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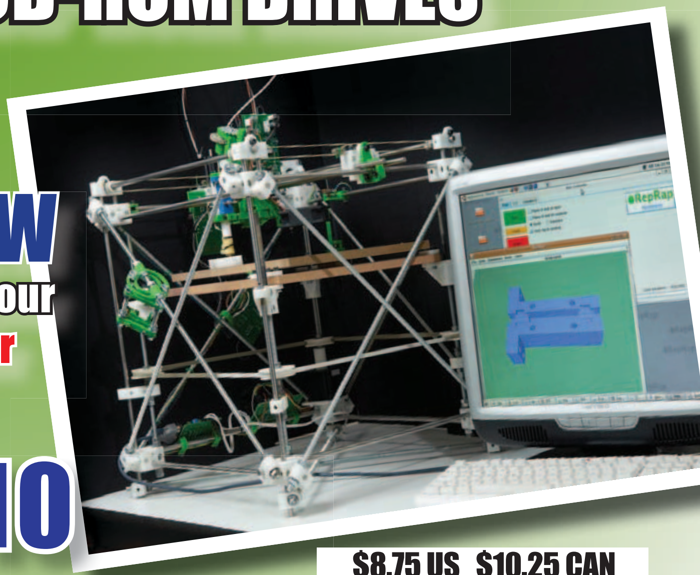

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The mTouch kit enables designers to quickly and easily develop capacitive touch user-interface applications using Microchip's 8- and 16-bit PIC microcontrollers (MCUs).

The flexible, comprehensive kit includes two main boards – one populated with a PIC16F72X 8-bit MCU and the other with a PIC24F256GB110 16-bit MCU; four daughter boards for developing capacitive-touch keys, sliders and a matrix; a PICkit Serial Analyzer; an easy-to-use Graphical User Interface (GUI); and several code and schematic examples. The modular kit makes it easy for designers to try different keypad configurations, and experiment with touch-pad sizes and shapes using the motherboards.

Touch-sensing technology is increasingly being adopted to improve the look and durability of user interfaces in appliances, consumer-electronic devices, medical electronics, automobiles and many other markets and applications. Microchip's new MCU-based kit provides a one-chip, highly integrated solution based upon either the PIC16F72X 8-bit or the PIC24FGB 16-bit general purpose MCU, providing a flexible evaluation platform that lowers costs and shortens time to market.

HOW TO ENTER

For your chance to win a Microchip mTouch Capacitive Touch Evaluation Kit, visit ***http://www.microchip-comp.com/epe-mtoucheval*** and enter your details in the online entry form.

CLOSING DATE

The closing date for this offer is **12 January 2010**

EPE EXCLUSIVE

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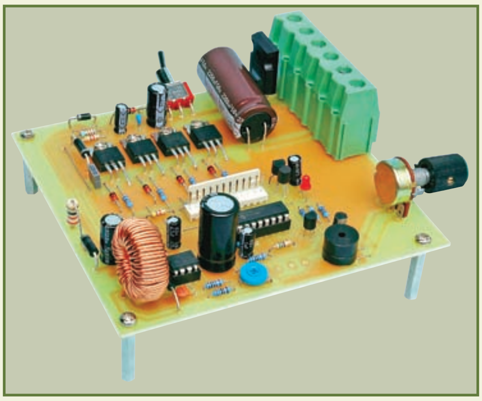

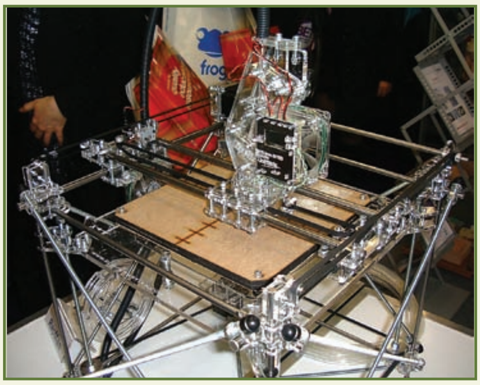

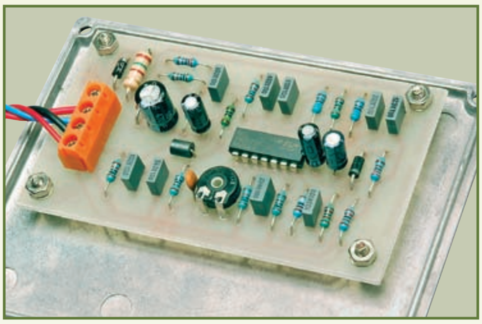

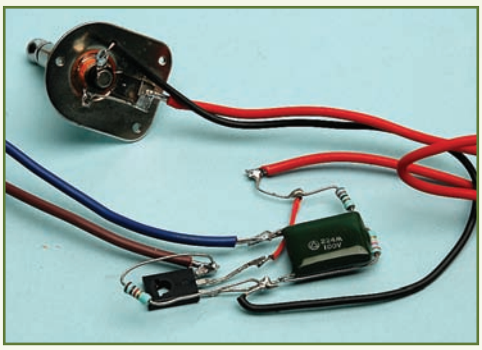

Our January 2010 issue will be published on Thursday 10 December 2009, see page 80 for details.

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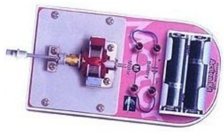

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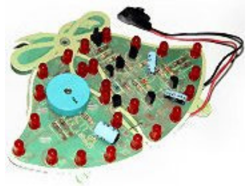

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EVERYDAY PRACTICAL ELECTRONICS
FEATURED KITS

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

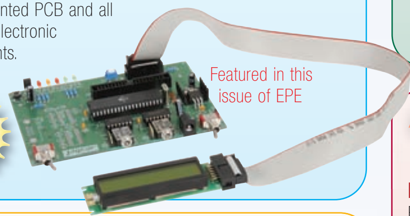
Jaycar Electronics

December '09

CD-ROM AUDIO PLAYBACK ADAPTOR

KC-5459 £19.00 plus postage & packing

Put those old CD-ROM drives to good use as CD players using this nifty adaptor kit. The adaptor accepts signals from common TV remote controls enabling drive audio functions to be controlled as easily as a normal CD player. Features pre-programmed micro controller, and IDC connectors to the included display panel. Supplied with solder masked and screen-printed PCB and all required electronic components.



Featured in this issue of EPE

NEW TO EPE

HIGH CURRENT MOTOR SPEED CONTROLLER

NEW TO EPE

KC-5465 £26.25 plus postage & packing

Controls a 12 or 24VDC motor at up to 40A continuous and features automatic soft-start, fast switch-off and a 4-digit display to show settings. Speed regulation is maintained even under heavy loads and the system includes an overload warning buzzer and a low battery alarm. Kit contains PCB and all specified electronic components.

Featured in this issue of EPE

STEREO HEADPHONE DISTRIBUTION AMPLIFIER

KC-5417 £10.25 plus postage & packing

Enables you to drive one or two stereo headphones from any line level (1volt peak to peak) input. The circuit features a facility to drive headphones with impedances from about 8-600Ω. Comes with PCB and all components.

Featured in EPE November 2009

Also recommended: Box HB-6012 £2.00

Power Supply Kit KC-5418 £6.00

ROLLING CODE IR KEYLESS ENTRY SYSTEM

KC-5458 £19.00 plus postage & packing

Features two independent door strike outputs and recognises up to 16 separate key fobs. This advanced system keeps coded key fobs synchronised to the receiver and compensates for out of range random button presses. Supplied with solder masked and silk screen printed PCB, two programmed micros, remote fob case, battery and all electronic components. The receiver requires a 12VDC 1.5A power supply. Some SMD soldering is required.

Featured in EPE Aug/Sept 2009

PROGRAMMABLE HIGH ENERGY IGNITION SYSTEM

KC-5442 £27.75 plus postage & packing

This advanced and versatile ignition system is suited for both two & four stroke engines. Used to modify the factory ignition timing or as the basis for a stand-alone ignition system with variable ignition timing, electronic coil control and anti-knock sensing. Kit includes PCB with overlay, programmed micro, all electronic components, & die cast box.

- Timing retard & advance over a wide range
- Suitable for single coil systems
- Dwell adjustment
- Single or dual mapping ranges
- Max & min RPM adjustment

Featured in EPE Sep-Nov 2009

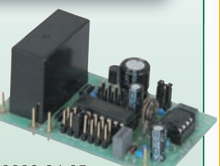
Also available to suit: Ignition Coil Driver Kit KC-5443 £13.75

Knock Sensor Kit KC-5444 £5.50

THE 'FLEXITIMER'

KA-1732 £6.00 plus postage & packing

Switches a number of different output devices on and off at accurately timed intervals, ranging from a few seconds to a whole day. This kit includes PCB and all components. Requires 12-15VDC - recommended mains plugpack MP-3282 £4.25



As published in EPE September 2007

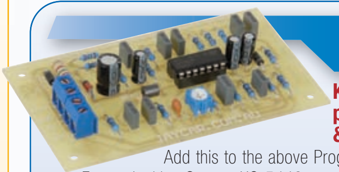
EMERGENCY 12V LIGHTING CONTROLLER

KC-5456 £20.50 plus postage & packing

Automatically supplies power for 12V emergency lighting during a blackout. The system is powered with a 7.5Ah SLA battery which is maintained via an external smart charger. Includes manual override and over-discharge protection for the battery. Kit supplied with all electronic components, screen printed PCB, front panel and case. Charger and SLA battery available separately.

Featured in EPE November 2009

KNOCK SENSOR



KC-5444 £5.50 plus postage & packing

Add this to the above Programmable High Energy Ignition System KC-5442 to automatically retard the ignition timing if knocking is detected. Ideal for high performance cars running high octane fuel. Requires a knock sensor which is cheaply available from most auto recyclers.

* Kit supplied with PCB, and all electronic components.

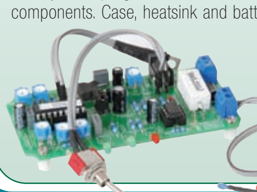
NEW TO EPE

Featured in this issue of EPE

FAST NI-MH BATTERY CHARGER

KC-5453 £12.50 plus postage & packing

Ideal for RC enthusiasts who burn through a lot of batteries. Capable of handling up to 15 of the same type of Ni-MH or Ni-Cd cells. Build it to suit any size cells or cell capacity and set your own fast or trickle charge rate. Features overcharge protection and temperature sensing. Kit includes solder mask & overlay PCB, programmed micro and all specified electronic components. Case, heatsink and battery holder not included.



As published in EPE August 2009

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As published in EPE August 2008

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VOL. 38 No. 12 DECEMBER 2009

Even the best of us make mistakes...

Over the last couple of decades, it would be hard to think of a British scientist or engineer who has had a greater effect on the lives of a sizeable chunk of the world's population than Sir Tim Berners-Lee. In 1989, he invented the World Wide Web, an internet-based hypermedia initiative for global information sharing, while at CERN, the European Particle Physics Laboratory. His combination of information, 'simple' links, networks of computers – and crucially – an absolute insistence on adhering to a common set of technical standards, revolutionised the use of information. In fact, many of you will be reading these words via the web, saving time, trees and hard-earned money.

To reach your latest edition of EPE you either clicked a pre-saved link, possibly googled 'Everyday Practical Electronics' or perhaps more simply typed in '**http://www.epemag.com**'. Have you ever stopped to wonder where those '//' symbols after 'http:' come from, and why they are there?

Well, the short answer is that Berners-Lee wrote them into his standard, and so he is the source. However, in an interview in the The Times newspaper this month, he 'confessed' that they don't actually have any use. In fact, they could have been left out. "..., it seemed like a good idea at the time, " he is quoted as saying, but in fact they were "unnecessary"

It was good of him to come clean on his 'mistake', but it reveals an important engineering principle that is worth remembering. When you start designing something, be very careful about what you build into your design, because some errors have a nasty habit of becoming next to impossible to remove, especially if your design is successful.

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A number of projects and circuits published in *EPE* employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

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

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NEWS

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

Windows 7 And An Apology

Wow! Hold the front page. It is not often you hear a computer software company apologise for inadequacies. Barry Fox reports.

MICROSOFT, for instance, is launching Windows 7 to replace Vista, which was foisted on PC users who were generally happy with Windows XP and soon heard so much about the problems with Vista that they refused to upgrade. At a recent pre-launch briefing held by Microsoft at Centre Point in London, guests were checked in by office staff using XP machines. The nearest Microsoft came to offering an apology for Vista was to boast that Windows 7 has a "smaller footprint than Vista and will thus run on netbooks."

In welcome contrast to Microsoft's behaviour, German company Nero, which competes head-on with Roxio in the market for multimedia software, is now re-launching its year old Nero 9 package as Nero 9 Reloaded after a public apology from CEO Udo Eberlein.

In January, Eberlein wrote an open letter to the 'Nero Community' admitting that "many of you have expressed concerns about the direction and quality of this product…and we recognize that the quality of our suite was compromised with this recent release… we strayed from our commitment to ease-of-use and high quality standards."

Too true. When I uninstalled Nero 9 because it behaved like an incoherent rag bag of separate programs, the uninstall process invited me to fill in a survey, but then sent me a message saying that the survey was closed!

Making a point

Nero 9 Reloaded is claimed to be compatible with Windows 7 and can handle the new Hi Def recording format used by camcorders, AVCHD. It also boasts a very interesting new feature: Nero 9 will convert Powerpoint presentations into DVDs or Blu-ray discs, so that they will play on a TV without the need for a PC. So Powerpoint presentations can be used for college or school presentations, corporate demos and in store promos, with continuous looping.

Nero says it is aware that Microsoft Office will soon offer something similar but more limited, with Powerpoint conversion only to WMV format files for DVD burning, without editing options. Nero 9 Reloaded will convert a Powerpoint file to any disc format, including MPEG-2 and MPEG-4, with the option to edit before burning to disc.

This prompts a couple of tips, based on hands-on tests with an advance copy version of Windows 7.

Upgrading from Vista to Windows 7 is much easier than upgrading from XP to Windows 7. The XP-to-7 upgrade loses previously installed programs. If XP isn't broken it will usually be better not to fix it.

The bad publicity for Vista has pressured Microsoft into a hurry to launch Windows 7, but consumers should not be in a hurry to install it. There are serious compatibility issues with some software that worked perfectly well with XP and even Vista. It will take several months for Microsoft to release Windows 7 patches and fixes in a software Service Pack. Also, the look and feel of Windows 7 is significantly different from XP, so many previously familiar routines will have to be re-learned.

Robot Building

A NEW UK website, launched for robot enthusiasts, helps to make robot building easier by guaranteeing that mechanical and electronic components will work together.

RobotBits.co.uk, a new start-up focused on providing robot kits and components to hobbyists, schools and universities, aims to make robot building easier and more accessible to enthusiasts of all ages by guaranteeing that the mechanical and electronic components purchased through their website will work together.

"One of the concerns many robot builders face, is having the confidence to know that the components they choose will actually fit and work together" says Jon Luke, founder of RobotBits.co.uk.

RobotBits have tackled this issue by including a 'works with' section on every product page of their website, helping customers choose components, confident in the knowledge that they will easily fit together. RobotBits also offers free advice through its local-rate telephone line.

To find out more, visit **www.RobotBits.co.uk** or call them on 0845 519 1282.

MUSEUM OF COMPUTING

The UK's first dedicated Museum of Computing *that was forced to close temporarily in Spring 2008, has recently been offered a three-year lease on new premises in Swindon's town centre by Swindon Borough Council. Numbers 6 and 7 Theatre Square is 30 metres from the town's brand new Central Library and 50 metres from the Wyvern Theatre in 'The Promenade'; a section of the town designated by The New Swindon Company as the cultural area in Swindon's regeneration plan. The museum reopened to the public in July.*

According to museum founder Jeremy Holt, who campaigned for 13 years to get the Museum of Computing *off the ground in 2002, this new location is ideal because "Our last venue in the University of Bath was very difficult to get to without a car. The Council's new offer puts the Museum in the heart of the town in a prominent place near bus routes. It will be good for the town because the collection of 2,500 items demonstrating Britain's role in the advances of technology has attracted worldwide interest. We attract 2000 visitors a year from over forty different countries. Our new home means we can attract many more local visitors." He adds "We're also delighted the three-year lease means the Museum can apply for professional accreditation by the Museums and Libraries Association."*

Museum Curator Simon Webb has a passion for gaming and says "Our Gaming exhibitions have been our most popular and we'll be able to give the public what they want – entertainment and a trip down memory lane! 80% of the collection is in working order and the history of gaming can be traced back 30 years. We'll be setting up championship league tables and are investigating the possibility of online competitions with other towns, which should help put the town on the map."

Sponsored by Intel, the multinational computer chip manufacturer with European Headquarters in Swindon, and IT PR firm Blue Click PR, the new Museum of Computing will have considerably more display space to house the main exhibition and themed exhibitions which change twice a year. Blue Click PR's Managing Director, Rhona Jack says "When the Museum's closure was announced last year, the website received over 56,000 hits in 48 hours, as well as letters to The Times *newspaper, so we know there are many 'techies' out there who care about the history they helped create. Many items have featured on BBC's World Service, CNN, Sky TV, ITV, regional TV and radio stations, and national newspaper features list the Museum of Computing in the top 25 places to visit in the country, so its good reputation is building.*

We were also delighted The Right Honourable, The Mayor of Swindon, Cllr Steve Wakefield handed over the keys to us on his last day of official engagements, as he has done much to support the development of Swindon's cultural heritage in his year in office."

Jeremy Holt specialises in IT law and is a founding partner of local solicitor's firm, Clark Holt. He adds "All technological breakthroughs are only possible because of what has gone before and we'd like to hear from technology-related groups who need a place to meet, as we want the Museum to be a resource for the local community. 'Wired West' and the Linux and Ubuntu user groups have already expressed an interest in holding regular meetings here. We look forward to hosting more industry events, allowing companies to showcase new developments here."

The Museum is currently planning its special events calendar and particularly wants to hear from IT companies who can give talks about different aspects of computing, as well as schools, whose visits could focus on curriculum areas such as ICT, mathematics, design and technology, business studies and 20th century social history.

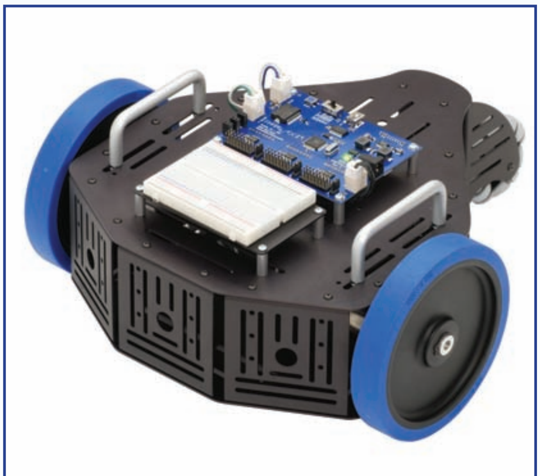
For further details or to offer to help with putting together an exhibition or becoming a volunteer, see **www.museum-of-computing.org.uk** *or call Simon Webb on mobile +44 (0) 7834 375628.*

New Products From Parallax

A RANGE of new products has been announced by Parallax (**www.parallax.com**) a selection is given here.

STINGRAY ROBOT

The Stingray robot (below) provides a mid-size platform for a wide range of robotics projects and experiments. The Propeller Robot Control Board is the brains of the system, providing a multiprocessor control system capable of performing multiple tasks at the same time.



The Propeller chip provides eight 32-bit processors, each with two counters, its own 2KB local memory and 32KB shared memory. This makes the Propeller a perfect choice for advanced robotics and the Stingray robot.

eTAPE LIQUID LEVEL SENSOR

The eTape Liquid Level Sensor is a solid-state sensor. Output resistance varies depending on the surface height of the fluid. It's primarily designed to be used in non-corrosive water-based liquids and dry fluids (powders). It does away with clunky mechanical floats, and easily interfaces with electronic control systems.

The eTape sensor's envelope is compressed by the hydrostatic pressure of the fluid in which it is immersed. This results in a change in resistance that corresponds to the distance from the top of the sensor to the surface of the fluid.

CH4 AND LPG SENSORS

The CH4 Gas Sensor Module is designed to allow a microcontroller to determine when a preset methane gas level has been reached or exceeded, while the LPG module similarly senses propane gas. The sensor modules are mainly intended to provide a means of comparing gas sources and being able to set an alarm limit when the source becomes excessive.

GYROSCOPE MODULE

The LISY300 Gyroscope Module is a single-axis yaw rate sensor providing up to 300°/s full scale rotation detection at up to 88Hz. Useful in balancing robots or autopilot systems, the module can detect how many degrees it has turned on its planar axis, allowing the host microcontroller to stabilize the platform or correct for drift. With a small DIP form factor and easy SPI interface, the LISY300 Gyroscope is suitable for almost any microcontroller-based project including balancing robots and R/C helicopter stabilization.

SD CARD ADAPTER KIT

The SD Card Adapter Kit allows you to easily connect an SD Flash Memory Card to your Propeller chip or other microcontroller. This adapter contains the components required for an SPI interface between the host microcontroller and an SD memory card, and includes a card detect switch, which allows you to detect when a memory card is physically present in the socket. It also includes an R/W switch to determine the read/write status of the inserted card, preventing accidental loss of data.

PRESSURE SENSOR

The VTI SCP1000 is an absolute pressure sensor, which can detect atmospheric pressure from 30 to 120kPa. The pressure data is internally calibrated and temperature compensated. The SCP1000 also provides temperature data and has four measurement modes as well as standby and power down mode. The sensor provides 1.5Pa of pressure resolution and 0.05°C temperature resolution through an easy SPI interface compatible with most microcontrollers.

SAFE-T-FLASH: A *Safe* Flash Trigger for

Many of today's digital SLR cameras risk serious damage if used with an external electronic flash, whether that is a portable type or a large studio 'strobe'. So, we have produced a flash trigger to ensure the camera's safety.

WE USE a relatively ancient but perfectly serviceable Balcar studio flash and softbox for in-house photography, coupled with a Nikon DSLR (digital SLR). The Nikon replaced three much-loved but 40-year-old Minolta (film) SLRs.

When we changed to the Nikon, there was a minor problem: no sync connector (commonly known as a PC connector, but it has nothing to do with personal computers). There was a hot shoe connector though, and we obtained a hot shoe-to-PC-socket adaptor to solve that problem.

The second thing we checked was the instruction manual for any warnings about using studio strobes. There were two: (a) the maximum strobe firing voltage that could be applied to the camera was 250V DC and (b) the polarity of the sync lead had to be tip positive.

Hmm! Both of these could be problems. The second certainly was because the phone-type plug which connected to the Balcar flash was tip negative. At least that problem was easily solved.

Then we wanted to know the voltage at the sync terminals. That's easy, right? We connected a digital multimeter to the sync terminals and it gave a reading of 224V. But a day or so later, when I repeated the test (to be sure, to be sure, etc) it was down to 103V.

By ROSS TESTER

your Digital SLR Camera

Hang about, nothing had changed, so what was happening? Surely not even a large mains variation could make that much difference? Something had changed, and it took a few minutes to realise that I had used a different DMM. The first one was a 10MΩ Tektronix TX3 DMM, while the second was a much cheaper model which, as it turned out, had an impedance of only 3MΩ.

Could a digital multimeter be loading the camera's sync circuit by so much? Well, yes it could, since the sync circuit is essentially a capacitor discharge circuit to fire the Xenon flash tube. When the camera's flash contacts close, they discharge the capacitor to fire the flash tube.

Alarming results

In essence then, the sync circuit is just a capacitor which is charged from a high-voltage source. So, to find out the open-circuit voltage from the sync circuit and the charging impedance, we decided to make a few more voltage tests with loads of 10MΩ (ie, with the Tektronix DMM) and 5MΩ (Tektronix DMM in parallel with a 10MΩ resistor). This gave results of 224V and 171V, respectively.

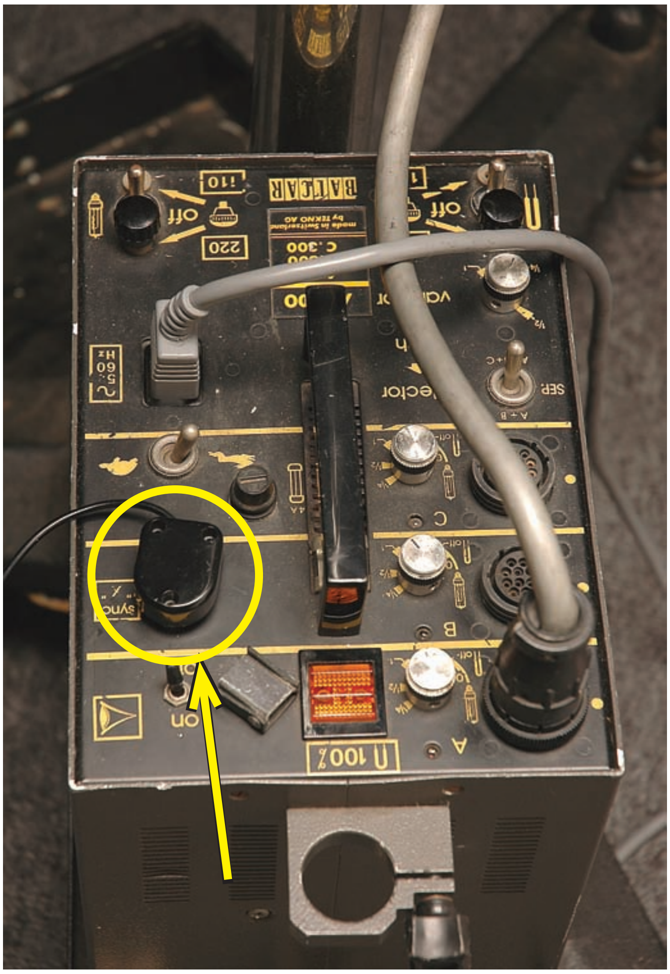
We then set up a pair of simultaneous equations (see panel). When the equations were solved, the results were that the open-circuit voltage was about 324V and the impedance around 4.5MΩ!

Well, 324V was quite alarming and could certainly do damage to any camera. To confirm this high voltage calculation, we decided to take a further voltage measurement using a 50MΩ high-voltage probe with our LeCroy oscilloscope. The scope revealed that the voltage was around 310V. In fact, we had quite a few problems trying to make sensible measurements with the oscilloscope and its 50MΩ probe because the Balcar's trigger circuit was floating with respect to mains earth and any connections to the scope tended to upset its operation.

However, we were able to confirm that the open-circuit trigger voltage from the Balcar flash was well in excess of 300V.

The answers are on the internet . . . NOT!

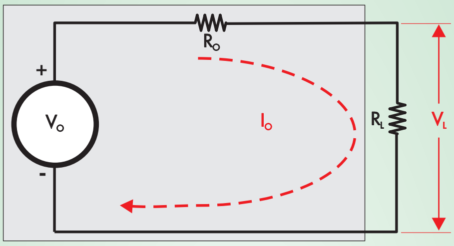
As part of the research for this project, we spent many hours on the internet looking for the experience of others. Several websites (including **www.botzilla.com/photo/strobevolts.html**, **http://photo.net/bboard/q-and-a-fetch-msg?msg_id=00KBWJ** and **http://aaronlinsdau.com/gear/articles/flashvoltage.html**) had pages and pages of strobe sync voltage readings. These were taken by photographers



It's an oldie but a goodie – our Balcar A1200 Studio Flash power pack, which mates with the flash head and softbox diffuser on the facing page. The Safe-T-Flash trigger we made is in the black 6.5mm plug (arrowed) – it reduces the sync trigger from 300V to about 7.5V (but can go even lower).

How DO you determine the source voltage and impedance?

The sync source of the Balcar electronic flash described in this article is the classic 'black box'. It had an unknown (high) source voltage and an unknown (high) source impedance. When you have two unknown values, how do you proceed? The first step is to draw the equivalent circuit, as shown below.



Inside the 'black box' is a voltage source V_O, connected in series with the output impedance R_O. This is connected to the 'outside world' to the load R_L. The next step is to measure the voltage across R_L, then repeat that step for a different value of R_L. We now resort to Kirchoff's Voltage Law, which states that the sum of the electrical potential differences around a closed circuit must be zero. So we draw up an equation based on that law (also known as Kirchoff's loop or mesh rule):

$$V_O = I_O R_O + V_L \qquad (1)$$

Since the same current (I_O) flows around the whole loop, we can calculate:

$$I_O = V_L/R_L \qquad (2)$$

and we substitute that into equation (1) to get:

$$V_O = (V_L/R_L)R_O + V_L \qquad (3)$$

We then take the voltage measurements for 10MΩ (224V) and 5MΩ loads (171V) and substitute them into equation (3) to get two new equations:

$$V_O = (224V/10M\Omega)R_O + 224 \qquad (4)$$

$$V_O = (171V/5M\Omega)R_O + 171 \qquad (5)$$

Next, we calculate the value for I_O in each equation and substitute its value into (4) and (5). This gives:

$$V_O = (2.24 \times 10^{-5})R_O + 224 \qquad (6)$$

$$V_O = (3.42 \times 10^{-5})R_O + 171 \qquad (7)$$

To solve these simultaneous equations to find a value for R_O, subtract equation (6) from (7) to get:

$$0 = 1.18 \times 10^{-5} R_O - 53 \qquad (8)$$

Therefore: $R_O = 53/1.18 \times 10^{-5} = 4.49M\Omega$

We can then substitute this value for R_O into equations (6) or (7) to calculate the value of V_O and the result is 324V. This is the true value for the open circuit voltage of the sync circuit; something that could not be obtained by any direct measurement.

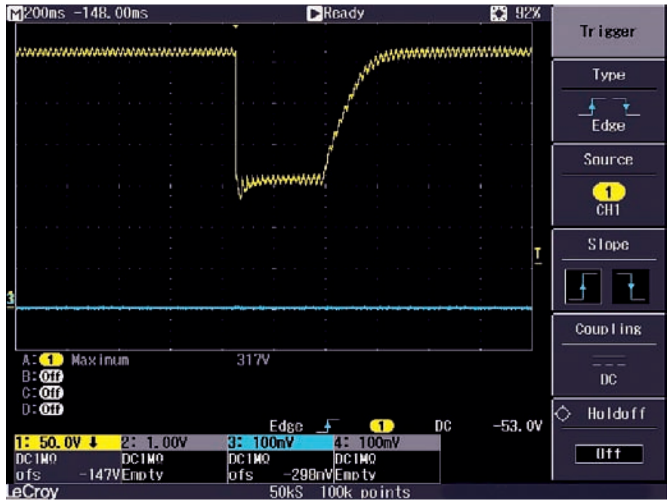


Fig.1: here's the actual firing of the Balcar strobe flash, with only the high-impedance (50MΩ) probe of our LeCroy DSO connected. The ripple on the trace is actually 50Hz hum. Note the maximum voltage reading of 317V.

all around the world on a huge variety of strobes and off-camera flashguns (many of which we've never heard of).

After our investigations, we would bet London to a brick that *all* of the sync voltage readings are wrong. Most were recorded as being done with a DMM, usually of unknown pedigree. By the web posters' own admission, at least a few of them were done with an analogue multimeter.

To prove the point, we measured the Balcar sync voltage with two different analogue multimeters. One, a typical model with 20,000Ω/V impedance, gave us a reading of 210V on its 500V range and 160V on its 250V range. The second, nominally 20,000Ω/V but dropping to 10,000Ω/V on its highest (300V) scale, gave us readings of just 70V on the 300V scale and 54V on its 100V scale.

Table 1 shows the actual voltage readings with various analogue meters.

These results are further confirmation of the high charging impedance of the Balcar sync circuit and, of course, are utterly misleading as an indication of the true voltage.

But based on their meter readings alone, most internet posters would say (and do say!) 'it would be safe to use the Balcar flash with a Nikon DSLR'. However, we know the true voltage is over 320V and is most definitely ***NOT*** safe.

The conclusion? You simply cannot use a multimeter – analogue or digital – to accurately measure voltage in such a high impedance circuit. They load the circuit too much to produce an accurate reading.

(Old timers may remember the same problem when trying to measure screen voltages in valve circuits. It was even worse back then, when the average meter was just 1000Ω/V or 2000Ω/V!)

Beware of JISP

By the way, if you spend much time trawling through websites, as we did, you'll find there is a lot of serious misinformation on the internet – JISP ('Jumbled Interpretation of Scientific Phenomena') as we tend to call it.

Like this gem: "beware of flash units with trigger (sync) voltages of 300V because these can kill you!" Or "there is no way that (brand X flashgun) trigger voltage can exceed 6V because it is powered by four 'AA' batteries and 4 × 1.5 = 6V." Hmmmm!

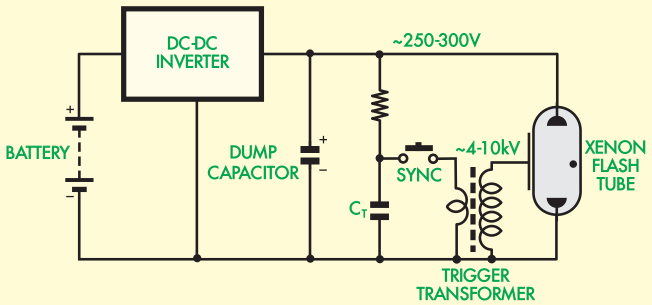
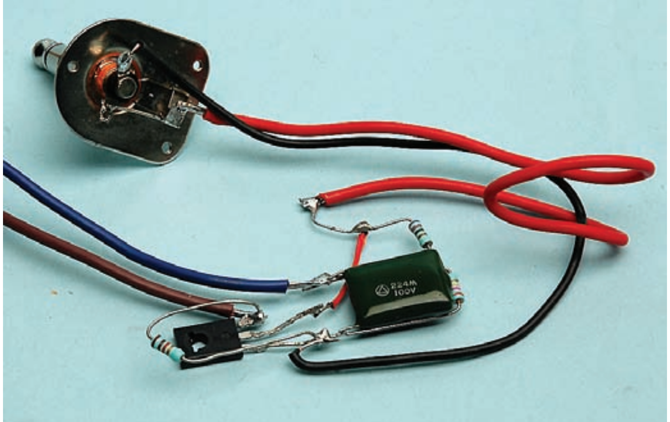


Fig.2: a somewhat-simplified diagram of an electronic flash which shows where the sync or trigger voltage comes from. The DC-DC inverter (or power supply in the case of a mains-powered studio flash) provides the high voltage from which the sync voltage is derived. When the flash is triggered, capacitor C_T discharges through the trigger transformer, generating a high voltage which in turn ionises the gas in the flashtube. The dump capacitor then discharges through the tube.



It's a lot easier to troubleshoot (and to change values if required) before you pack it into a tiny 'case'. You can then use these components in your final version. The resistor you may need to change is the 270kΩ; in this pic partially hidden by the 220nF capacitor. Lowering this resistor will lower the sync (trigger) voltage.

One chap even put into print "I am a graduate electronics engineer from such-and-such university, so I am competent in what I am doing" and then proceeded to measure sync voltages with a multimeter!

But it gets worse . . .

So far, we've been talking about our particular set-up with a Nikon digital SLR. But other brands, such as Canon, or Olympus have rather significantly lower maximum sync voltages – in fact, the two brands mentioned have a maximum of just 6V.

And the net is full of tales of woe about fried digital SLR cameras where their owners have unwittingly connected a flash or strobe with a high-voltage sync. If the camera can be repaired (and apparently that's often a big IF!), the repair bill can be huge: one report I read said that it was virtually as much as buying a new camera body!

We've singled out Canon and Olympus because they appear to have the lowest sync voltages. But we've seen others in the 6V to 12V range and yet more stating a maximum of 20V.

If you own a digital camera, we strongly recommend you look in the instruction manual for its maximum sync voltage *before* using any off-camera flash. If the manual doesn't tell you, call the local distributors and ask them!

By the way, there is an international standard for sync voltages – ISO10330 1992-11. It states the sync voltage should be between 3.5V and 24V. Most new flashguns and strobes are made to this standard, so a brand new set-up should be fairly safe – unless you happen to be using a DSLR with a 6V limit and a strobe with 20V+ sync!

Table 1: the various voltage readings with a range of analogue multimeters. What this table proves is that you cannot rely on any meter reading in a high-impedance circuit. Many photographers have been trapped by this 'little' problem!

Impedance	Scale	Voltage
50MΩ	(scope)	310V
10MΩ	500V	210V
5MΩ	250V	160V
3MΩ	300V (10kΩ/V)	70V
2MΩ	100V (20kΩ/V)	54V

Not just digitals

You might think the problem is confined to digital cameras, with their solid-state flash sync circuitry (in most cases, an open-collector transistor circuit). But you would be wrong.

Film cameras, at least until quite recently, almost always had a mechanical flash sync, with a pair of very fine contacts brought together at the appropriate moment to fire the flash once the shutter opened.

I mentioned Minolta film cameras earlier. Despite being over 40 years old, they had done sterling service (in a former life I was a wedding photographer) and I had a very good lens collection to suit them.

The main reason I managed to extract such a long life out of them was that every year, each of these went in for service and a good clean-out. The last time I put them in, I mentioned to the technician that one in particular sometimes had unreliable flash firing.

The technician returned that camera in a plastic bag in pieces, the bag labelled as being 'BER' (beyond economic repair). I was told that the flash sync contacts were essentially missing in action and that it would cost much more than the camera was worth to obtain the spare parts and replace them. The other two cameras were cleaned and repaired, but I was told that they too were way beyond reliable service life. Their contacts were still operational – but only just.

Having now found that there has been over 300V across those flash contacts ever since I started taking the magazine's photography, I'm not surprised they were pitted and burned. I'm actually surprised they weren't welded!

Incidentally, it was this that convinced us to make the switch to digital. That and the time it took to scan 35mm slides or negatives for use in the magazine!

Trigger circuit

Fig.3 shows the Safe-T-Flash, a circuit we developed to ensure that the strobe sync voltage presented to the Nikon was absolutely safe.

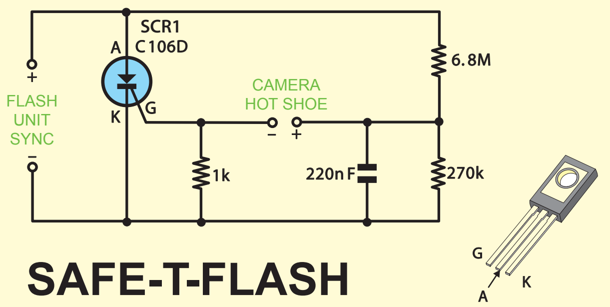


Fig.3: the circuit could hardly be any simpler – the voltage is limited to safe levels and the SCR (thyristor) fires the flash. This circuit is effectively a switch in series with the sync lead.

With a minor amendment, it can also be used on cameras with a much lower sync voltage (such as the 6V of Canons and Olympuses – or should that be Olympi?).

The circuit is simplicity itself. A voltage divider across the sync supply charges a 220nF capacitor to a much lower voltage than the original sync voltage. When the shutter is released, this capacitor discharges instantly into the gate (G) of the thyristor (commonly refered to as an SCR (silicon controlled rectifier)) connected across the sync supply. This then almost instantly turns on, shorting out the sync and firing the flash in the normal way.

We said almost instantly – we're talking microseconds here, very much faster than the 1/250th second sync speed of a modern digital camera. So, using this circuit will have no effect on exposure times or flash timing.

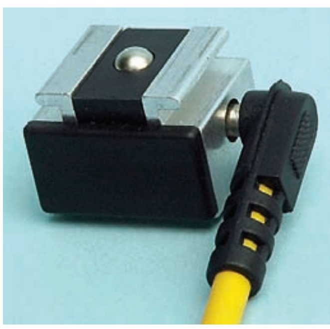
The voltage divider we used (6.8MΩ and 270kΩ) gives about 7.5V from a 320V sync supply. These two resistor values can be changed if (a) the strobe/flash you use has a lower sync voltage (most modern ones do), or (b) if your digital camera has a low maximum sync voltage.

For example, replacing the 270kΩ with 180kΩ will give about 5V with a 320V sync – ideal for Canon and Olympus. If your sync voltage is lower than 300V, you'll need to select the resistor to suit.

The SCR is a 'garden variety' type, albeit with a high-enough rating to deal with 300V+ sync voltages. We used a C106D, a plastic-pack (TO126) type with a 400V rating. The 1kΩ resistor from gate to cathode keeps the gate tied low until it receives a fair-sized trigger from the camera. Otherwise, induced voltages on the sometimes relatively long sync leads could lead to false triggering.

Speaking of sync leads, you're going to need one – either a new one or perhaps (if you're like me!) you'll find a couple of pensioned-off ones in the bottom of your camera bag or drawer!

And with most DSLRs, you'll also need a hot-shoe-to-PC-terminal adaptor. Both of these are relatively easy to obtain at camera stores. But be careful – some stores (particularly 'consumer' camera chain stores in shopping centres) tend to charge an arm and a leg for these relatively obscure items, especially if you buy 'genuine'. Trust us, the cheaper variety work just as well!



Many DSLRs do not have an 'X' (sync) connector but do have provision for a hot-shoe adaptor, such as this one shown with sync lead attached.

Polarity

There are two voltage polarities to check. First is the sync voltage. From our Balcar flash, the tip of the 6.5mm plug is negative and the body positive – just the opposite of what might be expected (sync leads sold for Balcar flash units take this into account).

Make sure you construct the circuit with the polarity that suits your strobe/flash.

The second is the polarity of the camera flash trigger. It makes sense to connect the more positive side (even if you're only measuring millivolts, which is quite possible) to the voltage divider/capacitor side and the negative to the 1kΩ resistor/SCR cathode (K) side.

Before construction

It's much easier to make any changes to the circuit (which you might have to do) before the components are packed into a small space. So the first thing to do is to 'tack together' your Safe-T-Flash without trying to miniaturise it, to ensure it is going to work with your particular strobe/flash and camera.

When finished and checked, connect your strobe/flash (only) at this stage, turn it on and measure the voltage across the lower (in our case 270kΩ) divider resistor. Depending on the voltage divider you have chosen and the sync voltage of your flash, it should be quite low – certainly no more than 20V or so, but it could be just a few volts if you have chosen a lower value resistor to suit your system, or if your strobe has a lower voltage sync.

If all appears well, short out the sync terminals in your circuit. The flash should fire immediately. Repeat this several times just to make sure the flash doesn't misfire.

Now connect the two wires in the sync lead from your camera to the two sync terminals – as we mentioned before, the more positive wire goes to the voltage divider/capacitor. Fire off a shot or two to ensure that the flash still works. If it does, you're ready to build the final version.

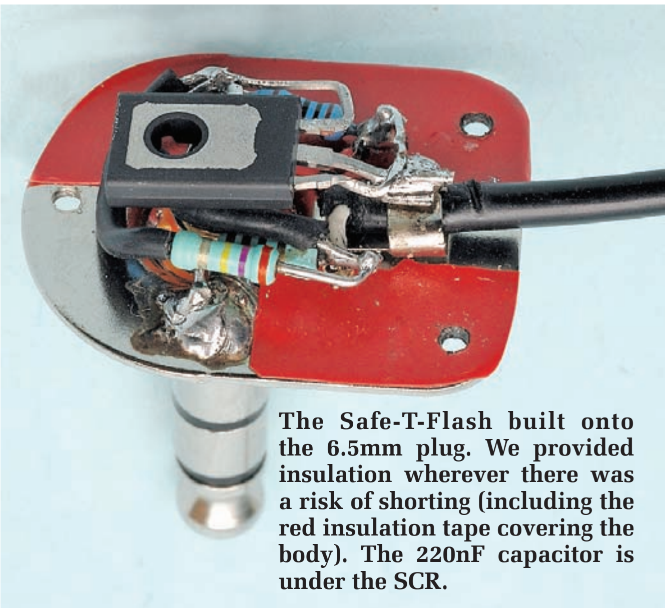
If it doesn't (or if the previous test didn't work), you either have a mistake to correct or perhaps a resistor to change to achieve the required voltage.

Parts List – Safe-T-Flash

1 Connector to suit your flashgun or strobe
1 Sync lead to suit your camera with appropriate PC male (sync) plug
1 Hotshoe-to-female-PC converter, if required
1 C106D 400V 4A thyristor (SCR) or equivalent
1 220nF 60V monolithic capacitor

Resistors (0.25W or 0.5W metal film)
1 6.8MΩ   1 270kΩ
1 1kΩ

Spaghetti insulation, insulation tape, potting compound etc, as required.



The Safe-T-Flash built onto the 6.5mm plug. We provided insulation wherever there was a risk of shorting (including the red insulation tape covering the body). The 220nF capacitor is under the SCR.

Here's another view, this time from the underside. Note that this is a stereo plug – the ring (the bit between the two black insulating discs) must be connected to the plug body.

Again, refer to camera and strobe/flash manufacturer's websites and/or distributors, agents, repair shops, etc for more detailed information. However, remember our warning earlier about misinformation on some websites!

Construction

The prototype Safe-T-Flash was built inside a 6.5mm side-entry jack plug because these are the sync connectors used on our Balcar studio flash. Each manufacturer has their own 'standard' and it's quite possible (in fact, probable) that this option will not be available to you because we don't know of too many manufacturers who use the 6.5mm plug.

Other ideas are building it inside a 'hot-shoe' adaptor, or perhaps simply as a 'lump in the sync cable' – eg, insulated with heatshrink tubing.

Another possibility is one that was used many years ago when making an optical slave flash trigger for a Metz flashgun, which (along with quite a few other flashguns and strobes) uses a 2-pin (US-style 110V) sync plug.

Mount the components on the back of the plug and 'pot' them in epoxy adhesive – once you've confirmed it works properly, of course. Five-minute Araldite makes a great potting compound if you make some type of container/mould to hold it while it is still runny.

But we'll leave that part up to you and your particular flash – our photos show how ours was constructed inside the 6.5mm jack plug.

We used a right-angle stereo jack plug, not because we needed stereo (in fact, exactly the opposite) but because this style of plug has plenty of room inside and the 'lid' is plastic. The mono version doesn't have much room at all and is also all-metal construction, which could be a problem with shorts!

If using the 6.5mm stereo plug, you will need to connect the ring and body together to convert it back into a mono plug – and hope that the point of contact inside the socket doesn't line up exactly with the insulator between the two! Yes, it is unlikely (it didn't on ours) but you never know when 'Murphy' is going to strike . . .

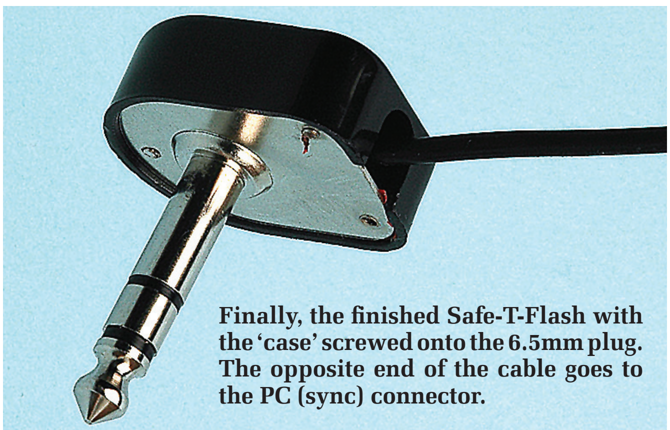
We simply soldered the appropriate tag down onto the plug body. The surface had to be scratched a little to remove the plating to get the solder to take. This then became the main positive connection point.

As there are only three resistors, a capacitor and an SCR inside the plug (and also due to the fact that many constructors won't be using the 6.5mm plug anyway) we haven't shown any form of wiring diagram. The close-up photos should give you all the info you need.

Just take care that no leads can short to any others or the plug cover, remembering that when the cover is screwed on some compression is possible. We covered any leads which might short with insulation (actually removed from other wires and slid onto the leads). You will note that we also covered the inside of the metal plug body with insulation tape – just in case.

Also note that the back of the SCR has a metal face which is connected to the anode (A). Make sure that nothing can short to this (we used it upside-down so that the anode was on top, against the plastic lid of the 6.5mm plug).

As you have already tested the 'large' version of the circuit and made any component adjustments needed, your miniature version should work perfectly if you haven't made any mistakes or allowed any components to short together. Remember that when you put the back of the plug on, it may compress the components so that they do short together – again, use spaghetti insulation if there is any danger of this happening. ***EPE***



Finally, the finished Safe-T-Flash with the 'case' screwed onto the 6.5mm plug. The opposite end of the cable goes to the PC (sync) connector.

Playback adapter for CD-ROM drives

Ever wanted to use an old CD-ROM drive as a CD player for audio playback? Now you can do it, with this nifty CD-ROM Playback Adapter. It can control one or two CD-ROM drives and has an infra-red remote control. A 16×2 line LCD screen provides track information and other data.

WE HAVE often been asked how to interface a hard drive or computer CD-ROM drive to a micro-controller. This is an interesting question, since there are countless old CD-ROM drives out there that are still in perfect functioning order, but which are 'obsolete'. Instead of letting them end up in landfill, you could do your bit and build this project.

Also, this project will be good experience for those readers who wish to learn more about the ATA interface and who want to use hard drives and CD-ROM drives in their own projects. The interface can be easily modified to suit any other micro, and only requires a few I/O ports and a reasonably fast processing core.

The main features of the Playback Adapter are listed below:

1) Can connect up to two ATAPI CD-ROM drives.
2) Auto detection of up to two connected drives.
3) Plays your favourite CDs.
4) Random play and repeat modes.
5) Controls volume (16 levels) and balance digitally.
6) Remote control with user-selectable key definitions.
7) Works with any RC5 remote control.
8) ISP (in-system programmable) if you wish to experiment with the firmware.
9) The CD is automatically locked when playing
10) LCD screen.

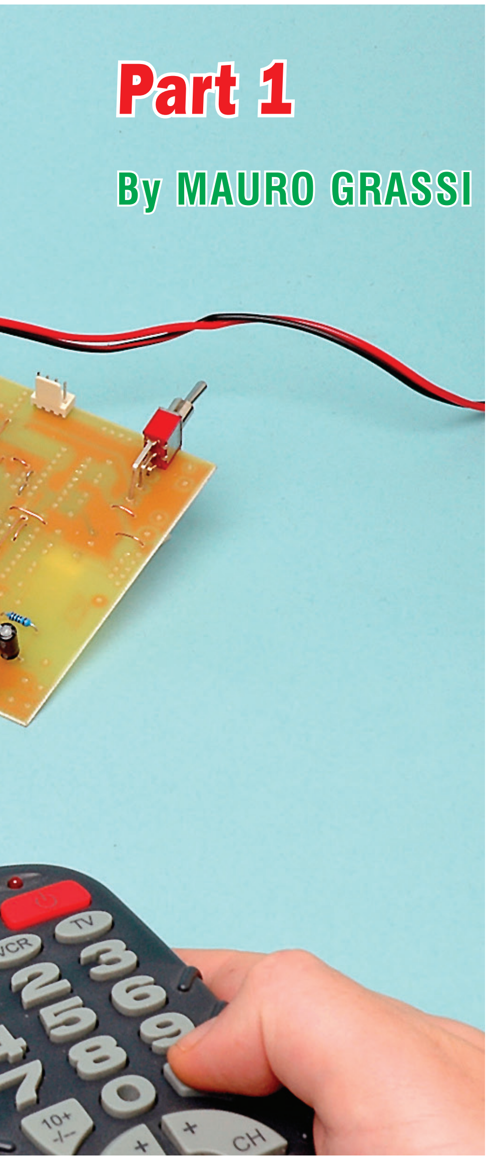


Table 1: the ATAPI register file. All ATA and ATAPI devices are controlled by reading and writing to these registers.

/CS1	/CS0	A2	A1	A0	/RD	/WR
1	0	0	0	0	Da t	Data
1	0	0	0	1	Error	Features
1	0	0	1	0	Sector Count	Sector Count
1	0	0	1	1	Sector Number	Sector Number
1	0	1	0	0	Cylinder Low	Cylinder Low
1	0	1	0	1	Cylinder High	Cylinder High
1	0	1	1	0	Device/Head	Device/Head
1	0	1	1	1	Status	Command
0	1	1	1	0	Alt Status	Device Control

Accessing an ATAPI device

The CD-ROM Playback Adapter presented here lets you connect one or two drives and control each independently using a standard RC5 remote control.

CD-ROM drives that conform to the parallel ATA (AT attachment) standard can be used with the adapter, and most old drives fall into this category. In fact, most CD-ROMs will be ATAPI devices, which is a superset of ATA. It just means they support the packet interface, a feature that was added to the original ATA interface.

The resulting protocol was renamed ATAPI, with the 'PI' standing for packet interface. Most CD-ROMs, as well as DVD drives, are ATAPI devices, although others conform to different standards, like SCSI and SATA (serial ATA). These have a different connector and are not compatible with this project.

Interfacing to an ATAPI device is simple because most of the work is done inside the drive. In effect, it acts as a black box. It conforms to a standard and the internal implementation is left to the manufacturer. That is why the standard was originally called IDE (integrated drive/device electronics). It just means that a lot of the complexity of the interface is in the drive and the drive responds to a uniform set of commands.

It speaks well of the design that one of the easiest parts of a computer to get working is the hard drive or CD-ROM/DVD drive. Plug any drive into any motherboard and it will usually work first time.

Overview of the ATA interface

The ATA interface is register-based. There are essentially two banks of eight registers, although only one of the eight registers in the second bank is ever used.

The interface consists of two chip select lines, called /CS0 and /CS1 which are active low. There are three address lines designated A0, A1 and A2, as well as the read and write control lines. The latter are designated /RD and /WR respectively, and are also active low.

In order to access a register, one sets the register address given by [A2:A0] and then brings either /CS0 or /CS1 low (but not both). Then it is a matter of bringing either /RD or /WR low and reading or writing the data through data port D7:D0.

Note that the data bus width is actually 16 bits, but for accessing the ATA registers, only the lower eight bits are used. However, the full width of the bus is used for data transfers.

Note also, that the name of the register sometimes changes, depending on whether you are reading from or writing to the specific address. For example, at address 110b and with /CS1 low and /CS0 high, reading will give the Alternate Status register (a read only register), while writing will affect the Device Control Register (a write only register).

All commands to control the drive are sent through the register file (ie, the set of ATA registers). For example, the Command Register can be written with the opcode for a particular operation – eg, 'SLEEP' – and the drive will respond by going into power saving mode, barring any errors.

Note: the order in which you assert the control lines on the ATAPI/IDE bus is important. For example, you would think that you could assert /RD or /WR first, and then bring /CS1 or /CS0 low. However, this approach does NOT work on all drives.

The correct procedure is to assert /CS1 or /CS0 first, then to assert either /RD or /WR. Of course, because we are using a general-purpose micro, and these pins are on different ports, it is impossible to assert them simultaneously. This is not required however, but would be closer to a native IDE/ATAPI port interface.

Low-level drivers

It is relatively simple to write to an ATAPI device. As explained, you first prepare the data and the address, bring the chip select line low and then apply either the read or write signal.

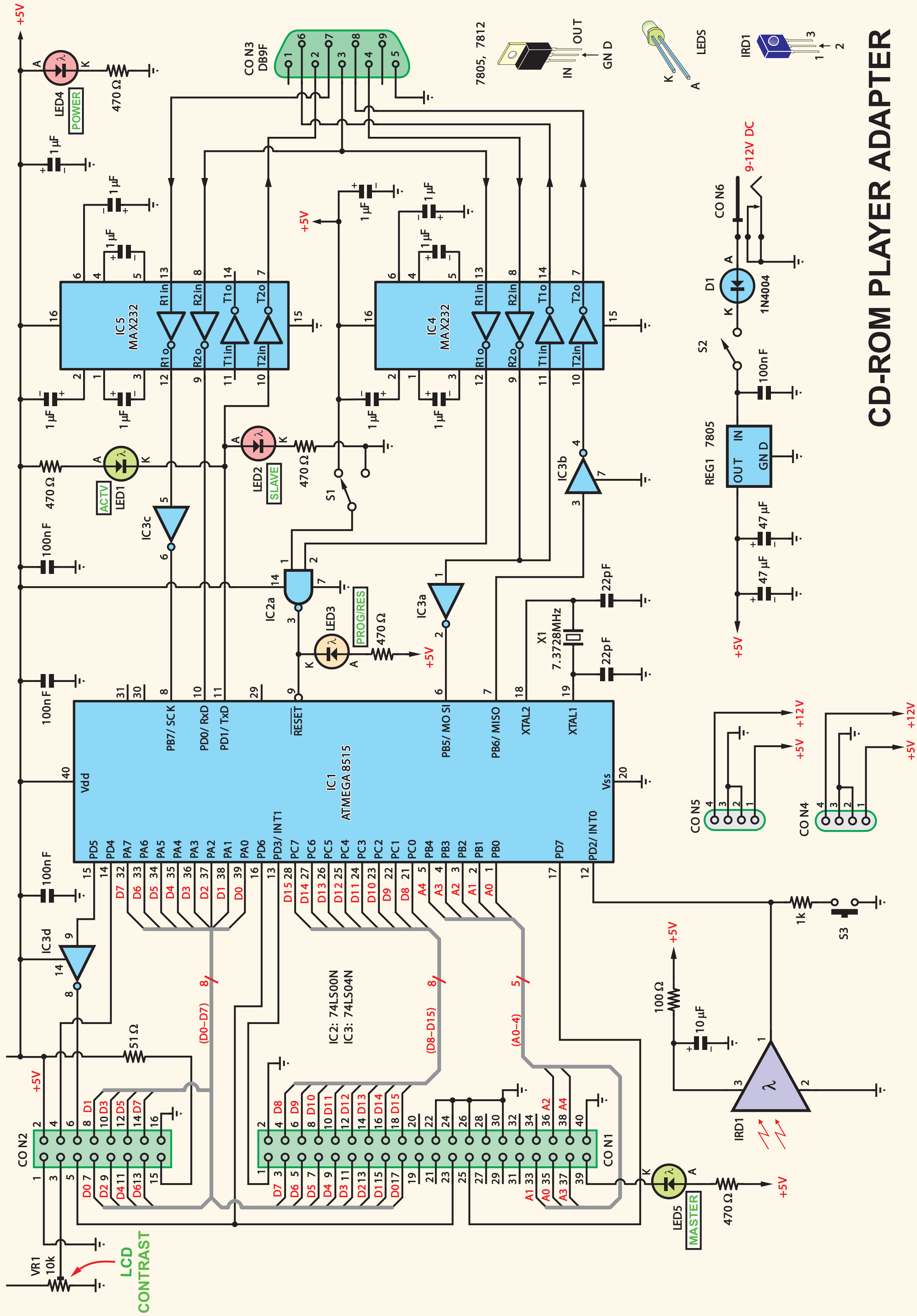


Fig.1: the circuit uses an Atmel ATmega8515 microcontroller (IC1) to interface to the CD-ROM drives (via CON1) and the LCD module (via CON2). IC4, IC5 and CON3 are optional, to provide in-circuit programming for the microcontroller.

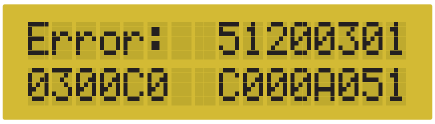


Fig.2: the Error screen. The numbers give information about the state of the program and the drive when the error occurred.

This is the minimum you would need to interface to an ATA device like a hard drive. It would not be the fastest interface possible – you'd have to get involved in DMA (direct memory access) for that – but it would work.

With ATAPI devices like CD-ROM drives, most operations are initiated by writing packets rather than single byte commands. A packet is a string of 12 or sometimes 16 bytes that are sent to the drive in sequence.

In order to send packets, a more involved algorithm than just writing to the register file is needed. Here you have to worry about bus timings and whether the drive is busy or requesting data. There is a well-defined protocol for PIO (peripheral input output) access to an ATAPI device.

Feedback is provided by the bits BSY (bit 7) and DRQ (bit 3) in the Status register, which can be polled to determine the current state of the drive. When the drive shows BSY=1 it does not respond to commands, and reading any register except the Status register is undefined. In other words, the only valid information that can be read from the drive is bit 7 (BSY) of the Status or alternate status registers (when it is busy).

Opening command

As an example, the packet to open the tray of the drive is given by the 12-byte string: 0x1B, 0x00, 0x00, 0x00, 0x02, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00. To send this packet, you first send the PACKET command 0xA0 to the command register and then follow the packet protocol, as outlined in Flowchart 1.

The protocol begins with a packet being written to the drive. Optionally, there may follow a data read or write transfer, depending on the packet written to the drive.

The CoD (command/data) and IO (input/output) bits are in the Sector Count ATA register (also known as the Interrupt Reason Register in ATAPI devices). CoD is bit 0 and IO is bit 1. When CoD is 0, data is being transferred and when it is 1, a command (packet) is being transferred.

Table 2: this table shows the pinouts of the ATAPI interface. Note that this project leaves many pins unused, as they are unnecessary for PIO transfer.

Pin	Name	Description
1	/RESET	A low level on this pin resets all connected drives
2, 19, 22, 24, 26, 30, 40	GND	All these pins are connected to the common ground plane
3, 5, 7, 9, 11, 13, 15, 17	[D7:D0]	3=D7, 5=D6 ...... 15=D1, 17=D0 These are the eight least significant bits of the data bus
4, 6, 8, 10, 12, 14, 16, 18	[D15:D8]	4=D8, 6=D9 ...... 16=D14, 18=D15 These are the eight least significant bits of the data bus
20	KEY	This pin is not connected and is used to prevent the cable being connected the wrong way round
21	DDRQ	Data request pin – not used in this project
23	/WR	Write strobe, active low
25	/RD	Read strobe, active low
27	/IOREADY	Device ready pin, active low, not used in this project. Used to slow a controller if it is too fast for the drive
28	ALE	Address latch enable – not used in this project
31	IRQ	Interrupt request – not used in this project
32	IO16	Obsolete since ATA-3 – not used in this project
33, 35, 36	[A2:A0]	35=A0; 33=A1; 36=A2, address bus
37	/CS0	Chip select 0
38	/CS1	Chip select 1
39	/ACT	A low level on this pin indicates that the drive is working. It can be connected directly to an LED to show drive activity

The IO bit indicates the direction of transfer. When IO is 0, the host writes to the drive, and when it is 1, the host reads from the drive.

When the above packet has been successfully processed by the drive, it will respond by opening the tray. This packet does not require any extra data transfer, but other commands, such as reading the CD TOC (table of contents), do require reading from the drive. Other packet commands, such as setting the volume, require both reading and writing to the drive (refer to the ATAPI specification for the relevant packet codes).

The firmware

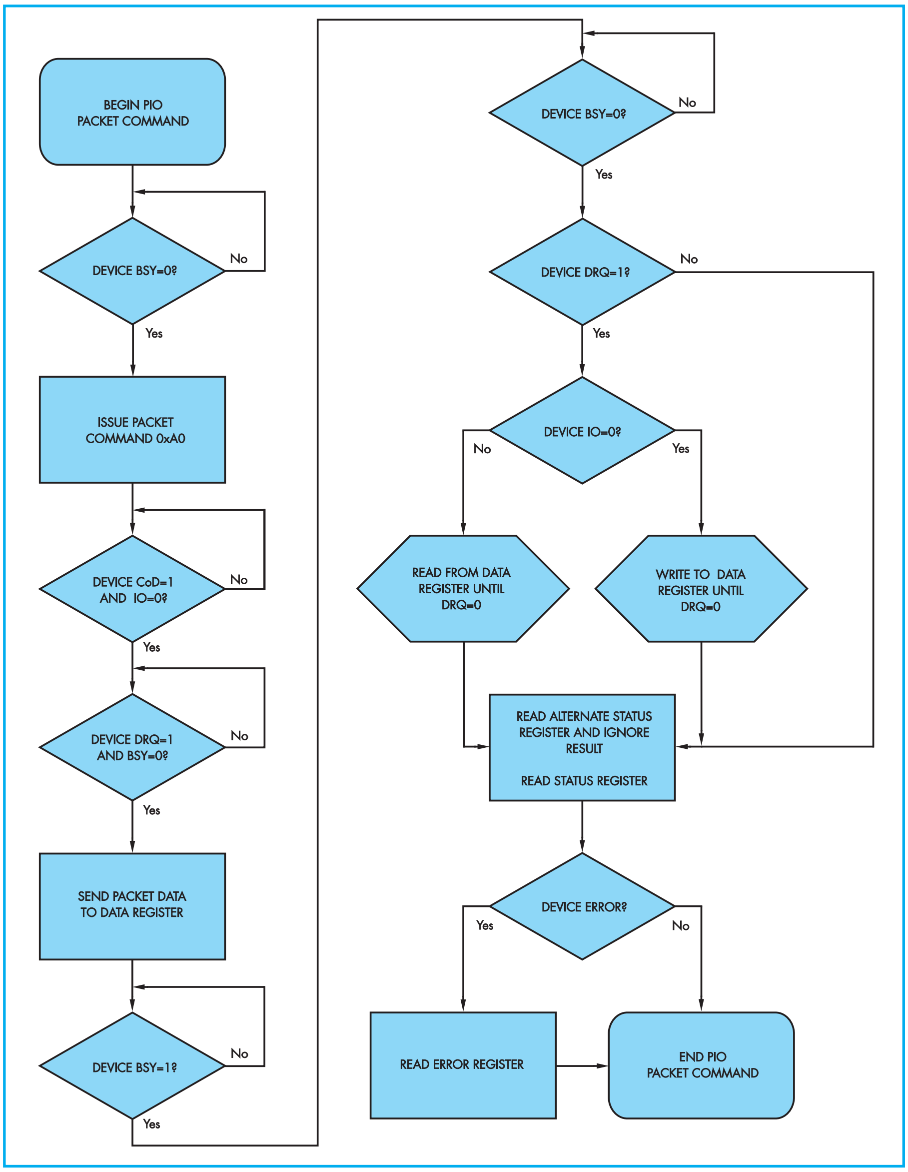
The main component of this project is the firmware, as the hardware is little more than an Atmel microcontroller. The firmware is responsible for interfacing to the drives, decoding the remote control signals, autodetecting the connected drives and controlling playback and volume, among other things.

All this is done with only 512 bytes of RAM! The firmware size is approximately 7.2KB and fits inside the micro's 8KB Flash memory.

ATA and ATAPI commands are either 'mandatory', 'optional' or not supported. To make sure that the CD-ROM Playback Adapter works with just about any ATAPI device, we've used only 'mandatory' commands as per the specification (rev 2.6 1996).

Note, however, that we cannot guarantee that it will work correctly with all ATAPI devices. Some are 'buggy' and the standard covers a period of many years. We've also come across drives that don't conform to the standard in every detail.

In our case, we tested the adapter with seven different ATAPI devices, including both CD-ROMs and DVD drives, and it worked correctly with six of these. The seventh drive had a problem in that it was not detected by the firmware and closer inspection and debugging revealed that the micro was unable to write to the drive's register



Flowchart 1: this is the packet writing routine used in the firmware. The interrupt signal INTRQ, intended for PCI buses on computers, is not used, and a method of polling for DRQ and BSY is used in its place.

file. Thus, it failed the first test of the autodetect subroutine, as explained below.

Basically, if a particular CD-ROM or DVD drive is not detected by the firmware on start-up, it will not be functional with the adapter. In that case, try using a different drive. Conversely, if the drive is correctly detected, there is a high chance that it will work correctly with this adapter.

How it works

Refer now to Fig.1 for the CD-ROM Player Adapter circuit details. The circuit is essentially just an Atmel ATmega8515 microcontroller (IC1) with its general IO pins configured to read and write to up to two drives. It also controls the LCD screen and reads the remote control sensor. Add in a power supply and a few support chips and that's about it.

IC4 and IC5 are MAX232 line drivers, and are used to interface the microcontroller to the serial port of a computer (RS-232). These devices are optional, and are only needed if you are planning to experiment by writing your own firmware.

Basically, they allow the board to be connected to a PC's serial port so that the microcontroller can be programmed in-circuit. The software to use for this job is called 'Pony Prog 2000' and is free for download from **www.lancos.com/ppwin95.html**.

IC2 and IC3 are simple logic gates, used here as 'glue logic' for the interface. These devices are 74LS00 and 74LS04 quad NAND gates and hex NOT gates respectively, but only one NAND gate and four NOT gates are used from these devices.

Infra-red receiver

IRD1 is an infra-red receiver module, containing a photodiode, amplifier, filter and demodulator – all in a compact package. It accepts a modulated infra-red signal on a 38kHz carrier and outputs a demodulated TTL level serial stream.

This stream is fed to pin 12 of IC1 and is decoded by the firmware in the microcontroller. Note that IRD1's output is usually high (around +5V) and varies as a square wave when an infra-red input is received.

Pushswitch S3 is used to select the remote control setup option at boot time. For normal operation it is open, and this allows the signal from IRD1 to pass to the microcontroller for decoding the remote control signals. Conversely, when S3 is pressed, it temporarily pulls this line low via a 1kΩ resistor to allow remote control set-up.

There are five indicator LEDs on the board. LED4 (red) is the power LED, while LED3 (orange) lights when the micro is being programmed or is in the reset state. This state can be entered using switch S1.

LED1 (green) shows the activity of the currently selected drive.

Finally, LED2 and LED5 make a pair. Only one will be lit at any one time. LED5 (green) indicates that the master device is being controlled, while LED2 (red) indicates that the slave device is being controlled. If you have two drives connected, you may toggle between them using the Line-In button on the remote.

Power supply

In order to power the drives, you will need a power supply capable of delivering +12V at 2A and +5V at 2A (eg, a computer power supply). By contrast, the board requires a +5V supply and draws just 200mA.

Basically, you've got two choices when it comes to the power supply. The first option is to power the PC board directly from a 9V to 12V plugpack supply and power the drives separately. In this case, the board supply is fed in via CON6 and is regulated to +5V using 3-terminal voltage regulator REG1. Diode D1 provides reverse polarity protection, in case the supply is connected the wrong way around.

The second option is to plug a +12V/+5V supply into either CON4 or CON5 on the PC board. The board will then be directly powered from this supply, while the supply for the drives can then be taken from the unused connector. Note that you will need a Y-splitter cable if there are two drives.

In this case, you can use a surplus computer power supply to power both the boards and the drives. This will simply plug straight into either CON4 or CON5. Another option is to use a ready-made adapter like the Jentec JTA0202Y (from Taiwan). This unit supplies +12V and +5V at 2A each, which is enough to power two drives and the PC board. It also comes with the proper plug, so all you need then is a Y-splitter cable.

Setting up the drives

The two drives must be configured before being installed. Specifically, if you wish to connect only one drive, it can be configured as either a slave or master device.

Usually, this is accomplished by a jumper setting on the back of the drive. The drive will usually have a label indicating the appropriate position of the jumper.

If you wish to use two drives, however, make sure that one is configured as a master while the other is configured as a slave. It doesn't matter which is which, as long as they are not both slaves or both masters.

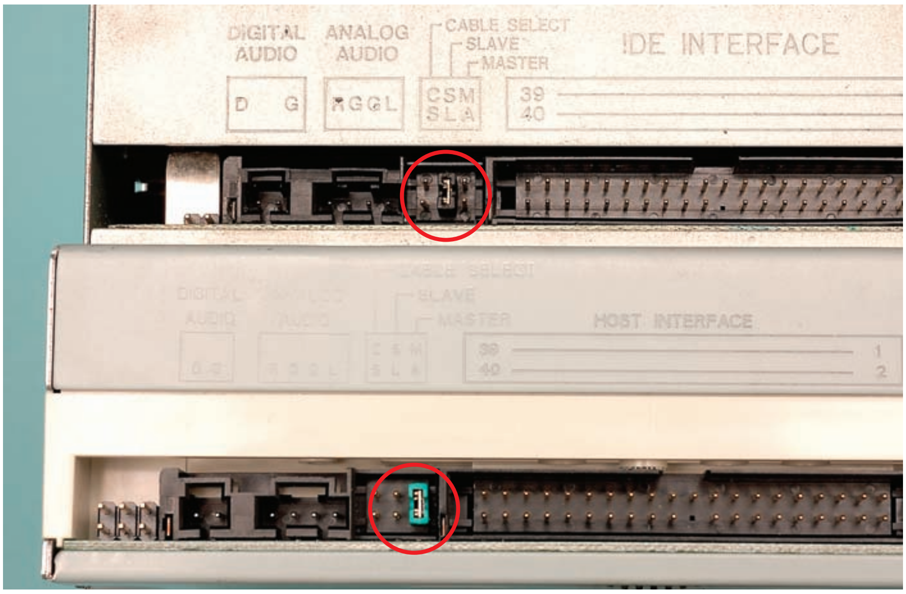
How auto-detection works

Let's now see how the micro detects any connected ATAPI devices at boot up.

First, a simple test is done. The micro writes a known value to an ATA register and then attempts to read that value. If the value read is the same as that written, the autodetect subroutine goes to the next stage.

Conversely, if the drive fails this test, it is assumed to be absent. Instead, 0xFF is returned as the value read due to internal pull-ups on all inputs (which incidentally, is not the value that is written).

The next stage of auto-detection involves searching for the signature that all ATAPI devices are required to have (according to the standard). In fact, all ATAPI devices have a unique signature of 0x14 and 0xEB (notice that 0x14 + 0xEB = 0xFF) in the Count Low and Count High registers on start up.



CD-ROM drives have three sets of jumper pins at the back to configure the drive. If you have just one drive, it can be configured as either a master (MA) or a slave (SL) using the jumper link. However, if you are using two drives, then one must be configured as a master and the other as a slave, as shown here.

The inquiry command of the ATA interface, while mandatory for ATA devices, is actually aborted by ATAPI devices. Instead, the effect of this ATA command on ATAPI devices is to put the ATAPI signature word in the Count Low and Count High registers. What is mandatory for ATAPI devices is to support the ATAPI inquiry command.

The algorithm for detecting the drives is as follows:

1) Perform a simple read-write test. Abort if this test fails, otherwise continue.
2) Select the drive by writing to the drive/head register.
3) Issue an ATA identify device command.
4) If the signature 0x14 0xEB in the Count Low and Count High registers is present, go to step 5.
5) If this signature is not present, the device is either absent or it is not an ATAPI device. Therefore, we may assume that no ATAPI device is present and terminate.
6) If the ATAPI signature is detected, we issue an ATAPI inquiry command to get further information about the drive and conclude that an ATAPI device is connected. The test is then terminated.

Firmware operation

Flowchart 2 shows the structure of the firmware. After initialisation, the program can optionally jump to a subroutine to set-up the remote control.

This should be done at least once, preferably the first time the program is run. Once the remote control has been successfully set up, the adapter is ready to be used.

The next stage in the firmware is the auto detection of the drives. Up to two drives can be connected, and they should be configured correctly as master or slave, as detailed previously.

The firmware then enters a 'finite state machine' by going to the neutral (or initial) state. It then listens for activity on the infra-red port and responds to the remote control commands.

There are three playing modes: 1) the default mode, 2) the repeat mode and 3) the random mode. In default mode, the adapter will play the current track and when that is done, will jump to the next track.

In repeat mode, the adapter plays the current track and then repeats it over and over. This mode is indicated by the digit '1' appearing as the last character of the first line of the display in playing mode.

Finally, in random mode, the adapter will play the current track and then select the next track randomly. This mode is indicated by the letter 'R' appearing as the last character of the first line of the display in playing mode.

In operation, the user can scroll between the default, repeat and random modes by pressing the 'Record'

What's a finite state machine?

A finite state machine (also known as a finite state automaton) is a set of states together with a transition table and a designated state that is the 'initial state'.

The transition table can be thought of as a table with three columns and a finite number of rows. The first column corresponds to the current state, the second column corresponds to the input,' and the third column corresponds to the next state. These triplets (X, I, Y) are interpreted as follows: if the machine is in state X and an input I is received, it moves to state Y. While there is no input, the machine stays in its current state.

For example, in our case, if the firmware is in the neutral state, and the user presses the Play key on the remote control, then the transition table dictates that the machine moves to the Playing state. This 'rule' would be written as the triplet ('Neutral', 'PLAY', 'Playing').

The user interface of this playback adapter is simply implemented as a finite state machine, meaning there are a number of rules that make up the transition table. The machine begins in the 'neutral' state, after a short initialisation.

Flowchart 2 shows the finite state machine implemented in the firmware. The transitions correspond to arrows, while the blue blocks are the possible states.

button on the remote control during play mode.

The volume is controlled by the Volume Up and Volume Down buttons on the remote. Up to 16 levels, ranging from muted (0) to full volume (15) can be selected.

The 'Mute' button has the usual effect of storing the current volume and then setting the volume to 0. If pressed again when the volume is 0, the original volume level is restored. The percentage balance of the right and left audio channels can be modified by the user, by pressing the Channel Up and Channel Down buttons on the remote. The percentages range from 0 to 100% in steps of 5%.

The volume for each channel is then calculated in terms of the balance using a simple formula:

1) Volume (left) =
(Balance left)/100 × Volume level

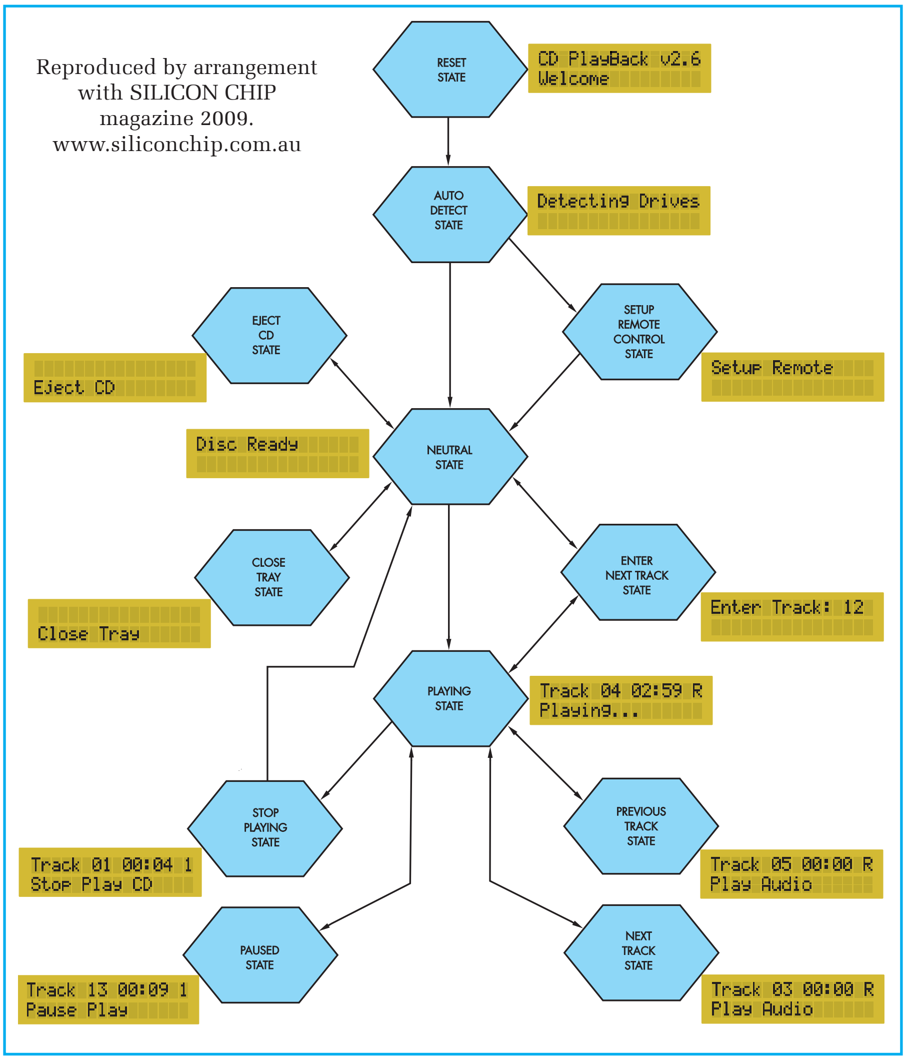
2) Volume (right) =
(Balance right)/100 × Volume level

In playing mode, there are the usual control options, such as going to the next track (pressing the Fast Forward button) or to the previous track (pressing the Rewind button). You can also pause playing (by pressing Pause) or stop playing (by pressing Stop).

The 20+ button on the remote can be used to either eject the CD or close the tray (depending on whether the tray is already closed or open). The Line-In button is used to switch between master and slave devices, if two drives are connected and have been correctly detected by the firmware.

The 0 to 9 number buttons are used to select a particular track number to play. Simply press the correct number (which will be shown on the screen) and then press Play to play the selected track number.

As you can see, the user interface has been kept deliberately simple and intuitive. By the way, you can use virtually any RC5-compatible remote control since you can assign the buttons during the set-up procedure (more on this next month). ***EPE***



Flowchart 2: this flowchart shows the 'finite state machine' implemented by the firmware. After a short initialisation, which includes the automatic detection of connected drives, the firmware goes into the neutral state. From there, it starts accepting remote control commands that change the state of the machine. Typical display readouts corresponding to each state are also shown.

Max's Cool Beans

By Max The Magnificent

Next Generation TV and Computer Displays

FOR many decades, cathode-ray tube (CRT)-based television and computer displays were the only game in town. More recently, liquid crystal displays (LCDs) have come to the fore. Unfortunately, LCDs don't have the vibrancy and clarity of their CRT counterparts. This was brought home to me last weekend when I was watching a DVD on the wall-mounted LCD in my study. Even though it was an overcast day, the slight amount of sunlight coming through the window totally washed out the image.

So, what other display technologies are available or on the drawing board? Well, of course we've all seen plasma display panels (PDPs) in the television stores. These displays offer bright, crisp, high-contrast images. In this case, we can think of each pixel (picture element) as being formed from three tiny fluorescent lights (like microscopic neon tubes). By one mechanism or another, these three tiny neon tubes can be coerced into generating red, green, and blue light, each of which can be controlled to form the final color coming out of that pixel.

Plasma displays are fantastic when it comes to presenting ever-moving images such as films. However, if they are instructed to present the same image over and over again, they suffer from 'burn-in' effects that leave 'ghost' images on the screen.

Going organic

Another option is presented by displays based on organic light-emitting diodes (OLEDs). These are devices that are formed from thin films of organic molecules that generate light when stimulated by electricity. OLED-based displays hold the promise of providing bright and crisp images while using significantly less power than their liquid crystal counterparts.

At some stage in the future, it may be possible to use OLEDs to create displays that are only a few millimeters thick and are two metres wide (or more); these displays would consume very little power compared to other technologies, and in some cases the display could be rolled up and stored away when it wasn't in use (OLEDs can be 'printed' onto flexible plastic substrates). But (despite some very exciting 'proof-of-concept' demonstrations), this technology isn't ready for 'prime time' usage just yet.

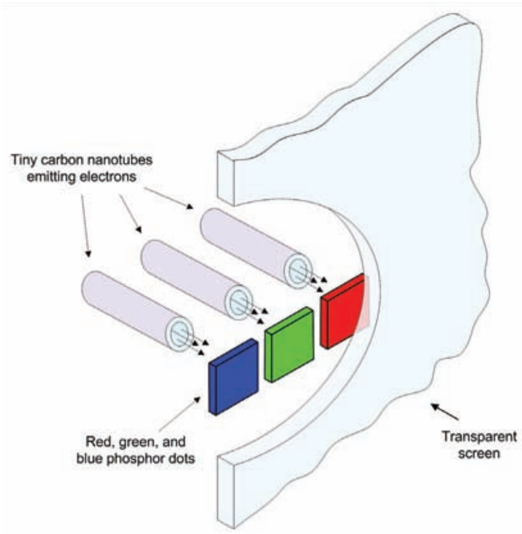
OLED-based displays are sometimes used for small-screen applications such as cellphones and digital cameras, but their widespread affordable deployment for applications like large screen television and computer displays may not come for another five years or more at the time of writing this (in fact, they may not make it at all if the SED technology discussed below fulfills its promise).

The future is SED

And thus we come to 'surface emission displays' (SEDs). This is where things start to get very exciting. Prior to the mid-1980s, graphite and diamond were the only forms of pure carbon that were known to us. In 1985, however, a third form consisting of spheres formed from 60 carbon atoms was discovered. Commonly referred to as 'Buckyballs,' the official moniker of this material is Buckministerfullerine, which was named after the American architect Richard Buckminister Fuller, who designed geodesic domes with a similar underlying symmetry.

Sometime later, scientists discovered a related structure that we now refer to as a carbon nanotube. Such nanotubes can be incredibly small, with a diameter only one thousandth of one millionth of a metre. Furthermore, they are stronger than steel, have excellent thermal stability, and are tremendous conductors of heat and electricity. In addition to functioning as wires, nanotubes can be persuaded to act as transistors.

Of particular interest to us here, is that they can also be coerced into emitting streams of electrons out of one end. Hmmm, tiny little electron guns; what I wonder, could we perform with these little rapscallions?



Well, imagine a screen that is thin and flat like a LCD, but is as bright and vibrant as a CRT-based display. That's what you end up with if the screen is formed from a carbon nanotube-based SED. In this case, the inside of the screen is covered with red, green, and blue phosphor dots (one of each to form each pixel), and each of these dots has its own carbon nanotube electron gun.

This technology has been skulking around in the background for some time. Toshiba hosted the first public demonstration of a large-scale carbon nanotube-based SED at the consumer electronics show (*CES*) in January 2006. Industry expert Dennis Barker attended the show; afterwards he said to me:

"High-definition television is incredibly realistic, but SED goes one step beyond. When I saw the Toshiba demonstration, it gave me chills and the hairs on the back of my neck stood to attention. I have seen the future and – to me – the future is SED!"

Originally, it was predicted that we would be seeing SEDs on the streets toward the end of 2006 and the beginning of 2007. It was later announced that the introduction of these devices was being held back until around the middle of 2008 (to coincide with the summer Olympics in Beijing). At the time of writing, this technology has not yet being widely deployed, but it appears as though most of the issues that have been holding it back have been resolved, and SED displays could well be poised to leap onto the centre stage. And when they do, I want one!

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

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

Weird Wireless

Mark Nelson

Although the days when we tuned the bands nightly for something interesting to listen to are past for most of us, we can all probably recall the thrill of dropping into really strange transmissions on the airwaves. Mark Nelson looks at some of the more odd incidents.

I have a confession to make. As a young teenager I used to listen to my beloved transistor radio under the bed clothes and I suspect I was not alone in this. There was something strange, but intensely satisfying in this clandestine activity. Tuning up and down the medium wave in the hope of hearing the close-down of *Radio Caroline* North, the repeated interval signal of *Radio Moscow* or Willis Conover intoning the 'Jazz Hour' on *Voice of America*.

Your mileage may vary, as they say, but it's an indisputable fact that scanning the airwaves has an immense appeal for devotees, as they search for something different to excite their ears. And this article is all about exciting – or bewildering – broadcasts.

Spiritual radio

No, 'spiritual radio' is not about religious broadcasting (remember 'The World Tomorrow' with Garner Ted Armstrong?), although the devotees are unquestionably 'believers'. Their fervour is devout, but the spirits they believe in are not holy. In fact, their passion is for paranormal communication with spirits who have departed life on earth. Traditionally, this has been carried out through the medium of psychics and clairvoyants, but just as radio has been applied to medical imaging and astronomy (astrology can't be far off), it is also employed by spiritualists.

I'll deal with the details in a moment, but first let's journey back to the 1980s, when for the then rather pricey sum of 60p you could buy a partwork magazine called *The Unexplained: Mysteries of Mind, Space and Time*. If you didn't lose your nerve, and continued buying all 26 issues, you ended up with a veritable encyclopedia of utter nonsense (albeit intriguing nonsense) about the paranormal. Purchasers did get some reward for their loyalty though, as our Scottish correspondent now relates.

"Although 60p an issue was a fair amount back then for a silly magazine, what got all my school friends and me excited and spooked was the first issue having a flexi disc with the awe-inspiring title *Breakthrough: An Amazing Experiment in Electronic Communication with the Dead*, printed in white letters on jet black plastic. Yes, it all seemed plausible, never mind the fact that listening now, the voice of Churchill sounds like a BBC announcer picked up from a very distant radio station. Of course, thirty-odd years ago I knew nothing of how radio waves travelled. It seems almost incredible to think that we took this seriously and found it unsettling.

There was also a TV advert for the first issue of the magazine, which cleverly gave you a snatch of one of the voices. When that came out, I found myself in the local newsagent one Saturday afternoon, with busy people snapping up the magazine from an extra large batch. I could see there were only a few issues left.

Now, thanks to this website (**http://blog.wfmu.org/freeform/2006/09/voice_from_the_.html**) I have heard the disc in full again for the first time in 29 years. They have it on MP3 and you can listen by clicking on the links, assuming you have QuickTime installed.

It's exactly as I recall it too, with a prim female announcer lending credibility and those ghostly sounds from goodness knows where. Not actually a hoax, but sincere, even if the results were dubious. Arguably, the story of how the disc scared a generation of school kids is just as much a part of a strange legend as the Welles Martian invasion radio hoax."

The Ghost of 29 Megacycles

Even more fantastic is the theory propounded in the 1970s by American investigative writer and broadcaster John G. Fuller. He asked, is it possible that, when certain audio frequencies are combined with a tape recorder, the dead can communicate with us, not through a medium but using their own voices? That was the proposition set out in his book *The Ghost of 29 Megacycles* (not to be confused with a performance/art collective of the same name in Australia).

This substantial and level-headed paperback, published in 1985 and still easy to find, was devoted to research on the subject of electronic voice phenomena (EVP). American investigators were convinced the dead could communicate with us by radio, setting up a half-million dollar project called 'Spiricom' to establish the proof.

It was pretty obvious that they would never establish scientific proof, even if they themselves believed their findings were real. They argued that if it had been legitimate for Marconi to investigate the subject in the 1930s, why should they not do so now using more sophisticated equipment.

Where credibility broke down was that for some reason these 'transmissions' from the dead were confined to the 29MHz band. Even the book's author was not entirely convinced, conceding on the first page, "This is a strange story. It is either true or it is not."

Interest in the subject has not gone away, and today, apparently some 30,000 people in more than 87 countries are members of electronic voice societies, believing they can record the voices of the dead, and messages from the other side on normal analogue tape recorders. Despite the emergence of digital technology, the growing new wave of such belief systems is "a seemingly irrational response to an increasingly irrational world" as one commentator puts it.

Yuletide cheer with a sour taste

Our final example of weird wireless is older. During the Second World War, the need to sustain morale on the home front was a crucial mission for which radio worked extremely well. Hitler's propaganda minister Josef Goebbels certainly knew this, declaring radio to be "the most modern and most important instrument of mass influence that exists anywhere".

You could say that during that conflict nobody (mis-) used broadcasting more effectively than the Nazis. One of their technically most accomplished, yet strangest stunts was the Ringsendung or link-up transmission of Christmas 1942. The purpose was to let German citizens at home hear upbeat messages from their battle zone troops on all the fighting fronts. Stunningly impressive is the only way to describe this heart-jerking broadcast, which fortunately survives on recordings. You can get a very good feel for it if you 'tune in' to **www.youtube.com/watch?v=iQ4vLynW3yg** and listen to the spooky programme *Silent Night on All Fronts* for a few minutes.

It's spooky because the audio quality is quite chilling: weird echoes and distortions lend an eerie and almost supernatural feel, making the brave voices sound as if on the far side of the moon. Utterly unreal in fact and unfortunately that's exactly what these transmissions were. They were concocted, in a masterly way, entirely in the Reichsrundfunk studios in Berlin using echo chambers, ring modulators (presumably) and other devices that the future BBC Radiophonic Workshop might have died for.

You have to admire this magnificent effort, notwithstanding the fact it's a forgery. I ought to add that some people do consider the programme to be genuine and many Germans do not admit that they were duped on this occasion, even though Goebbels was such a master of lies. Why not make up your own mind when you listen?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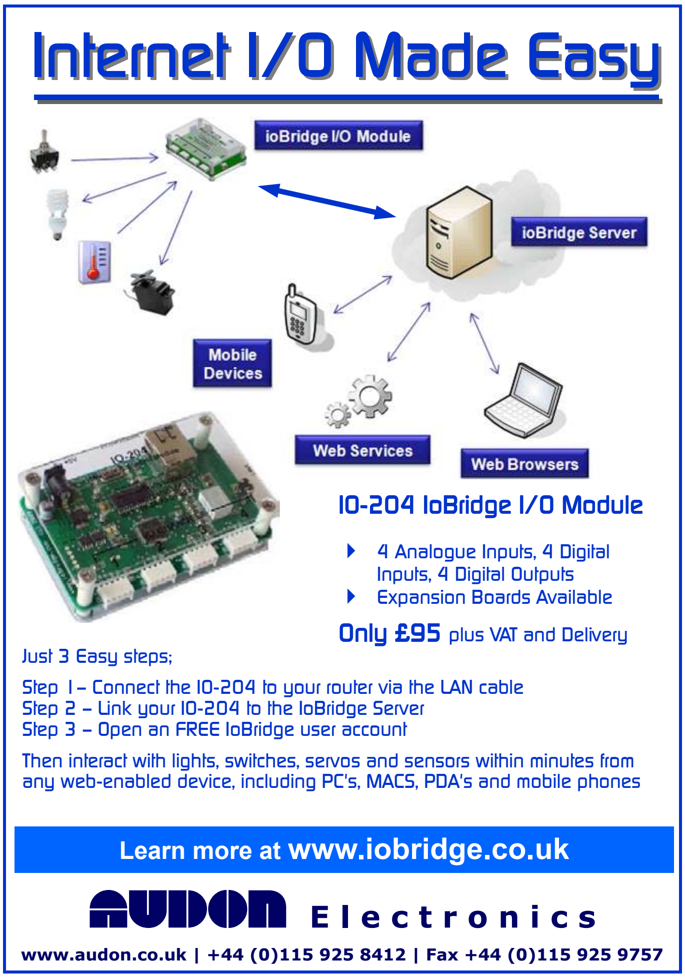
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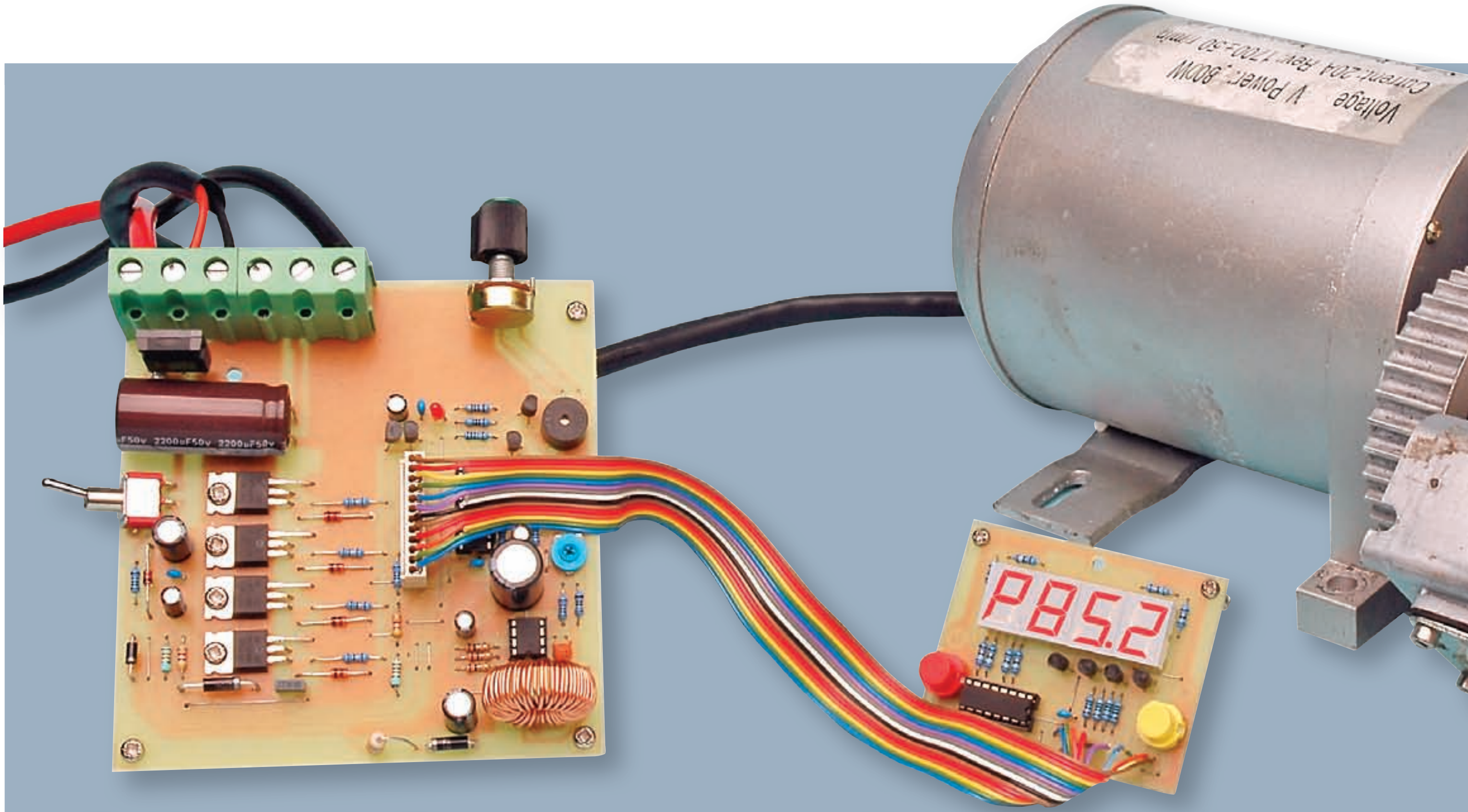


12V-24V High-Current Motor Speed Controller

This 12V or 24V high-current DC Motor Speed Controller is rated at up to 40A (continuous) and is suitable for heavy-duty motor applications. All control tasks are monitored by a microcontroller and as a result, the list of features is extensive.

THIS high-current motor speed controller is based on a PIC16F88 microcontroller. This micro provides all the fancy features, such as battery monitoring, soft-start and speed regulation. It also monitors the speed setting potentiometer and drives a 4-digit display board, which includes two pushbuttons.

The 4-digit display board is optional, but we strongly recommend that you build it, even if you only use it for the initial set-up. It unlocks the full features of the speed controller and allows all settings to be adjusted.

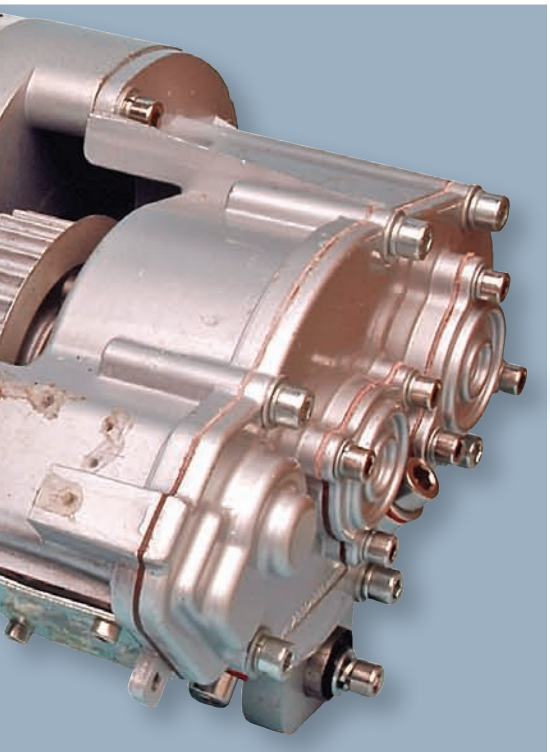
The microcontroller will detect whether the display board is connected, and if not, the speed controller will support only the basic functions. In this simple mode, it will function as a simple speed-regulated controller with automatic soft-start and with the speed being directly controlled by a rotary potentiometer (VR1). All the other settings will be the initial defaults or as last set (with the display board connected).

When connected, the 4-digit display allows you to monitor the speed and the input voltage (useful when running from a battery). It also enables you to navigate through the various menus to adjust the settings.

The circuit can run from 12V or 24V batteries and can drive motors (or resistive loads) up to 40A. Furthermore, this is our first DC speed controller (except for train controllers) incorporating speed regulation under load. In other words, a given motor speed is maintained, regardless of whether the motor is driving a heavy load or not.

Monitoring the back-EMF

In speed controllers which do not have good speed regulation (ie, the vast majority of designs), the more a motor



Part 1
By MAURO GRASSI

is loaded, the more it slows down. In order to provide speed regulation, the circuit must monitor the back-EMF of the motor, since this parameter is directly proportional to its speed.

As a result, this speed controller monitors the back-EMF of the motor. ‘Back-EMF’ is the voltage generated by any motor to oppose the current through its windings. EMF stands for ‘electromotive force’ and is directly proportional to the motor speed and so by monitoring this parameter, we have a means of controlling and maintaining the motor speed.

In practice, the main control loop of the microcontroller tries to match the speed of the motor (back-EMF) to the speed set by the pot or a value recalled from a preset memory. If the measured speed is lower than the set speed, the duty cycle of the pulse width modulation (PWM) signal used to drive the power MOSFETs that control the motor is gradually increased. In other words, if the speed tends to drop, more power is fed to the motor and vice versa.

The frequency of the pulse width modulation can be set from 488Hz to 7812Hz. This is a useful feature, since different motors will have different frequency responses, as well as different resonant frequencies. It is important to reduce the audible buzzing from the pulse width modulation, as these frequencies are well within the range of hearing.

Window of opportunity

By now, you’re probably wondering how the microcontroller monitors the back-EMF of the motor, considering that the motor is continuously driven with pulse-width modulated DC. The answer is that the micro periodically turns off the PWM signal to the motor for just enough time for the back-EMF to stabilise.

This ‘window’ needs to be wide enough to ensure that we are measuring back-EMF and not the spike generated by the last PWM pulse. On the other hand, we don’t want the window so wide that the maximum power to the motor is significantly reduced or that the motor noticeably slows.

The compromise value is that the motor is monitored for 200μs every 7.4ms (ie, about 135 times a second), as shown in the scope screen shots in Fig.3 to Fig.7. As a result, the fact that we do monitor the back-EMF around 135 times a second means that the power applied to the motor is slightly less than the theoretical maximum, although this effect is negligible.

A low-battery alarm is also incorporated to warn when the battery level drops below a preset value. This is especially useful for applications like electric wheelchairs.

There are also eight memory speed settings. All settings are persistent, meaning they are retained in non-volatile memory.

Soft-start

When the motor is switched off, perhaps by an external switch in series with one of its terminals, the voltage at the drain (D) of the MOSFETs will be 0V (this is due to the voltage divider used to scale the back-EMF voltage to within the operating range of the microcontroller). The microcontroller converts this analogue value to a digital value using an on-board ADC (analogue-to-digital converter).

Main Features

- Good speed regulation under load
- Automatic soft-start and fast switch-off
- Eight memory settings
- 4-digit 7-segment display
- Variable frequency for pulse width modulation (PWM)
- Battery level meter
- Low-battery alarm
- Persistent settings and defaults
- Rated up to 40A continuous current
- 12V or 24V DC input voltage

The firmware detects this 0V condition and sets the duty cycle of the PWM to 0%. This ensures that when the motor is switched in, its speed will increase gradually from the stationary state to the desired speed setting.

Turn-on currents for motors can be very high and it is desirable to reduce these surge currents as much as possible. That is why the automatic soft-start feature has been incorporated into the firmware. It will ensure that the motor is brought up to the set speed gradually.

Fast switch-off feature

Another feature that has been incorporated into the firmware is the so-called ‘fast-off’ feature. This means that the duty cycle of the PW modulation is set to 0% (turning off the motor) whenever the selected speed setting of the pot goes to 0%. Rather than decreasing the speed gradually, setting the pot to its lowest setting turns the motor off immediately.

This design also incorporates our extensive experience with previous speed controllers. As a result, it uses four high-current MOSFETs to do the switching (pulse width modulation), uses very wide tracks on the PC board and heavy-duty (40A) terminal blocks to carry the large currents.

User interface

Two pushbuttons on the display board are used to navigate through the menus, while the potentiometer (VR1) is used both to vary the speed and to vary certain settings.

Parts List – 12V/24V High-Current DC Motor Speed Controller

Main Board

1 PC board, code 736 Main, available from the *EPE PCB Service*, size 124mm × 118mm
2 heavy-duty PC-mount terminal blocks (3-way)
1 8-pin DIP IC socket
1 18-pin DIP IC socket
1 SPDT toggle switch (S1)
1 50A 'gold' fuse (FS1) (Jaycar SF1976 or similar)
1 60A in-line fuseholder (Jaycar SZ2065)
1 12-way pin header
1 PC-mount mini piezo beeper (Jaycar AB3459 or equivalent)
1 220 H inductor (L1) (Jaycar LF1276 or equivalent)
1 10kΩ 16mm PC-mount linear single-gang potentiometer (VR1)
1 500Ω horizontal trimpot (VR2)

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 0910308A.hex (IC1)
1 MC34063 switchmode DC-DC converter (IC2)
1 BC327 *PNP* transistor (Q1)
3 BC337 *NPN* transistors (Q2-Q4)
4 IRF1405 *N*-channel MOSFETs (Q5-Q8) (Jaycar ZT2468)
1 1N4004 400V 1A rect. diode (D1)
1 1N5819 Schottky diode (D2)
2 MBR20100CT 20A diodes (Jaycar ZR1039) OR
1 40EPF06PBF 40A ultra-fast diode (Farnell 910-1560) (D3)
5 1N4745 16V 1W Zener diodes (ZD1-ZD5)
2 1N5364BG 33V 5W Zener diodes (ZD6-ZD7) (Farnell 955-8217)
1 3mm red LED (LED1)

Capacitors

1 2200 F 50V low-ESR electrolytic
1 470 F 16V electrolytic
1 100 F 63V electrolytic
1 100 F 25V electrolytic
1 10 F 25V electrolytic
3 4.7 F 16V electrolytic
1 220nF 100V MKT polyester
1 100nF 100V MKT polyester
3 100nF monolithic
1 470pF ceramic

Resistors (0.25W, 1% metal film)

2 33kΩ	1 100Ω
2 4.7kΩ	1 56Ω
1 3.6kΩ	1 22Ω 1W
5 1kΩ	4 15Ω
2 470Ω	3 1Ω

Display Board

1 PC board, code 737 Display, available from the *EPE PCB Service*, size 73mm × 58mm
1 200mm length 16-way rainbow cable
1 12-way pin header
2 12-way header plugs (to terminate cable)
1 SPST PC-mount momentary-contact switch, yellow (Jaycar SP0722) (S2)
1 SPST PC-mount momentary-contact switch, red (Jaycar SP0720 (S3)
1 16-pin DIP IC socket (optional)
1 100nF monolithic capacitor

Semiconductors

1 74HC595 shift register (IC3)
4 BC337 *NPN* transistors (Q9-Q12)
4 7-segment common cathode red LED displays (Jaycar ZD1855 or similar

Resistors (0.25W, 1% metal film)

4 470Ω
8 39Ω

The two pushbuttons are sensitive to two types of presses, short and long. A short press is of the order of half a second or less, while a long press is around one second.

To change a setting, a long press is usually needed. This prevents unwanted changes to the settings, which are stored in EEPROM and thus recalled at the next switch on.

Because of the capabilities offered by the PIC microcontroller, we have been able to incorporate a large number of features into the firmware, as described in the separate panel later.

Circuit description

The circuit for the speed controller is shown in Fig.1. As noted previously, it can work with 12V or 24V batteries, but has been optimised for operation at 24V. Within the circuit itself, there are two separate voltage rails: +5V for the microcontroller and +16V for driving the gates (G) of the MOSFETs. Both are derived from the +24V input supply.

The main input supply is filtered by a 2200 F low ESR capacitor, to minimise high-voltage transients which can be produced by the inductance of the battery connecting leads. This capacitor is absolutely vital to the proper operation of the speed controller at high currents.

Power switch S1 and diode D1 protect the low-power part of the circuit (IC1 and IC2) from reverse polarity. A 22Ω 1W resistor, a 33V 5W Zener diode (ZD7) and a 100 F capacitor also protect the MC34063 DC-DC converter IC from transients on the supply rail.

The filtered supply is fed to the MC34063 (IC2), which operates in a standard step-down converter configuration to provide the +5V rail. Three 1Ω resistors between pins 6 and 7 are used to set the maximum switching current. The output voltage is set by the voltage divider associated with trimpot VR2.

Only about 200mA is ever drawn from this supply, and most of this is used to drive the display.

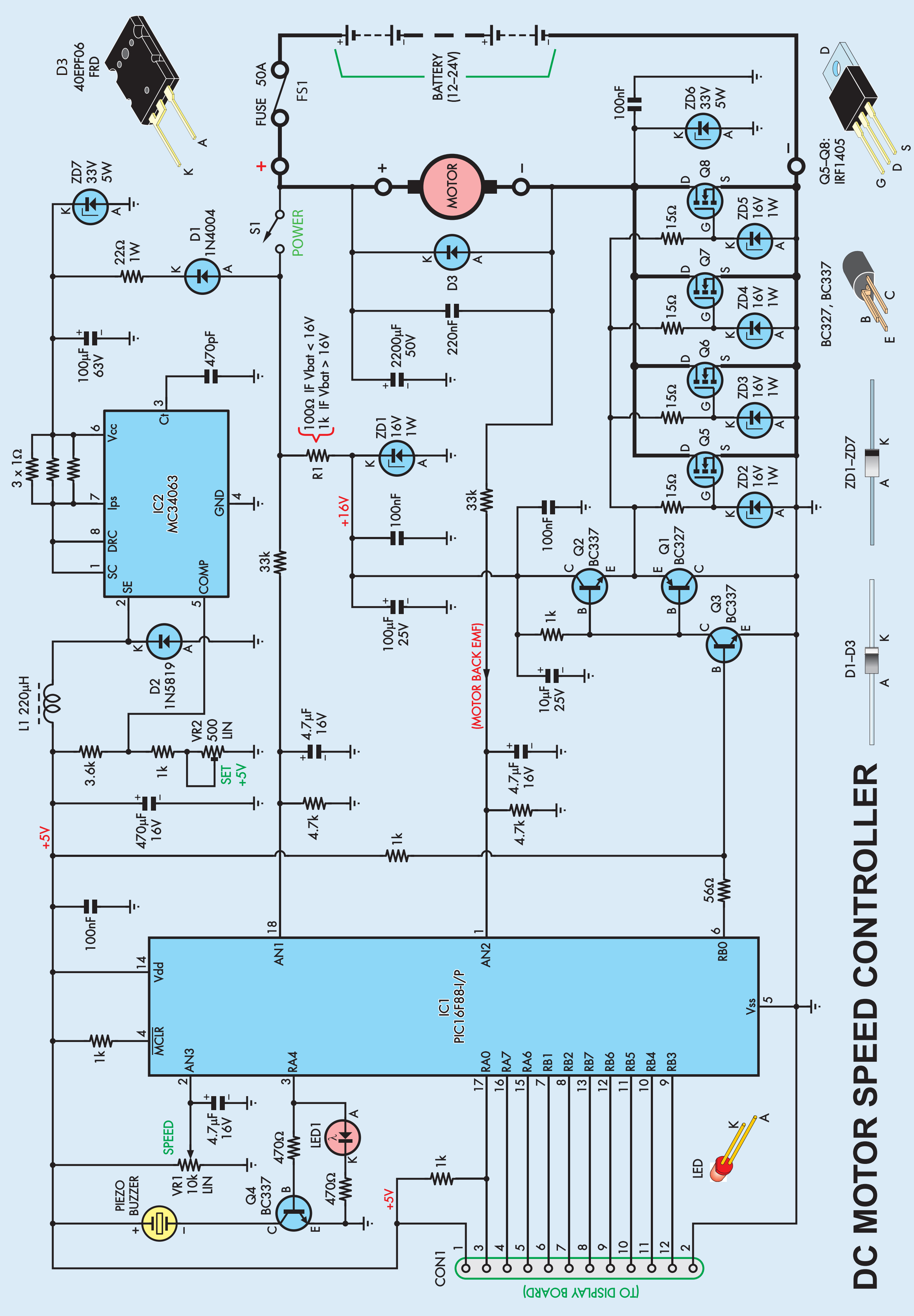
IC1 is the heart of the circuit and is the popular PIC16F88 microcontroller, which incorporates a number of peripheral functions. Of these, the timers, hardware PWM (pulse width modulation) and three ADC inputs are used.

The three ADC inputs used are at pins 1, 2 and 18. As these need to be within the 0V to 5V range, voltage dividers consisting of 33kΩ and 4.7kΩ resistors are used to scale both the input voltage rail (which could be as high as 29V) and the back-EMF from the motor, to be fed to the ADC inputs at pins 1 and 18. The ADCs convert the monitored voltages to 10-bit values.

Gate driver

The +16V rail is used as the gate drive supply for the MOSFETs and is derived from the 24V supply via a 1kΩ resistor and a 16V 1W Zener diode (ZD1). Bypassing of this rail is particularly important and is accomplished using 100 F and 100nF capacitors near ZD1 and adjacent to the transistors Q1 and Q2.

If the battery supply is to be 12V, the 1kΩ resistor feeding ZD1 should be reduced to 100Ω. In this case, the supply will actually be between 12V and 14V (depending on the actual battery voltage); still enough to provide adequate gate drive for the MOSFETs and ensure minimum heat dissipation (low on-resistance).



DC MOTOR SPEED CONTROLLER

Fig.1: the circuit uses PIC16F88 microcontroller IC1 to provide PWM drive to power MOSFETs Q5 to Q8, which in turn control the motor. The microcontroller also monitors the back-EMF from the motor to provide speed regulation. IC2 is a DC-DC switchmode converter, and this provides a +5V rail to power IC1.

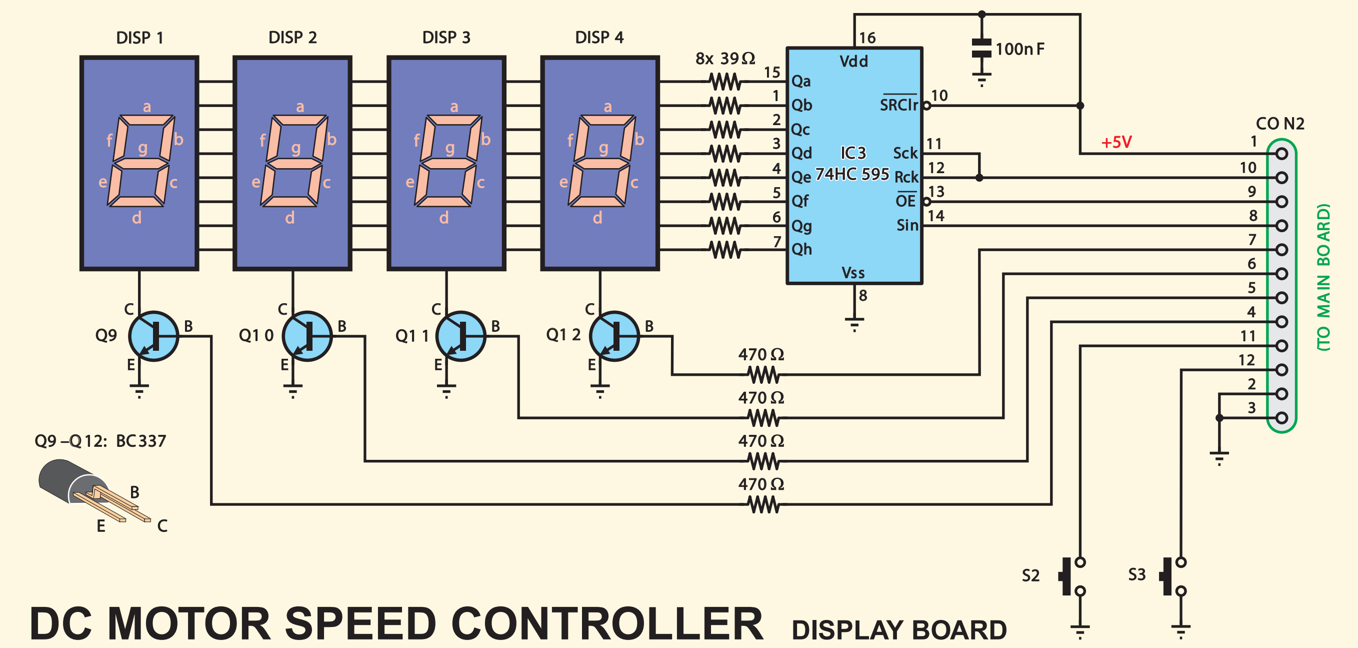


Fig.2: the display circuit interfaces to the microcontroller and uses a 74HC595 shift register (IC3) and transistors Q9 to Q12 to drive four 7-segment LED displays. Switches S2 and S3 are used to control the display and for software set-up

The PWM output of the PIC16F88 (adjusted by firmware) appears at pin 6 and drives transistor Q3, which then drives complementary transistors Q1 and Q2. Transistor Q1, Q2 and Q3 thus provide buffering and voltage level translation for IC1's PWM output to drive the gates of MOSFETs Q5 to Q8, via 15Ω resistors.

Note that these resistors need to be relatively low in value (ie, 15Ω) in order to ensure quick charging and discharging of the gate capacitances. That's because the gate capacitance of these MOSFETs can be quite high, of the order of 5000pF to 10,000pF each. If the gate charging time is too long, the MOSFETs will spend too much time between the on and off states and this will lead to much higher heat dissipation.

In fact, the gate voltage transitions need to be very fast, of the order of 1 s or less. This has been accomplished, as shown by the oscilloscope screen grab of Fig.4.

The specified MOSFETs are from International Rectifier, type IRF1405. This is a 55V 169A *N*-channel HexFET with an exceptionally low on-resistance (Rds) of 5.3 milliohms (5.3mΩ) typical. Their pulse current rating is a stupendous 680A.

The IRF1405 is specifically intended for automotive use, in applications such as electric power steering, anti-lock braking systems (ABS), power windows and so on, and is therefore ideal for this speed control application.

Why four MOSFETs?

In fact, since the ratings of this MOSFET is so high, you might think that just one device on its own would be enough to handle the 40A rating of this speed controller project. So why are we using four MOSFETs in parallel?

As always, real world use brings us down to earth. For a start, we are using these MOSFETs without heatsinks, apart from the heatsink effect of bolting them to the copper side of the PC board – not much heatsink benefit there. Their thermal characteristic is 62°C per watt (junction to ambient), if they are mounted in free air (which they are not).

Assuming an ambient temperature of 25°C and an on-resistance of 10mΩ (conservative), we can approximate the temperature of the MOSFETs at their highest operating current (10A per MOSFET for a total of 40A). At 10A and 10mΩ on-resistance, the power dissipated is: $10^2 \times .01 = 1$W

Therefore, the temperature of the case will be approximately: $25 + 62 \times 1 = 87$°C

This means that at full current, the MOSFETs will be very hot to the touch. Careful: they will burn you. Our measurements produced a top temperature of around 77°C after a test period of half an hour.

In practice, even with much higher ambient temperatures, the MOSFETs should not get quite this hot because in 'real world' operation, the speed control is not likely to be providing full power to the motor on a continuous basis. At 24V and 40A, the motor would have 960W applied (ie, more than 1HP) and this equates to relatively high power operation.

Protection

Zener diodes ZD2 to ZD5 are included to protect the MOSFETs from excessive gate voltages. In normal circuit operation, these Zener diodes do nothing.

Additional protection for the drains of the paralleled MOSFETs is provided by 33V 5W Zener diode ZD6, in parallel with a 100nF capacitor. The Zener is there to clip any residual voltage transients which get past the 2200 F low-ESR input filter capacitor.

The MOSFETs are further protected by fast-recovery diode D3 and its parallel 220nF capacitor. These parts are wired across the motor terminals and are used to suppress the high back-EMF spikes caused by the armature inductance when the motor is switched off by the MOSFETs.

These components are crucial to the operation of the speed controller. Without them, the high voltages generated can and probably would destroy the MOSFETs.

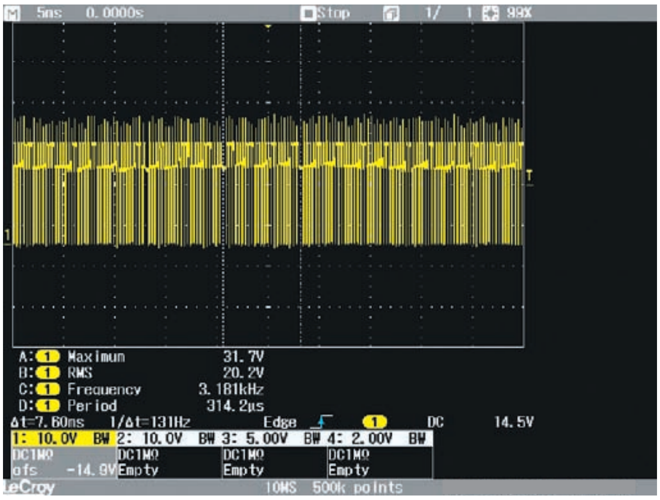


Fig.3: the yellow trace is the voltage waveform at the drain of the MOSFETs when a motor is connected. There are narrow spikes up to 31.7V when the MOSFETs switch off due to the inductance of the armature. The small windows where the MOSFETs are switched off to sense the back-EMF of the motor can also be seen. The two vertical cursors show that the period between such intervals is of the order of 7.6ms. In other words, the speed of the motor is monitored at 131Hz.

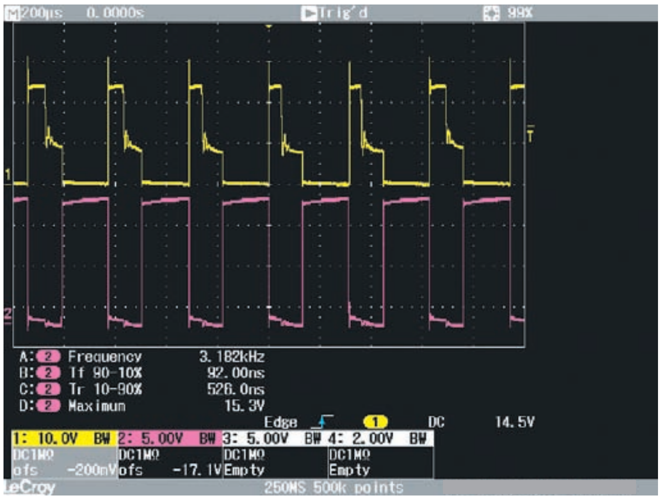


Fig.4: the yellow trace is the voltage waveform at the drain of the MOSFETs, while the purple trace is the gate drive. The gate drive goes as high as 15.3V. The rise time of the gates is 526ns, while the fall time is 92ns. When switching the MOSFETs on and off, it is necessary that the transition be fast, ideally under 1µs, otherwise the MOSFETs will dissipate more heat than is necessary. To ensure fast switching of the MOSFETs, their gate capacitance needs to be charged and discharged very quickly.

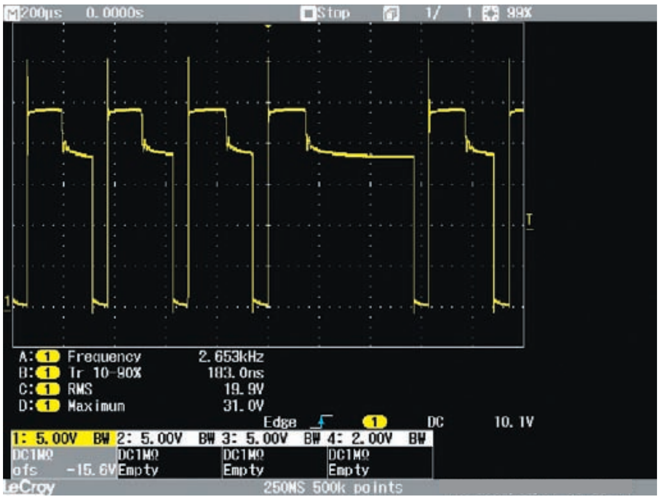


Fig.5: the yellow trace shows the voltage waveform at the drain of the MOSFETs when a motor is connected. The irregular waveform corresponds to the back-EMF monitoring. The MOSFETs are then off and the voltage is now directly proportional to the speed of the motor. The window is narrow enough for the motor's deceleration to be negligible. Turning off the MOSFETs to monitor the back-EMF is asynchronous to the PWM driving the MOSFETs.

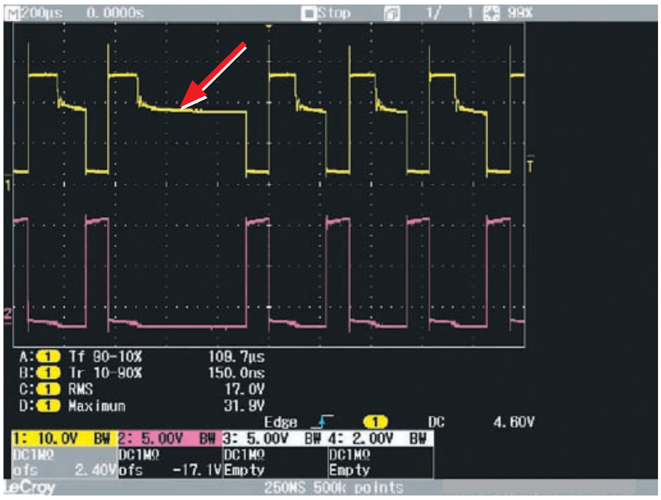


Fig.6: the yellow trace is the voltage waveform at the drain of the MOSFETs and the purple trace is the waveform at the gate of the MOSFETs when a motor is connected. Again, the irregular yellow waveform (arrowed) corresponds to the period when the MOSFETs are switched off to sense the back-EMF and hence the speed of the motor. You can see from the purple trace that the gate drive during this time is 0V.

Other protection measures

As already mentioned, diode D1 provides reverse polarity protection for microcontroller IC1 and the switchmode supply (IC2). Zener diode ZD1 is self-protecting in the case of reverse supply connection. However, if the supply is reversed, there will be a heavy conduction path via fast recovery diode D3 and the internal substrate diodes in the four power MOSFETs. If you are lucky, the 50A fuse will blow before the MOSFETs are damaged, but there is no guarantee of this. **SO DON'T REVERSE THE BATTERY CONNECTIONS!**

In a similar vein, if the outputs are shorted while power is applied, high current will flow through the MOSFETs. Again, if you are lucky, the 50A fuse will blow before the MOSFETs go up in smoke. In reality, the 50A fuse is there to stop a fire! **SO DON'T SHORT THE OUTPUTS TO THE MOTOR.**

If the motor is under heavy load and becomes stalled, high currents will flow in its armature. Depending on the motor's rating, this may or may not blow the fuse. If the fuse does not blow during stall conditions of the motor, the MOSFETs should survive, although they may get very hot.

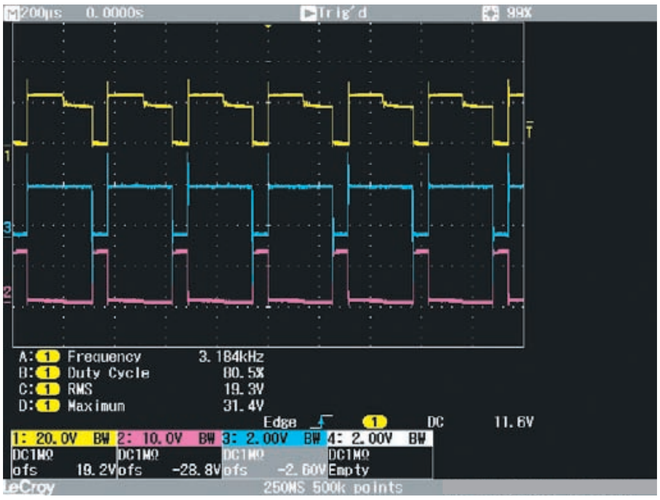
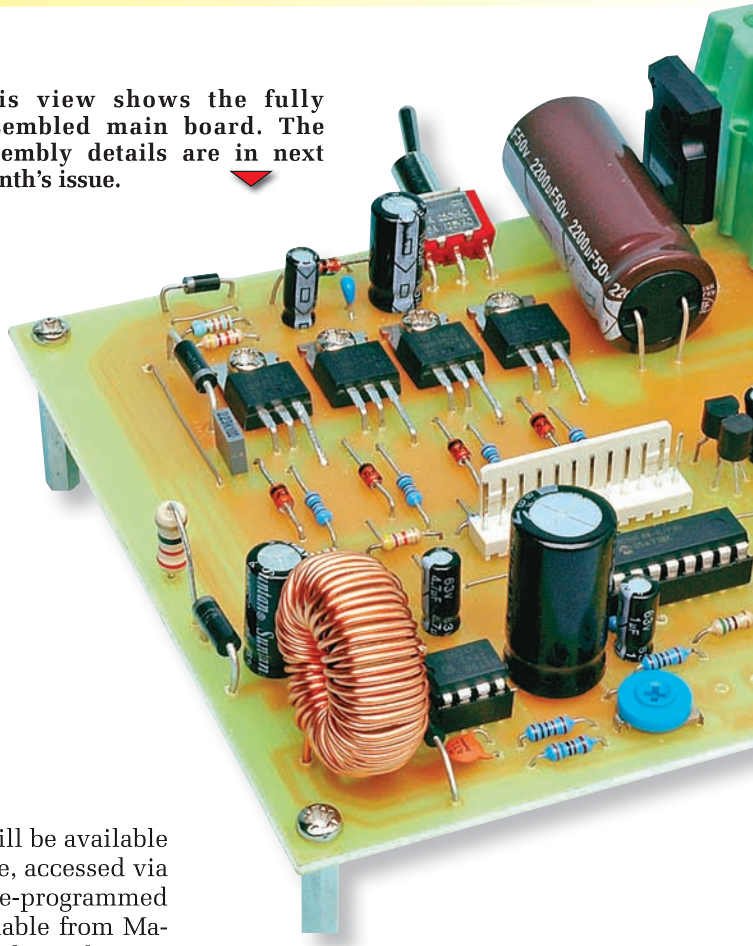


Fig.7: the yellow trace shows the voltage waveform at the drain of the MOSFETs; the purple trace shows the voltage waveform at the gates; and the cyan trace shows the voltage waveform at the PWM output of the microcontroller IC1. Note that transistors Q1 to Q3 provide voltage translation by stepping up the 5V output from the microcontroller to 12 to 16V. This higher voltage is needed to ensure that the MOSFETs are fully turned on.

This view shows the fully assembled main board. The assembly details are in next month's issue.



Warning buzzer

If the circuit is overloaded, the battery voltage should drop to the point where the warning buzzer sounds.

LED1 and its 470Ω current-limiting resistor are switched by a high level on the output of pin 3 of the microcontroller. This is configured as a simple digital output. It also turns on transistor Q4 and the piezo beeper. This output is controlled by the firmware and can be disabled.

A 1kΩ pull-up resistor is used on pin 4 (reset) of the PIC16F88-I/P. This ties the reset pin high, which means that the microcontroller is reset only at power-on.

Finally, the rest of the outputs of the microcontroller, namely pins 7 to 13 and 15 to 17, are used to drive the optional display board.

Software

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

Display board

Fig.2 shows the optional display board circuit. It connects to the main board via 12-pin header CON1 and a ribbon cable.

The display board consists of two pushbutton switches, four 7-segment displays, which are multiplexed by the firm-ware, four transistors and some resistors, as well as a 74HC595 shift register (IC3).

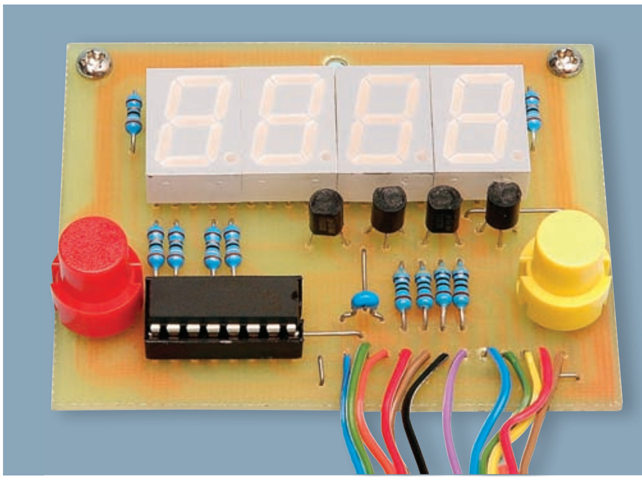
Pins 1 and 2 of the 12-way connector CON2 supply +5V to the display board. Pin 3 is connected to a digital input of the microcontroller (pin 17) and is pulled high by a 1kΩ resistor on the main board. Conversely, it is pulled low by the display board. This is used by the microcontroller to detect whether the display board is connected or not.

Pins 4 to 7 of CON1 are used to drive transistors Q9 to Q12 on the display board. These transistors switch the 7-segment display cathodes (K).

Pins 8 to 10 of CON1 are respectively the CLK, DATA and OUTPUT ENABLE lines and these go to the 74HC595 shift register (IC3). The microcontroller drives these lines to load a new 8-bit value into the shift register. The outputs of the shift register are connected across the four 7-segment displays and drive the anodes.

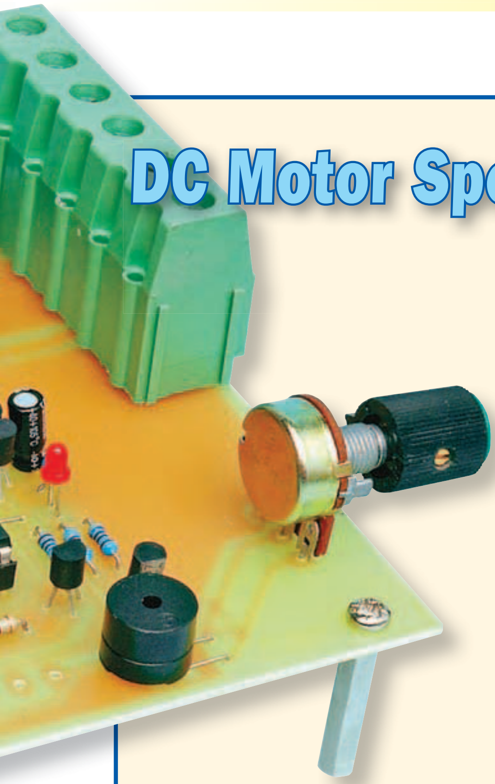
Finally, pins 11 and 12 are connected to pushbutton switches S2 and S3 on the display board. They are also connected to digital inputs on the microcontroller (which have internal pull-ups enabled) and these inputs are used to monitor the pushbuttons.

Next month, we will cover the construction and troubleshooting of the speed controller. In the meantime, take a look at the 'Software Features and Set-up' panel on the following pages.



The optional display board is connected to the main board via a 12-way ribbon cable. It displays the motor speed as a percentage of full speed and is used for the software set-up.

DC Motor Speed Controller: Software Features and Set-up



THE STRUCTURE of the firmware for the DC Motor Speed Controller is shown overleaf in Fig.8. The transitions between the various menus are made using the switches on the display board and are indicated with labelled arrows.

There are four possible switch presses, either 'Short' or 'Long' and either the Left (L) or Right (R). Thus, for example, 'Short R' refers to a short press of the right pushbutton.

Main menu

The Main menu is as shown in Menu 1. It consists of the letter 'P' (for 'percentage') and three digits with a decimal point indicating the range 00.0% to 99.9%. The percentage value indicates the fraction of full speed the motor is currently running at.

In this mode, the motor's speed can be adjusted by varying the pot. The letter 'P' will flash while the motor's speed increases or decreases to the new setting. When the current speed reaches the speed set by the pot, the letter 'P' will stop flashing and there will be a short beep (if enabled).

Since there is a small periodic window when the pulse width modulation (PWM) is turned off by the firmware in order to read the back-EMF, at full speed the reading will not indicate 99.9% but will achieve its maximum at around 98% or so.

Monitoring the input voltage

From the Main menu, press 'Short R' once and you will be taken to the display shown in Menu 2. It consists of a 'b' (for battery) followed by three digits with a decimal point indicating a level from 00.0V to 99.9V, to monitor the battery. For good voltage accuracy, it is important that the +5V supply rail be precisely set using trimpot VR2.

In practice, with the supply rail to the microcontroller set at 5V, the level will not register any higher than around 40.1V. This is because the voltage divider used to derive the voltage reading consists of 33kΩ and 4.7Ω resistors. The relatively high series resistance of 37.7kΩ was chosen to avoid damaging the input of IC1 if the input voltage goes any higher than around 40V.

To go back to the Main menu, either press 'Short L' or press 'Long R'. If you press 'Long L', you will set the low-battery alarm level to 91.6% of the current voltage input level (and then return to the Main menu). This is a shorthand way to set the low-battery alarm level when you know that the batteries are fully charged.

For a typical 12V battery, they are fully charged at around 13.8V (with charger connected) and should not be discharged beyond 11V.

Press 'Short R' to go to the low-battery alarm level menu.

Setting the low-battery alarm

From the Main menu, press 'Short R' twice. You will be taken to the low-battery alarm level menu as shown in Menu 3.

It consists of an 'A' (for alarm) followed by three digits, which indicate a level between 00.0V and 41.6V. This will show the current setting of the low-battery alarm or rather, the voltage level below which the alarm will sound (if enabled).

Whenever the input voltage is below this level, the display will flash (with increasing frequency as the voltage drops) while if the alarm sound is enabled, there will be a flash from LED1 and a beep.

To set the low-battery alarm level press 'Long L'. The 'A' will start flashing and then the low-battery alarm level can be modified by adjusting the pot setting. To turn the alarm off completely, simply set the level to 00.0V.

When you have reached the required level, simply press any button and the level will be recorded (and stored in EEPROM). Then there will be a beep (if enabled) and you will be taken to the Main menu.

Note that the motor will be turned off automatically when setting the low-battery alarm level.

Setting the PWM frequency

From the Main menu, press 'Short R' three times. You will be taken to the frequency menu, as shown in Menu 4.

This consists of an 'F' (for frequency) followed by three digits with a decimal point indicating a level between 0.48kHz and 7.81kHz. This is the current PWM frequency. As the frequency increases, the resolution of the PWM setting decreases.

At 0.48kHz (actually 488Hz) the resolution is 10 bits. This decreases to six bits at 7812Hz. Thus, the

. . . continued next page

DC Motor Speed Controller: Software Features and Set-up . . . continued

resolution is at worst six bits or 64 levels, and at best 10 bits or 1024 levels.

While in this menu, press 'Long L' and you will be able to set the frequency. The 'F' will start flashing and then the frequency will be modified according to the pot setting.

When you have reached the required frequency, simply press any button and the level will be recorded and stored in EEPROM. Then there will be a beep (if enabled) and you will be taken to the Main menu.

Note that the motor will be automatically turned off when setting the frequency.

Enabling and disabling audible cues

From the Main menu, press 'Long L'. You will be taken to the settings menu as shown in Menu 8. It consists of 'A' (for alarm) followed by either '0' or '1' (0 = disable, 1 = enable) and a 'b' (for beep) followed again by either '0' or '1' (0 = disable, 1 = enable). In this menu, pressing 'Short L' will toggle the alarm setting (enable/disable) and pressing 'Short R' will toggle the beep setting (enable/disable).

When the alarm setting is disabled, there will be no beeping when the input voltage falls below the alarm level. There will still be a warning flashing on the display, however. To disable the latter, simply set the alarm level to 00.0V. When the beep setting is disabled, audible beeps emitted by the firmware at certain points (as when setting certain values or when the desired speed is reached) will be blocked.

If you do not want any beeping from the piezo buzzer, simply set 'A' to 0 and 'b' to 0. In this menu, pressing 'Long L' will take you to the Reset Menu, as explained below. Pressing 'Long R' will take you back to the Main menu.

Reset menu

From the Main menu, press 'Long L' twice. You will be taken to the Reset Menu, as shown in Menu 9.

It consists of the letters 'CL' (for clear) followed by two digits and a decimal point of the form X.X.

The X.X represents the current version of the firmware, which for this release stands at 3.0. It is possible that future releases of the firmware will add new features or refinements to critical sections of the code.

While in this menu, press 'Short L', 'Short R' or 'Long R' to go back to the Main menu.

Note, however, that pressing 'Long L' will reset all settings to the default values and the speed controller will lock until power is turned off. When a power-on reset next occurs, the default values for the frequency, low-battery level alarm and audible beeps will be restored.

This feature is useful for initialising the firmware variables and for making sure that you begin from a known state. Most of the time, it will not be used.

Memory speed mode

From the Main menu, press 'Short L' to enter memory mode. The display will be as shown in Menu 6.

It consists of the letter 'C' (for constant) followed by a digit from 1 to 8 (indicating one of the eight available memories), in turn followed by two dashes.

Now adjusting the pot will select one of the eight memories. When the pot becomes stable for a short period, the speed of the motor will be set according to the current value of that memory.

The display will change as shown in Menu 7. This display still consists of the letter 'C' followed by the number of the memory, but it will then have a decimal point followed by two digits representing the speed percentage from 00% to 99% (the first two letters will flash until the set speed is reached).

Adjusting the pot will now change the selected memory and the speed setting will be recalled from one of the eight stored memory speed settings (after a short beep, if enabled).

To go back to normal mode, where the motor speed is controlled directly by the pot, simply press any key, long or short.

Setting the memory

To set one of the eight memory speed values you press 'Long R' from the Main menu. The display will change as shown in Menu 5. It consists of the letter 'C' (for constant) followed by a digit from 1 to 8 (indicating one of eight memory settings) and two dashes.

Now adjusting the pot will select one of the eight memory settings to store the current value of the speed of the motor.

When the pot becomes stable for a short period, the speed of the motor will be stored at that particular memory. This can be recalled later by entering memory mode, as explained in the previous section.

There will be a short beep (if enabled), indicating that the value has been stored and you will be taken back to the Main menu.

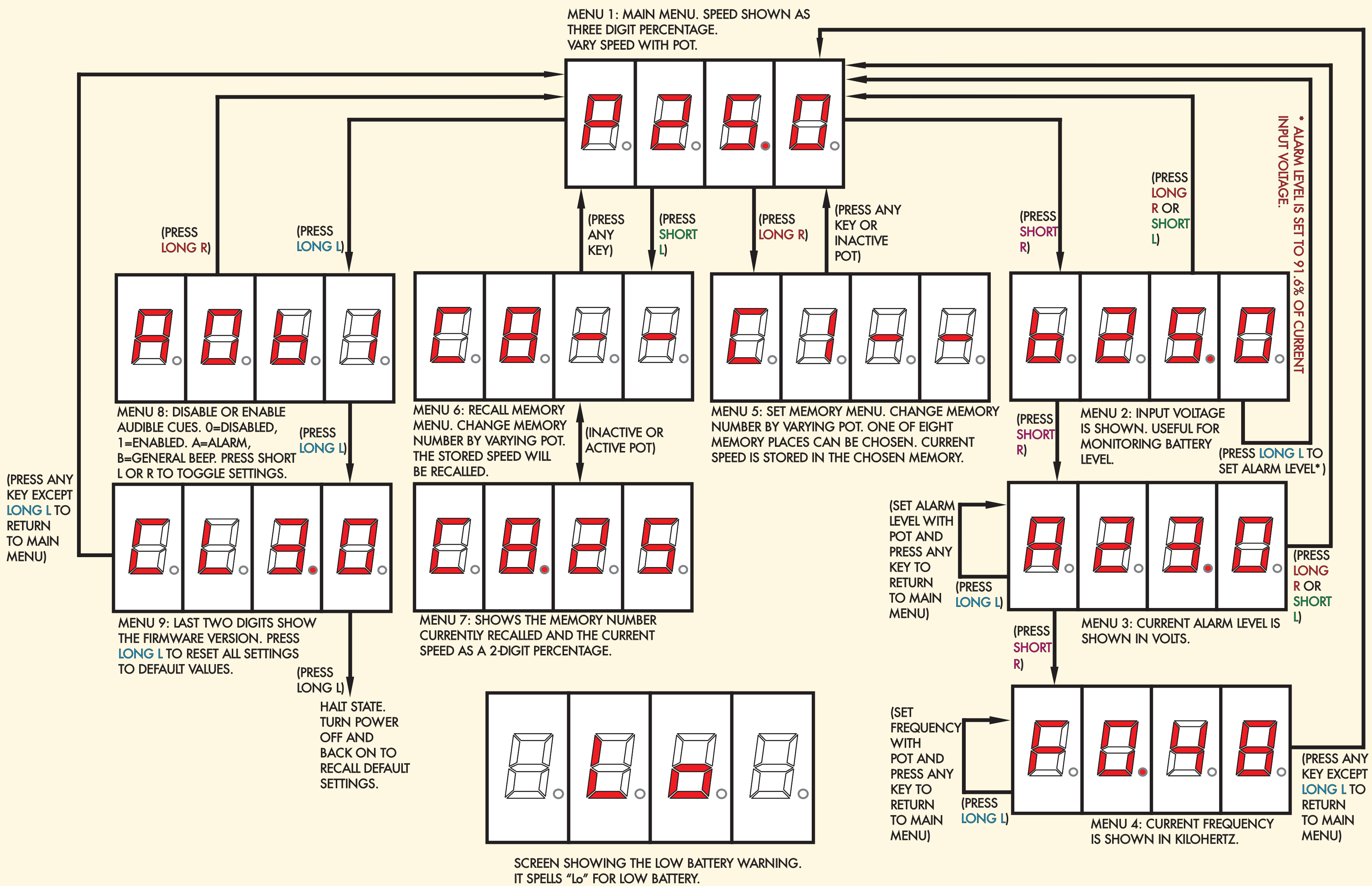
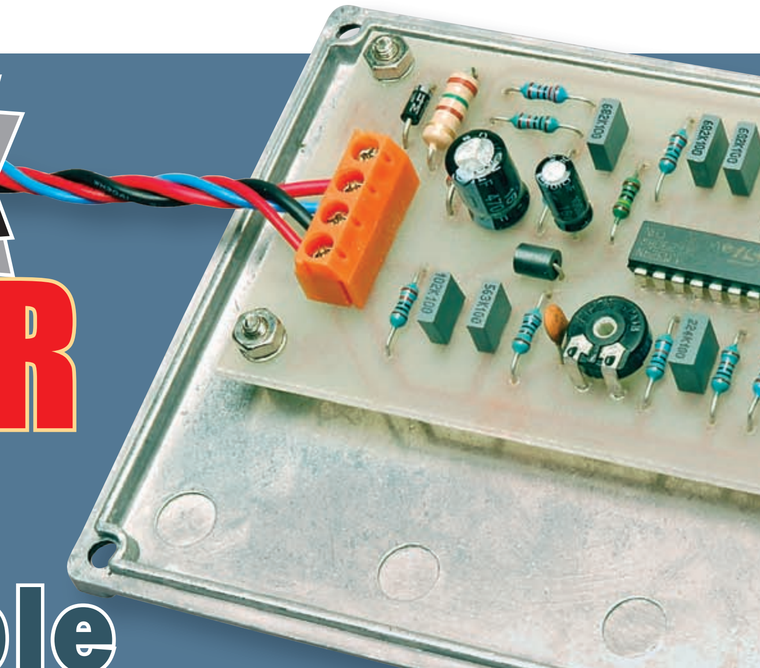


Fig.8: this diagram shows the structure of the firmware for the DC Motor Speed Controller. The transitions between the various menus are made using the switches on the display board and are indicated with labelled arrows.

A KNOCK DETECTOR

For The Programmable Ignition System



Use it to help program engine timing and/or to automatically retard the ignition timing in response to knock level

The Programmable Ignition System (Sept/Nov '09) would not be complete without the addition of engine knock sensing. This Knock Detector is useful for adjusting ignition timing maps and can also automatically retard the ignition timing if engine knock is detected.

ENGINE knock is a problem in cars, and can cause serious engine damage if allowed to continue. In severe cases, knocking can burn holes in pistons and cause premature engine failure. And even when knocking is only light, it can reduce engine power.

So how does knocking occur and what can be done about it? In a typical internal combustion engine, one or more pistons travel up and down inside cylinders to turn a crankshaft. As a piston rises inside its cylinder during the compression stroke, a mixture of fuel and air is compressed. In petrol and gas engines, this fuel-air mixture is then ignited to drive the piston as it starts its downward stroke.

However, if the mixture is ignited too early, it will 'push' against the piston as it rises towards top dead centre (TDC). If this ignition is early by only a small amount, then the engine will exhibit a 'knocking' sound as the piston rattles within the cylinder. This effect is called 'detonation', 'pinking' or 'knocking'.

Knocking is typically caused by the timing being too far advanced. It can also be caused by higher than normal operating temperatures or by using a lower octane fuel than normal.

As a result, all modern cars with engine management systems are fitted with one or more piezoelectric knock sensors. These monitor for engine knock over specific frequency ranges and automatically retard the ignition timing if knocking begins to occur.

This allows the ignition timing maps to be set close to the advance limits to ensure best performance. In addition, the use of knock sensors ensures maximum engine performance with fuels of different octane ratings, without damaging the engine.

On vehicles that don't have knock sensors, the ignition timing advance has to be set conservatively to prevent knocking. And if it does occur during driving, the only remedies are to ease off on the accelerator pedal or change down a gear.

Knock detector

If you are building the *Programmable Ignition System* (described in the Sept to Nov '09 issues), then you will almost certainly want to add the Knock Detector described here. As in the designs used in modern cars, it detects and automatically corrects engine knock by retarding the timing advance at certain map sites.

BY JOHN CLARKE

In addition, any detected engine knock can be displayed on the LCD Hand Controller (see Oct '09). This makes the Knock Detector a handy tool when it comes to adjusting the programmed ignition maps in the Ignition Timing Module.

As shown in the photographs, all the parts for the unit are mounted on a small PC board and this is housed in the same diecast aluminium case as the Ignition Timing Module. It takes its signal input from a commercial automotive knock sensor, while its signal output leads connect to the main board via a 2-way pin header.

Power for the circuit is derived directly from the main board.

The sensor unit itself is mounted on the engine block, to monitor the sounds from the engine. It comprises a piezoelectric element that produces an electrical signal when subject to vibration. This is mounted in a robust housing that's suitable for the automotive environment.

Basic scheme

Fig.1 shows the general arrangement of the Knock Detector. In operation, the output signal from the knock sensor is first fed to the Knock Detector circuit for processing. This processed signal is then fed to the Programmable Ignition Timing Module and displayed on the LCD Hand Controller.

Signal processing is necessary because the knock sensor also detects all the other noises that the engine makes. This means that the wanted knock signal is buried among the sounds produced by piston movement, valves and tappets opening and closing, and

Main Features

- Simple add-on PC board
- Fits inside the Programmable Ignition System box
- Uses an automotive knock sensor
- Knock is indicated via the LCD Hand Controller display
- Five knock intensity levels displayed
- Single trimpot for sensitivity adjustment
- Optional automatic ignition retard
- Two RPM limits for knock detection

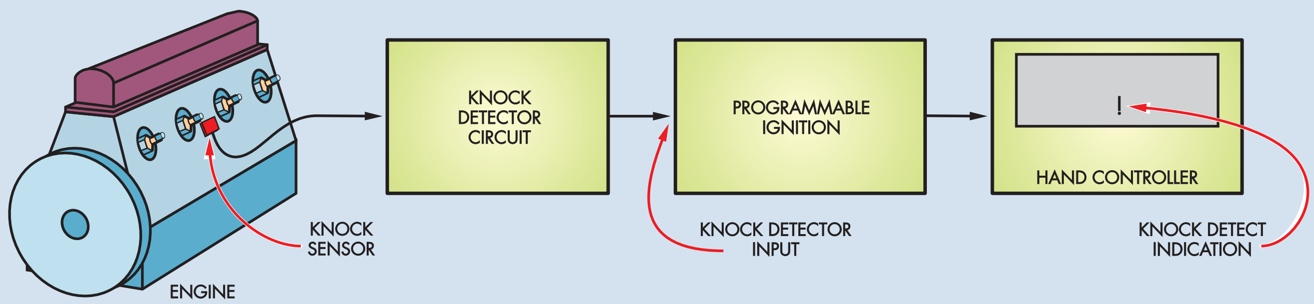


Fig.1: this diagram shows the general arrangement of the Knock Detector. The output signal from the knock sensor on the engine block is first fed to the Knock Detector circuit for processing. It's then fed to the Programmable Ignition Timing Module and displayed on the LCD Hand Controller.

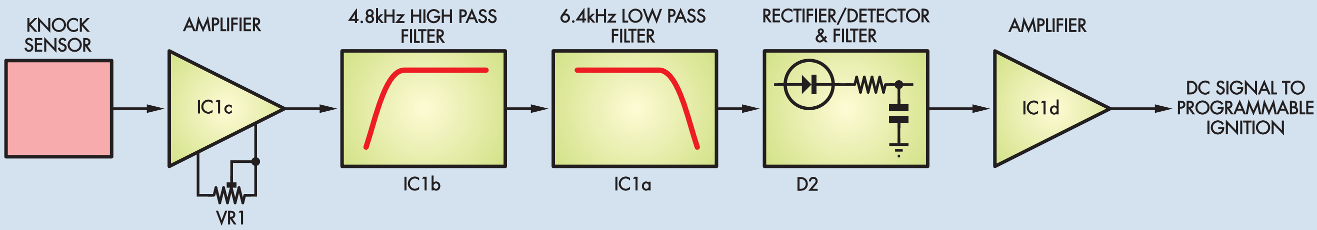


Fig.2: the block diagram of the Knock Detector circuit. The incoming knock signals are first amplified and then bandpass filtered to remove unwanted engine noise signals. This processed signal is then rectified and filtered to provide a DC signal that is then fed to the Programmable Ignition Timing Module.

Specifications

Knock input range: 0V to 5V (0V to 1.25V no retard, 1.25V to 5V progressive retard – see Table 3).

Knock monitoring: monitored for the first 6ms after firing. This period is reduced at higher RPM to the start of the dwell period.

Knock monitoring limit: alternative 4000 RPM or 6000 RPM sensing limit.

Ignition retard activation period: a minimum of 10 sparks at the onset of knocking.

Ignition retard hold period: retard value reduced by 0.5° or 1° (depending on resolution setting) every 10 sparks until zero unless knocking re-occurs.

by various other operating parts, both inside and outside the engine.

This in turn means that some way of removing these unwanted signals is necessary. Fortunately, there are some strategies that can be used to separate out the knock signal from the rest of the noises.

Block diagram

Fig.2 shows the block diagram of the Knock Detector. As shown, the knock sensor output is first fed to an amplifier stage based on IC1c. Trimpot (VR1) is used to set the gain of this amplifier stage, to set the correct sensitivity for engine knock.

According to the car manufacturers, engine knock signals generally only cover a narrow frequency range from about 4.8kHz to 6.4kHz. This means that we can more readily detect engine knock if we remove signals outside this range. That's the purpose of the following high-pass and low-pass filter stages based on IC1b and IC1a. These only allow the frequencies of interest – ie, between 4.8kHz and 6.4kHz – to pass through.

The resulting signal is then rectified by diode D2 and filtered to provide a DC signal voltage. This is then amplified by IC1d and fed to the Programmable Ignition Timing Module.

However, that's not the end of the signal processing, as further processing now takes place in the Ignition Timing Module itself. Engine knock only occurs when a piston is around top dead centre (TDC), so if the signal is only monitored around this time, we can readily remove further unwanted noise.

In practice, engine knock is monitored by the Programmable Ignition System for the first 6ms after ignition. However, at high RPM values, there is less than 6ms between successive plug firings and so the knock signal is monitored between each firing and the start of the dwell period.

Another problem at high engine RPM, is that the knock signal is often swamped out by engine noise. This can lead to incorrect knock sensing. To prevent this happening, engine knock is only detected at the lower RPM ranges. This unit gives you the choice of monitoring engine knock up to 4000 RPM or up to 6000 RPM.

Knock indication

When engine knock is detected, the level is displayed on the LCD Hand Controller using an exclamation (!) mark. This is shown on the second line of the timing display, between the RPM site and the LOAD site values.

The relative levels of knock are shown as variations on the width of this exclamation mark. For very low knock levels, a narrow single-pixel-wide exclamation mark is used. Successively higher levels of knock are then indicated by progressively wider exclamation marks. They range from 'level 1' indication at one pixel wide, through to 'level 5' indication at five pixels wide.

You can use this knock signal indication to determine the ignition timing sites where knocking occurs. The timing can then be retarded at those sites to minimise knocking. Note that knocking may be more severe when the engine is hot.

Parts List – Knock Detector

1 PC board, code 735, available from the *EPE PCB Service*, size 96mm × 55mm
1 engine knock sensor – from an automotive scrapyard
2 2-way PC mount screw terminals
1 5mm ferrite bead (L1) (Jaycar LF-1250 or similar)
4 M3 × 12mm screws
4 6mm M3 tapped spacers
4 M3 nuts
4 3mm star washers
1 2-pin DIL socket (2.5mm spacing)
1 40mm length of 0.7mm tinned copper wire
1 2m length of automotive wire
1 100mm length of green medium duty hookup wire
1 200mm length of red medium duty hookup wire
1 47kΩ horizontal mount trimpot (code 473) (VR1)

Semiconductors
1 LM324 quad op amp (IC1)
1 1N4004 400V 1A rect. diode (D1)
1 1N5819 Schottky diode (D2)
1 8.2V 1W Zener diode (ZD1)

Capacitors
1 470 F 16V electrolytic
2 100 F 16V electrolytic
1 1 F16V electrolytic
1 220nF MKT polyester
1 56nF MKT polyester
1 12nF MKT polyester
1 10nF MKT polyester
3 6.8nF MKT polyester
1 3.3nF MKT polyester
1 1nF MKT polyester
1 330pF ceramic

Resistors (0.25W, 1%)
1 1MΩ
1 100kΩ
1 22kΩ
4 10kΩ
2 5.6kΩ
1 3.9kΩ
1 2.7kΩ
3 2.2kΩ
2 1kΩ
1 150Ω 1W

Automatic retard

An option within the Ignition Timing Module can be set to automatically retard the timing when knocking is detected. The amount depends on the severity of the knock signal – the higher the knock signal, the greater the retard.

If the timing map has been set up with 0.5° resolution, the retard ranges from 0.5° at light knock levels through to 6.0° at severe levels. Similarly, for the 1° resolution, the retard ranges from 1° to 12°.

When knocking is detected, the ignition is retarded for a period of 10 sparks. The retard value is then decreased by either 0.5° or 1° (depending on the resolution) every 10 sparks until it reaches zero or until there is further detection of knock.

This slow release of ignition retardation helps to prevent the knock level increasing to any more than a very light level. It does this because as retardation is reduced, a small amount of knock may again be detected and so the timing will again be retarded to eliminate this. If there is no knock signal, then the ignition timing reverts to normal until knock is again detected.

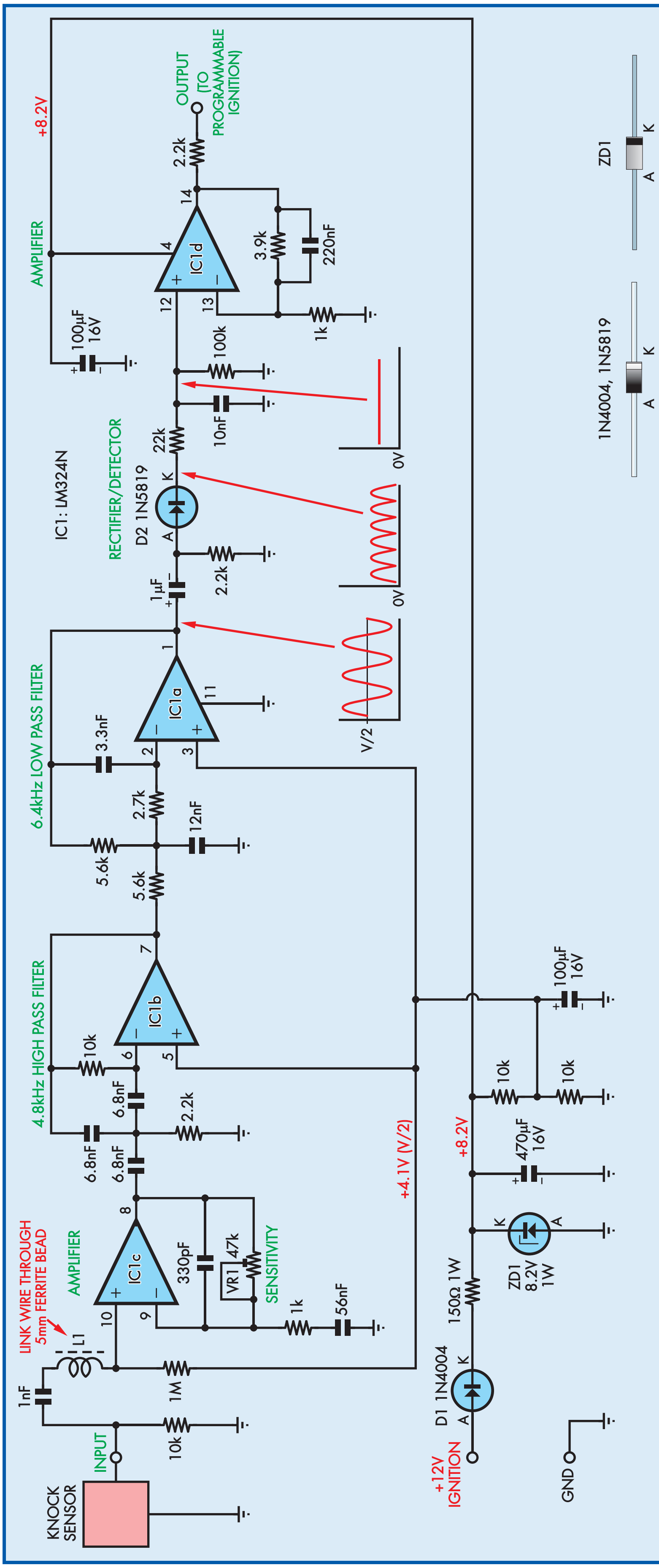
Note that we do not advocate advancing the ignition timing map to the point where there is constant knocking and then relying on the knock retard feature to correct for this. Instead, the Knock Detector is just there as an insurance against excessive knock in unusual circumstances – eg, when the fuel octane rating is lower than normal, or if the engine is abnormally hot, or there is some other unusual operating condition.

Circuit details

Refer now to Fig.3 for the complete circuit details. The circuit designations all correspond to the designations on the block diagram (Fig.2), so the circuit should be easy to follow.

Basically, a single LM324N quad op amp (IC1) is used to perform all the amplification and filtering of the knock sensor signal. As shown, the signal from the knock sensor is loaded using a 10kΩ resistor to reduce the tendency to pick up electrical noise.

From there, the signal is AC-coupled to pin 10 of IC1c via a 1nF capacitor and



KNOCK DETECTOR (PROGRAMMABLE IGNITION)

Fig.3: the circuit is based on a single LM324 quad op amp. IC1c amplifies the incoming knock signal, while IC1b and IC1a are the high-pass and low-pass filter stages. Diode D2 rectifies the bandpass filtered signal and feeds op amp IC1d, which then drives the Programmable Ignition Timing Module.

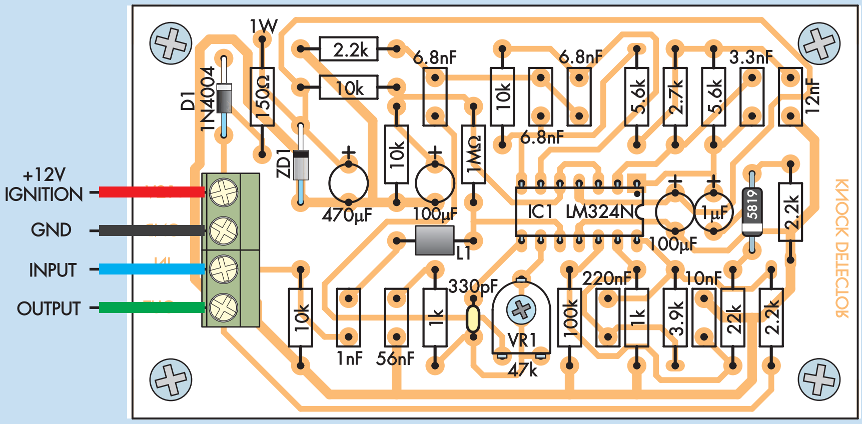
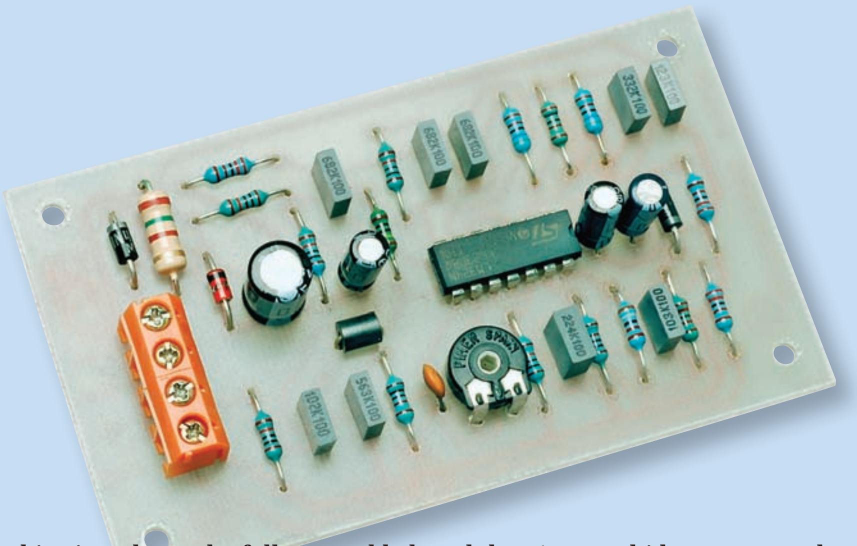


Fig.4: follow this parts layout diagram to assemble the PC board. It should only take you half an hour or so to build, but watch the orientation of all polarised parts (ie, the IC, diodes, Zener diode and electrolytic capacitors).



This view shows the fully-assembled module. It's a good idea to secure the electrolytic capacitors using hot-melt glue around their bases, to prevent them from vibrating and breaking their leads.

inductor L1. The latter is included to reduce radio frequency (RF) signal pick-up.

IC1c functions as a non-inverting amplifier stage, with gain set by trimpot VR1. Its pin 10 input is biased to half-supply via a 1MΩ resistor and two 10kΩ resistors across the 8.2V supply rail – ie, it is biased to 4.1V. This allows IC1c's output to swing symmetrically above and below this 4.1V bias voltage.

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
220nF	0.22 F	224	220n
56nF	0.056 F	563	56n
12nF	0.012 F	123	12n
10nF	0.01 F	103	10n
6.8nF	0.0068 F	682	6n8
3.3nF	0.0033 F	332	3n3
1nF	0.001 F	102	1n0
330pF	NA	331	330p

Depending on the setting of VR1, IC1c can provide a gain of up to 48 times. The 1kΩ resistor and 56nF capacitor on pin 9 roll off the gain below 2.8kHz, while the 330pF capacitor across the 47kΩ trimpot rolls off the gain at high frequencies to prevent oscillation.

IC1c's output appears at pin 8 and is fed to pin 6 of IC1b via an *RC* filter network.

IC1b functions as a 4.8kHz high-pass filter, as set by the 6.8nF capacitors and the 10kΩ and 2.2kΩ resistors in the input and feedback networks. Signals above 4.8kHz can pass through to the pin 7 output, while signals below this frequency are attenuated.

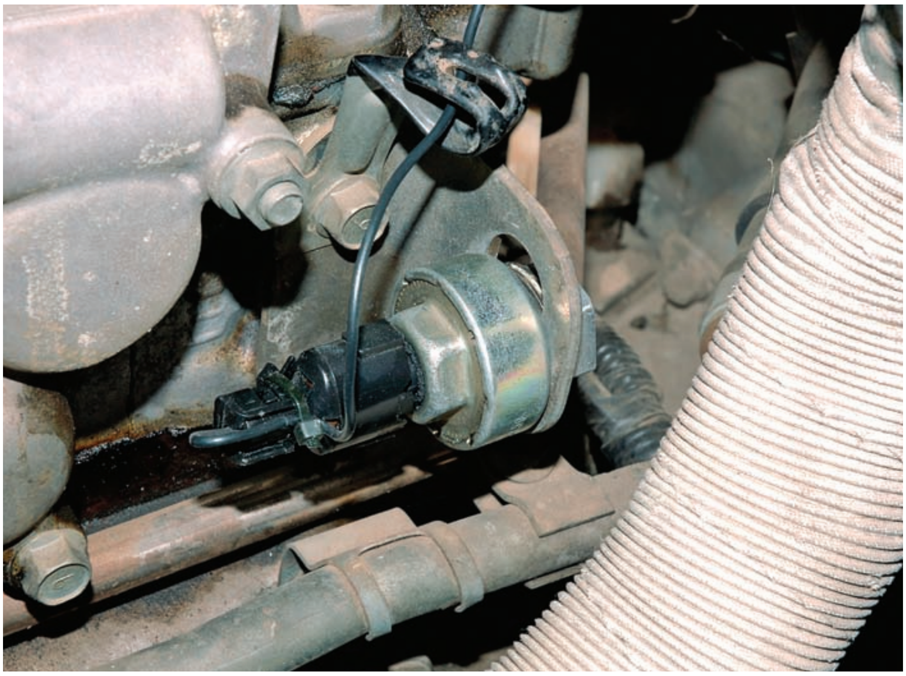
In operation, any signals below 4.8kHz are attenuated by 40dB (100 times) per decade. So at 480Hz, the output level at pin 7 is some 100 times less than for signals above 4.8kHz, assuming the same level of signal is applied to the input to the filter.

IC1b in turn feeds IC1a, which is configured as a low-pass filter. This filter attenuates signals above 6.4kHz, as set by its associated 12nF and 3.3nF capacitors and the 5.6kΩ and 2.7kΩ resistors.

As with IC1c, both IC1b and IC1a are biased at half-supply voltage (ie, Vcc/2) and so the output signal from

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	1MΩ	brown black green brown	brown black black yellow brown
❏	1	100kΩ	brown black yellow brown	brown black black orange brown
❏	1	22kΩ	red red orange brown	red red black red brown
❏	4	10kΩ	brown black orange brown	brown black black red brown
❏	2	5.6kΩ	green blue red brown	green blue black brown brown
❏	1	3.9kΩ	orange white red brown	orange white black brown brown
❏	1	2.7kΩ	red violet red brown	red violet black brown brown
❏	3	2.2kΩ	red red red brown	red red black brown brown
❏	2	1kΩ	brown black red brown	brown black black brown brown
❏	1	150Ω	brown green brown brown	brown green black black brown



The knock sensor can be mounted directly on the engine head or attached to it via a bracket as shown here. Knock sensors are readily available secondhand from scrapyards.

pin 1 of IC1a swings above and below this point.

Rectifier stage

Following IC1a, the signal is AC-coupled via a 1 F capacitor to diode D2. This diode rectifies the signal, allowing only positive excursions of the waveform to pass through. The rectified signal is then filtered using a 22kΩ resistor and a 10nF capacitor. The 100kΩ resistor discharges the capacitor in the absence of a signal.

In practice, the 100kΩ resistor gives a discharge time of around 1ms. This time constant is long enough to smooth out the 4.8kHz to 6.4kHz signals, but still short enough to quickly discharge the capacitor in the absence of a knock signal between cylinder firings.

Finally, the rectified and filtered signal is fed to non-inverting amplifier stage IC1d. This operates with a gain of 4.9, as set by the 3.9kΩ and 1kΩ feedback resistors.

In practice, it amplifies the DC signal at pin 12 from a typical maximum of 1.2V to 5.88V. Its output appears at pin 14 and is fed to the Ignition Timing Module via a 2.2kΩ current-limiting resistor.

Power supply

Power for the circuit is derived from the vehicle's 12V ignition supply via reverse-polarity protection diode D1. In practice, this supply is picked up from the Ignition Timing Module's PC board.

Following D1, the power is fed via a 150Ω 1W resistor to Zener diode ZD1, which regulates the supply rail to 8.2V. This rail is then filtered using a 470 F electrolytic capacitor, and is used to power IC1.

In addition, a half-supply rail is derived using two 10kΩ divider resistors. This is decoupled using a 100 F electrolytic capacitor, and is used to bias IC1c, IC1b and IC1a, as indicated previously. A second 100 F electrolytic capacitor provides additional supply rail decoupling for IC1.

Construction

All the parts for the Knock Detector mount on a small PC board, code 735, measuring 96mm × 55mm. (This board is available from the *EPE PCB Service*.) Before assembly, check the PC board for correct hole sizes and that all the copper tracks are intact and that there are no 'bridging' shorts between tracks.

Fig.4 shows the component assembly details. Begin by installing the resistors, using Table 1 as a guide to selecting the values. As usual, it's also a good idea to check them using a digital multimeter, just to make sure.

Next, install diodes D1 and D2, followed by Zener diode ZD1. Be sure to install the correct part in each location and make sure they are all oriented correctly.

Op amp IC1 can now be soldered directly onto the PCB, make sure it is oriented correctly before soldering. Be as quick as possible when using the hot iron. If you're thinking of using an IC socket – don't, the possibility of IC1 shaking loose from engine/road vibrations is highly likely.

The capacitors can now all go in, starting with the smaller polyester MKT and ceramic types (see Table 2 for the capacitor codes). Follow these with the electrolytics, taking care to orientate each one as shown on Fig.4.

Finally, install trimpot VR1, the 4-way screw terminal block and inductor L1. The inductor simply consists of a tinned copper wire link fitted with a 5mm-long ferrite bead.

Mounting details

The Knock Detector PC board is mounted on the inside of the case lid used for the Ignition Timing Module. As shown in the title page photo, it must be positioned towards one side, so that it does not foul the Sensym manifold pressure sensor on the main PC board (if fitted).

The first step is to mark out and drill four 3mm mounting holes in the box lid. That done, mount the PC board on 6mm-long stand-offs and secure it using M3 x 12mm screws, M3 nuts and star lockwashers.

After that, it's just a matter of running the external wiring connections, as shown in Fig.5. These include the +12V, GND and Output leads to the main board. The Input signal lead is run to the knock sensor via the cable gland in the side of the box.

Mounting the knock sensor

The knock sensor should be mounted directly on the engine head if possible. If this is not easy to do, the next best option is to use a mounting bracket. This bracket must be solid enough so that it does not vibrate and cause false knock signals.

In our case, we mounted the knock sensor via a bracket because the screw thread on the sensor was too large to directly bolt into the engine head. This worked quite satisfactorily and was sufficient to detect knock.

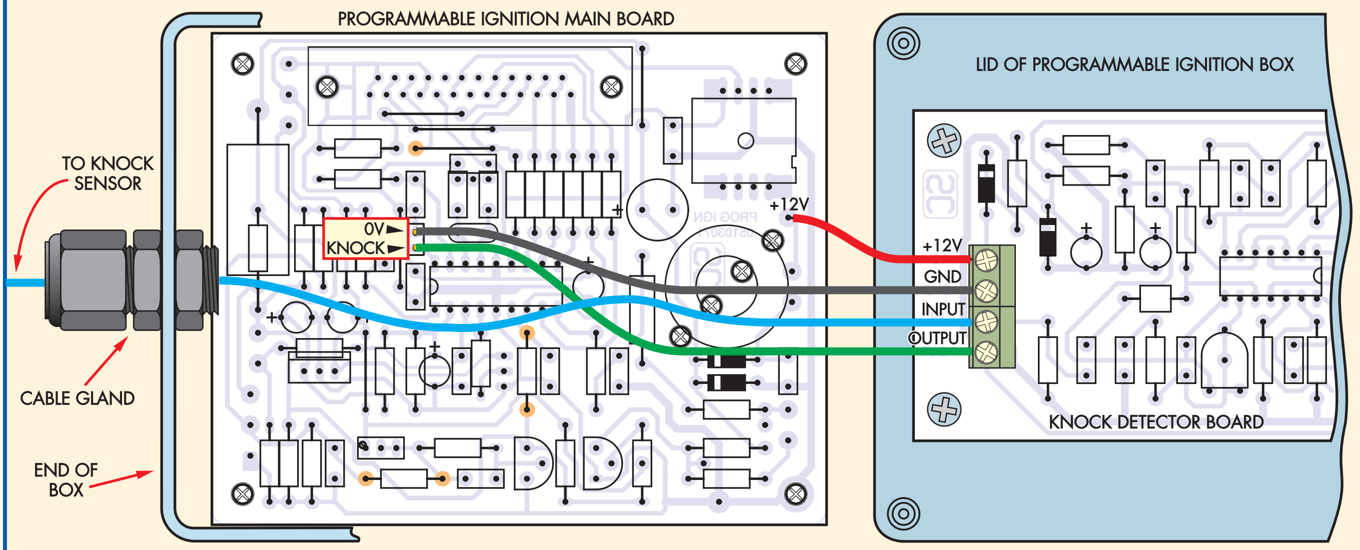


Fig.5: the Knock Detector PC board mounts on the case lid of the Programmable Ignition Timing Module and is wired to the main board and to the knock sensor as shown here.

Table 3: Timing retard vs knock intensity		
Displayed knock intensity	**Retard range for 0.5-degree resolution**	**Retard range for 1-degree resolution**
1	0.5-1.0 degree	1-2 degrees
2	1.5-2.0 degrees	3-4 degrees
3	2.5-3.0 degrees	5-6 degrees
4	3.5-4.5 degrees	7-9 degrees
5	5.0-6.0 degrees	10-12 degrees

Setting it up

The setting-up procedure is quite straightforward. Just follow these steps:

1) In the settings mode for the Programmable Ignition, set the ‘Knock’ option to OFF (this simply turns off automatic retard) and set the RPM limit to 4000 RPM. Alternatively, if your car’s engine spins out further than 6000 RPM, use the 6000 RPM maximum. Note, however, that you may need to revert to the lower limit if the engine is noisy enough to cause false knock detection above 4000 RPM.

2) Set trimpot VR1 fully clockwise.

3) Rev the engine up and down its range and slowly adjust VR1 anticlockwise until no knock is indicated during this procedure. This is done because the engine is unlikely to knock when just free revving, and so we can set the sensitivity just low enough to prevent false knock indication due to normal engine noises. However, this setting should still be sufficiently sensitive to detect true engine knock if it occurs.

Typically, engine knock can occur when an engine is in its mid-rev range and under load. Find any trouble spots that cause knocking and note the timing values for these RPM and Load sites. The timing at these sites can then be reduced until the knock level is minimised or removed.

If you wish, the ‘Knock’ option can now be set to ON using the LCD Hand Controller. This will enable the automatic knock retard feature in the Programmable Ignition. Table 3 shows the amount of retard for each of the displayed knock intensity levels. ***EPE***

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PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Real Time Operating Systems – Part 3

Last month we looked at a range of real time operating systems for use with Microchip processors, and picked one to play with over the next couple of articles – FreeRTOS, a completely free real time operating system.

RTOSs can be a rather dry subject at times, so to lighten things up we are going to create a fun circuit: a digital clock that displays the time in binary on sixteen LEDs. We will start the hardware design here and finish off next month.

Brief recap

But let's just recap for a moment: why are we doing this, playing with an RTOS? A binary clock could be written in a hundred lines of assembly without any need for a fancy operating system. What does an RTOS give us?

First, not all applications are as simple as our example; as projects get larger they quickly become difficult to develop and certainly difficult to test. The use of an RTOS positively encourages the splitting up of a design into small independent programs, which do well defined jobs, and communicate with each other through messages. This is the holy grail of writing software and reduces a fairly complicated project into easy-to-manage chunks.

Second, RTOSs often come with lots of supporting code such as Flash memory disk file systems, TCP/IP stacks, USB stacks and more, which can be easily incorporated into your own applications. And of course, it's fun learning something new!

FreeRTOS

FreeRTOS is supplied as a collection of 'C' language source files and a few very short assembly language files. You include the source files into your MPLAB project, and the operating system is built into your .hex file – there are no complicated download procedures to learn.

For the Microchip implementation based on the PIC24, just six source files are required, so you can appreciate that it is very small and is not going to be difficult to learn. You do not even have to study these source files – you only need to understand the application programming interface, or API, which consists of a list of a few functions that you can use. The API is very clearly documented on the website.

The complete FreeRTOS download consists of many source files, as it supports many different processors. Unless you intend to branch out into different processors (unthinkable, of course, to a *PIC n' Mix* reader!), you can completely ignore these other files and even delete them if you wish. The installation directory structure makes it very clear which files are important.

The author of FreeRTOS has created two eBooks on the operating system, one a practical guide and the other a reference manual to the API. The guide is an excellent read and well worth purchasing, and while the content of the reference manual is all available as a series of pages on the website, the eBook brings it together in a more easy-to-access format, so we recommend obtaining both if you are serious about using FreeRTOS.

Getting started

An operating system intended for use with an embedded system is normally supplied with one or more 'board support packages' – a set of demonstration projects which have been designed to run on a commercial development system PCB. These boards are produced by third party companies and come equipped with lots of interesting peripherals.

Engineers use these boards to start the development of software before their own hardware is ready, and often use the PCB as a basis for it. Engineers are lazy, or as we like to say, resourceful when it comes to engineering.

FreeRTOS is no exception, and a demonstration application has been provided for use with the Explorer 16 board manufactured by Microchip. This board is not cheap (although it is by normal commercial standards – development boards often cost over a thousand pounds.) Hobbyists operate on a more frugal budget, and so we are going to make an inexpensive, simple-to -build development board which can be re-used for other projects, and provide a fun example application to test FreeRTOS out. Construction costs will be around £10.

Software installation

Let's start by installing and configuring all the software required. We'll walk through the entire process starting from the MPLAB IDE. If you already have Microchip's software tools installed it's worth checking your version – Microchip frequently update their tools, and even we were surprised to find ourselves several versions out of date.

So, we start with MPLAB IDE, (v8.36 at the time this article was written,) which like all the other tools can be found on the 'Design/Development Tools' page of the Microchip website. The file is zipped, so once downloaded extract the files to your desktop and run the setup program. Accept the default option to all questions asked. Once installed, you can delete the installation files from your desktop.

Then download and install the C compiler for the PIC24, which can be found from the main Microchip webpage, under 'Design', then 'Development Tools', then 'Compilers' (displayed in the Software list) followed by 'MPLAB C Compiler for PIC24 MCUs'. Download by clicking on the 'MPLAB C Compiler for PIC24 vx.xx Standard-Eval Version – do not download the 'LITE' version.

Don't be put off by the statement displayed on the page saying "this version is limited after 60 days"; it is still a fully functioning version which supports large projects – it simply reduces the number of optimisation features enabled in the compiler. This will result in slightly larger code and possibly slightly slower performance, but we certainly haven't noticed any problems with it, even on some large projects.

You will need to register on the Microchip website to download the file, but registration is free and does not result in any 'spam' email messages.

The download is an executable file, so simply run it, agree to the license terms and accept the default option to all questions asked.

Now to install FreeRTOS. A link to the download page is available on the main webpage, although you have to scroll down and look through the text to find a further link to the actual file history list. The latest version is at the bottom; scroll down and click on the last version to reveal the actual files. You have a choice of *.zip* or *.exe* file; we downloaded the .zip file. Simply extract the files – all four thousand of them! – to your hard disk. We downloaded them to *c:\freertos-V5.4.2*, and will refer to this location in the examples that follow.

Don't be put off by the number of files in FreeRTOS; the vast majority of these are demonstration files for the wide range of supported processors.

Building the code

We can now test the installation by building the demo PIC24 application supplied with FreeRTOS. Locate the directory C:\freertos-V5.4.2\FreeRTOS\Demo\PIC24_MPLAB, and double-click on the file *RTOSDemo.mcw* to open the project workspace. Then select the 'build' option in MPLAB. You will be prompted that the directory for some of the tools has changed; that's fine, simply accept the new directory location and continue.

If the application built without errors, you have installed the MPLAB IDE and compiler successfully. We can't run this code on our hardware, however, as the demo has been designed for the Explorer 16 development board. Of course, if you have that, then go right ahead. We've decided to go with a different PIC24 variant and our own hardware design.

Why did we choose a different processor? Well, because our design is significantly cheaper, simpler and something you can build for yourself on stripboard, and because it more accurately reflects what you would want to do yourself.

We are going to use the PIC24 demo project as a starting point for our project, so we kick off by copying the project files RTOSDemo_PIC24.mcp, RTOSDemo_PIC24.mcw to our own, RTOSBINARYCLOCK.mcp and RTOSBINARYCLOCK.mcw.

Making a change

Opening up RTOSBINARYCLOCK.mcw, the first thing we need to do is to remove the old project file (that's the .mcp file) by selecting **Project** followed by **Close** from the main menu. Now click **Project** followed by **Open**, and then select our project file RTOSBINARYCLOCK.mcp. The contents are, of course, exactly the same at the moment. It just looks tidier.

The first change is to remove the reference to the processor-specific header file from the file FreeRTOSConfig.h. Change the line

```
#include <p24FJ128GA010.h>
```

to

```
#include <p24HJ128GP202.h>
```

We also need to change another parameter in the file that defines what the processor clock speed is. The operating system has no idea what crystal you have fitted on the PCB, so it relies on us telling it through a #define value, **`lkªd@MR\ CLOCK_HZ**. We are fitting an 8MHz crystal to our circuit (see Fig.2) and will set up the phase-locked loop within the CPU to generate a clock speed of 40MHz, so we change the value of this #define from 16000000 to 40000000 (leaving the other characters on the line unchanged.)

Finally, change the setting of configUSE_CO_ROUTINES from 1 to 0, and configUSE_IDLE_HOOK from 1 to 0. These are features we won't be using, and disabling them will save valuable code and data space.

There may be other parameters in this file that need changing, but for now everything looks acceptable, so we can move onto the next issue.

We need to remove one of the files, p24FJ128GA010.gld, from the list of project files. This file determines how the linker program will assemble your compiled source files into a format suitable for loading onto the PIC processor, and as you might guess, it's very processor type specific.

Simply right-click over the file in the Project window and select **Remove**. Now add our process-specific default linker file by right-clicking over the 'Linker Script' folder in the Project window, and select **Add Files...** Now navigate to the directory C:\Program Files\Microchip\MPLAB C30\support\PIC24H\gld, and open the file **p24HJ128GP202.gld**.

```
#include <stdio.h>
#include "FreeRTOS.h"
#include "task.h"
#include "queue.h"

void task0( void  *params )
{
   for ( ;; ) {
      LATAbits.LATA0 = 1;
      vTaskDelay( 1000 / portTICK_RATE_MS );
      LATAbits.LATA0 = 0;
      vTaskDelay( 1000 / portTICK_RATE_MS );
   }
}

void task1( void  *params )
{
   for ( ;; ) {
      LATAbits.LATA1 = 1;
      LATB = 0xAAAA;
      vTaskDelay( 2000 / portTICK_RATE_MS );
      LATAbits.LATA1 = 0;
      LATB = 0x5555;
      vTaskDelay( 2000 / portTICK_RATE_MS );
   }
}

int main( void )
{
   /* Configure the hardware  */
   /* Set processor to run at appropriate speed */
   CLKDIVbits.PLLPOST = 0;
   PLLFBDbits.PLLDIV = 38; /* PLL_80MHZ */

   /* Make digital pins I/O rather than analogue */
   AD1PCFGL = 0xFFFF;

   /* Set PORTA  pins to outputs except RA0 - they are used by the tasks */
   TRISA = 0x0001;

   /* Create the tasks */
   xTaskCreate( task0, "Task0", 1000, NULL, 1, NULL );
   xTaskCreate( task1, "Task1", 1000, NULL, 1, NULL );

   /* Finally start the scheduler */
   vTaskStartScheduler();

   /* Will only reach here if there is
     a problem with the scheduler */
   return 0;
}
```

Change of view

Now it's time to change the MPLAB workspace's view of what processor we are using. MPLAB needs to know what processor the source code should be compiled for, and also what the configuration bits should be set to, since these are not 'hard coded' into the source code. These values will be stored in the .mcw file, so you could, in theory, have one set of source files, but several .mcw files to target the build process towards a variety of processor types.

From the main MPLAB window select **@lkªdrob** followed by **Select Device...** In the Device drop down list, select PIC24HJ128GP202. Note how the dialog updates to indicates that the PicKit2 is supported for both programming and debugging. That's great, as it's the tool of choice in the *PIC n' Mix* lab. Click the OK button to confirm the change.

Now select **@lkªdrob)** followed by **@lkªdro^qflk ?fqp+++** Each of these parameters should be set to the required configuration, as determined by our simple hardware design. As there are so many we won't list them here, but you can check the settings by examining the source code that accompanies next month's article, which can be downloaded from the *EPE* website. Needless to say, each bit needs to be carefully thought out as the default settings are rarely appropriate, and certainly are not in our case.

Next, we can remove all 'demo' source code files from the project, leaving just the core operating system files and the main.c file. Right clicking over each file in turn within the project window and selecting **Remove** does the trick. Bear in mind that these changes only affect the list of files 'known' by our project; it does not actually delete them from the hard drive. You can remove them for tidiness or leave them there for later reference as you wish.

A final run through the build options of the demo project shows that debugging options are left enabled in both the debug and release builds; this is a bit surprising, since it means that the release code will be slower and bigger than necessary, but this will be something we come back to. The RTOS designers may have done it for a good reason. Our first priority will be to get something simple working on our own hardware.

Hacking it

A quick hack through the source of main.c to remove the references to the original demonstration code and add some very simple code of our own resulted in the listing shown in Fig.1. Building this resulted in no warnings or errors being displayed, and an output program file called RTOSBINARYCLOCK.hex to be created. So far, so good.

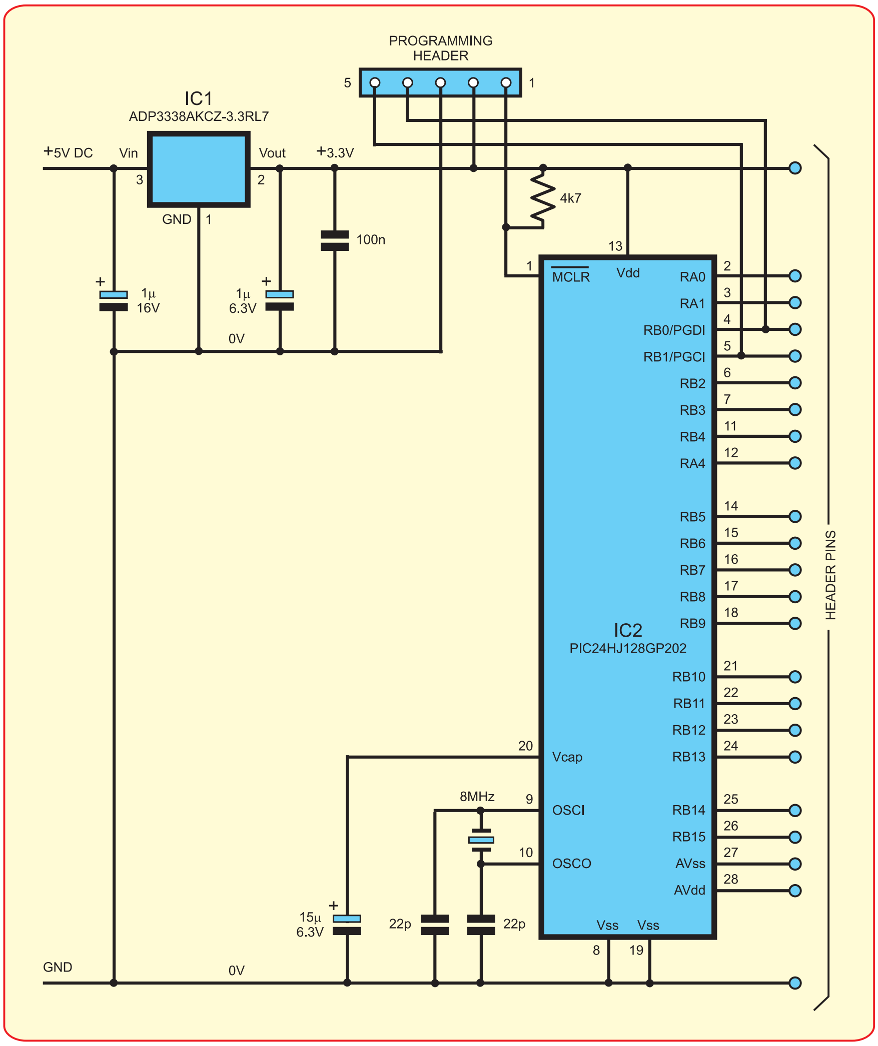
What does the application do? It runs two tasks, each of which toggles a port pin, slow enough to be detected by a multimeter. It demonstrates a number features:

- The CPU oscillator is running
- The Clock Frequency is correct
- The OS is running pre-emptively

FreeRTOS uses the term *task* to describe a thread running in the OS; we will use the same terminology throughout the remaining articles. Referring back to the source code in Fig. 1, you can see that the 'main' function simply configures the oscillator and the PORTA pins, creates the two tasks and then starts the operating system running. 'Main' does nothing else now; the call to vTaskStartScheduler() will not return. Instead, the two functions task0 and task1 will start to run in parallel, operating as though they were completely independent programs.

This requires quite a shift in thinking now: *you* don't call task0() or task1(), the operating system does. You cannot, for example, call task1 within task0. It's already running. You are, however, completely at liberty to write other functions that you call from either of these tasks; just treat task0() and task1() as though they were each the main() function of a program. Tasks can communicate with each other using messages, which we will demonstrate in next month's article.

Using the File-Export options from the main menu of MPLAB to create our .Hex file, it took just a few minutes to load this application onto our development PCB using a PicKit2 programmer. And a minute later, a voltmeter confirmed the two pins were toggling at the correct rate, meaning everything is working and we can now proceed with the design of our main application.



Looking ahead

We've jumped a little ahead of ourselves here, as we haven't yet described the hardware. This will be presented in two parts, with the main control circuit detailed this month and the application circuit in the next article. We have gone with a two-board design, constructed on stripboard, to make the control circuit as re-usable as possible. It also makes it easier to fit this project into a small, custom-made case.

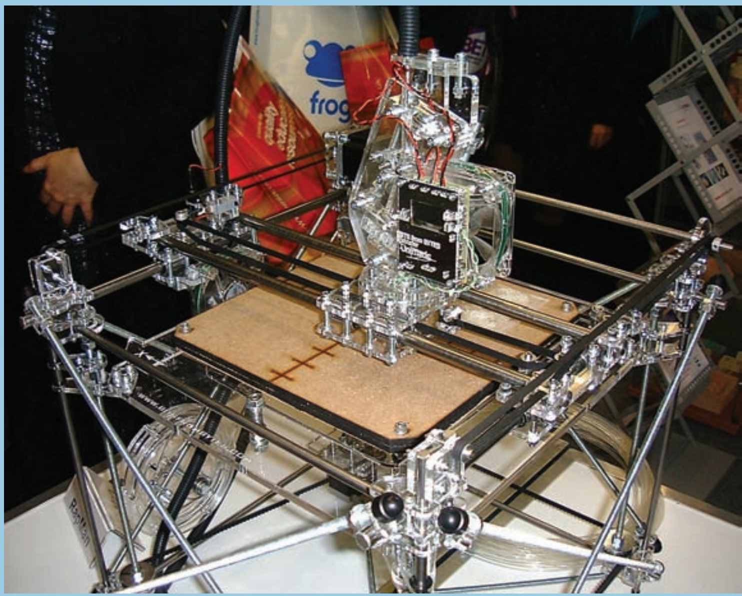
The control circuit is shown in Fig. 2. This is an extremely basic circuit, with all the free I/O signals brought out to header pins. A rather specialised voltage regulator (ADP3338AKCZ-3.3RL7) has been chosen here (available from Farnell, part number 1651283.) This is a small, low dropout regulator that helps to keep the circuit compact and run off a 5V power pack, but you are, of course, free to use whatever regulator you wish.

Next month, we describe the application circuit and go into the detail of designing a clock application with the aid of an OS.

RapMan – The 3D Printer

Part 1

by Mike Hibbett



Introducing the 'RapMan' a low cost 3D Printer – it stands out from the rest!

ISN'T it wonderful when you come across an invention that gets you excited and fired up, so enthused with the wonder of it that you feel like Charlie in the Chocolate factory? That's exactly what happened to us back in February at the *Betts Education* exhibition in London when we came across 'RapMan', a low cost 3D printer.

3D Printers are not a new idea, but have been in common use for around two decades. They provide rapid prototyping services for industrial designers enabling them to produce accurate, realistic solid models of their designs. Typical uses include mobile phone cases, car parts and even furniture.

The problem with these machines is that they are *expensive* – horribly so. A typical machine cost in excess of £100,000 and the materials used are also expensive, with a small mobile phone case prototype costing hundreds of pounds.

Needless to say, services such as these were way out of the hobbyist's league. The parts created were also very fragile and only suitable for photographing, or creating moulds from (although the author was lucky enough to have access to a radio pager encased in such a material, until it disintegrated after a few days use – but that's another story.)

Thanks to science

As time went by, technology, and more importantly material science, improved. New processes for creating solid models evolved, the cost of the machines fell and the kind of materials from which objects could be created expanded. Today, you can purchase a small 3D printer for tens of thousands of pounds, although the material costs are still quite expensive and the objects created still rather delicate.

Tens of thousands of pounds remains out of the reach of all but the most committed, not to mention wealthy, hobbyist.

That's why the demonstration at the Betts show was such an eye opener. A 3D printer which you assemble yourself, costing well under a thousand pounds. And, unlike the more expensive machines, it prints objects in cheap standard plastics such as ABS and creates objects that are mechanically robust enough to be put to practical use.

It's a RapMan

The product, RapMan, is produced by British company BitsFromBytes, and an example of one is shown above (taken during its debut at Betts.) We will look at RapMan in more detail next month, but for now we will look at how it came about, growing out of the similarly named open source project RepRap.

RepRap is the brain child of Dr. Adrian Bower, senior lecturer in mechanical engineering at Bath university. He dreamt of a machine that could mimic the symbiosis of nature, in particular that between bees and plants.

Plants need the bees to move pollen to other plants, and the bees in return get some of the pollen to take back to the hive. It's a process that has been working well for over 100 million years, so could a similar relationship be created between man and machine?

From this idea, Adrian has designed a 3D printer that is capable of printing its own parts (that's reproduction) while we, in return, can print whatever we want (that's the symbiosis.) We humans are required, of course, because the machine has to be loaded with raw plastic, operated and, of course, assembled in the first place!

Adrian has released the design of the printer to the general public for free through an 'Open Source' license, which is more commonly used for free software, such as the operating system Linux. This license allows for anyone to copy the design, modify it and sell products based on it without royalty payments or fees – the proviso being that those design changes are made freely available under the same license.

Glue gun

The printer works on the same principle as a hot-melt glue gun. A filament of plastic enters a heated barrel, melts, and is squeezed out of a 0.5mm hole at the other end. A slowly rotating motor provides the pressure to keep the filament moving through the heater barrel at a constant rate, and the heater assembly is mounted on a two-axis platform that is controlled by two stepper motors, giving an accurate placement in the X and Y directions.

The platform onto which the plastic is extruded can move up and down, allowing layers of plastic to be built up. As the plastic cools it fuses to the adjacent layers creating a strong, mechanically robust structure. As you can see from the pictures, it's even possible to print shoes!

The plastic filament can be purchased on rolls like electrical wire, and cost between £25 to £50 per kilogramme. The coat hook shown here cost less than 70 pence in raw material, so it's very cost effective.

So what can it make? Pretty much anything in plastic, limited only by the positional accuracy of the machine (0.1mm) and the thickness of the filament when it is extruded (0.5mm).

The technology cannot compete with the versatility of 'injection molding', as used for creating the vast range of plastic goods we purchase, but it can compete in a large number of areas, and opens up for the first time the possibility of printing your own custom case designs, control knobs, jigs, models, and toys – limited only by your imagination. Within a week of building his own printer, the author created replacement wheels for a dishwasher tray, parts which were no longer available, and with a total build cost of less than two pounds.

This plastic coat hook was produced from about 70p-worth of raw material

Website

The RepRap design information is available on the RepRap website **reprap.org**. A large community has developed around this site, with a number of people suggesting and making changes to the design.

It's a rather difficult website to navigate, with the home page focusing more on what they would *like* the machine to do, rather than what it currently *can* do. Identifying what parts you need to purchase or make is also a challenge, as there are a number of permutations, 'improved' parts and obsolete parts all listed together, although things seem to be improving over time.

Unfortunately, some of the parts required are only available in the US, so you will either have to take your chance with finding suppliers in your own country or face some fairly steep delivery charges. It's unavoidable of course; this is a complex machine that uses a variety of technologies, which you simply cannot expect to source from a single supplier.

The RepRap website claims that "As RepRap 1.0 Darwin can copy itself...". This is quite an exaggeration; you can use a RepRap machine to print the plastic parts used by the machine, but it will be many years before such a machine could print the motors, metal rods, bearings and circuit boards required. In fact it's unlikely that it ever will – the requirements for a machine to produce a circuit board are very different to those for creating plastic objects.

CAD software

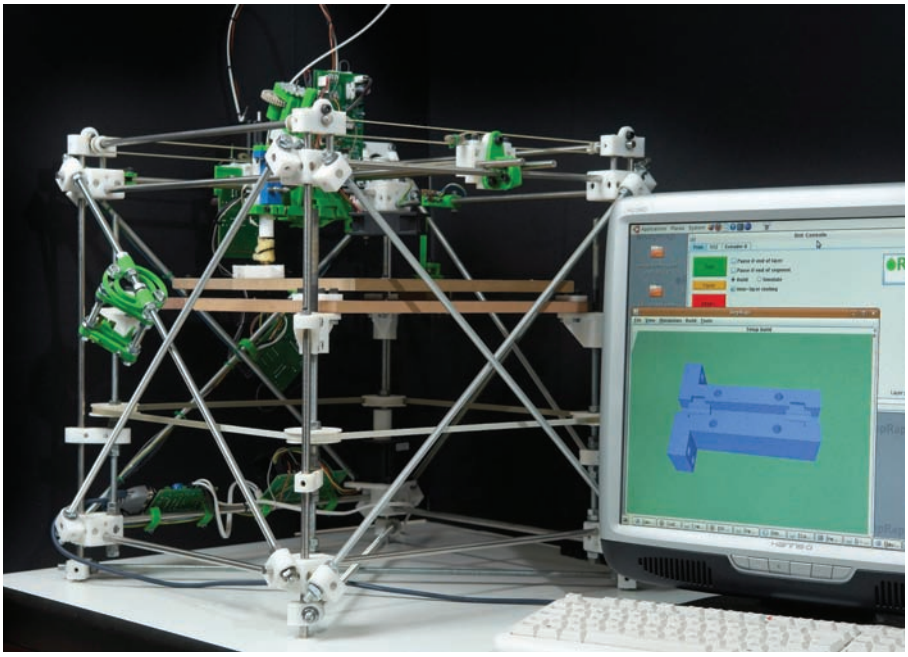
Just as a normal printer requires a document to be created in a word processor, so a 3D printer requires a drawing of an object to be created in a CAD program. CAD stands for 'computer aided design' and refers to graphics programs that help you create accurate drawings of three dimensional objects.

The printer uses files created in an industry standard format, STL, and there are many freely available CAD programs that can be used to create them. The author's favorite, CoCreate, is actually a full commercial product that has been made available for free, if used for non commercial use.

It's a fantastic application and very easy-to-use – the author, who is not mechanically minded, was able to master its basics within a few evenings experimenting. Other popular programs include GoogleSketch, Art of Illusion and MeshLab.

You are, of course, not limited to printing objects you have designed yourself – there are a growing number of object designs available for download on the Internet (**www.thingiverse.com** for example) and we expect the number of designs available to increase as 3D printers become more widespread. Maybe

Plastic sandals produced using the 3D printer



The 3D Printer station in action

we will soon see electronics articles published with STL files for the case design made available for download, alongside the PCB design files and software!

Kits

For those of you who do not wish to embark on the adventure of sourcing and constructing the machine from scratch, there are currently two kits available. *CupCake CNC* from MakerBot in the USA and *RapMan* from BitsFromBytes in the UK. CupCake has a small printing area and is really intended to help you create the plastic parts for a larger 3D printer. RapMan has a much larger print volume of up to 275mm×205mm×210mm making it suitable for use in a wide range of applications.

BitsFromBytes have made a RapMan kit available to us and we will be looking at the assembly of the machine in Part 2, next month. For those of you who remember the days of putting together a HeathKit product, it will be like a trip down memory lane!

EPE Reader Offer

The RapMan printer kit is available from **www.bitsfrombytes.com**. For readers of *EPE*, BitsFromBytes are offering a 15% discount on all products. Just enter the code **EPEYRK** when prompted for a coupon code on the Cart screen prior to Check Out.

TEACH-IN 2010

LADDER LOGIC PROGRAMMING FOR THE PIC MICRO

Part 2: Working with Combinational and Sequential Logic

By Walter Ditch

THIS is the second instalment of a six-part series, discussing the use of ladder logic programming methods with PIC microcontrollers. Ladder logic is the fundamental basis of Programmable Logic Controllers (PLCs), which are a specialised type of industrial computer, designed to be easily programmed by engineers. Thus, the aim of using ladder logic is to simplify the development process, making PIC programming accessible to the widest possible audience.

You may recall that last month we discussed the use of ladder diagrams to graphically represent simple electrical circuits, and converted these to executable machine code programs for the PIC micro by using commands such as: 'ld' (read an input bit); 'out' (send result to an output bit); plus their negative logic counterparts 'ld_not' and 'out_not' respectively. We saw that a PLC-style program executes by following a repeating cycle of reading inputs, performing calculations and controlling outputs, known as the scan cycle.

The PLC software itself consisted of a series of 'header files', available for a number of common PIC microcontrollers, including the 16F627A, 16F628A, 16F648, PIC16F88 and PIC16F887. By including the appropriate header file into our source code programs, we were able to use the freely available MPLAB Integrated Development Environment (IDE) to assemble our ladder logic programs into executable machine code programs, which could then be downloaded to a variety of commonly available PIC development boards.

Hardware demonstrated in Part 1 included the Velleman K8048 board, Microchip Direct's PICkit 2 Debug Express board, Matrix Multimedia's PICmicro MCU Development board, plus Proteus VSM electronic circuit simulation software from Labcenter Electronics.

Moving on

In this second instalment, we'll continue our tour of ladder logic by looking at:

- Creation of repeating waveforms by using 'oscillators'
- Combining inputs using simple combinational logic operators (AND and OR)
- Availability of other logical functions (NOT, NAND, NOR, XOR, and XNOR)
- Using internal memory locations (auxiliary relays) to hold intermediate results and to solve complex logic networks
- Creation of latched (stored) outputs to capture momentary input signals, including the provision of set and reset inputs outputs.

We'll then use these concepts to develop a simple and extendable alarm circuit, using just a few lines of code, and suitable as the basis of either a car alarm or burglar alarm. Features will include multiple input sensors, a latched alarm status output, and a pulsed armed/disarmed LED.

Simple systems

The above concepts will be drawn together to create a number of simple but useful systems, including a flashing 'system armed' indicator, plus a simple alarm circuit. These simple building blocks may be used as the basis of a wide variety of more complex systems, with potential applications being mainly limited by your imagination.

The article concludes by discussing the PLC software's internal operation in a little more detail. This knowledge will prove useful when debugging your own programs, or should you decide to modify or extend the PLC software to suit your own purposes.

All program listings for this article are available from the **Library > Project Code** section of the *Everyday Practical Electronics* website (**http://www.epemag.com/**). You'll also need the files from Part 1 – particularly the various PIC header files – so I'd suggest that you 'unzip' all files into a single folder. Also, make sure you have installed

Listing 2.1. Creating a 2Hz pulsed output (Lst2_1.asm)

the freely available MPLAB IDE software, which will be needed to actually assemble the example programs. And of course, in order to actually test the programs, you will need a suitable PIC development board or simulation software.

Creating repeating waveforms by using oscillator bits

The PLC software provides two 8-bit registers, OSCH and OSCL, which contain a total of 16 oscillators, with periodic times ranging from 512μs to 16.77 seconds, based on the default clock frequency of 4MHz. Available periodic times and frequencies are shown in Table 2.1.

OSCH (High Frequency Oscillators)		OSCL (Low Frequency Oscillators)	
Bit position	**Periodic Time/Frequency**	**Bit Position**	**Periodic Time/Frequency**
0	512 µs / 1.953 kHz	0	131.1 ms / 7.629 Hz
1	1.024 ms / 976.6 Hz	1	262.1 ms / 3.815 Hz
2	2.048 ms / 488.3 Hz	2	524.3 ms / 1.907 Hz
3	4.096 ms / 244.1 Hz	3	1.049 s / 0.954 Hz
4	8.192 ms / 122.1 Hz	4	2.079 s / 0.477 Hz
5	16.38 ms / 61.04 Hz	5	4.194 s / 0.238 Hz
6	32.77 ms / 30.52 Hz	6	8.389 s / 0.119 Hz
7	65.54 ms / 15.26 Hz	7	16.77 s / 0.06 Hz

Table 2.1. Square wave signals available from the OSCH and OSCL registers

An obvious application of these signals is to create a flashing output using an LED. All that is needed is to load the required oscillator bit and then send it to the desired output port. This is illustrated by the example of Listing 2.1, which is suitable for use either with the PICkit 2 Debug Express board, or with Proteus VSM electronic simulation software.

Note: The examples in this series are written for a variety of PIC microcontrollers, in order to reflect the wide range of devices commonly available. You can easily adapt any of the programs in this series to work with other supported PIC microcontrollers – just modify the first line to load the appropriate header file, and then change the identity of input and output port bits to suit those available. Use the information previously given in Part 1 as a guide (see Table 1.2 and associated text for more details).

In the next section, we'll see how oscillators may be usefully combined with simple Boolean logic functions, so that an output flashes only when a predetermined condition is true.

Waveform production

For the benefit of inquisitive readers, this section explains how the oscillator waveforms are produced, and also covers the derivation of the periodic times of Table 2.1. (This is not essential reading, so you can skip this and come back to it later.)

Recall from Part 1 that the PLC software assumes an oscillator frequency of 4MHz. This signal is used to generate a number of other waveforms, including four non-overlapping (quadrature) 1MHz waveforms (Q1, Q2, Q3, Q4) and also a basic 1MHz square waveform, as may be confirmed by studying the appropriate PIC data sheet. The PLC software uses this 1MHz square wave signal to continuously increment an 8-bit timer register (Timer0, also referred to as OSCH here), but using a 1:256 prescaler (frequency divider). Thus, the OSCH register increments once every 256μs.

A 0 1 transition followed by a 1 0 transition is required to produce one complete square waveform, resulting in the stated periodic time of 512μs for bit 0 of OSCH. Periodic times of subsequent bits are derived by repeatedly doubling this initial value (and frequencies are, of course, calculated as the reciprocal of periodic times.)

The PLC software uses a Timer0 (OSCH) overflow interrupt to increment the low frequency oscillator register (OSCL), in effect creating a 16-bit timer register in software, from the 8-bit timer provided in hardware.

These waveforms may be used directly in user programs. However, it is important to also be aware that they are also used internally as time references by several other PLC commands yet to be considered, including timers and PWM (pulse width modulated) outputs. For this reason, the use of a different clock frequency to the assumed value of 4MHz is likely to cause time-critical programs to run correspondingly faster or slower.

Simple combinational logic functions

Simple switch-based and ladder logic circuits may easily be developed to implement Boolean logic functions such as AND and OR, as shown in Fig.2.1.

Two or more switches in series creates an AND function, since all input contacts must be simultaneously closed to activate the output device (or output coil). Similarly, parallel switch contacts will provide a logical OR arrangement, with one or more closed contacts creating a route for the power to flow along the rung, thus activating the output device.

Notice in Fig.2.1 that all inputs and outputs have been labelled, thus it is possible to state the logical operation of the upper and lower systems in Fig.2.1 as:

- 'LAMP = A AND B', (switches in series), and
- 'LAMP = A OR B' (switches in parallel).

The example program of Listing 2.2 shows a possible coding for these logical operations, based on the 16F88 microcontroller.

In this case, the output on Port B bit 0 is generated by ANDing the lower two input bits on Port A, while Port B bit 1 is the result of ORing bits 2 and 3 of Port A. This method is extendable, simply add successive logical operators in order to increase the number of inputs. Also, note that NAND or NOR operators may easily be created by replacing the 'out' instruction with its negative logic equivalent 'out_not'.

A simple application which combines oscillators with logic functions

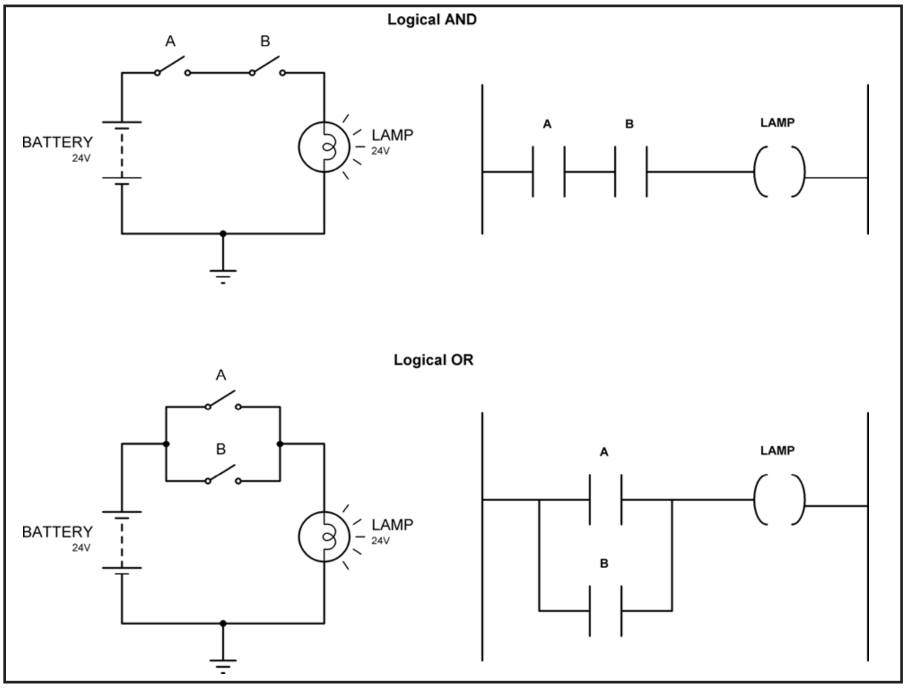


Fig.2.1. Switch-based and ladder logic versions of Boolean logic functions

Listing 2.2. Simple logical functions (Lst2_2.asm)

would be to enable a pulsed output only when a key is pressed. A simple example is shown in Listing 2.3 – this time written for for the PIC16F627/627A microcontroller.

1

Listing 2.3. Generating waveforms using oscillators and simple logic (Lst2_3.asm)

This example demonstrates the wide range of frequencies available, with the high frequency signal on Port B being much too fast to see with the naked eye. Fig.2.2 shows the result of connecting a virtual oscilloscope to Port B bit 1 using the Proteus VSM software.

As can be seen, the measured periodic time of 530μs, obtained using the Proteus VSM simulation, compares quite well with the predicted value of 512μs from Table 2.1. (Some random fluctuation is inevitable, since the changing oscillator bit will not be 'seen' by the PLC software until its next pass through the scan cycle.)

Other logical operations

It was previously seen from Fig.2.1 that two normally-open switches in series creates a logical AND function, while parallel switches provide a logical OR (inclusive-OR to be precise). The related exclusive-OR function provides an output if precisely one of the inputs is true, which is logically equivalent to the statement 'The output is true if (A is true and B is false) OR (A is false and B is true)'. Listing 2.4 gives an example.

In addition to optionally inverting the output bit, as previously discussed, it is also possible to perform logical operations where one of the input bits is inverted. The full range of Boolean logic functions, based on normally-open or normally-closed input contacts, is shown in Table 2.2.

Using internal memory to hold intermediate results

While the above methods may be used to solve simple Boolean logic circuits, more complex logical problems may require an alternative technique. Consider for example the ladder diagram of Fig.2.3.

The trick in this case is to use standard logical operators to solve each horizontal 'rung' of the ladder diagram, writing the result to a series of auxiliary relays. These intermediate results may then be combined using standard logical commands to calculate the final output state.

Listing 2.5 demonstrates the use of the least significant bit of register AUX0 to hold the intermediate result from the first rung, this being logically combined with the result from the second rung to produce the final output on bit 0 of Port B.

You should now have a good understanding of the 'single bit' combinational logic capabilities of the PLC software. For future reference, it is worth mentioning that a number of 'byte oriented' logical commands are also available, which will be discussed later in the series.

The next section demonstrates how the application of feedback from output to input may be used to create a simple latch, which is, of course, the basis of sequential logic.

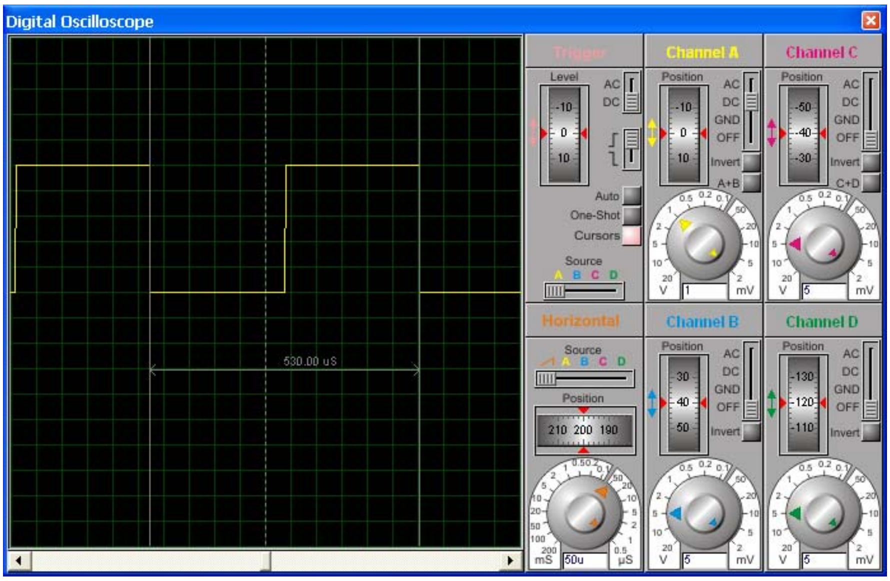


Fig.2.2. Connecting a virtual scope to the Port B bit 1 output in Proteus VSM

Listing 2.4. The exclusive-OR operator (Lst2_4.asm)

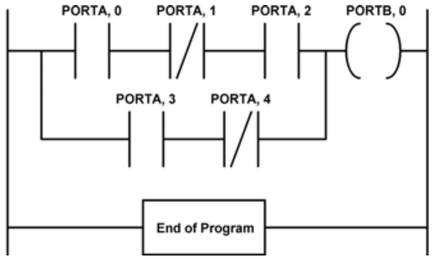


Fig.2.3. A complex logic circuit requiring a two-stage approach

2.6, which is suitable for use with the PIC16F88 microcontroller.

The PLC software also includes a dedicated latch command, which provides an alternative to using separate ladder logic commands. Fig.2.5 shows a ladder diagram incorporating the latch, while Listing 2.7 gives a modified listing, also based on the 16F88 microcontroller

While the use of the latch command does reduce the source code by a couple of lines, the actual machine code generated is identical in either case. Which approach to use is therefore a matter of personal preference.

Using feedback to create latched outputs

Surprisingly, it is possible to read the state of an output in just the same way as an input. This allows feedback to be applied, which in turn enables the creation of circuits where a momentary input signal causes an output to be Set or latched until it is manually cancelled. Fig.2.4 shows the creation of a latch circuit using standard ladder logic commands.

In this case a momentary signal on the Set input, Port A bit 0, enables the latch output (commonly referred to as Q in bistable circuits), which is connected to Port B bit 0. The key to understanding this circuit is to notice from Fig.2.4 that the state of the Q output is also connected in parallel with the Set input, proving a logical OR arrangement. Thus, the latch is held in the on state once the momentary Set input is removed. The circuit remains enabled until the normally closed Reset input (Port A, 1) is pressed, which breaks the circuit and resets the latch.

The ladder diagram also contains an optional second rung which reads the Q output (Port B bit 0) and generates an inverted (Not Q) output on Port B bit 1. A program listing is given in Listing

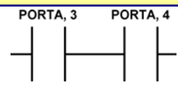
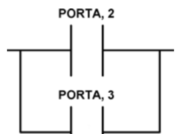
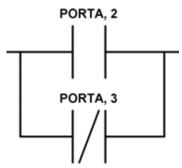
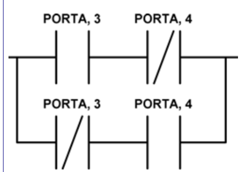
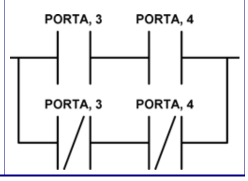
		
		
		
		
		
		

Table 2.2. Single-bit Boolean logic commands

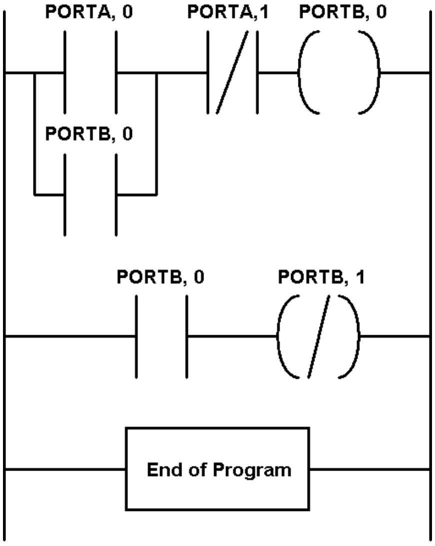


Fig.2.4. Creation of a latched output by using standard ladder logic commands

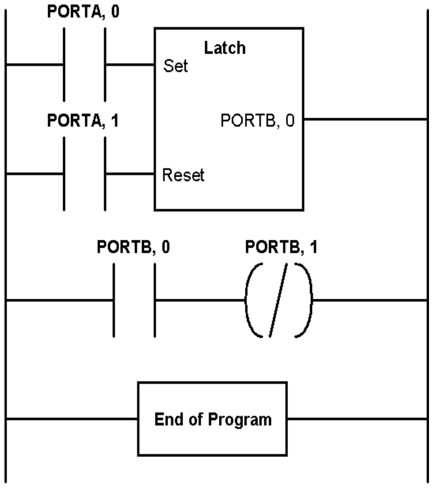


Fig.2.5. Using a dedicated latch, rather than separate ladder logic commands

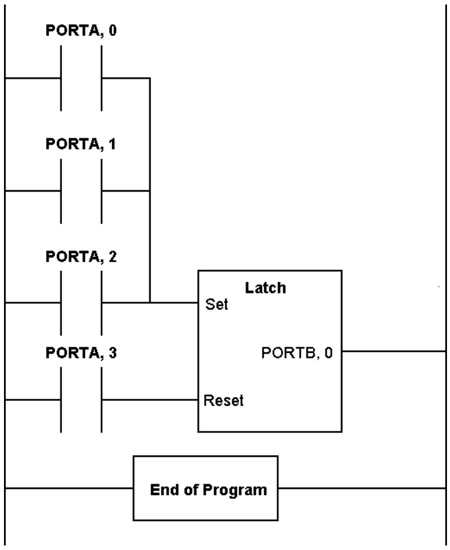


Fig.2.6. Ladder diagram for a simple alarm with three sensors

Building simple systems

To bring together some of the concepts discussed, let's begin by creating a briefly flashing LED output, as might be found in the 'system armed' output of an immobiliser circuit. We'll use a latch to arm or disarm the circuit, with the output being sent in the first instance to an auxiliary relay. When enabled, the output will be made to flash by ANDing with a 1Hz oscillator signal, and the pulse width will then be reduced by ANDing together several higher frequency oscillator bits. Listing 2.8 shows a possible solution, based on the PIC16F887 microcontroller.

It can be seen from Listing 2.8 that the latch uses Port B bits 6 and 7 as the Set and Reset inputs, with the latch output being sent initially to auxiliary relay AUX bit 0. The latched signal is made to pulse at 1Hz by ANDing with low frequency oscillator register OSCL bit 3, and is displayed by outputting to the LED connected to Port D bit 0. The intervening three AND statements are optional, having the effect of reducing the pulse width to 1/8 of its initial value.

The program may be executed either using the appropriate Proteus VSM simulation (for those readers with access to this software), or by using the PICkit 2 Debug Express board. In the latter case, recall from Part 1 of the series that you can use the PICkit 2 Logic Tool to set and reset the bistable. Pin 5 is connected to Port B bit 6, thus being used as Set, while Pin 4 (Port B bit 7) acts as Reset. (Slightly confusingly, you need to configure these two pins as outputs in the Logic Tool since they are used to drive the corresponding inputs on the PIC.)

Our final example is a simple alarm circuit with three sensor inputs and a latched alarm output. If one or more of the sensors is momentarily activated then the alarm will be triggered, and remain in this state until the alarm is manually cancelled. The ladder diagram for the alarm is shown in Fig.2.6.

Listing 2.5. Using internal relays to solve complex logic circuits (Lst2_5.asm)

The program uses bits 0 to 2 of Port A as input sensors, and Port A bit 3 as a Reset signal (1 = reset, 0 = system armed). Notice that the sensor status automatically becomes the input to the latch, with the latch output being sent to an LED connected to output PORTB bit 0 (this might be a buzzer or sounder in a real alarm). Momentarily pressing the switch connected to Port A bit 3 resets the latch, cancelling the alarm. A possible program for the 16F627 microcontroller is given in Listing 2.9.

Possible enhancements would include a pulsed alarm output, and the provision of a 'system armed' indicator, similar to that seen previously. These additions are left as exercises for the reader.

A further potential development would be the automatic cancellation of the alarm after a given period of time, in order to prevent unnecessary annoyance due to false triggering. This enhancement will have to wait until next month, when timers will be covered.

Internal operation of the PLC software

A more detailed understanding of the underlying operation of the PLC software is useful at this stage, not only for curiosity's sake, but also to explain the types of error messages which will inevitably be encountered as you begin to write programs of your own.

As you will be aware, the MPLAB Integrated Development Environment (IDE) uses an assembler to transform your source code text file into an

Listing 2.6. Creating a self-latching circuit by reading the state of an output (Lst2_6.asm)

Listing 2. 7. Using the latch command (Lst2_7.asm)

Listing 2.8. Creating a 'system armed' flashing output (Lst2_8.asm)

Listing 2.9. A simple alarm program (Lst2_9.asm)

executable machine code program. This powerful software has a macro facility, which allows a text string to be automatically replaced by a section of user-defined text, prior to assembly. The macro definition may optionally expect one or more arguments (text strings), and the user supplied values will be automatically inserted into the output text by the assembler, prior to conversion to machine code. Consider the implementation of the 'ld' instruction as an example, as shown in Fig.2.7.

As can be seen, the 'ld' macro accepts two arguments, ld_arg1 and ld_arg2. The macro substitution causes the original source code line to be replaced by three lines of assembly language. It is important to be aware that any assembler errors are likely to relate to the source code after the macro substitution, which does admittedly make the debugging process a little more difficult.

Notice that the above section of code results in the logic level present on the input port being placed into the least significant bit of the (LSB) Working register (W), which is actually a general feature of the PLC software. The corresponding 'out' instruction, for example, simply takes whatever it finds in the LSB of the W register and sends it to the selected output port, as may be confirmed by examining the appropriate header file in a text editor such as Windows Notepad.

An interesting observation at this stage relates to the 'endp' or end program PLC instruction, which is of course, yet another macro. An examination of the header file shows that this is simply a jump instruction, which forces the PLC program to run

Fig.2.7. Macro substitution, as used by the PLC software's 'ld' instruction

continuously – this being the basis of the PLC's repeating scan cycle.

An obvious conclusion based on the above macro substitution is that any machine code programs are likely to be considerably larger than the source code might suggest. Thus, the main advantage of the ladder logic approach is in simplification of the design process, rather than reduction in code size.

Summary and next steps

This second part of the series began by considering the creation of flashing outputs of a wide range of frequencies by using oscillator bits. We also looked at single-bit combinational logic functions, including AND, OR and Exclusive-OR, and discussed the potential incorporation of inverted inputs and outputs (NAND and NOR for example). More complex logical circuits were solved by use of internal storage (auxiliary relays) to hold intermediate results. We then used feedback from outputs in order to create simple self-latching circuits (simple sequential logic) and combined these concepts to create a simple flashing 'system armed' warning light and an alarm circuit.

We also discussed the macro substitution method used by the PLC software, and saw that the final machine code program will be considerably larger than the source code would suggest.

Hopefully, the power of ladder logic as a design tool has been in part demonstrated by the fact that a simple burglar alarm system could be created in approximately five lines of source code (as seen in Listing 2.9), and without any need to delve into the internal architecture of the chosen PIC microcontroller.

The next part of the series will continue the tour of the sequential logic capabilities of the PLC software, by looking at timers and shift registers. The use of timers will enable an action to be performed for a given period of time, while shift registers will make it easy to create simple running light displays.

Transformers and Impedance

USER posted the following question on the *EPE* discussion forum ( ).

I have just purchased a couple of audio transformers (Eagle LT700 Maplin code LB14Q) and on the cardboard label attached to the plastic bag that it came in, it states that the primary winding is 1.2kΩ, and the secondary winding is 3.2Ω. When I placed my multimeter across the primary winding (it has a centre tap) I get a reading of 66Ω, and from one side of the primary to the centre tap it is 33Ω. The secondary winding is reading 0.7Ω.

I tested both transformers and they both read the same values. I have not had a lot of experience with audio transformers and can't quite understand why the impedance is different to what it says on the bag.

The LT700 is a miniature audio output transformer, which can handle around 200mW. These are now regarded as a 'vintage' component because they were used extensively in early transistor circuits, but are far less common in modern designs. Transformers were (and still are) widely used in valve (tube)-based audio circuits (of course these are usually 'vintage' too).

The LT700 is still readily available and only cost a couple of pounds, so it does not cost much to get one to experiment with. Although they are intended for coupling a speaker to the output stage of an amplifier, people have found other uses for them and several examples can be found on various circuit websites.

Versatile transformer

Transformers were used in audio circuits because they provided a means of impedance matching and signal level conversion, provided electrical isolation, could be used to help produce balanced signals for interconnection, and could be used to extract signals for negative feedback purposes in amplifiers. Modern design techniques using transistors or integrated circuits have greatly reduced the use of transformers in audio, which is seen as an advantage because of their size, weight and cost, and because transformers typically exhibit non-linearities which can distort signals. Of course, these non-linearities may contribute to the 'vintage sound', which some people actively seek in audio gear.

The LT700 is intended for use in impedance matching from the output of a transistor stage. As Mel states, it has a 1.2kΩ centre-tapped primary and a 3.2Ω secondary. This enables it to match impedances suitable for driving by the transistors (eg kΩs) with a low impedance speaker (eg 3Ω). The LT700's centre-tapped primary facilitates the use of push-pull driver circuits in which one transistor amplifies the positive half cycle of the waveform and another amplifies the negative half cycle.

Basic principles

The resistance measured by a multimeter is not the impedance of the transformer. There is not really a single impedance value, and any measured value will be frequency dependent. Transformers reflect impedances and this is what is important in matching and load driving applications. To appreciate why this is useful it is helpful to look at the basic principles of transformer operation and the concept of matching.

Transformers consist of coils of wire in close proximity, often wound round a core or former. For the simpler situation of a single coil (ie an inductor), with a constant inductance, *L*, the following relationship exists between the current through the inductor, *I*, and the voltage across it, *V*:

$$= - \quad \overline{\quad\quad}$$

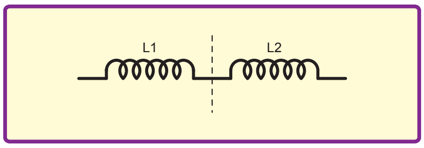
In this equation the term *dI/dt* is a differential – it represents the rate of change of the current with time. This is the fundamental property of an inductor; a change of current in the inductor induces a voltage across the inductor which opposes the current.

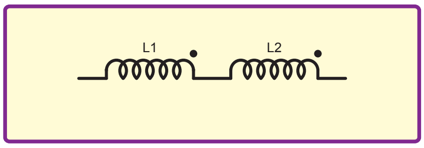
From the above equation, if the current does not change (that is for DC) the voltage across the inductor is zero. If a component has zero volts across it, with a direct current through it, then its resistance must be zero. Indeed, this is the case for an ideal, or perfect inductor, but real inductors also have some resistance. The values Mel measured for the LT700 using the DC output produced by the multimeter to measure resistance are, therefore, the resistances of the windings and are not related to the inductance, or the quoted impedance values.

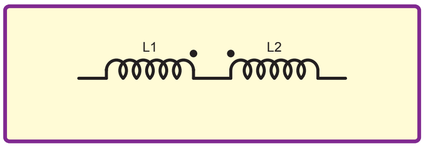
Mutual inductance

The properties of an inductor are due to the relationship between electricity and magnetism. A current flowing in a conductor creates a magnetic field, and a changing magnetic field across a conductor induces a voltage. Because the inductor is inducing the voltage in itself, this is sometimes referred to as *self-inductance*, although we usually just use the term inductance when dealing with single inductors.

A single coil forms an inductor, but a transformer comprises two or more inductors, whose close proximity means that their magnetic fields interact. This interaction is referred to as *mutual inductance*.







If two inductors are present in a circuit, for example as shown in Fig.1, but are physically very far apart, or are magnetically shielded, then there is no magnetic interaction between them. The total inductance in such a series circuit is *L1* + *L2* and there is no mutual inductance.

If two inductors are able to interact magnetically, then their magnetic fields may either oppose or support each other, depending on their magnetic orientation. This is shown in Fig.2 and Fig.3. Here the orientation of the coils is indicated by a dot, something which is also shown on some transformer schematic symbols, where the dots are used to indicate the relative phase of the signals in the windings.

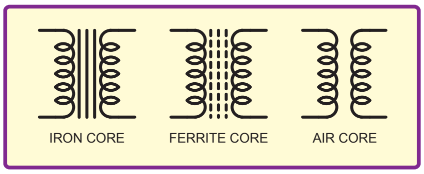
The magnetic orientation of two physically separate coils will be determined by their physical orientations. If the coils are on the same former or core then the direction of winding will determine relative magnetic orientation.

For the circuit in Fig.2 there is mutual inductance as well a self-inductance, and because the inductors are orientated the same way, the fields support and the total inductance is *L1* + *L2* + 2*M*, where *M* is the mutual inductance. In Fig.3, the opposing effect of the magnetic fields reduces the total inductance to *L1* + *L2* –2*M*.

The actual value of *M* depends on the amount of magnetic interaction between the coils, which is measured by the coupling coefficient, *k*. The value of *k* varies between 0 and 1 and would be 0 for Fig.1, if we assumed perfect shielding. If *k*=1 we have all of the magnetic flux of one coil coupled to the other, which is an ideal case. For two coupled inductors *L1* and *L2,* the mutual inductance *M* is given by:

$$= - \sqrt{L1\ L2}$$

Unlike the coils in Fig.1 to Fig.3, the individual windings of transformers are not usually wired together. The electrical isolation provided by transformers is one of the key reasons why they are used in a variety of application. However, even if the coils are not electrically connected they are still magnetically coupled and have a mutual inductance given by the above equation. The schematic symbols for transformers depend on the type of core on which the coils are wound, as shown in Fig.4.

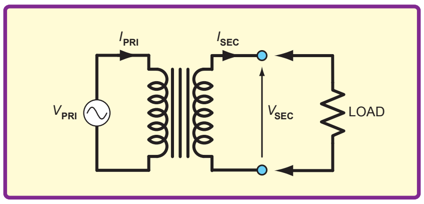


Parameters

A transformer has a primary (pri) winding, to which we connect a signal, or driving voltage, and a secondary (sec) winding from which we take an output signal. A key transformer parameter is the turns ratio, *n*, which is defined as the ratio of the number of turns in the primary coil to the number of turns in the secondary coil:

$$= \frac{\quad}{\quad}$$

The turns ratio is also defined the other way round (N_{pri}/N_{sec}) in some places – so take care!



If we apply an AC voltage V_{pri} to the primary (as shown in Fig.5) we get an AC voltage from the secondary V_{sec} given by:

$$=$$

When a load is connected to the secondary of an ideal transformer, the power delivered to the load is equal to the power delivered to the primary. As power is equal to voltage times current we must have:

$$= \left(- \right)$$

Matching problems

For a real transformer some power is always lost, so the power delivered to the load is less than that supplied to primary.

As already mentioned, transformers can be used to match a source to a load. The 'matching' problem is basically choosing the most appropriate load impedance, Z_L, given that we know the source impedance, Z_S, (or vice versa). However, in some circuits the properties of components, or other design constraints, mean that we cannot choose optimal values for either. In such cases, transformers can sometimes be used to provide the matching. Before looking at how this works we will define the matching problem in more detail.

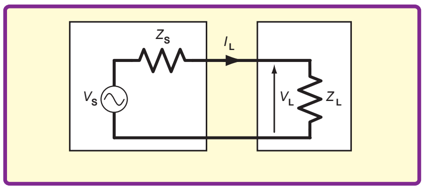


Fig.6 shows a source with output voltage V_S and source impedance Z_S connected to a load with impedance Z_L. The two impedances form a potential divider. Thus, the voltage across the load, V_L, is given by:

$$= \frac{\quad}{(\quad + \quad)}$$

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

The current in the load is given by:

$$= \frac{\quad}{(\quad + \quad)}$$

Thus, if we want the current in the load to be as high as possible we need to make Z_L much smaller than Z_S (we are assuming Z_S is fixed).

Given that the term 'matching' would imply $Z_S = Z_L$, the two scenarios we have just looked at – maximum V_L by making Z_L much larger than Z_S, and maximum I_L by making Z_L much smaller than Z_S indicate what happens when load and source are not 'matched'. However, we should be asking, what is the most appropriate load for this source? – matching in the sense of $Z_S = Z_L$ is not always what we want.

For example, a high impedance input (Z_L much greater than Z_S) may be most appropriate for amplifying the voltage from a sensor. In fact, in very many cases, circuits are designed to have much larger input impedance than the source impedance so that loading does not modify the voltage at the input.

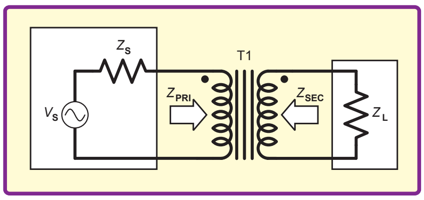
So what happens when $Z_S = Z_L$, and why might this be useful? The answer is that maximum power is transferred from source to load. In order to prove this you have to use calculus (you find the maximum of the relationship between load power and load resistance, but we will not go into the details here).

Power transfer

The power transfer aspect of matching is important in power amplifier outputs. For example, consider a small audio power amplifier producing a 1.6V RMS signal with a 3Ω output impedance; the powers delivered into loads of various impedances are listed in the table below. The maximum power is obtained for a load of 3Ω – matching the source impedance. The maximum power delivered to the load is half of the power taken from the source at that point, as the load impedance increases above being equal to Z_S a greater proportion of the source's power ends up in the load, but the actual power delivered decreases.

Ω source at 1.6V RMS)	
1Ω	160mW
2Ω	205mW
3Ω	213mW
4Ω	209mW
6Ω	190mW
8Ω	169mW

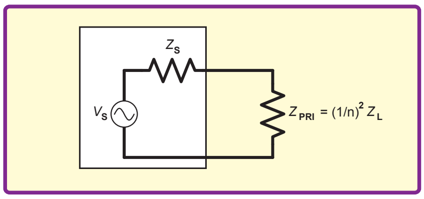
When a transformer is connected between a source and load, as shown in Fig.7 the source 'sees' the load as having a different impedance to its actual impedance. The impedance presented by the transformer



primary depends on the load connected across the secondary and the turns ratio. This is known as the *reflected impedance* and is given by:

$$=\left(\frac{\;}{\;}\right)$$

Note that it is the *square* of the turns ratio which is important here, not just the turns ratio, as with voltage and current relationships from primary to secondary. We can draw an equivalent circuit for Fig.7, as shown in Fig.8, where the transformer and load are replaced with the reflected impedance.



Note also that impedance is reflected the other way too (the source as 'seen' from the secondary).

For example, if a transformer has a turns ratio of 0.05, a load of 3Ω connected to the secondary will be reflected in the primary as a load of 1.2kΩ:

$$=\left(\frac{\;}{\;}\right)\Omega = \quad \Omega$$

Thus, transformer windings do not really have impedances themselves, but reflect the impedances connected to them.

The impedances quoted for a matching transformer will be typically source and load impedances that the transformer was designed to match. However, real transformers also have imperfections such as winding resistance and capacitance, which reduce the performance of the transformer from the ideal case of 100% power transfer from primary to secondary

Recycle It!

BY JULIAN EDGAR

The good bits inside flatbed scanners!

It's not hard to obtain a computer flatbed scanner for next to nothing – they're a frequent discard that can be found at car boot sales, or your local tip. But what use can be made of the parts inside? Despite first appearances, quite a lot.

PULLING a scanner apart is easy: most models just clip together and can be separated by the judicious use of a screwdriver. Inside, you'll find a moving carriage on which the cold cathode fluorescent lamp (CCFL), focusing lens and charge-coupled device (CCD) image sensor are mounted. In addition, the carriage contains two or three mirrors to reflect the image to the lens.

The carriage is driven by a geared-down stepper motor that operates a toothed belt. There's usually also a position sensor to detect when the carriage is in its 'start' position and, of course, the necessary image processing circuitry.

So, getting the bits is easy – but what can you do with them?

The CCFL

The cold cathode fluorescent light (CCFL) is run by a high voltage (HV) power supply which produces several hundred volts. **Warning – it's high enough to give you a nasty shock or burn your skin! In fact, given the right circumstances, a shock could be fatal.**

Salvaging this part of the system is very easy – in most scanners, the HV power supply is mounted close to the CCFL on the carriage or alternatively, is mounted remotely and is connected to the CCFL via some HV wires. The HV power supply is a separate circuit board and contains a transformer, inductor, a few capacitors and some transistors.

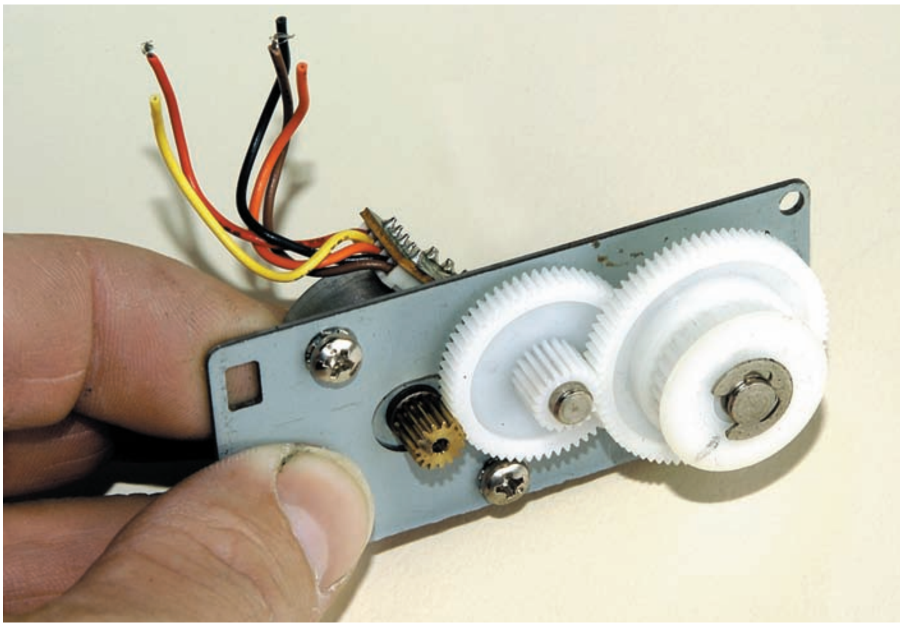
The power supply is fed by either two or three wires. When there is a pair, you'll normally find that they are red and black – red for positive, black for negative.

Observing the polarity, connect a variable voltage power supply to these wires and slowly wind up the voltage. The CCFL will first light at anywhere from 4.5V to 21V, but note that the HV power supply itself delivers several hundred volts to the lamp. If the original input voltage is unknown, don't go up any more than a few volts over the 'light-up' voltage of the CCFL.

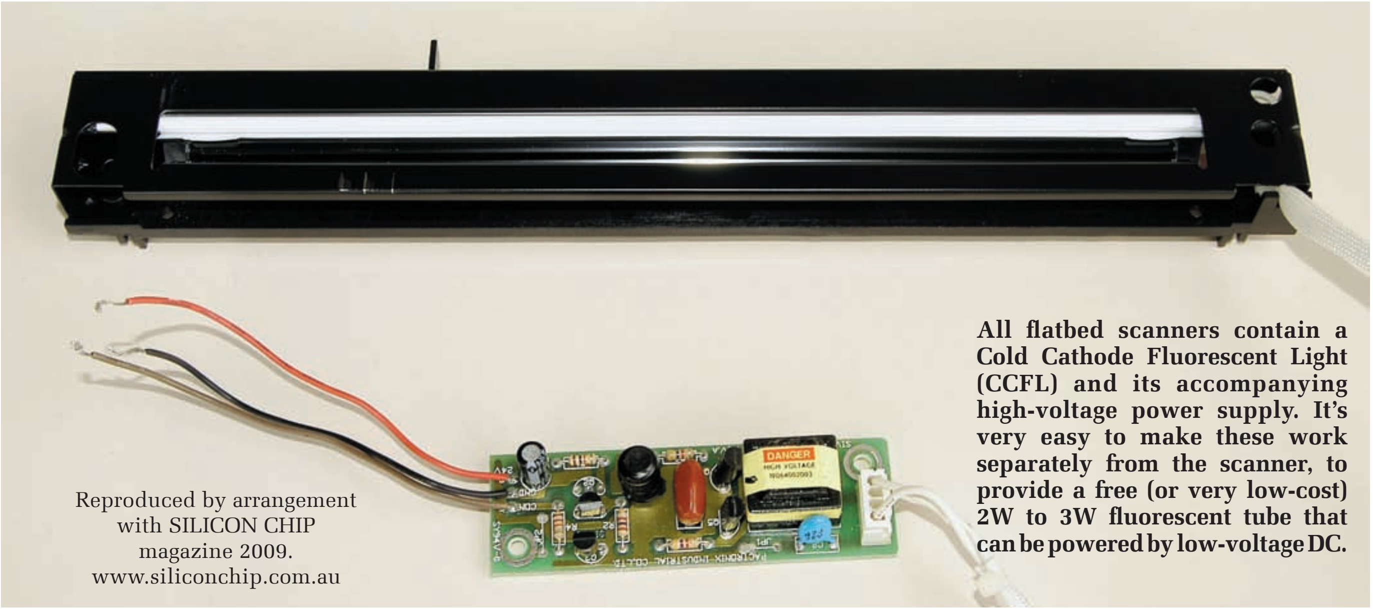
A three-wire power supply also includes a 'control' input (in addition to the red and black wires). If power is applied via the red and black wires, supplying this control input with a small voltage (eg, 1V) will cause the CCFL to light.

CCFLs have some major advantages over other lighting sources. First, the tubes are extremely thin – 2.5mm is common. Second, they provide a diffuse light, usually with good colour rendition. Third, they are quite bright, but at the same time remain cool!

However, you must remember that the tubes are also very fragile – where possible, they should be supported in exactly the same way as they were in the scanner carriage. ***Remember also that the power supply should be***



Many scanners use small stepper motors integrated into a reduction gear train. These make excellent hand-cranked generators (complete with a ~1:16 step-up ratio) or they can be used conventionally in a host of projects.



All flatbed scanners contain a Cold Cathode Fluorescent Light (CCFL) and its accompanying high-voltage power supply. It's very easy to make these work separately from the scanner, to provide a free (or very low-cost) 2W to 3W fluorescent tube that can be powered by low-voltage DC.

housed in a plastic case and the lamp connections must be well insulated and away from probing fingers.

Scanner CCFLs are typically rated at 2W to 3W and are ideal for use in model railway layouts (where they can provide concealed factory and station lighting), for low voltage lighting (eg, in a caravan or solar home) and for instrument and gauge lighting.

Front housing

The front of the scanner consists of a flat sheet of high-quality glass mounted in a plastic 'frame' housing. And that's it – most times, the electronics, carriage and motor are all in the bottom half of the scanner. So what use is this top half? Well, it isn't an electronic application, but if the housing is placed over a shallow tray that's been filled with soil, you get an ideal device for germinating seeds.

Want some other uses? The front housing can also be used to protect solar cells that aren't already under glass, or you can make a picture frame that matches the glass size. When I was a kid, I made a solar pie warmer that used a front glass sheet very similar in size to a typical flat bed scanner's glass panel – so there's another use.

In short, wherever you need a pre-cut, zero cost small sheet of good quality glass, here it is! Why on earth would you throw it away?

Stepper motor

Scanners use stepper motors that are attached to compact reduction gears. Unlike many discarded consumer goods from which you can obtain steppers, the scanner stepper and its gear train often comprise a standalone, easily removable assembly. So, if you want a small stepper (they're typically 25mm to 35mm in diameter) that's integrated with a ~16:1 reduction drive and forms an assembly that's only about 70 × 50 × 40mm, reach for the nearest discarded scanner.

To drive these motors, you'll need a stepper motor control circuit. Of course, the scanner already incorporated this, but it's easiest to use new circuitry to achieve the control you want – such has the *Stepper Motor Driver* described in the May '09 issue of *EPE*. See also Magenta's advert.

Alternatively, you can apply physical effort to rotate the output shaft and so generate power! The 16:1 reduction ratio then becomes a 1:16 step-up ratio.

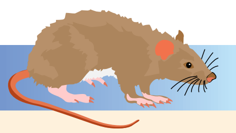
By adding a crank handle to the output cog (this is easy because this cog originally needed clearance to drive the belt, and so always stands proud), you can take advantage of the gear train to turn the stepper motor at an easily-achievable 1500 RPM! The resulting power is enough to charge a battery or run a white LED. For more information on using stepper motors as alternators, see *Human Powered LED Torches* in the September 2006 issue of *EPE*.

The benefit of taking this approach over using a larger, direct-driven stepper is that a very compact generator or hand-cranked torch can be built. The disadvantage is that the plastic gear train may have a short life.

Bits and pieces

Don't forget the other bits and pieces inside the scanner. I always salvage the chrome-plated steel bar on which the

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 scanner cover makes the ideal top half for a small seed germinator. Alternatively, the glass can be used to cover solar cells in small solar projects, or even in a picture frame!

carriage rides (and it runs in bronze bushes, no less!). These bars are typically 8mm in diameter, and if you have a metal turning lathe and/or a set of thread-cutting dies, are excellent raw material for all sorts of projects.

You'll also find front-faced mirrors (that is, the reflected light doesn't have to pass through the glass) and Hall effect position sensors.

I've nearly forgotten one of the gems – the final focusing lens. Scanners contain a variety of pre-focusing lenses – and curved mirrors – but it's the lens closest to the image sensor that's the 'good 'un'. Often only about 8mm diameter by 10mm long, these typically have a focal length of just of 15mm and make for extremely effective close-up hand lenses.

They're not super bright, but they're of excellent quality and provide huge magnification. They're just the thing for inspecting solder joints or checking just how dull the ends of those supposedly sharp multimeter probes are.

Finally, most scanners are powered by plugpacks and many people throw these away at the same time as they're getting rid of the scanner. It's worth keeping – you can never have too many different plugpacks on the shelf.

Conclusion

Not interested in free low-voltage fluorescent lighting? Or seed germination boxes? Or geared stepper motors? Or hand-cranked generators? Or a compact, high-magnification hand lens? Or salvaging another plugpack without cost?

That's OK – just be sure you give any old scanners that you have to someone who can really make use of them! ***EPE***

INTERFACE

By Robert Penfold

OPTO-ISOLATION

When recently experimenting with MIDI (musical instruments digital interface) projects, I was faced with the problem of opto-isolation on each MIDI input. Few computer interfaces have any form of isolation circuit, and instead simply have the computer hard-wired to the peripheral devices. This does not result in technical hitches or peripheral gadgets such as printers and scanners being 'zapped' left, right, and centre, so why is it sometimes essential to use an isolation circuit?

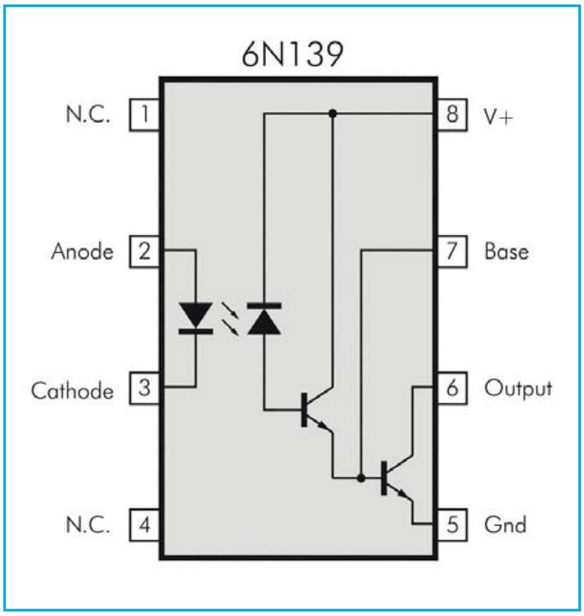
Missing link

The function of an isolation circuit is to transmit an electrical signal from one unit to another without using any direct electrical connections. The isolation circuit is often required to withstand very high voltages without breaking down, and in most cases a potential as high as a few thousand volts is insufficient to breach the isolation circuit.

I suppose that radio systems such as Bluetooth and Wi-Fi and the infra-red IrDA system offer the ultimate in electrical isolation, with no physical connection of any kind between the computer and any peripheral devices. In the case of a Wi-Fi connection, the computer and the peripheral might not even be in the same building.

There are two normal reasons for using an electrically isolated link, and in the case of the MIDI musical instrument interface it is mainly used as a means of avoiding unwanted signals appearing on the audio outputs of the instruments. There are two sources of this noise, and one of these is earth loops that can introduce 50Hz mains 'hum' into the audio signal.

Using an isolation circuit for digital links in the system does not guarantee that there will be no trouble with mains 'hum' due to earth loops, since there may well be other interconnections that could give rise to this problem. However, it does at least eliminate a potential source of this problem by making sure that the digital links have no direct chassis-to-chassis connection that could introduce earth loops. Any problems due to earth loops caused by the audio interconnections have to be sorted out in the usual way.



The other type of audio noise that can be troublesome when mixing audio and digital circuits is the breakthrough of digital signals into the audio signal path. Again, using an isolation circuit does not guarantee that the audio signal will be noise free.

Each unit in the system must be carefully designed so that any local breakthrough of digital noise into the audio signal is reduced to insignificant levels. Using an isolation circuit does at least prevent the digital interconnections from exacerbating the problem.

Isolated case

The second reason for using an isolation circuit is that there is a risk of a high voltage difference being present between the chassis of two items of equipment. On the face of it, this should not happen, but in practice it can occur under certain circumstances.

It will not occur if the two items of equipment are both reliably earthed to the mains earth connection, since their chassis will both be at earth potential. There is little risk of problems occurring if the items of equipment are battery powered, or one is battery powered and the other is mains powered and has a mains earth connection.

The risk of getting a large potential difference becomes much higher if one of the items of equipment is mains powered but has no earth connection, and it is very high if both units are of this type. With the chassis of the two items of equipment left 'floating' it is possible for a high potential difference to be present between them.

Desktop PCs usually have an earthed metal case and chassis, which helps to minimise the risk. Portable computers are increasingly popular, and these often use double insulation rather than having an earthed chassis, making them more at risk.

This is not a theoretical problem that can simply be ignored in practice. Many years ago, I interfaced a Commodore 64 computer to an up-market communications receiver using an RS232C-style serial link. This type of link normally operates using a direct connection, but the handbook for the communications receiver warned against this method and recommended using an opto-isolator at the serial input of the receiver.

I ignored the warning and had to pay nearly a hundred pounds to get the computer repaired! A high voltage existed between the chassis of the computer and the receiver, resulting in some interface chips in the computer being 'zapped' as soon as the two items of equipment were connected together.

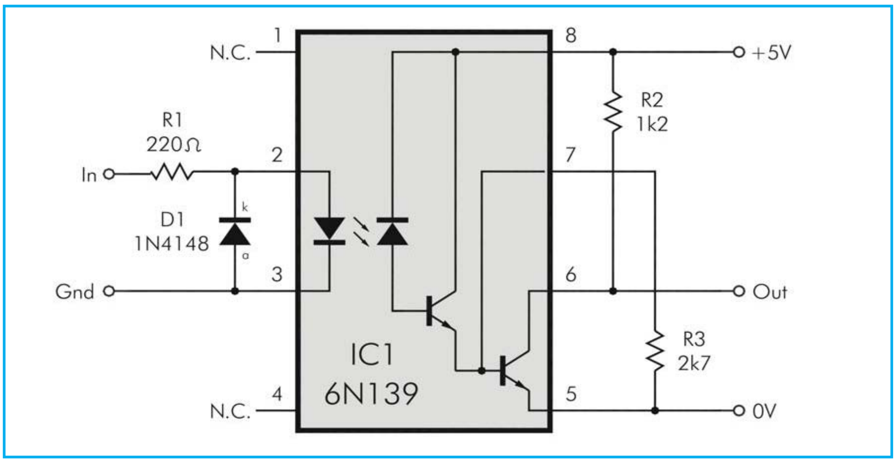
The high voltages that can exist between two items of equipment do not represent a significant danger to the user, since the maximum current flows are minute. Unfortunately, most semiconductors are easily damaged by high voltages, even if they are only present very briefly and the current flow is minute. This is similar to the problem of static discharges in the environment that are quite capable of destroying some types of semiconductor, even though they are not large enough to make their presence apparent to anyone in their vicinity. In this case though, it seems to be practically any type of semiconductor that is at risk, and not just the MOS variety.

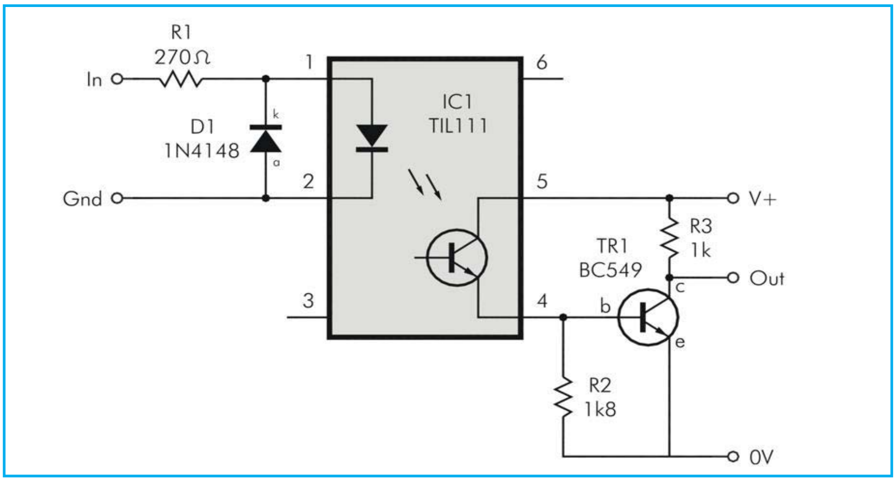
Light relief

An optical system of some kind is the usual solution when an isolated digital link is required. The link can be implemented using a system that utilises a fibre-optic cable, or, as in the case of a MIDI interface, an ordinary wired connection can be used together with an opto-isolator circuit at each input.

Although using an opto-isolator is simple in theory, it tends to be less straightforward in practice. The problem is simply one of speed, or to be more concise, a lack of speed. A 'bog standard' opto-isolator consists of an infra-red LED having its 'light' output directed at a phototransistor. The component is housed in an opaque case that prevents any ambient light from reaching the phototransistor.

The phototransistor normally exhibits a very high resistance between its collector and emitter terminals, just like any silicon transistor that has no base current applied. However, the leakage level of the phototransistor becomes quite high when it receives the infra-red output of the LED. This can be used to couple a logic signal from one unit to another, while avoiding any direct electrical connection using a very simple circuit. Most opto-isolators are guaranteed to block potentials of at least two thousand volts, which should be more than sufficient to prevent either unit in the link from being damaged.





Opto links

A basic opto-isolator link is much slower than might be expected. The phototransistor might be capable of switching at 100MHz or more when used in the normal way with a signal applied to its base terminal, but its maximum operating frequency is a minute fraction of that when controlled by a light source. A simple opto-isolator circuit produces a rather sorry looking output signal when fed with a 1kHz square-wave input signal, and the output signal is likely to virtually disappear if the input frequency is raised to a few kilohertz.

Such a slow switching speed is of no consequence in very basic applications, where a few lights or relays are being controlled, or bytes of data are being sent or read very infrequently. Clearly though, it is very limiting in other situations, and there is no way that something like a fast RS232C-style serial link can be used with such a slow isolation circuit.

Fortunately, faster opto-isolators are available, albeit at substantially higher prices. They are still very slow by the normal standards of logic circuits, but they can be used successfully with something like a reasonably fast serial link. Using eight or 16 isolators to transfer parallel bytes or words of data it should be possible to transfer data at dozens of kilobytes per second.

Fast transfer

The high gain split-Darlington 6N139 device (Fig.1) is an example of a fast opto-isolator, and on the input side this has the usual infra-red LED. On the output side it has a photodiode driving a two-stage transistor amplifier. The first transistor is used as an emitter follower buffer stage, which drives a common emitter switching transistor. This arrangement gives a much better signal transfer, with an output current that can exceed the input current. It also gives much faster operation than a simple opto-isolator.

Fig.2 shows the circuit diagram for a simple opto-coupler based on the 6N139. Resistor R1 is the usual current limiter on the input side of the circuit. Resistor R2 and R3 are respectively the load resistors for the emitter follower stage and the common emitter output stage.

Although it is much faster than an opto-coupler circuit based on a simple opto-isolator, the speed of this circuit is still quite limited by normal electronic standards. MIDI operates at a baud rate of 31250, and a circuit of this type can comfortably accommodate the MIDI baud rate. It will therefore handle the highest normal RS232C baud rate of 19200 baud with relative ease.

A PC's RS232C serial port can usually operate at higher non-standard board rates of up to 115000 baud, and practical experience suggests that this represents the upper limit for this type of opto-isolation circuit. Even at 115000 baud, it might be necessary to tweak the values of resistors R2 and R3 in order to obtain reliable operation.

Budget isolator

It is possible to obtain faster operation from a 'bog standard' opto-isolator by using it in conjunction with a discrete transistor amplifier. This provides a lower cost solution than using an upmarket opto-isolator, although the maximum operating speed is unlikely to be quite as high as that obtained using an expensive opto-isolator. A circuit of this type can easily accommodate the highest standard baud rate of 19200, but very high rates of over 100,000 baud are not usually possible.

The circuit for a high-speed opto-isolation circuit based on a TIL111 or similar device is shown in Fig.3. This utilises an arrangement that is essentially the same as the one used in the 6N139 device, but here the photodiode and first transistor of the 6N139 are replaced by the phototransistor of the opto-isolator (IC1).

Discrete transistor TR1 provides the common emitter switch at the output of the circuit. The additional amplification ensures that there is an efficient signal transfer, and also gives an increase in speed by avoiding the need for the phototransistor to virtually reach saturation before the output changes state.

It should be noted that the isolation circuits of Fig.2 and Fig.3 both provide an inversion, and must be followed by an inverter stage if the design of the main circuit cannot accommodate this. In practice, it is a good idea to include a Schmitt trigger at the output of an opto-isolation circuit. This avoids any noise problems that might otherwise be caused by the relatively slow rate of change that occur during transitions at the output of the circuit. Using an inverting Schmitt trigger will ensure a 'clean' output signal.

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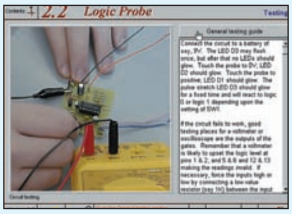
ELECTRONICS PROJECTS



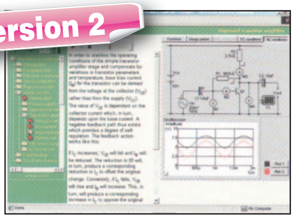
Logic Probe testing

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

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

ELECTRONIC CIRCUITS & COMPONENTS V2.0

Version 2

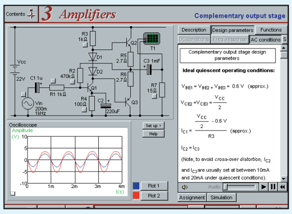


Circuit simulation screen

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

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

ANALOGUE ELECTRONICS



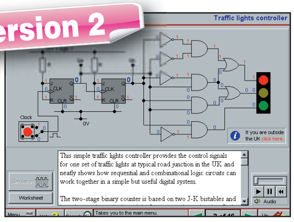
Complimentary output stage

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

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

DIGITAL ELECTRONICS V2.0

Version 2



Virtual laboratory - Traffic Lights

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

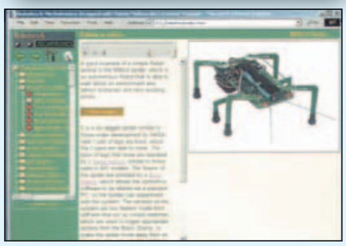
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry,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

ANALOGUE FILTERS

Filter synthesis

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

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

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

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

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

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

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

PICmicro TUTORIALS AND PROGRAMMING

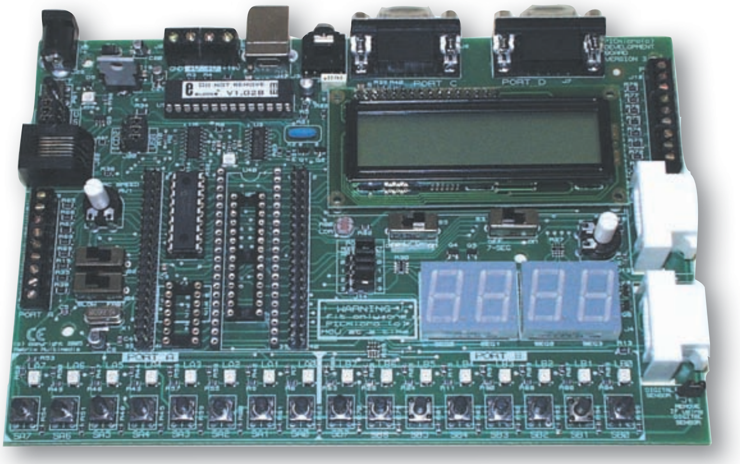
HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

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

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual LEDs, quad 7-segment display and alphanumeric LCD 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

SOFTWARE

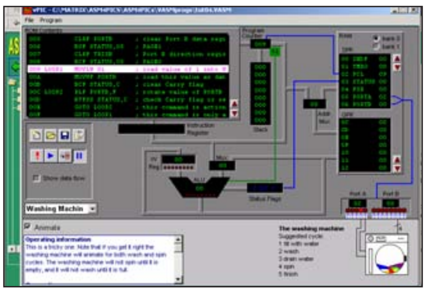
ASSEMBLY FOR PICmicro V3

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

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

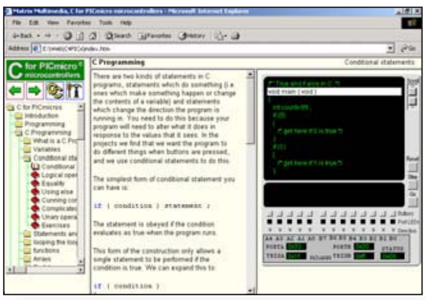


'C' FOR 16 Series PICmicro Version 4

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-ROM 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, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

FLOWCODE FOR PICmicro V4

FREE with Flowcode V4 (student and institutional versions) ECIO board – a 28-pin reprogrammable microcontroller.

Flowcode is a very high level language programming system 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 LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. 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 ● 16-bit arithmetic strings and string manipulation ● pulse width modulation ● I2C. New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. 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)

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

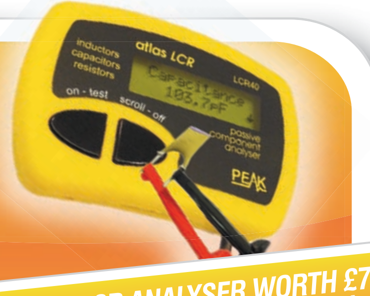
Hobbyist/Student	£44	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional/Professional 10 user (Network Licence)	£350	plus VAT
Site Licence	£699	plus VAT
Flowcode Institutional (Schools/HE/FE/Industry)	£149	plus VAT
Flowcode 10 user (Network Licence)	£399	plus VAT
Flowcode Site Licence	£799	plus VAT

READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly



WIN AN ATLAS LCR ANALYSER WORTH £79

An Atlas LCR Passive Component Analyser, kindly donated by Peak Electronic Design Ltd, will be awarded to the author of the Letter Of The Month. The Atlas LCR automatically measures inductance from 1mH to 10H, capacitance from 1pF to 10,000μF and resistance from 1Ω to 2MΩ with a basic accuracy of 1%. www.peakelec.co.uk

★ LETTER OF THE MONTH ★

CD-ROM-drive-powered flight – yes really!

Dear EPE

After reading the letter from Harm (from the Netherlands) and his excellent recycling idea in *Readout* (Aug '09) I felt I should share my use for dead (or even living) PC CD-ROM drives.

As a keen reader of *EPE* and an aero-modeller for the last 35 years, I have often combined my love of electronics and aviation. I own a computer repair business (another interest sparked by reading *EPE* in the 70s) and witnessed the dawn of the CD and how it changed our lives. I'll never forget paying the equivalent of £300 for a 2-speed CD writer, though I have to admit it did get a good workout and probably paid for itself by the time it eventually failed.

Nowadays though, DVD burners are so cheap and plentiful that when they fail, they often get thrown straight into the bin. A while ago, however, I began hoarding old burners from my workshop because I had discovered another use for them: model aircraft motors.

No doubt some *EPE* readers are already familiar with this home-workshop-based 'technology'. With advances in battery and electric motors, many modern model aircraft are electric, so no more potentially hazardous and messy fuel, just a few spare lithium polymer batteries and a car charger. Electric motors also mean quieter and safer flying, with many models flying where they couldn't before, due to noise or danger to spectators – even indoors!

Creating a usable model aircraft motor from a dead CD drive seemed incredible, but it is possible and actually very simple. My very first motor is still going strong two years after building it.

The main drive motor is removed, modified, rewired and re-assembled with a propeller shaft and holder and the result is a home-built brushless motor that easily competes with commercial units. The results are staggering, and all my models now sport CD-ROM-based motors that out-perform their 'far-more-expensive' comm-ercial equivalents.

While we can always just go and buy a motor, many of us prefer to 'roll our own', controlling and fine-tuning our creations with different gauge wire, prop size, magnets and stator windings until we find the best combination. The motors are driven by a standard 18A brushless motor controller, and while such a controller is far beyond the scope of this letter, it would make an excellent PIC-based constructional article.

What you need

All you need to create your own motor is a dead CD/DVD drive, a few metres of suitable enamelled copper wire, 12 small neodymium magnets (available at low cost from many online suppliers) and the patience to rewire the stator by hand. The steel shafts the laser unit runs on are removed and one is threaded for the prop shaft for our motor.

For the recycler, CD/DVD drives contain all sorts of goodies. Aside from the main motor, most models have another motor to operate the drawer. This 'smaller' motor is also very powerful and can also be used in models (retracting undercarriage etc). The circuit boards usually contain several PCB-mounted electrolytic capacitors, microswitches, edge connectors and ribbon cables, while the mechanics offer worm drives, stepper motors (on some models), mirror-steel shafts, plastic gears, cogs, wheels and rubber drive belts. So, before throwing away that dead drive, think of the useful things you might be wasting.

Thanks and keep up the great work; I look forward to seeing what is new in *EPE* every month.

Excellent tip Dave – few things are more satisfying than making your own 'better-than-bought' devices using 'free' materials… and thank you for the appreciative comments. It's always a thrill when we are told that the EPE *team's efforts are read and enjoyed right around the world.*

Thank you Godfrey

Dear EPE

I have a total lack of knowledge where electronics is concerned. So, as a last resort, when I needed some assistance with the repair of a photographic exposure meter and how I might test it, I wrote to you asking for help.

One of your expert readers – Godfrey Manning – kindly responded and has taken a considerable amount of time to help and educate me.

The result is that the meter is now up and running. Thank you for enabling an outsider to be assisted in this way by your unselfish community spirit.

Thanks Terry and especially Godfrey; many readers know Godfrey to be a regular Readout *writer, always generous with his time and 'can-help' attitude to the* EPE *'community', as you so accurately called our loyal readers.*

No free lunch

The *Techno Talk* (Oct '09) entry about power from plates in the road at Sainsbury's store implies the power is 'free'. This cannot be the case. A small amount of energy is taken from the vehicle operating the plates, which will slow it slightly. This is the energy which generates power and which, of course, when added to all the other shoppers' contributions is a useful amount.

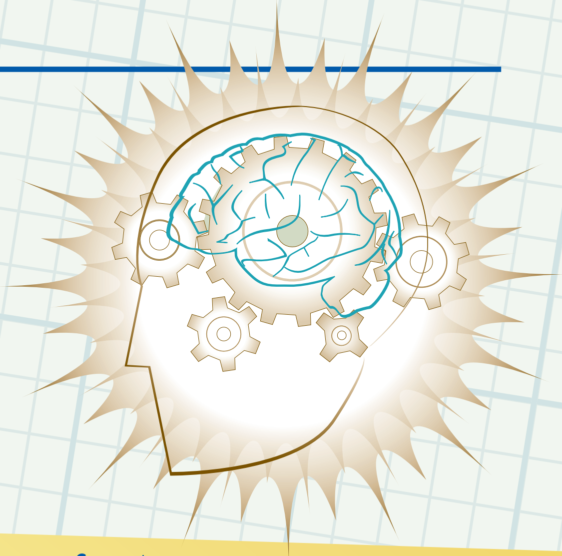
The truth is that Sainsbury is extracting a tithe from its customers, incrementally increasing their fuel consumption, although by so small an amount as to be unnoticeable. The first law of thermodynamics applies here.

You're right Tony, energy is never 'free'; someone (or something) always provides (pays) for it.

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

Ingenuity Unlimited

Our regular round-up of readers' own circuits



WIN A PICO PC-BASED OSCILLOSCOPE WORTH £799

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

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC-based oscilloscope could be yours.

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

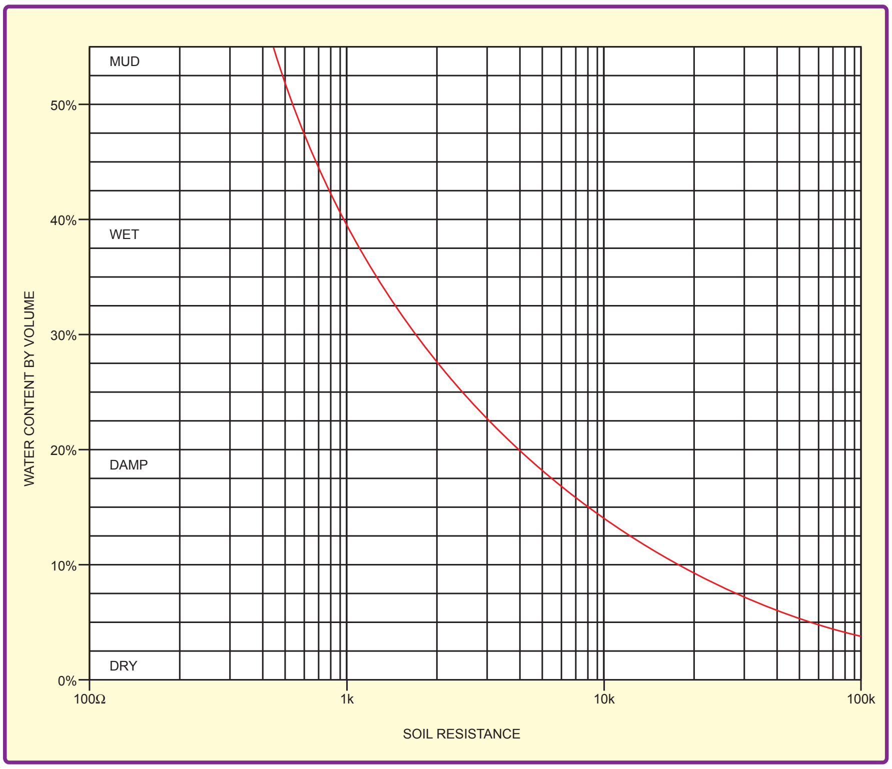
We pay between **£10** and **£50** for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas must be the reader's own work and **must not have been published or submitted for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

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

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

GOING away on holiday is great, but will the tomatoes in their grow bags survive without water? Commercial irrigation systems are a bit elaborate for small scale domestic use, hence this design for a simple automatic watering device.

Some rather messy experiments showed that the electrical resistance of a grow bag soil sample, with electrodes spaced about six inches apart, varies with its water content, as shown in Fig.1. If a constant voltage is applied across the electrodes, through a known resistance, the voltage across the electrodes will indicate the soil humidity.



Circuit details

The 'domestic watering' circuit in Fig.2 shows the principle. It is preferable to supply an AC voltage to the electrodes to prevent polarisation – which could cause errors. The 555 oscillator, IC1, provides a slow clock signal of about 200Hz to IC2, a D-type flip-flop. Its Q and NOT Q outputs (pins 1 and 2), via buffers IC4a and IC4b, drive the 'H' configuration transistors (TR1 to TR4), which supply a stabilised AC voltage, through resistor R6, to the electrodes.

The AC voltage at 'X' depends on the water content of the soil. This is rectified by the half-wave active rectifier IC3b and IC3a, smoothed to DC by resistor R7 and capacitor C3. The

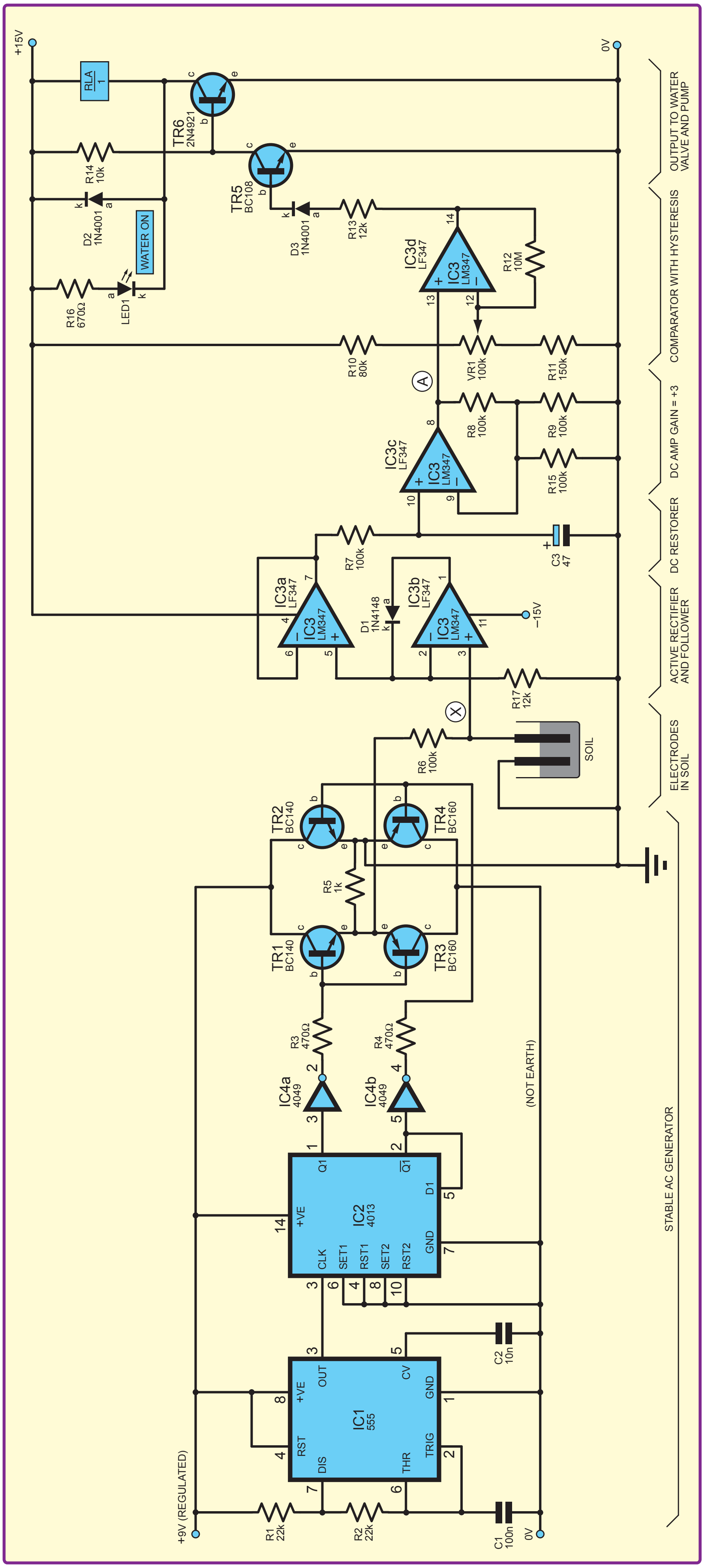


Fig.2. Circuit diagram for the simple domestic Holiday Watering System

DC amplifier, IC3c (gain = 3), feeds this voltage to a comparator, IC3d.

When the soil is dry, the output of IC3d switches TR5 off and TR6 on, pulling in relay RL1, which energises a low voltage water valve and pump. The desired water content is set by potentiometer VR1.

Some practical points

The electrodes need to be large and heavy to minimise the effects of any disturbance to the soil – often caused by an inquisitive squirrel in my case. Old lead diving weights buried in the soil about six inches apart are ideal.

As the plants grow, and fertiliser is added, the *PH* and hence the conductivity of the soil changes, so some adjustment of VR1 is needed over time. It's a good idea to limit the 'water on' time in case the connection to the electrodes goes open circuit. This is easily done with a timer IC, such as a 555.

The DC voltage at 'A' gives a useful indication of the water content of the soil – which can be displayed on a voltmeter after amplification and inversion.

Stephen Stopford, London

Net Work

Alan Winstanley

Seventh heaven

By the time you read this, Microsoft's latest operating system, Windows 7, will have been available for about a fortnight. Plenty of advice from the computer press is available regarding the pros and cons of upgrading, but for the present time the author is sticking firmly with Windows XP Professional. I doggedly refused to update to Vista, and in my business experience I can think of only two customers who adopted that shiny but ill-starred operating system – and that's only because Vista came with their new laptops. I hate working on Vista-based systems because Vista just gets in the way of things; to quote James May when describing mobile phone animated icons, "it is rather like a juggler jumping out at you when you are on the way to the pub." I haven't had that much success with Linux either.

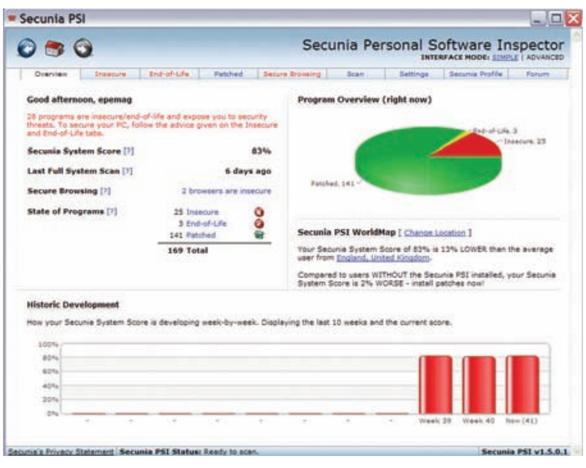
I would simply never bother upgrading the operating system of a perfectly healthy machine that works and surfs the Internet as it should. There are all sorts of caveats relating to software and hardware compatibility: will favourite software still function properly or will it need to be (whisper) upgraded as well? Will hardware manufacturers release drivers for their peripherals? Will my nine-year old HP1220C Officejet run under Windows 7? As it is, the XP driver is already only available as a download. All sorts of obscure downloads and bits of software may suddenly fail to work in Windows 7, and when the new operating system breaks cover, the computer retail 'sheds' will be relishing the task ahead.

For those contemplating updating their system, a compatibility troubleshooter is available online via: . When it comes to backwards-compatibility with older software, Windows 7 has a trick up its sleeve. By using Microsoft Windows Virtual PC you can emulate a Windows XP environment within Windows 7 Professional or Windows 7 Ultimate. If you have this in mind for your system, the place to start is: which will point you to a utility download that identifies whether your Intel or AMD-based system is compatible with the required hardware virtualisation. My own 3.0GHz Pentium failed the test.

Double-whammy

So now, modern home computers are powerful enough to run a virtual operating system: emulating Windows XP (or other OS) from within a Windows 7 shell. For the owner, this gives rise to the onerous prospect of maintaining two systems in one; managing software and hardware patches for a virtual XP system as well as Windows 7 could double the cost of routine maintenance in terms of time.

Given that most systems are now connected full-time to the Internet, keeping track of current versions, upgrades and patches is a constant headache that adds to our TCO (total cost of ownership), and any useful free essentials – especially anti-virus or anti-malware packages – are welcome.



Microsoft has now released its free Microsoft Security Essentials for consumer PCs, which claims to guard against viruses and malware. For a free download you can visit: and I hope to be following up on this service in coming months.

On the subject of managing patches and upgrades, another interesting free download this month is Secunia Personal Software Inspector. This powerful and attractive utility program runs in the background and monitors the vulnerabilities of all installed software. It has 'simple' and 'advanced' modes, and apart from clearly listing the version number of all installed software, Secunia PSI generates a graphical report of any end of life, insecure or obsolete products and it provides links for downloads or updates. Secunia PSI joins my list of 'must haves' alongside Malwarebytes' Anti Malware and you can download it free from:

Spirited Fellowes

I was shredding a heap of old bills recently and I was staggered, if not completely shocked, at the horrendous cost of IT and Internet access incurred back in the 1990s and early 2000s. In my mind, a sobering analogy formed between the two decades of relentless and sometimes wasted cash that my hardware, software, connectivity and upgrades burned through, and the shredding of the corresponding paper invoices into a pile of confetti (which at least can be recycled).

A mere double-speed CD-ROM drive cost £250 ($400) with Soundblaster interface card, and a PC having just 1% of today's capacity cost £2,000 ($3,200). A 17-inch monitor, HP Scanjet and HP laser printer were all £650 ($1,000) each. MS-DOS 6 and Windows 3.1 ruled the waves. They did not understand TCP/IP at all and Windows needed Trumpet Winsock to connect to the Internet through an expensive 14.4Kbps modem. There was no world wide web, and connecting successfully through Demon's permanently engaged Point of Presence was harder than winning the lottery. In the days of dial-up Internet access, my itemised phone bills were typically 25 pages long as my groaning document shredder can confirm. The bills overflowed with hundreds of 0845 dial up sessions, at a minimum 5p per call.

As an aside, my Fellowes shredder kept shutting down every four minutes, accompanied by a worrying smell of melting ABS, hence the 40mm DC cooling fan from Maplin powered by an old back-up drive's 12V SMPSU that I fitted to help the shredder motor keep its cool. The Onstream Echo backup system originally cost £500+ to help preserve my critical data, but ironically the only use it has today is helping to power the shredder that decimates old phone bills. If nothing else, IT has given me a unique turbo-assisted paper shredder – now that's what I call a timesaving hardware upgrade.

You can Email me at and also visit *Net Work* online at .

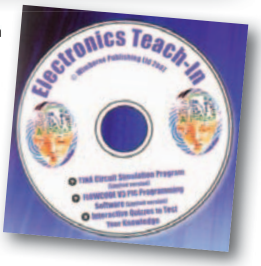
DIRECT BOOK SERVICE

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

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

3 **All prices include UK postage**

Electronics Teach-In 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 series (originally published in) 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 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 series.

The interactive Review tests will help you to check your knowledge at the end of each part of .You can take these tests as many times as you like, improving your score with each attempt.

The final test covers all aspects of and will provide you with a means of checking your overall knowledge of electronics. Once again, you can take the test as many times as you like.

CD-ROM [redacted]

ROBOTICS

INTRODUCING ROBOTICS WITH LEGO MINDSTORMS
Robert Penfold

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

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

288 pages - large format [redacted]

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

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

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

198 pages [redacted]

ANDROIDS, ROBOTS AND ANIMATRONS
Second Edition – John Iovine

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

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

224 pages [redacted]

RADIO

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

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

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

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

263 pages [redacted]

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

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

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

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

92 pages [redacted]

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

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

150 pages [redacted]

COMPUTERS AND COMPUTING

ELECTRONICS TEACH-IN 2
USING PIC MICROCONTROLLERS
A PRACTICAL INTRODUCTION

FREE CD-ROM

This series of articles was originally published in in 2008 and, following demand from readers, has now been collected together in the book.

The series is aimed at those using PIC microcontrollers for the first time. Each part of the series includes breadboard layouts to aid understanding and a simple programmer project is provided.

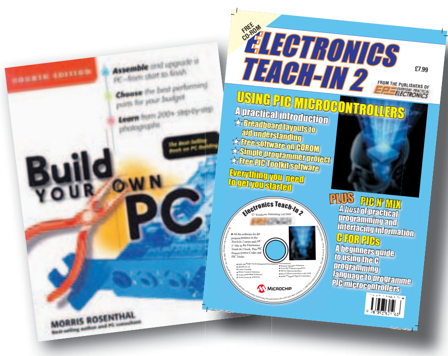
Also included are 29 articles, also republished from . These provide a host of practical programming and interfacing information, mainly for those that have already got to grips with using PIC microcontrollers.

An extra four part beginners guide to using the C programing language for PIC microcontrollers is also included.

The free cover-mounted CD-ROM contains all of the software for the series and articles in this book plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Micrcontrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

160 pages + CD-ROM [redacted]



BUILD YOUR OWN PC – Fourth Edition
Morris Rosenthal

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

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

224 pages - large format [redacted]

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

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

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

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

496 pages +CD-ROM [redacted]

NEW FULL COLOUR COMPUTING BOOKS

WINDOWS 7 – TWEAKS, TIPS AND TRICKS
Andrew Edney
This book will guide you through many of the exciting new features of Windows 7. Microsoft's latest and greatest operating system. It will provide you with useful hints, tips and warnings about possible difficulties and pitfalls. This book should enable you to get much more out of Windows 7 and, hopefully, discover a few things that you may not have realised were there.

Among the topics covered are: A brief overview of the various versions of Windows 7. How to install and use Upgrade Advisor, which checks to see if your computer meets the minimum requirements to run Windows 7 and that your software and drivers are supported by Windows 7. How to use Windows Easy Transfer to migrate your data and settings from your Vista or XP machine to your new Windows 7 computer. Exploring Windows 7 so that you will become familiar with many of its new features and then see how they contrast with those of earlier versions of Windows. How to connect to a network and create and use Home Groups to easily share your pictures, videos, documents, etc.,with the minimum of hassle. Why Windows Live Essentials is so useful and how to download and install it. A brief introduction to Windows Media Center. The use of Action Center, which reports security and maintenance incidents. Windows Memory Diagnostic to detect the fairly common problem of faulty memory and Troubleshooting tools.

120 pages [redacted]

HOW TO BUILD A COMPUTER MADE EASY
R.A. Penfold
Building your own computer is a much easier than most people realise and can probably be undertaken by anyone who is reasonably practical. However, some knowledge and experience of using a PC would be beneficial. This book will guide you through the entire process. It is written in a simple and straightforward way with the explanations clearly illustrated with numerous colour photographs.

The book is divided into three sections:
Covers understanding the fundamentals and choosing the most suitable component parts for your computer, together with a review of the basic assembly.
– Explains in detail how to fit the component parts into their correct positions in the computer's casing, then how to connect these parts together by plugging the cables into the appropriate sockets. No soldering should be required and the only tools that you are likely to need are screwdrivers, small spanners and a pair of pliers.
– This final section details the setting up of the BIOS and the installation of the Windows operating system, which should then enable all the parts of your computer to work together correctly. You will then be ready to install your files and any application software you may require.

The great advantage of building your own computer is that you can 'tailor' it exactly to your own requirements. Also, you will learn a tremendous amount about the structure and internal workings of a PC, which will prove to be invaluable should problems ever arise.

120 pages [redacted]

AN INTRDUCTION TO eBAY FOR THE OLDER GENERATION
Cherry Nixon
eBay is an online auction site that enables you to buy and sell practically anything from the comfort of your own home. eBay offers easy access to the global market at an amazingly low cost and will enable you to turn your clutter into cash.

This book is an introduction to eBay.co.uk and has been specifically written for the over 50s who have little knowledge of computing. The book will, of course, also apply equally to all other age groups. The book contains ideas for getting organised for long term safe and successful trading. You will learn how to search out and buy every conceivable type of thing.The book also shows you how to create auctions and add perfect pictures. There is advice on how to avoid the pitfalls that can befall the inexperienced.

Cherry Nixon is probably the most experienced teacher of eBay trading in the UK and from her vast experience has developed a particular understanding of the issues and difficulties normally encountered by individuals.

So, if you are new to computers and the internet and think of a mouse as a rodent, then this is the book for you!

120 pages [redacted]

GETTING STARTED IN COMPUTING FOR THE OLDER GENERATION
Jim Gatenby
You can learn to use a computer at any age and this book will help you acheive this. It has been especially written for the over 50s, using plain English and avoiding technical jargon wherever possible. It is lavishly illustrated in full colour.

Among the many practical and useful subjects that are covered in this book are: Choosing the best computing system for your needs. Understanding the main hardware components of your computer. Getting your computer up and runnning in your home. Setting up peripheral devices like printers and routers. Connecting to the internet using wireless broadband in a home with one or more computers. Getting familiar with Windows Vista and XP the software used for operating and maintaining your computer. Learning about Windows built-in programs such as Windows Media Player, Paint and Photo Gallery.

Plus, using the Ease of Access Center to help if you have impaired eyesight, hearing or dexterity problems. Installing and using essential software such as Microsoft Office suite. Searching for the latest information on virtually any subject. Keeping in touch with friends and family using e-mail. Keeping your computer running efficiently and your valuable data files protected against malicious attack.

This book will help you to gain the basic knowledge needed to get the most out of your computer and, if you so wish, give you the confidence to even join a local computer class.

120 pages [redacted]

THEORY AND REFERENCE

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
Third Edition
Mike Tooley
A comprehensive reference text and practical electronics handbook in one volume – at an affordable price!

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

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

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

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

400 pages [redacted]

BEBOP TO THE BOOLEAN BOOGIE
Third Edition
Clive (Max) Maxfield
BOOK + CD-ROM

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

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

500 pages [redacted]

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

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

Over 800 pages in Adobe Acrobat format

CD-ROM [redacted]

FUNDAMENTAL ELECTRICAL AND ELECTRONIC PRINCIPLES
Third Edition
C. R. Robertson
Covers the essential principles that form the foundations for electrical and electronic engineering courses. The coverage of this new edition has been carefully brought in line with the core unit 'Electrical and Electronic Principles' of the 2007 BTEC National Engineering specification. This qualification from Edexcel attracts more than 10,000 students per year.

The book explains all theory in detail and backs it up with numerous worked examples. Students can test their understanding with end of chapter assignment questions for which answers are provided. In this new edition, the layout has been improved and colour has been added. A free companion website with additional worked examples and chapters is also available.

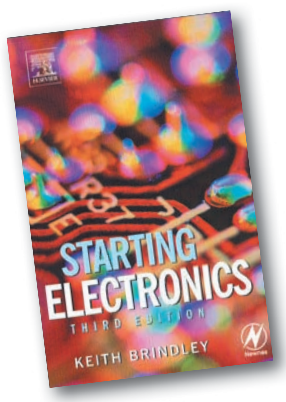
368 pages [redacted]

STARTING ELECTRONICS
Third Edition
Keith brindley
A punchy practical introduction to self-build electronics. The ideal starting point for home experimenters, technicians and students who want to develop the real hands-on skills of electronics construction.

A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

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

288 pages [redacted]



MUSIC, AUDIO AND VIDEO

MAKING MUSIC WITH YOUR COMPUTER
Stephen Bennett

Nearly everyone with musical aspirations also has a computer. This same computer can double as a high quality recording studio capable of producing professional recordings. This book tells you what software and hardware you will need to get the best results.

You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

92 pages [redacted]

QUICK GUIDE TO MP3 AND DIGITAL MUSIC
Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

How to play MP3s on your computer; How to use MP3s with handheld MP3 players; Where to find MP3s on the Web; How MP3s work; How to tune into Internet radio stations; How to create your own MP3s; How to record your own CDs from MP3 files; Other digital audio music formats.

Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages [redacted]

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

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

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

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

124 pages [redacted] ~~£10.95~~

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones*. These books include, the four volumes of our own *Wireless For the Warrior* by Louis Meulstee. These are a technical history of radio communication equipment in the British Army and clandestine equipment from pre-war through to the 1960s.

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

PROJECT BUILDING AND TESTING

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

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

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

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

135 pages [redacted]

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold

Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

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

138 pages [redacted]

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold

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

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

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

132 pages [redacted]

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.

[redacted]

BOOK ORDERING DETAILS

. For postage to Europe (air) and the rest of the world (surface) please add £3 per book. Surface mail can take up to 10 weeks to some countries. For the rest of the world airmail add £4 per book. CD-ROM prices include VAT and/or postage to anywhere in the world. Send a PO, cheque, international money order (£ sterling only) made payable to or card details, Visa, Mastercard or Maestro to:

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– PSU	689	£6.50
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★ PIC Probe (double-sided)	717	£9.50

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★ Random Mains Timer	724	£9.51
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EPE SOFTWARE

★ All software programs for *EPE* Projects marked with a star, and others previously published can be downloaded free from the Library on our website, accessible via our home page at:

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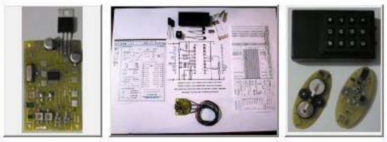

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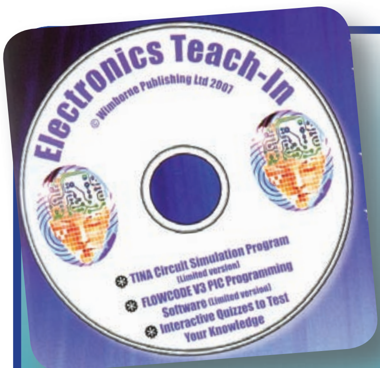

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NEXT MONTH

We have a super pair of complimentary projects lined up in the next issue: a Remote-Controlled Mains Switch and a UHF Remote Mains Switch Transmitter. If you need to switch mains appliances on and off remotely then our UHF Switch can do it for you. And when you've built that, you'll want the hand-held transmitter, which can operate over a 200m range. Naturally it's 'smart', since it's based around a PIC micro. We've even used a pre-assembled transmitter module, making it easy to build and get going quickly

Following on from this month, when we explained the circuit details of our new CD-ROM Player Adapter, we now show you how to build it – including the neat and useful LCD display.

If Part 1 this month whetted your appetite for our powerful (high current) motor controller, then you'll be pleased to hear that next month we highlight its construction and testing. Everything from populating the two PCBs to software initialisation is covered.

Our scavenging series turns its magpie eyes to old receivers next month, with special attention paid to meters – both digital bargraph and traditional analogue displays. So, as ever, don't bin it, recycle it, and get something worthwhile for nothing courtesy of !

JANUARY '10 ISSUE
ON SALE 10 DECEMBER

Content may be subject to change

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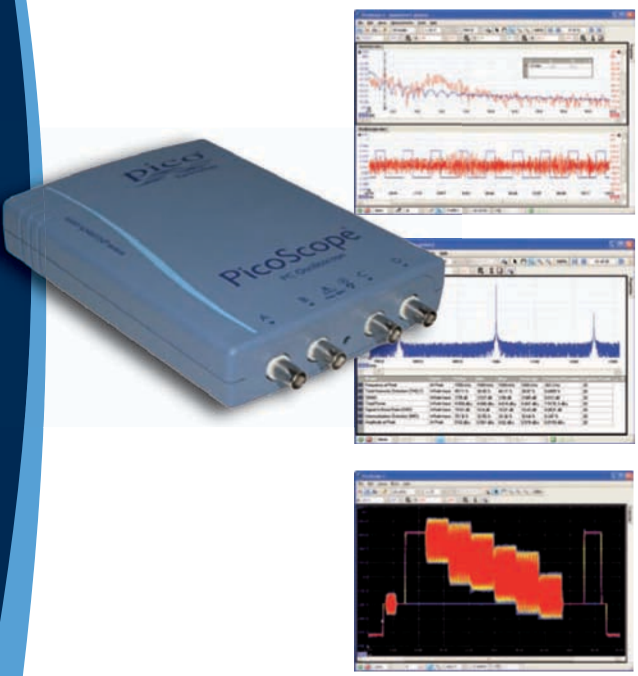

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