is what mathematicians call a *differential equation*. All circuits build from various combinations of resistors, capacitors and inductors (with at least one capacitor or inductor), and all the active filter circuits that we have been looking at for the last three months can be characterised in terms of differential equations. These are the fundamental descriptions of what the circuits do in the *time domain* (note that the equation has time (t) in it).

In principle, we could use the differential equation of a filter or other similar circuit to work out exactly what it would do for any input signal. Unfortunately, this involves solving the differential equation, which happens to be very difficult and in many cases impossible to do directly. This is where transforms come to the rescue.

The basic idea is illustrated in Fig.2. We take a circuit in which the input and output signals (*x(t)* and *y(t)*) and the input-to-output relationship *f(t)* are described in terms of how things vary with time and transform this into another form using another variable, *s*, instead of time.

If we know *x(t)* and *y(t),* we have to solve a differential equation to find the output *y(t)* in the time domain, but in the transformed system we use, the output is simply given by $Y(s) = H(s)X(s)$, that is, we can just multiply the input signal by the transfer function to find the output.

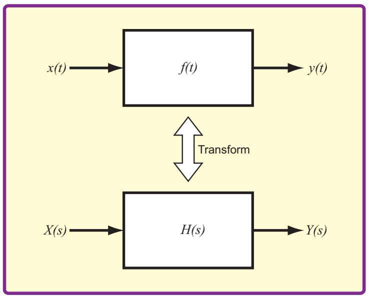


Fig.2. We transform the description of a system from a time domain function to some other form in order to solve problems such as finding the input-output relationship. The result of a calculation can then be inverse-transformed back

Sinewave fundamentals

Before looking at the transform itself, it is worth looking at some of the properties of sinewaves, which helps explain why the transform works.

Adding a set of sinewaves of the same frequency produces another sinewave at that frequency, even if the phases (relative time shift) of the sinewaves are not equal. This is not true for any other periodic (repeating) waveform.

Also, sine functions are easy to differentiate – you get another sinusoidal function – so, if our circuit is described by a differential equation we will be able to solve it (ie find the output) if the input is a single sinewave. With a more complex input wave we will be unlikely to be able to solve the differential equation directly.

Another key fact is that any waveform can be formed by adding together a set of sinewaves of various frequencies and different amplitudes. This 'sum of sinewaves' is known as a *Fourier series* and was developed by Jean Baptiste Joseph Fourier (1768–1830), a French mathematician and physicist, while studying mathematical modelling of heat transfer. Readers may be familiar with this in the context of the Fourier analysis provided by some oscilloscopes, and which produces a spectrum showing the relative amplitude of the frequencies present in the signal.

For example, a square wave may be described as being at 1kHz, but this is just the *fundamental frequency*; there are other frequencies present too. For the 1kHz square wave, the sinewaves which can be added together to form it are approximately (first figure is amplitude)

1.27 at 1 kHz
0.42 at 3 kHz
0.25 at 5 kHz
0.18 at 7 kHz

and so on to infinity.

Recap

So, to recap, first, we can represent the signals in our circuit as sums of sinewaves; and second, sinewave functions make the differential equations easy to solve. This means we can find the output of any (linear) circuit, for any input signal, by breaking the input down into constituent sinewaves, solving the differential equation for each one in turn, and adding all the individual output contributions together to find the final output. If this sounds laborious, don't worry the transform does all this for us.

This almost gets us to the transform we need, but there are a couple of additional complexities. First, the sum of sines' as a list of discrete frequencies, as in the square wave example above, does not work for certain types of waveform We need a refinement in which we use a value which varies con inuously with frequency, rather than just a set of specific frequency points.

The other issue is that frequency alone is not enough to define the sinewave contributions to our signal; we have to take account of phase as well. To do this we use a system of two-part numbers, which effectively encapsulate both the phase and frequency information for each wave.

These two-part numbers are known as *complex numbers*; the two parts are called the *real* and *imaginary* parts. The term 'imaginary' is employed because the square root of –1 is used in this type of mathematics. There is no 'normal' number which when multiplied by itself gives –1, but it is a very useful mathematical concept for describing things that really happen.

In pure mathematics, the square root of –1 is given the symbol *i*, but in electronics the symbol *j* is usually used to avoid confusion with the symbol for current. A complex number is one of the form

$$a + jb$$

in which *a* and *b* are real (normal) numbers and $j^2 = -1$. *a* is referred to as the real part of the complex number, and *jb* is the imaginary part.

The variable *s,* which we use in the transformed versions of our signals and transfer functions, is a complex number given by

$$s \ = \sigma + j\omega$$

s is referred to as the complex frequency.

So, the transformation of our circuit problem takes us from the time domain into the complex frequency domain.

In *s*, ω is 'angular' frequency, measured in radians per second. To convert a frequency from cycles per second (Hertz) to radians use $\omega = 2\pi f$, where *f* is the frequency in Hertz. If you have not met angular frequency before, don't worry too much – you probably have in fact been thinking in this way if you have ever used the idea of *phase shift*.

The complete cycle of a waveform is 360 degrees, which is 2π radians (degrees and radians are two ways of measuring angle: we use whichever is most convenient). A phase shift of 90˚ is a quarter of a cycle, or π/2 radians. The reason that angular frequency (ω) is used is because this makes it easier to manipulate equations in which we are dealing with both frequency and phase shift (because they are both in 'angular' form).

Laplace transform

And finally we get there! The transform that takes us from the time domain into the complex frequency domain is called the *Laplace transform* and was developed by the French mathematician Pierre-Simon marquis de Laplace (1749–1827). The complex frequency domain is also referred to as the *s-domain* or *Laplace domain*.

The Laplace transform takes a mathematical function describing, in the time domain, either a circuit transfer function r a signal, and converts it into a form related to the summation of an infinite number of sinewaves at infinitesimally closely spaced frequencies (actually, of course, they are complex frequencies).

Written in a formal mathematical way, the Laplace transform is defined as

$$X(s) = \int_0^\infty x(t)e^{-st}dt$$

Where *x(t)* is the function (circuit equation or signal function) being transformed and *X(s)* is the transformed result. *s* is as defined above. e^x is the exponential function, which you should find on any scientific calculator, either as an **ex** key or as an **exp(x)**. The number *e* is sometimes called Euler's number and has a value of approximately 2.71828. There is a similar inverse transform equation which get us from *X(s)* back to *x(t)*. Again, do not worry if the maths symbols do not mean much to you, it is the concept behind it (as described above), which is of importance in this article.

From the previous discussion, you may have expected to find a sine function in the Laplace transform equation. In fact, it is there, because there is a close relationship between sine and cosine functions and exponentials of complex numbers (remember *s* is a complex number).

This relationship, which was discovered by Swiss mathematician Leonhard Paul Euler (1707–1783), is called *Euler's formula* and is regarded as one of the most important developments in mathematics. The e^{-st} in the Laplace formula actually 'contains' a sinewave and a cosine wave (sine wave with 90° or π/2 radians phase shift).

Using the Laplace transform as described above seems like a lot of work, but in practice it is often straightforward because the transforms of well know functions are readily available in tables (echoing the use of log tables we mentioned earlier). Furthermore, and this is very important, we can 'Laplace transform' the impedances of basic components and then use familiar circuit analysis techniques to obtain the Laplace transfer fu ction of the circuit. This means we do not have to find the transfer function and then try to calculate the transform, which would usually be more difficult.

The Laplace impedance of a capacitor is $1/sC$ and for an inductor it is sL. For a resistor it is simply R, because resistors are not frequency dependent. You may have noticed a similarity with a more familiar form of the impedances for C and L.

Now $s = \sigma + j\omega$, but if we only consider a value for which $\sigma = 0$ we get $s = j\omega$. If we just consider the magnitude of the complex value (its numerical 'size') then we get ω, converting to Hertz, we have $\omega = 2\pi f$. Under these simplified conditions we can replace s with $2\pi f$. Substituting this into the Laplace impedance of a capacitor, $1/sC$, gives the familiar $1/2\pi fC$ for its impedance.

What was the question?

At this point you may have forgotten Zack s original question, w ich was about the effect poles and zeros have on the frequency response The reason we have developed the idea of transforming the circuit into the s-domain is beca se his is where the poles and zeros really exist If you only think in terms of ordinary' frequency (as we assume Zack has) rather than the complex frequency, s, the apparent properties of poles and zeros may seem misleading

We will illustrate poles and zeros from an s-domain perspective using the simple *RLC* bandpass filter shown in Fig 3. The total impedance of the serie inductor resistor and capacitor, sing s-domain impedances, is $sL + 1/sC + R$. We can divide v_i by this to get the current through the ircuit. Mul iplying this current value by R gives the output oltage, v_o. So we get the following formula for the gain in the s-domain.

$$H(s) = \frac{v_o(s)}{v_i(s)} = \frac{R}{sL + 1/sC + R}$$

Multiplying the top and bottom of the equation by s/L gets it into a more convenient form.

$$H(s) = \frac{(R/L)s}{s^2 + (R/L)s + (1/LC)}$$

If we do not attempt to choose realistic component values and just set R=1, C=1 and L=1 for the sake of simplicity, we get:

$$H(s) = \frac{s}{s^2 + s + 1}$$

Zeros occur when $H(s)$ is zero, that is when the numerator is zero, which in this case occurs when $s = 0 + j0$. Poles occur when $H(s)$ becomes infinite, which happens when the denominator is zero.

In this case, setting the denominator to zero gives us a complex quadratic equation:

$$s^2 + s + 1 = 0$$

This has two solutions:

$$s = -\frac{1}{2} + j\frac{\sqrt{3}}{2} \text{ and } s = -\frac{1}{2} - j\frac{\sqrt{3}}{2}$$

These are the poles of $H(s)$.

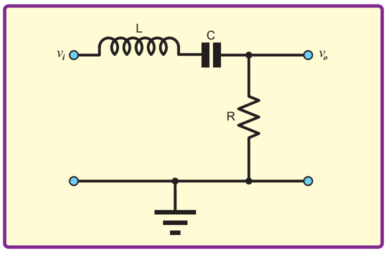


Fig.3. RLC bandpass filter

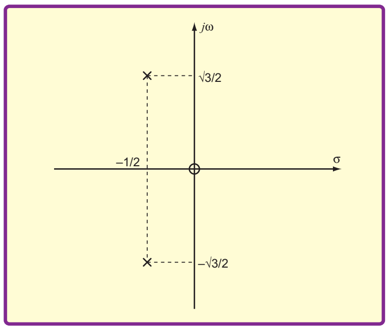


Fig.4. Pole-zero diagram for the circuit in Fig.3

S-plane

As s has two 'dimensions' (σ and ω), we can show any value of s as a location on a 2D graph, with coordinates given by the values of σ and ω. This is referred to as the *s-plane* (or in more general terms, the *complex plane* or *Argand diagram*). It is useful to plot the locations of the poles and zeros of a transfer function on such a graph. This is known as a *pole-zero diagram*. The pole-zero diagram for the circuit in Fig.3 is shown in Fig.4.

The pole-zero diagram can provide useful insights about a circuit for people familiar with its properties. For example, if any poles occur on the right hand side (right of the ω axis) then the circuit will be unstable It is possible to work out how poles will move around the diagram as things change in the circuit (eg, as the gain of an amplifier changes). This can be used to investigate what conditions will cause a system to become unstable.

To visualise the effect of poles and zeros on a transfer function it is useful to plot a full three-dimensional graph of $H(s)$. Such a graph for the circuit in Fig.3 is shown in Fig.5. It might help to think of this as a large rubber sheet, under which vertical poles are placed (at the poles of course) and which is pinned to the floor wherever a zero occurs.

We can effectively see the usual frequency response within the 3D pole-zero plot by looking at the height of the surface directly above the positive ω axis. This is illustrated in Fig.6.

Summing up

A key point to note in finally answering Zack's question, is that, in general, the poles and zeros do not coincide with the frequency response line; that is they are generally not directly on the ω axis of the

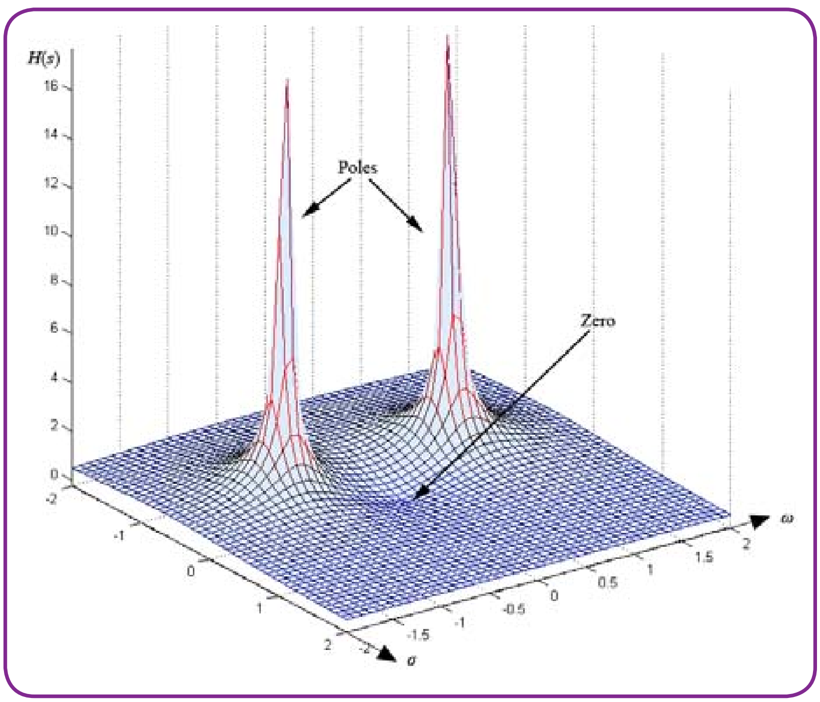


Fig.5. 3D plot of the s-domain transfer function of the circuit in Fig.3.

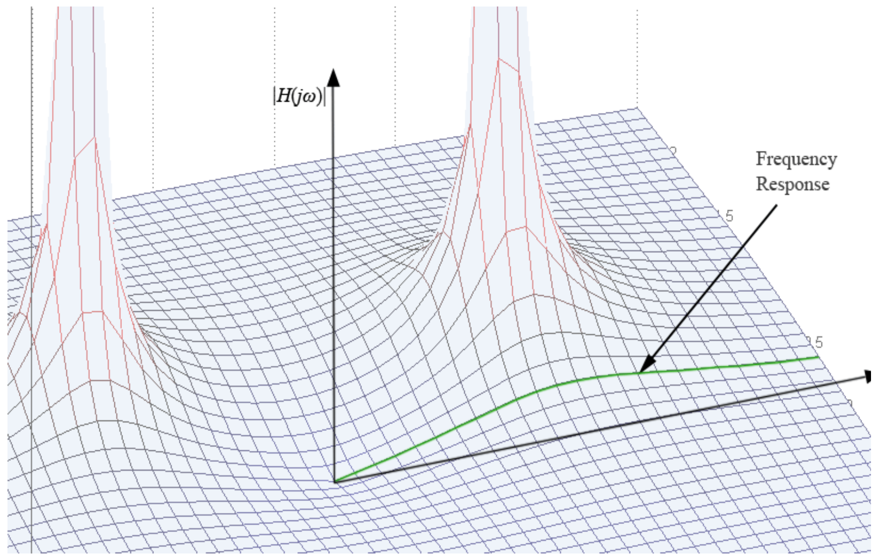


Fig.6. Showing the relationship between the 3D s-domain plot and frequency response. This is a zoom-in on part of Fig.5. Note that frequency response here has linear axes unlike a conventional log plot

s-plane, with the exception of zeros at the origin, as in our example. If poles occur on the ω axis this implies the output of a steady sinewave of frequency ω and the concept of frequency response is not meaningful under such conditions.

The *s*-domain gain is infinite at the poles, but remember we are looking at a *transformed* version of the circuit response, and the value of *s* does not have such a direct meaning as the physical gain being infinite at the pole frequency. To get some intuitive understanding of the direction of change in the frequency response caused by the poles and zeros, the rubber sheet view of the 3D plot is useful.

If the sheet is pinned down to zero at a particular frequency, then the gain will *increase* as we move away from that point. Similarly the poles pull the sheet up at their location, but it slopes downwards (gain *decreases*) away from this point. The poles are not directly on the frequency response line (above the ω axis) so they influence the response curve from a distance across the *s*-plane.

Zack's question seemed simple enough, but we needed to review a large body of the most important mathematics relating to electronic circuit design in order to answer it. We have attempted to explain the ideas without using too many equations or mathematical derivations, and hope readers without an advanced mathematics background have been able to follow the discussion.

If you would like to know more, there are numerous textbooks aimed at university students with titles like *Signals and Systems*, which treat the subject in depth. You can also search the web using the terms we have introduced in this article, such as 'Laplace transform'.

Max's Cool Beans

By Max The Magnificent

ONE of the hot topics on everyone's lips these days is that of 'Power'. I'm not waffling on about the 'I want to rule the world' variety; instead, I'm talking about optimizing and reducing the amount of power that is consumed by ... well, all sorts of things really...

Motors

Let's start by pondering electric motors, which are ubiquitous and appear in a seemingly infinite variety of applications, including residential (refrigerators, fans, washers, pumps...), commercial (heating, cooling, ventilation...), and industrial (actuators, robotics systems...).

Have you ever wondered just how many motors there are and their impact on the environment? In fact, over 20 million motors are produced every day around the world, which equates to more than seven billion new motors each year. And how much energy do these little rascals guzzle? Well, as one example, it is estimated that motors consume over 50% of the total energy production in the United States.

Larger motors tend to be the most efficient, because they are constructed from the ground up with efficiency in mind. The theoretical maximum efficiency for a motor is around 95%, and the larger motors typically achieve 93% to 94%. Unfortunately, for every large electric motor there are tens of thousands of smaller ones, the vast majority of which are highly inefficient. The efficiency of small AC motors, for example, can be as low as 50%.

What does this mean? Well, if a motor is 50% efficient, then only half of the power it consumes is being converted into useful work; the other half is burned off as heat, which means each motor is actually acting like a small (or not-so-small) radiator. This can add up to a huge amount of 'lost' energy in an industrial setting like a factory, which actually receives a 'double whammy.' This is because it is now necessary to provide cooling systems to remove the undesired heat, and these cooling systems use ... you guessed it ... yet more inefficient electric motors.

One solution is to add intelligent load-matching and variable speed control, which can increase efficiency by anywhere from 14% to 30%. Implemented broadly, electronic motor control could result in savings of as much as 15% of the total electric power used in the US. This equates to an annual reduction in energy consumption of as much as 300 billion kWh, thereby saving $15 billion and reducing greenhouse gasses by more than 180 million metric tons a year. When extrapolated on a worldwide basis, the potential savings are staggering.

Laptop Computers

Have you ever noticed that the battery duration claims made by the manufacturers of notebook and laptop computers bare only a tenuous relationship with reality?

Actually, I don't know about you, but I'm a fool to myself, because I keep on falling for this sort of stuff. Whenever I purchase a new laptop computer I read the specs and say "Ooooh, mega-cool, this one will last for xxx hours before the battery needs recharging!" And then the first time I get on a plane I'm surprised when my battery is drained after only half the specified time (if I'm lucky).

It's awkward enough if all you're doing is watching a DVD or playing a game, but it's a real pain if your battery dies just before you finish a critical report or presentation, like the young lady caught on camera on the left.

The reason I mention this here is that a company called Rocky Research has just launched a product called the Laptop Warrior (**www.LaptopWarrior.com**). This little scamp is presented in the form of a USB memory stick that you plug into your laptop (see below). As soon as you do so, Warrior's auto-running software immediately leaps into action, constantly analysing the system and dynamically optimizing it to maximize its battery life between charging cycles.

It replaces and outperforms the operating system's default power-management utility and is claimed to increase the system's up-time by as much as 30%! Put another way, if your battery usually lasts for only three hours, for example, then Laptop Warrior may boost this to almost four hours!

Of course, the software can only work with whatever charge your battery currently contains. Ideally, you will start with a fully-charged battery ... you can't wait until your system says "I'm about to run out of power" before using Warrior (if you only have 30 seconds of power remaining, the best you can hope is that it will boost this to 40 seconds).

But truth to tell, I would be happy with almost anything I can get. There are numerous occasions when even as little as an extra 10 or 20 minutes of up-time would have made my life so much easier. So, I for one think that this sounds like a jolly interesting product that's well-worth investigating further.

Laptop Warrior comes in the form of a USB memory stick.

Check out
'The Cool Beans Blog'
at www.epemag.com

Catch up with Max and his up-to-date topical discussions

Our periodic column for PIC programming enlightenment

Real Time Operating Systems – Part 1

This month, we start a two-part investigation into the world of *operating systems*, and how they can be used with small microprocessors, such as the PIC. In this first article we discover what a *real-time operating system* (RTOS) is, and explain the important features and terms.

It's quite a complex subject and not a normal area of interest to hobbyists, but as the power of cheap and easily available microcontrollers grows, the opportunity to start using an RTOS is becoming a reality. Also it's a fascinating subject to learn about too!

Next month, we will look under the hood of half a dozen freely available operating systems, but for now let's start by explaining some of the terminology used when describing the operation of an operating system.

Operating system – abbreviated to OS, an operating system is a collection of software that acts as a host for programs that run on the hardware. It provides an interface for programs to the underlying hardware, and may supply other useful interfaces for communication or reliable operation of the system as a whole.

Real-time operating system – abbreviated to RTOS, is an OS which has not been designed to enable programs running under it to meet required time limits. You may, for example, require that a request to the OS to turn a motor on can be guaranteed to occur within the next 9ms to 10ms.

An ordinary OS will simply receive your request and perform the action at some undefinable (but quick) time in the future; an RTOS will always action the request within the required time. A library database search engine can run on an ordinary OS; the control system for an aircraft engine cannot!

Process – an application (sometimes referred to as a 'task') that is running on a processor. An 'application' is the collection of computer instructions; a 'process' is the actual execution of those instructions, and includes the data that is currently being used.

A process contains one or more 'threads' (see below) which are independent sections of code. At any one time, only a single thread is running on a processor. A process will typically be given it's own area of memory to work in, independent and sometimes isolated from other processes.

Thread – a section of executing code that can be paused by the operating system, allowing the OS to restart another thread. Threads are the 'workers' of an application, performing some well defined action independently of other threads.

An application may have several threads, but only one is running at any one time, with the other threads either blocked, waiting for data from another thread, or ready to do some work and waiting for the OS to allow them to run.

Multitasking – used to describe how an operating system uses a single CPU to execute multiple processes apparently concurrently. A high speed interrupt, typically firing every few microseconds, triggers the OS to re-evaluate which process should be allowed to run next. Operating systems can employ different techniques, called '*scheduling algorithms*', to decided which runs next.

If a currently running process needs to wait for some data to become available – say a byte from a serial port – it will become blocked, and the OS will stop executing that process until the data becomes available. It will then pass control, or 'context switch', to another, waiting process.

Message – to aid the development of stable and fault tolerant software, processes are normally completely isolated from each other, and have no way to pass data between themselves. Instead, they use a feature of the operating system called '*message passing*', which allows them to send and wait for messages from other processes by making the request through the OS.

When process 'A' sends a message to process 'B', the operating system will place the message (which is simply a collection of bytes that you want to send) into a queue for process 'B'. When process 'B' next runs, the message will be delivered to it by the OS.

Multitasking is clearly the key to an OS providing the appearance of multiple processes running concurrently. By switching between them at high speed, the OS can keep many processes running, apparently in parallel.

Now you may think, 'If I have ten processes running on the CPU, they will just run at one-tenth of the clock speed'. Whether this is true or not will depend on how you design and write your processes. In the vast majority of cases this linear reduction in speed does not happen. Processes are designed to spend most of their time 'blocked', waiting for a message that they process, send out a response message, and then go back to a blocked state waiting for the next message to handle.

This is where most of the effort in learning how to write software for an RTOS comes in: you have to change your mindset, moving away from a big application that 'does everything' to a series of processes that spend most of their time doing nothing, waiting for work to do. It's quite a mindset change, but we will give some examples in a later article. Don't forget that software designed this way can scale easily to handle large applications, in a way that a monolithic application cannot.

Example operating systems

We are all familiar with using an operating system, whether we realise it or not. Microsoft Windows XP, Linux, Unix, Apple MAC OS X (which itself is based on Unix) are the most common. While quite diverse in use, they all share a number of common attributes: each is a general purpose OS, providing a platform for you, the user, to load, execute and interact with applications of your choice.

None of these are real-time operating systems; they do not guarantee a fast, deterministic response to input from the outside world. For what we use them for, that's not an issue. Indeed, they may appear to be operating in 'real time', for example when streaming a video off the Internet.

Try plugging in a USB memory stick the next time you are watching a full screen video, however, and see what happens – the video will pause and the audio will go crazy. Now imagine what would happen in a car's antilock braking system if the same thing were to happen. That's why, for time critical application, we need a (hard) real-time operating system.

You're less likely to be familiar with the names of common embedded real-time operating systems, simply because by design they are embedded within a product and locked into performing a single task. Within the home, an RTOS is typically found in high-end media players, home network routers, broadband adaptors, Sky boxes and some modern televisions – so you are quite likely to have one or two in your home somewhere! Common examples of an RTOS include ucLinux (a cut down version of Linux), eCos and FreeRTOS.

Some products blur the distinction between a general purpose OS and an RTOS, such as a mobile telephone running Microsoft Windows Mobile OS. Although present for the purpose of controlling your connection to the GSM network, it also allows you to download games and applications of your choice.

Simple RTOS

When hobbyists write software, we typically use a 'main loop', a simple infinite loop that calls a series of functions one after the other and then loops back to the beginning. A more advanced version of this may include one or more interrupts being used, which make data available for functions running within the main loop.

This type of design is referred to as a foreground/background design, with the interrupts running in the foreground – always running when they need to – and the main loop functions running in the background whenever they get a chance. In a way this is a form of operating system (very crude of course) and is actually very popular in the commercial world; vending machines, electricity meters and even telephone exchange digital equipment can work like this.

As mentioned earlier, however, this kind of design does not work well with larger more complex problems. A complex application with real-time requirements would be very difficult to design, and very difficult to validate, without the use of a proper operating system.

PIC RTOS

One of the problems facing designers wishing to use an OS on a PIC microcontroller is that an OS typically demands a lot from the processor, in particular for it to be able to quickly suspend one application and switch to another. The OS must be able to 'freeze' the application in its tracks, storing all the processor registers at that point in time, so that the OS can restore it at a later time with no corruption of data.

Some of the smaller PICs make this difficult to do, forcing operating system designers to come up with a series of compromises, dependant on the type of processor used. It's only when you reach the level of the PIC18F and above that fewer compromises are required and it becomes possible to implement a 'proper' RTOS without having to take magic short cuts!

It's a lot easier to understand the operation of an RTOS if you can examine one that hasn't been especially tweaked, so we will be looking, in a later article, at the RTOS named FreeRTOS running on a PIC18F device. As the name suggests, this is a completely free operating system, and you can find a link to it at the end of this article.

Why use an RTOS?

So why should we consider using an RTOS when designing our software?

From a hobbyist's point of view, because it's fun, and a new challenge. As climbers say when ask why they climb a mountain, 'Because it's there.' There is a practical reason too, if you are interested in becoming an embedded software engineer, it will look very good on your CV to have had experience with a proper RTOS.

It will certainly be a challenge. Not only do you have to learn the features available from the OS, and work out which you will need and which you will not, but there is also the mindset change in your approach to designing your application. You have to think about breaking the design into logically separate parts, each of which communicates with the others in an orderly fashion.

That's a good thing, however, and will give you a broader understanding of software development, and more 'tools in your toolbox'. So, why not take up the challenge?

In preparation for next month's article on an overview of specific operating systems you may want to take a look at the websites of those we will be covering, the details of which can be found in the references at the end of this article. Many books are available that discuss operating system design and operation and one freely available book that can be downloaded from the Internet can be found at **www.iu.hio.no/~mark/lectures/os.pdf**. You may also want to browse the Internet for the terms we have defined above for additional background reading.

References

Microchip PIC16 Application Note: AN585

FreeRTOS: **www.freertos.org**

eCos: **ecos.sourceware.org**

ucLinux: **www.uclinux.org**

PIC18 paper: **www.dedicated-systems.com/Magazine/01q3/2001q3_p010.pdf**

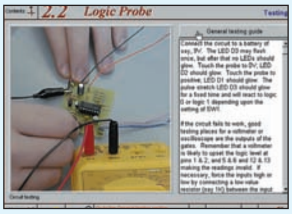
Contiki: **www.sics.se/contiki**

PicoOS **picoos.sourceforge.net**

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS

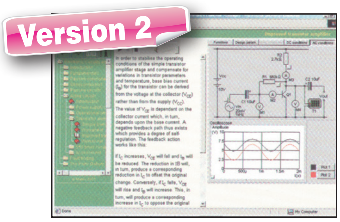


Logic Probe testing

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

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

ELECTRONIC CIRCUITS & COMPONENTS V2.0

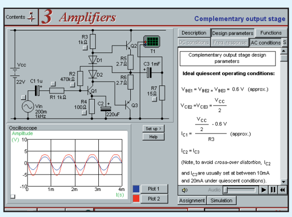


Circuit simulation screen

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

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

ANALOGUE ELECTRONICS

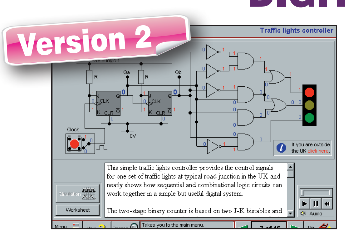


Complimentary output stage

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

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

DIGITAL ELECTRONICS V2.0

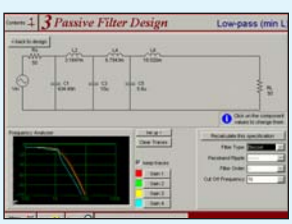


Virtual laboratory - Traffic Lights

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

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

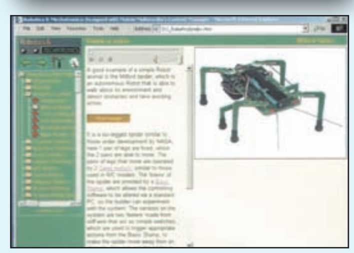
ANALOGUE FILTERS



Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

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

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

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

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

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

PICmicro TUTORIALS AND PROGRAMMING

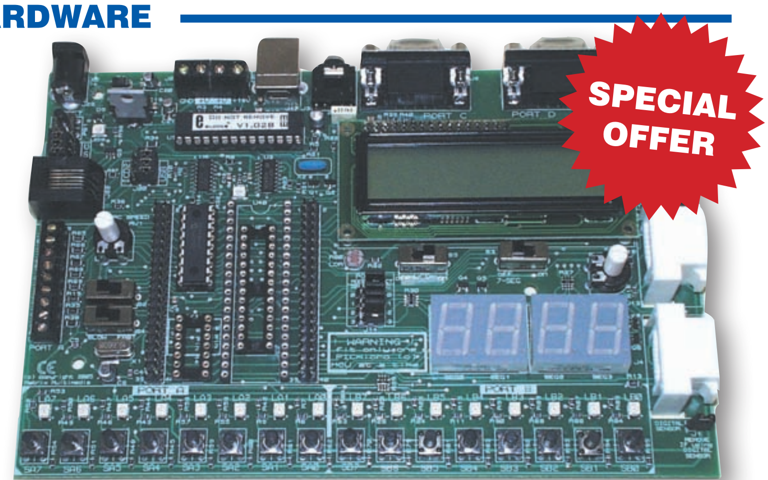
HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

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

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



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

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

SOFTWARE

ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

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

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

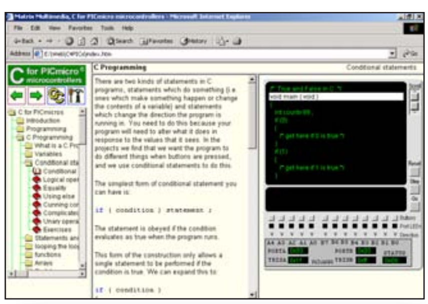
● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture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

'C' FOR 16 Series PICmicro Version 4

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

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

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



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

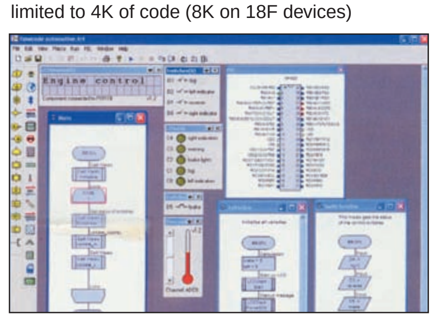
FLOWCODE FOR PICmicro V3

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

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

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

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



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

Hobbyist/Student	£44	inc VAT
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Institutional/Professional 10 user (Network Licence)	£300	plus VAT
Site licence	£599	plus VAT
Flowcode 10 user (Network Licence)	£350	plus VAT
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SPECIAL PACKAGE OFFER

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

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

£50.00 inc. VAT and p&p

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

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

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

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

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

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

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

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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.
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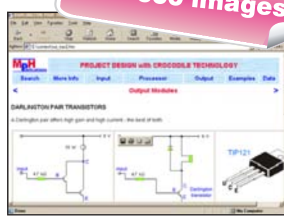

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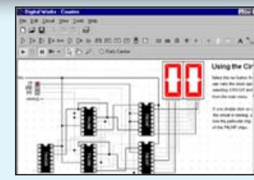
Runs in Microsoft Internet Explorer
All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

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.

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☐ Digital Works 3.0

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

☐ PICmicro Development Board V3 (hardware)

☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
☐ Electronic Components Photos; Version 1.1
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Note: The software on each version is the same, only the licence for use varies.

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READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly

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☆ LETTER OF THE MONTH ☆

Tribute to John Becker

Dear EPE

I read the article on the sudden death of John Becker, and I was saddened. Even though I did not know him personally, I would like to send my condolences to his family and friends.

I wish to thank John for all the contributions he made to our magazine. He was instrumental in helping me learn the practical side of electronics, a difficult subject to master. He managed to make it easy for me to grasp the concepts and get started building all sorts of circuits; starting with easy ones and then progressing to more complex ones.

He was a tutor who managed to build the bridge between the theoretical and practical sides of electronics. This is the most difficult part for us students to learn. (I call myself a student, even though I am 40 years old and have been working in electronics for the past 15 years – and have even taught electronics for the past six years.) I always felt there was something to learn from masters such as John.

I feel that I have lost a special friend who, without him knowing, was always there for me. Whenever I found it difficult to solve a problem in my designs I always referred to his contributions in the magazine.

Once again, 'thank you John', for sharing your knowledge, and helping us become engineers!

Kind regards

Joseph Attard, Malta

Joseph, thank you for your kind and generous words. John was so much part of EPE *it is difficult to believe his unique contributions are at an end. I like to think that his words and designs live on in* EPE *magazines and on workbenches right across the globe. He is missed, but not forgotten.*

PICs and CdS pieces

Dear EPE

I purchased my first copy of *EPE* for the first time in more years than I care to remember, and was pleasantly surprised by the quality of the projects offered these days. No doubt regular reader will be 'old hands' at programming PICs, but being a novice to these devices I noticed that many, if not all of the projects appear to be designed to be programmed on board rather than using a PIC programmer. Has *EPE* published a standard interface cable for these, or can you point me in the right direction for a suitable cable, preferably home made.

In your *Readout* page (August 2009) Terry Buchanan indicated he was looking for a source of CdS cells. Although these have not been in common use for a number of years, many older street lighting controls used them. It may be worth asking your local street lighting department if they have any surplus cells in their 'recycle pile'. The two-part type are the easiest to salvage because the sensor is in a plastic container containing only the CdS cell and is easily removed from the enclosure if required.

The CdS types are easy to tell apart from their more modern phototransistor cousins – the cell has a silver colour and is slightly smaller than a five pence piece. The scratch lines in the silver paint on the cell are used to calibrate the cell, and the paint must be removed completely to reuse the cell for another purpose.

Len Paget, by email

Thank you for your input on CdS cells. Returning to your question, we do publish some projects where PICs can be programmed on board, but no specific lead has been designed to do this – you simply connect up as required.

Remote control issues

Dear EPE

When I first saw the Remote Volume Control project in the June 2009 issue I was greatly excited – here at last was a project for the amplifier that I built from *EPE* a couple of years ago – or so I thought. I am partially disabled and find it difficult to reach the hi-fi and turn it on and off, so this remote control was going to be a godsend. I asked someone to rush out and buy a copy of *EPE* for me, but was disappointed to see that there is no feature for switching the amp or preamp on or off using the remote control – you still have to get up and physically do it.

Unfortunately, designers just don't think of us people with disabilities when designing circuits anymore. Is it possible to get a modified version of the software where one of the spare pins, say 2 or 3, can toggle high and low for each press of the 'Power' button on the remote control? One could solder a lead directly from the pin to the 'not connected' terminal next to the +ve connection and use it to switch a relay on and off on a modified power supply board. I have already designed one in anticipation.

A further question – why don't you provide the asm files with the hex files anymore? It was one way I was trying to learn about programming.

Last, I am sorry to learn of the passing of John Becker. He, along with Andy Flind, were my biggest influences and will be sorely missed.

Mike MacLeod, by email

Many thanks for taking the time to write to us. The project you mentioned originates from Silicon Chip and unfortunately it is unlikely that we can provide working details of modifications ourselves. Although we cannot offer details of modifications, as an alternative you could ask via our EPE Chat Zone **(www.chatzones.co.uk)** *where like-minded readers may have some practical ideas to help.*

We do still provide .asm files when they are available to us – a quick look at July and August shows that .asm files are included in the .zip files.

Many thanks for your continued interest.

Best regards, Alan Winstanley

IF YOU HAVE A SUBJECT YOU WISH TO DISCUSS ON THIS PAGE PLEASE EMAIL US AT:
editorial@wimborne.co.uk

Net Work

Alan Winstanley

On the shoulders of giants

We were all saddened to hear the news that John Becker, our Technical Editor and one of the founder members of the entire hobby electronics fraternity, had passed away suddenly when visiting Wimborne. John had been fighting a number of health-related setbacks for some time, but had continued to work stoically and professionally at all times, culminating in his marvellous tutorial series *Teach-In 2008*: *An Introduction to the PIC Microcontroller*.

John's creative work with PICmicro projects is legendary and, as one *Chat Zone* user put it, his endeavours have given us the gifts of 'thousands of tiny little memorials ticking away into the future.' Our sympathies go to John's wife, Gill, and family, and I have devoted a personal tribute to John in my August 2009 online *Net Work* column at **www.epemag3.com**.

In the same online feature I saluted another milestone in history: the 40th Anniversary of the *Apollo* moon landings. I reviewed two marvellous books on *Apollo*. First, the Haynes Owners Workshop Manual ('1969 including *Saturn V*') by Dr Christopher Riley and Phil Dolling. This is a glorious review of all the technology of the *Apollo* moonshot, with cutaways, engineering drawings and illustrations done in the uniquely engaging style that only Haynes knows how to do. This book should be a part of everyone's library, if only to remind today's generation of the incredible frailty of the 1960s moonshot programme, and as a reminder of how today we enjoy the fruits of technology that pioneered our quest to land on the moon.

In his book *How Apollo Flew To The Moon* by W. David Woods (Springer, ISBN 978-0-387-71675-6), we're reminded how the *Apollo* programme swallowed no less than half of the world's entire integrated circuit production up to 1969. The 80kHz discrete logic systems were written in machine code to squeeze out every spare bit of the 64kB memory. They were tremendously admired for reliability, and never used their backup systems in flight.

Today, I have just scrapped an old dishwasher that had all manner of electronic panels, sensors and displays, but the principles of the embedded controller hail directly from the navigation and guidance systems invented for the lunar module, forty years ago.

Back in 1969, on 20 July, the world gathered round their black and white TV sets to watch *Apollo* land successfully on the moon's 'Sea of Tranquility'. Today, we have NASA TV available online (**http://www.nasa.gov/multimedia/nasatv/index.html?param=public**) and I have just watched a fascinating insight into a recent launch of space shuttle *STS-127*, the same shuttle that we mentioned in *Practical Electronics*, June 1977 when NASA transported a space plane atop a Boeing 747.

On live streaming TV via the web, aided by an excellent commentator, we saw technicians sealing the hatch and performing various tests for a gas-tight seal, and then watched the countdown. For spaceshot fans, be sure to keep an eye on NASA TV in between times.

Bing goes Yahoo search

Bing (**www.bing.com**) is the new search engine released by Microsoft. Bing replaces Live Search and is starting to gain some traction in the search engine market. In a ten-year deal, Yahoo has also handed over the mantle of search to Microsoft, though the Yahoo front-end is expected to remain pretty much the same: expect to see 'powered by Bing' logos appearing gradually. Our choice of search engine technologies (remember Lycos, Excite, Fast, Inktomi and others?) has distilled down to precisely two: Google and Bing.

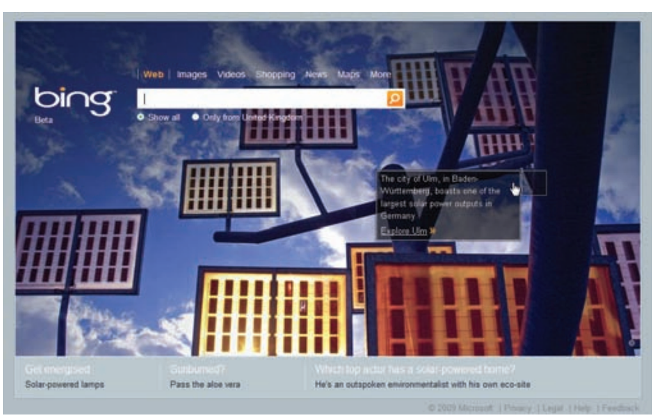
Microsoft's Bing search technology promises to give (in our case) better UK results, and more refinements are to come. Among other features, it offers a different home page every day, based on a striking photo, making a pleasant change from Google white.

What are less obvious are the 'hot spots' hidden in the Bing home page. When you mouse over them, a pop up shows an interesting fact related to that topic. The solar panels in the screenshot highlighted various facts about solar energy and pointers to how to make your own solar energy.

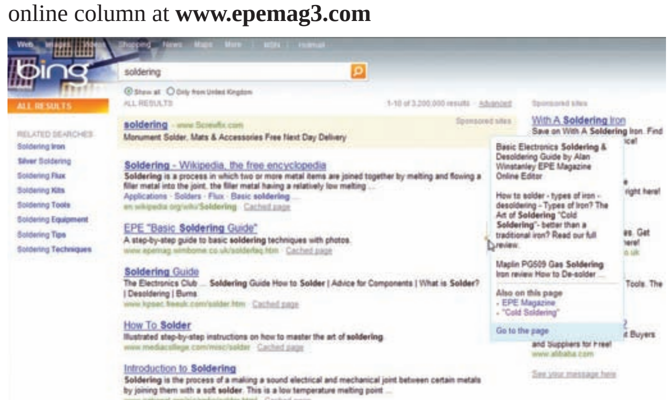
Google's artificial intelligence yields a list of blue links and a textual snippet derived from the website's meta tags. Bing goes much further than this: alongside the results is a small button which, when you mouse over it, pops up a useful window containing more information. The screenshot below shows what happens in Bing when you roll over the *Basic Soldering Guide* articles. Simply look for the small orange dot down the right hand side, which scrolls up and down as you mouse around the page. More information will then appear.

Bing is still in Beta mode, but promises more enhancements in coming months. After years of having to stare at white pages full of blue links, perhaps Google may yet meets its match.

You can email me at **alan@epemag.demon.co.uk** and check my online column at **www.epemag3.com**



The home page of Bing features a striking colour image with hidden 'hot spots' that pop up interesting facts



Bing search results display a scrolling 'More Info' tooltip that pops up with details of the target website

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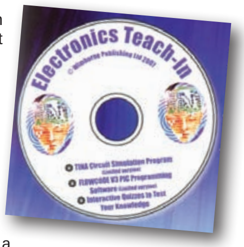
Electronics Teach-In CD-ROM

Mike Tooley



A broad-based introduction to electronics – find out how circuits work and what goes on inside them. The CD-ROM contains the whole *Teach-In 2006* series (originally published in *EPE*) in PDF form, plus 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. There is also a MW/LW Radio project in the Teach-In series.

CD-ROM **Order code ETI CDROM** **£8.50**

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The complete collection of The Amateur Scientist articles from *Scientific American* magazine. Over 1,000 classic science projects from a renowned source of winning projects. All projects are rated for cost, difficulty and possible hazards.

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Over 1,000 projects

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PROJECT CONSTRUCTION

IC 555 PROJECTS
E. A. Parr

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are over 70 circuit diagrams and descriptions covering basic and general circuits, motor car and model railway circuits, alarms and noise makers as well as a section on 556, 558 and 559 timers. (Note. No construction details are given.) A reference book of invaluable use to all those who have any interest in electronics, be they professional engineers or designers, students or hobbyists.

167 pages **Order code BP44** **£5.49**

POWER SUPPLY PROJECTS
R. A. Penfold

This book offers a number of power supply designs, including simple unstabilised types, and variable voltage stabilised designs, the latter being primarily intended for use as bench power supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits. The information in this book should also help the reader to design his own power supplies. Includes cassette PSU, Ni-Cad charger, voltage step-up circuit and a simple inverter.

91 pages **Order code BP76** **£5.49**

HOW TO USE OSCILLOSCOPES AND OTHER TEST EQUIPMENT
R. A. Penfold

This book explains the basic function of an oscilloscope, gives a detailed explanation of all the standard controls, and provides advice on buying. A separate chapter deals with using an oscilloscope for fault finding on linear and logic circuits, plenty of example waveforms help to illustrate the control functions and the effects of various fault conditions. The function and use of various other pieces of test equipment are also covered, including signal generators, logic probes, logic pulsers and crystal calibrators.

104 pages **Order code BP267** **£5.49**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

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

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

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

135 pages **Order code BP392** **£5.99**

TEST EQUIPMENT CONSTRUCTION
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This book describes in detail how to construct some simple and inexpensive but extremely useful, pieces of test equipment. Stripboard layouts are provided for all designs, together with wiring diagrams where appropriate, plus notes on construction and use.

The following designs are included:-

AF Generator, Capacitance Meter, Test Bench Amplifier, AF Frequency Meter, Audio Mullivoltmeter, Analogue Probe, High Resistance Voltmeter, CMOS Probe, Transistor Tester, TTL Probe. The designs are suitable for both newcomers and more experienced hobbyists.

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Jim Gatenby

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

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

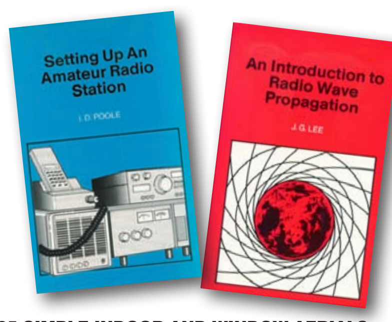
RADIO

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

The aim of this book is to give guidance on the decisions which have to be made when setting up any amateur radio or short wave listening station. Often the experience which is needed is learned by one's mistakes, however, this can be expensive. To help overcome this, guidance is given on many aspects of setting up and running an efficient station. It then proceeds to the steps that need to be taken in gaining a full transmitting licence.

Topics covered include: The equipment that is needed; Setting up the shack; Which aerials to use; Methods of construction; Preparing for the licence.

86 pages **Order code BP300** **£4.45**



25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave-listening, for even a 20-foot length of wire stretched out along the skirting board of a room can produce acceptable results. However, with some additional effort and experimentation one may well be able to improve performance further.

This concise book tells the story, and shows the reader how to construct and use 25 indoor and window aerials that the author has proven to be sure performers.

50 pages **Order code BP136** **£2.25**

AN INTRODUCTION TO RADIO WAVE PROPOGATION
J.G. Lee

Radio wave propogation is one of the more important discoveries made in the early 20th century. Although technology lagged behind early experimenters pursued this newly discovered phenomenon eagerly for, in understanding the physics of propagation, they were discovering more about our Universe and its workings.

Radio wave propagation has its origins in the world of solar physics. The Sun's radiation provides the mechanism for the formation of the ionosphere. How the ionosphere is formed, and how it provides long-distance communication, is carefully explained. Non-ionospheric propagation, including 'moonbounce' or satellite communications, is covered as well.

This book has been written with the average electronic hobbyist in mind. Technical language and mathematics have been kept to a minimum in order to present a broad, yet clear, picture of the subject. The radio amateur, as well as the short-wave listener, will find explanations of the propogation phenomena which both experience in their pursuit of communications enjoyment.

116 pages **Order code BP293** **£4.45**

THEORY AND REFERENCE

BEBOP TO THE BOOLEAN BOOGIE
Second Edition
Clive (call me Max) Maxfield

This book gives the "big picture" of digital electronics. This in-depth, 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.

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

470 pages **Order code BEB1** **£35.99**

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Clive (Max) Maxfield
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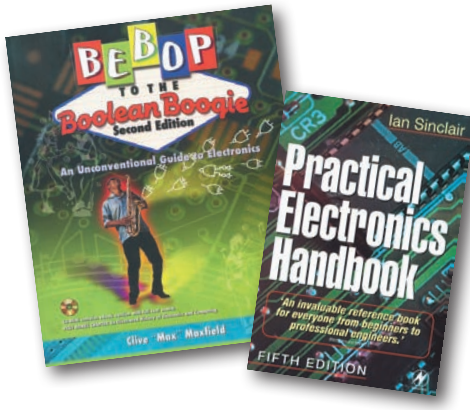

INTERFACING PIC MICROCONTROLLERS
Martin Bates

An essential guide to PIC interfacing techniques, using circuit simulation to aid learning.

Explore in detail microcontroller interfacing techniques using the popular PIC 16F877. Work through step-by-step examples interactively using circuit simulation software, supplied as assembly source code.

Interfacing PIC Microcontrollers provides a thorough introduction to interfacing techniques for students, hobbyists and engineers looking to take their knowledge of PIC application development to the next level. Each chapter ends with suggestions for further applications, based on the examples given, and numerous line drawings illustrate application of the hardware.

Step-by-step examples in assembly language are used to illustrate a comprehensive set of interfaces, and these can be run interactively on circuit simulation software, used to aid understanding without the need to build real hardware.

A companion website includes all examples in the text which cam be downloaded together with a free version of Proteus's ISIS Lite.

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types.

In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

TEMPORARILY OUT OF PRINT

DIGITAL GATES AND FLIP-FLOPS
Ian R. SInclair

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

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

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OPERATIONAL AMPLIFIER USER'S HANDBOOK
R. A. Penfold

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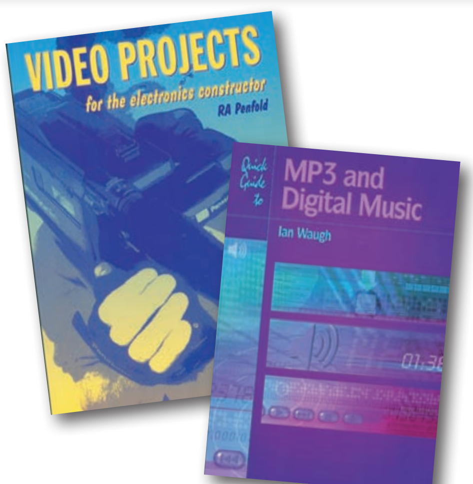

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R. A. Penfold

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FAULT FINDING, CIRCUITS AND DESIGN

PIC BASIC PROJECTS – 30 PROJECTS USING PICBASIC AND PICBASIC PRO
Dogan Ibrahim

BOOK + CD-ROM

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Robin Pain

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Simple circuit examples are used to illustrate principles and concepts fundamental to the process of fault finding. This is not a book of theory, it is a book of practical tips, hints and rules of thumb, all of which will equip the reader to tackle any job. You may be an engineer or technician in search of information and guidance, a college student, a hobbyist building a project from a magazine, or simply a keen self-taught amateur who is interested in electronic fault finding but finds books on the subject too mathematical or specialised.

The fundamental principles of analogue and digital fault finding are described (although, of course, there is no such thing as a "digital fault" – all faults are by nature analogue). This book is written entirely for a fault finder using only the basic fault-finding equipment: a digital multimeter and an oscilloscope. The treatment is non-mathematical (apart from Ohm's law) and all jargon is strictly avoided.

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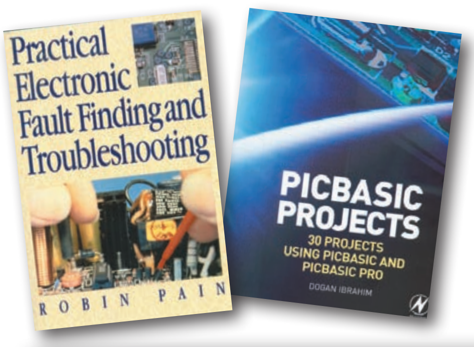

A BEGINNERS GUIDE TO CMOS DIGITAL ICs
R. A. Penfold

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The topics covered in this book include: the basic concepts of logic circuits; the functions of gates, inverters and other logic "building blocks"; CMOS logic i.c. characteristics, and their advantages in practical circuit design; oscillators and monostables (timers); flip/flops, binary dividers and binary counters; decade counters and display drivers.

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