THE No 1 UK MAGAZINE FOR ELECTRONICS TECHNOLOGY & COMPUTER PROJECTS

EPE EVERYDAY PRACTICAL ELECTRONICS

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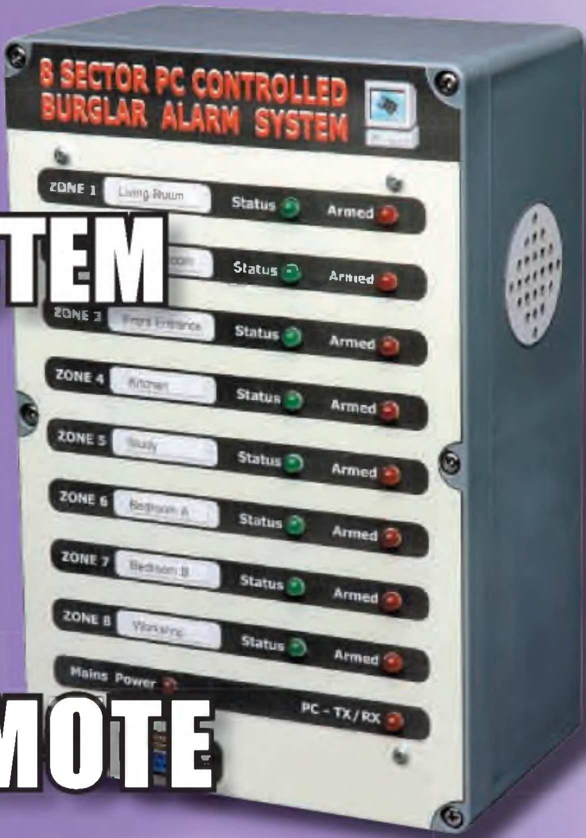

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POPULAR FEATURES . . .

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EPE EVERYDAY PRACTICAL ELECTRONICS

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

HB9 Stirling engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm. approx. 2,000 min
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min.
Available as a kit £97.75 or built £101.99
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HB10 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,6 Kg Base plate: beech Working rpm. approx. 2,000 rpm
Bearing application: 6 high-class ball-bearings
Material of the engine: brass, aluminium, stainless steel
running time: 30-45 min
Available as a kit £97.75 or built £101.99
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HB11 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 0,7 Kg Base plate: beech
Working rpm: 2000 - 2500 rpm/min.run Bearing application. 4 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass Rest aluminium, stainless steel.
Available as a kit £97.75 or built £101.99
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HB12 Stirling Engine
Base measurements: 156 mm x 108 mm x 130 mm, 1 Kg Base plate beech Working rpm: 2000 - 2500 rpm/min.Bearing application: 6 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel.
Available as a kit £136 or built £140.25
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HB13 Stirling Engine
Base measurements: 156 mm x 108 mm x 150 mm, 0,75 kg Base plate: beech Working rpm. 2000 - 2500 rpm/min.
Bearing application: 6 high-class ball-bearings Material: screw, side parts total stainless steel Cylinder brass
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Everything in the kit enables you to build a fully functional model steam engine. The main material is brass and the finished machine demonstrates the principle of oscillation. The boiler, uses solid fuel tablets, and is quite safe. All critical parts (boiler, end caps, safety vent etc.) are ready finished to ensure success. The very detailed instruction booklet (25 pages) makes completion of this project possible in a step by step manner. Among the techniques experienced are silver soldering, folding, drilling, fitting and testing. £29.70 ref STEAMKIT Silver solder/flux pack £3.50 ref SSK
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HB14 Stirling Engine
Base measurements: 156 mm x 108 mm x 150 mm, 1 kg Base plate: beech Working rpm: 2000 - 2500 rpm/min, . Incl. drive-pulley for external drives. Bearing application: 10 high-class ball-bearings Material: screw, side parts total stainless steelCylinder brass Rest aluminium, stainless steel. Available as a kit £140.25 or built £144.50
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HB15 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 0,75 kg Base plate beech Working rpm: 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 6 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel
Available as a kit £97.75 or built £102
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HB16 Stirling Engine
Base measurements: 128 mm x 108 mm x 170 mm, 1 kg Base plate: beech Working rpm. 2000 rpm/min. (the engine has a aluminium good cooling Cylinder)
Bearing application: 10 high-class ball-bearings
Material: screw, side parts total stainless steel
Cylinder brass Rest aluminium, stainless steel
Available as a kit £140.25 or built £144.50

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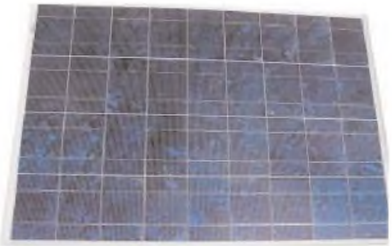
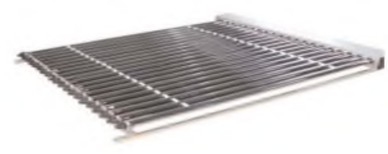


Solar Panels
We stock a range of solar photovoltaic panels. These are polycrystalline panels made from wafers of silicon laminated between an impact-resistant transparent cover and an EVA rear mounting plate. They are constructed with a lightweight anodised aluminium frame which is predrilled for linking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



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

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The **75 in 1 electronic** kit includes an nintroduction to electrical and electronic technology. It provides components that can be used to make and test a wide variety of experiments including Water Sensors. Logic Circuits and Oscillators. The kit then progresses to the use of an intergrated circuit to produce digital voice and sound recording experiments such as Morning Call and Burglar Alarm Requires: 3 x AA batteries £20 ref BET1806
www.slips.co.uk

PCB Production - Development

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25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
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100 x 500mm	39T / 199H	£6.20
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Solderless Breadboard

Tie Points	& Size	Power Rails	
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640	175 x 42mm	0	£3.08

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

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Soldering Station

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

Model 167-540 £41.66

Soldering Station

A 48W adjustable temperature soldering station with a rotary dial, Digital Temperature Indication, on-off switch, iron holder and tip cleaning sponge. This station features accurate heat sensing for instant compensation & stable temperatures. Adjustable temperature range of 150 - 480°C, Low voltage iron with Silicone cable. Supply: 240V, Iron: 24V 48W

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Price: £11.47

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Technical Specifications

DC voltage 200mV - 1000V (±0.5%)
AC volts 2V - 700V (±0.8%)
DC current 2mA - 20A (±1.2%)
AC current 200mA - 20A (±1.8%)
Resistance 200 Ohms - 20M Ohms (±0.8%)
Capacitance 2000pF - 20µF (±2.5%)
Temperature 0°C - 1000°C (±1.5%)
Frequency 20kHz (±1%)
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Power supply 9V (PP3 battery)
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229 x 159mm working area
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Model 333-004 £208.48

Any of these items, carriage £5.50

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

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100 x 160mm Double	£1.09
100 x 220mm Double	£1.25
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
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9 x 12"	£6.30	£7.70	£8.40	£9.38
10 x 12"	£8.19	£10.01	£10.78	£11.83
12 x 12"	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.83	£7.70

PCB Production - Chemicals

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

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20 Way	£0.20	£10.72
26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
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50 Way	£0.50	£26.80
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1 Module Blank	£0.35
2 Module Blank	£0.45

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Format is everything

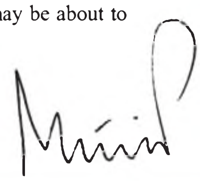
The engineers and executives at Japanese electronics giant Sony experienced a rare emotion last month – triumph! The news that Warner Bros, the world's largest DVD producer, had chosen the Blu-ray format for all new releases, thereby dumping the HD-DVD alternative, finally pushed Sony's arch-rival Toshiba into conceding victory in the high-definition DVD format war. Toshiba have now announced that they are pulling the plug on the manufacture of its HD-DVD players.

Sony will know how they feel; they famously lost out in the VHS-Betamax fight for the domestic video market in the 1970s, and despite the phenomenal success of the CD – designed with Philips – their music recording technology strategy took a couple of very expensive hits with the failure of (DAT) digital audio tape and mini-disc to gain any real market acceptance. I'm sure Toshiba will lick their costly wounds and look to the future, because if one thing is certain in electronics, you can never be certain about the future. In global markets, format is everything and over the next decades there will be new technologies providing new opportunities. To their credit, that is the lesson Sony learnt.

Smarter keyboards

A keyboard is a keyboard; wireless operation aside, it's hard to think of any real innovation in this home and office perennial since computers stopped being fed punch cards and accepted keystrokes. In fact, the keyboard as we know it predates electronics, with the fundamentals of the QWERTY layout patented in 1874. Ever wondered why the character layout is so odd? – it's deliberate, but not to make typing quicker, rather to slow it down. Early typists were becoming so fast with superior layouts that the typewriters' 'hammers' were becoming entangled. So, to slow them down, US newspaper editor Christopher Sholes rearranged the characters to make clashes less likely, but at the same time the speed of typing was compromised.

Nevertheless, the 'format' he chose stuck and became the standard for most keyboards ever since. There have been attempts to ergonomically improve the layout – the most famous being the Dvorak design, but it never really caught on. However, all this may be about to change with the arrival of truly user-definable keyboards. As Barry Fox reports in *News* this month, the Optimus Maximus keyboard has a tiny LED display built into each key, so it can represent any character, including continental accents, and presumably Arabic, Hebrew, or even Japanese. Maybe QWERTY, the oldest of computer formats, is finally bowing to the inevitable and facing change.



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

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

COMPONENT SUPPLIES
We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.
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News . . .

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

Las Vegas CES Show

Barry Fox looks at more of the new products at this year's CES Show

One Laptop per Child

The much talked about One Laptop per Child, which will give children in developing nations a chance to learn IT skills and communicate, has been seen by some adults in developed nations as a sneaky cheap option for business use.

From hands on demos of OLPC at *CES*, though, this is unlikely. The tiny keys will remind those with long memories of the early Sinclair computer keypads, once famously described as like shaking hands with a dead man. OLPC, clearly, really was designed for children.

Tucked away in a small booth, lost in a side aisle, the Asus Eee PC (designed in Taiwan, made in China) will remind the long-memoried of the first real portable PC, the easy-to-use and bombproof Tandy 100. Eee PC is half the size of most notebooks, weighs under 1kg and comes with Linux dressed up to look like Windows.

With 4GB of flash memory instead of a hard drive it costs £200, and looks and feels hugely desirable. The demonstrator from Taiwan giggled as she admitted it was being sold in some countries by toy stores. But Eee PC is clearly no toy and could prove a loud wakeup call both for Microsoft and all the companies – like Dell – who were showing luggable laptops bloated with Windows.

Organic LEDs

LCD has been ousting plasma as the best bet for big screens. Eyes at *CES* are now on OLED, organic light-emitting diodes, as a possible ouster of LCD – or possibly another big tech flop. Sony set the show ball rolling and grabbed the headlines with the launch of slim, black and stylish TVs that use OLED panel screens.

Because OLEDs, like plasma panels, emit their own light, there is no need for a bulky backlight. So the screen can be very thin. Sony's is just 3mm. But the price is very high. Sony is charging over $2000 for its 11in/28cm OLED TV – which is the price of a giant plasma or LCD home theatre screen.

While Sony drew drooling crowds to the main show floor, a small exhibit a mile or so across town showed a perhaps more practical use for OLED technology. Each of the 113 keys on the Optimus Maximus PC keyboard is coated with OLED material so each key becomes a 48×48 pixel colour mini-screen. The keys can change appearance and case with shift controls, show small clear, moving images, maths functions or different language letters and pictograms.

The first products go on sale next month, and will cost around $1500. But if Sony – along with other OLED-fanciers like Samsung – can drive down the price of panel production, keyboards may eventually take on a video life of their own (see **www.artlebedev.com/everything/optimus/**).

Optimus Maximus PC keyboard

The screen on a new pocket translator from Krown of Fort Worth is a lot lower tech, but has higher value use. A small flip top device, like a calculator, stores 4500 words and translates each into a short video clip that shows how the word should be signed with hand language. "Our mission is to improve the quality of life for people who are deaf and hard of hearing" says Krown. The device should cost around $180 when launched in three or four months (see **www.krownmfg.com**).

Air Sound

British company Air Sound was founded by recording engineer Ted Fletcher with the mission to squeeze stereo from a single speaker box that normally only delivers mono. Building on theories patented in the early thirties by UK audio pioneer Alan Blumlein, Air Sound takes the left and right channels from an iPod, MP3 player or radio and performs two calculations; the two channels are added together and the sum fed through a single speaker cone in the front of the speaker box, while the same two channels are subtracted from each other and the difference signal pumped through cones mounted in the left and right sides of the box.

The sum and difference sounds mix in the room to give a good approximation of two speaker stereo from a single point. The first commercial box is due soon for £200, but the company's main aim is to licence the technology to larger manufacturers (see **www.airsound.net**).

Mobile DVDs

Watching your DVDs on the move just got a whole lot easier. Pinnacle Systems (part of the Avid group, which makes the editing equipment used by TV and movie producers) has a little silver box the size of a shaver that connects between a home DVD player and any USB memory store, video iPod or Sony PSP portable games player. At the press of one button, Pinnacle's Video Transfer box converts whatever the DVD player is playing to digital standard used by the portable player.

There is no need for the user even to own a computer. The only option is between good, better or best quality. The cost of the box is $130.

Astronomical and Microscopic

You can now become your own Patrick Moore for $1900. SkyScout from US company Celestron is a palm-size tube with LCD display that amateur astronomers can look through to find or identify stars. Using GPS and a level sensor, the tube displays the name of a star when pointed at it and clicked; or if the name of a star is entered the tube shows red spots of light which guide the user onto the star. The SkyScout tube also connects electrically to a powerful astronomical telescope with powered mount. Pressing a button on the tube after selecting a star moves the telescope into exactly the same alignment. The system comes with a database of 6000 stars, planets and galaxies.

More down to Earth, Celestron is offering students a microscope in which the eyepiece has been replaced with a colour LCD screen. This gives a clear image of whatever the microscope is focussed on. So several people can watch at the same time, and discuss discoveries. An integrated camera chip captures either still or moving pictures of whatever the screen is displaying.

Recording Temperature Extremes

Independent recording of high and low temperatures has been made both affordable and easy to implement with the introduction of the EL-USB-TC temperature USB data logger from Lascar Electronics. The EL-USB-TC is the latest addition to the market-leading EL-USB range of standalone data loggers. It accepts an input from a K-, J-, or T-type thermocouple and can measure and record temperatures from −200° to +1300°C depending on the sensor used.

Each data logger is supplied with a copy of Lascar's EL-WIN-USB software, a K-type probe and a 1/2AA lithium battery to power the data logger. With the data logger plugged into the USB port, this allows the user to quickly set-up the data logger. Options include logger name, sample rate, high and low alarm and delayed start time. Once the study is complete, the software is also used to download the data, which is saved in .txt format. This file can be graphed within the EL-WIN-USB software or exported to Excel for further analysis.

The EL-USB-TC is available immediately directly from Lascar Electronics at a price of £49.00 at 1-off. Discounts for quantity are available upon request. To find out more visit the Lascar website at **www.lascarelectronics.com** or call the sales team on +44 (0)1794 884567.

LOW-COST 2-CHANNEL PC SCOPES

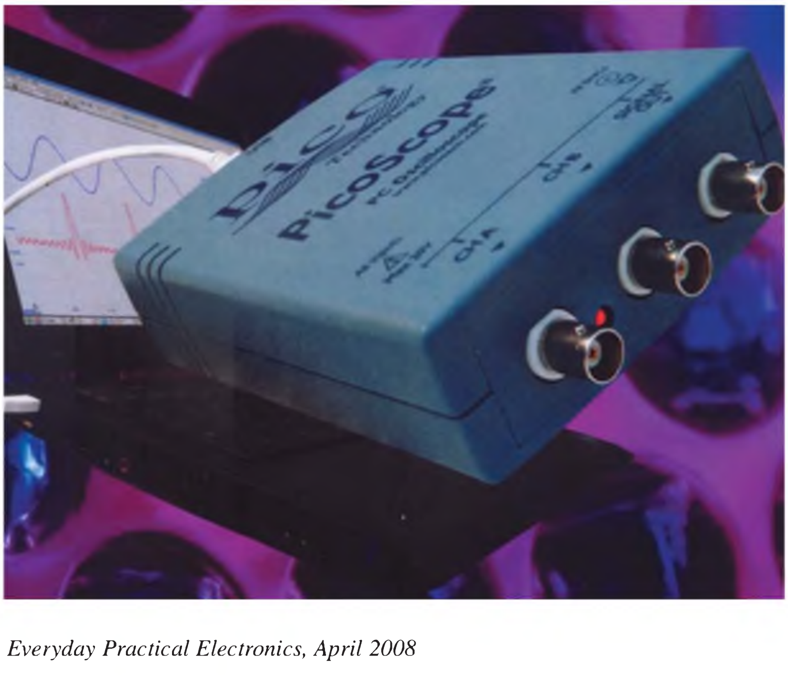
A trio of new PicoScope 2000 series scopes offers serious performance and excellent value for money say Pico. Each new model in the series is an oscilloscope, spectrum analyser, signal generator and arbitrary waveform generator (AWG) all in one unit, making it extremely versatile and economical. Unbeaten for functionality and price, with bandwidths up to 25MHz and sampling rates up to 200MS/s, the new scopes have a compact footprint of 100mm × 135mm (3.93in × 5.31in), small enough to fit easily into a laptop or travel bag.

The new scopes have two BNC input channels, a third BNC for a signal generator and arbitrary waveform generator output, and a USB port. Power is taken directly from the PC, and the scopes use the full USB 2.0 bandwidth of 480Mbps to achieve rapid display updates without compromising accuracy and detail.

All PicoScope PC scopes are supported by the same fully functional version of PicoScope 6 for Windows, which makes the most of the PCs processing power, storage, graphics and communications. The familiar Windows interface and controls make the software easy to learn and operate, and convenient for everyday use.

PicoScope owners can download software updates, feature extensions and improvements that will remain free of charge for the lifetime of the product. They can also contact Pico's technical specialists for support by web, email, phone or Skype, at no extra charge.

PicoScope 6 can save data in a range of formats, including CSV text, PNG and BMP images and MATLAB binary files. Drivers and examples are included for LabVIEW, C, C++, Delphi and Visual Basic for integration into custom applications.



Alan Tong, Managing Director of Pico Technology, explains, 'We've packed an amazing amount of performance into these little scopes. We think that the combination of high speed, built-in signal generator and attractive price will make them perfect for field service engineers and in education, as well as appealing to traditional scope users.'

The new PicoScope 2203, 2204 and 2205 PC scopes are available from local distributors, or direct from Pico Technology at **www.picotech.com**, priced from £159 to £300 + VAT and delivery.

New Matrix Products

"Is the ECIO the World's lowest cost USB PICmicro development tool?" ask Matrix Multimedia. The new ECIO range of ultra-low cost products is designed to allow students to learn PIC programming and project development at home. Initially, two products are available in this range: a 28-pin and a 40-pin version based on the 18 series of PICmicro devices. Full details are available at: ***www.matrixmultimedia.com/datasheets/ECIO-60-1.pdf****.*

Matrix have also recently completed a new version of the CPLD/FPGA programming board, which now operates using the USB port (as opposed to printer port). The datasheet can be found at: ***www.matrixmultimedia.com/datasheets/EB020-30-3.pdf****. If there are customers who need a USB programming function then please specify this, as Matrix still have some original stock in stores.*

New E-blocks boards – Matrix have just received stock of Zigbee wireless area network boards and RFID boards. Datasheets are not available yet but please keep an eye on their website for details. Flowcode macros for these will follow in due course. New versions of the industrial and educational E-blocks brochures arrived with Matrix in January.

For more information, contact Matrix Multimedia, The Factory, Emscote Street South, Halifax, W. Yorks, HX1 3AN. Web: ***www.matrixmultimedia.com****. Tel: +44 (0) 1422 252380. Fax: +44 (0) 1422 252381.*

A PC-Controlled Burglar Alarm System

Fancy a full-featured alarm control panel with dialler capabilities? This one is PC-programmed and controlled and can handle up to eight zones. The PC only needs to be powered up for arming and disarming, or you can use an optional keypad.

Part 1: By TRENT JACKSON

BURGLAR ALARM SYSTEMS are hardly new, but this DIY PC-controlled unit is something different. It's an extremely versatile unit, but despite that, it's not expensive.

In fact, the most expensive component used is the case, but there's nothing special about the unit specified. If you already have a suitable case, or can make one using materials to hand, you'll save yourself about £15.00.

the unit can control two separate door strikes.

Defined privileges can be used so that only certain individuals can arm and/or disarm certain zones. This effectively restricts access to certain parts of the building to certain people. As such, this system is ideally suited to the small business looking for a serious alarm system at a budget price.

Of course, that's not to say that it isn't suitable for domestic use as well. It's just that the wide range of access control that's built into the system makes it very attractive to the commercial end of the market.

A feature of this unit is that you don't need a keypad to arm and disarm it – that's done using a PC. And if you're wondering about a power blackout preventing you from powering up your PC to disarm the system, don't be too concerned – a hard-wired 'key' (which plugs into a D9 connector on the front panel) can be used to disarm the entire system if there's a blackout or computer malfunction.

Alternatively, for those that want a traditional keypad, a suitable unit will be presented in Part 2 next month. The keypad is entirely optional, however, and you must still use a PC to initially program the unit (ie, for setup).

Eight zones

Most low-cost alarms only cater for five or six zones but this unit can handle up to eight. Each of which can be independently armed or disarmed and monitored by the Windows-based software. In addition, the unit can control two separate door strikes.

PC options

You don't need to have your PC permanently powered up and connected to the system in order for the alarm to function – at least, not unless you require the software-based dialler function. Of course, if the computer is left running, the monitor can be switched off (eg, overnight) and that's good practice in most cases.

As mentioned, the alarm is programmed via the software interface and all entry and exit delay times (from 1 to 255 seconds) are fully definable for each zone. The siren times are also definable and are also set from 1 to 255 seconds. This is well within the designer's local legal limit of 300s (five minutes) but it would be a good idea to check the noise pollution regulations in your locality before setting the siren duration.

The system automatically rearms after the siren duration has expired and will immediately retrigger if further sensors are tripped. However, you can set the maximum number of trips for any one zone from one to five, so that a faulty sensor will eventually be locked out. You can also set the maximum number of trips for all sectors combined; in this case, any number from one to ten (more on this next month).

As is common with all units of this type, the system has full battery backup (via a rechargeable, sealed lead-acid (SLA) battery). If there is a blackout, this should be sufficient to keep the system operating for one to two hours, assuming a modest number of peripheral components hanging off it – ie, PIRs and any other sensors requiring power.

Access control

The software access control is what sets this unit apart from conventional

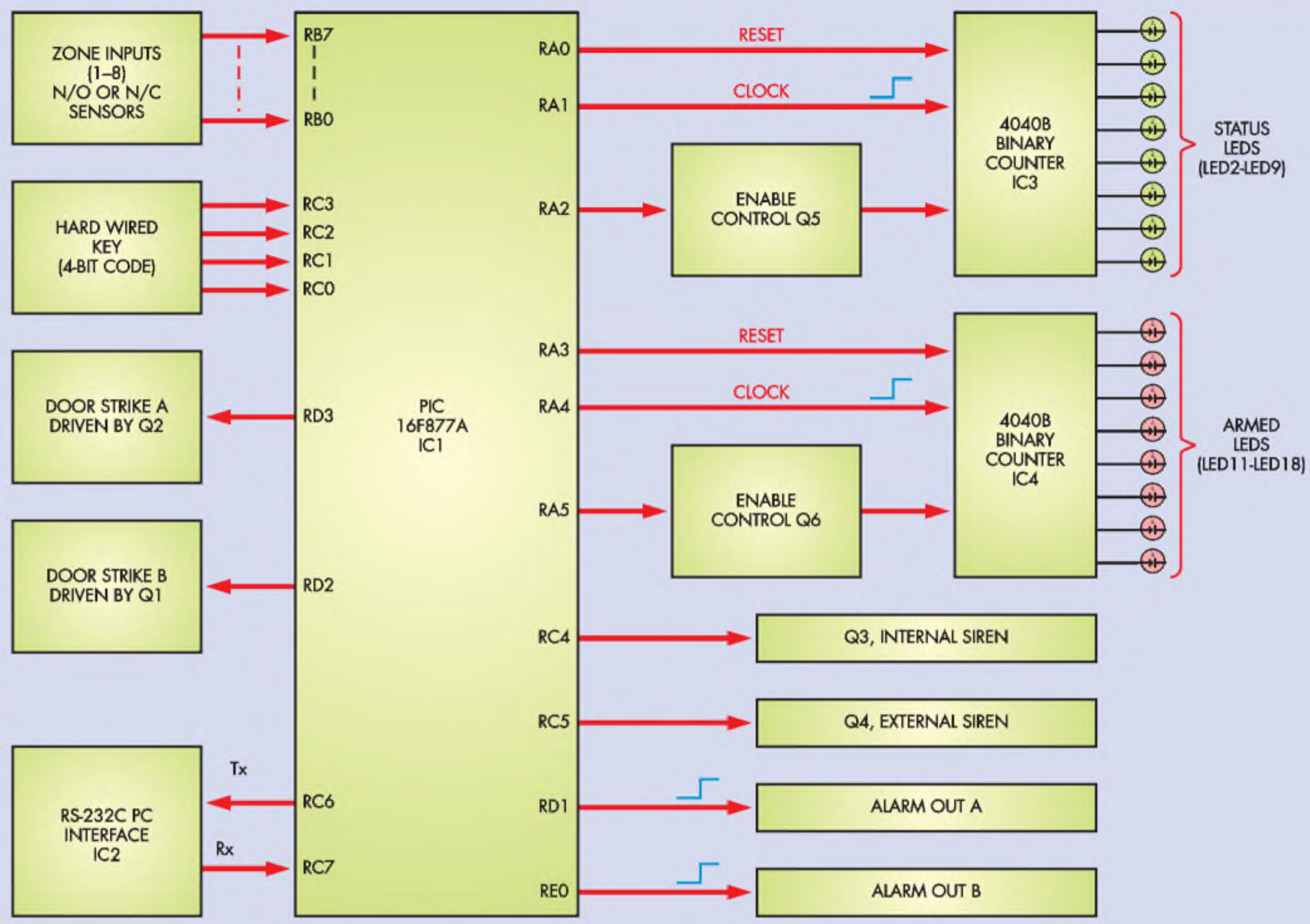


Fig.1: the block diagram for the PC-Controlled Alarm. A PIC microcontroller arms and disarms the zones, scans the sensors and controls the alarm outputs and door-strikes. It also relays logging information back to the PC.

alarm control panels. It allows for up to four 'Owners', eight 'Admins' and 16 'Users' – each group having different privileges.

Owners have the power to do whatever they like with the system, while 'Admins' have the power to create and delete 'Users' and have almost full control over the system. 'Users' have defined degrees of access only.

The software is easy to use and you'll pick it up in seconds – see 'Driving The Software' in Part 2 next month for further information.

Another key feature is the logging side of things. Picture this: you run a small company with several employees working different shifts. Maybe you have a punch card or similar system, or perhaps you rely on complete faith.

In either case, this system allows for such monitoring. Employees enter the building at the start of their shift and key in their PIN. The software places a date and time stamp next to their name within the log. You can then review this log on a regular basis to ensure that things are as they should be.

But wait – couldn't someone just enter their PIN and then go to the pub for a couple of hours? Well, that's not possible due to the fact that you can set the system up to automatically rearm itself again, so that the PIN has to be re-entered at regular intervals.

Hard-wired key

As previously mentioned, the 'hard wired key' is used to disarm the system if a PC is unavailable (eg, during a blackout). It's really very simple and consists of nothing more than a D9 connector and backshell, with just a few wire links used inside to set an inverted 4-bit code.

Only 4-bit – hang on, isn't that going to be easy to crack? Well no, because the key needs to be inserted (and removed) a preset number of times, as defined within the software. So, for example, you could wire the key for a code of '7' and specify that it has to be inserted and removed four times to turn the alarm off.

If there is too much time taken between inserting and removing the key (or if it is done too quickly), the system fails to disarm. In practice, you need to leave about one second between each insertion and removal.

Note that the hard-wired key can only be used to disarm the system and is intended for emergency use only. It cannot be used to arm the alarm.

The D9 socket used on the front of the unit also has the RS232 connections for the PC on it as well (these RS232 connections are wired in parallel with a screw terminal block on the main PC board). This means that you could also use a notebook computer to disarm the system in the event of a power failure or other malfunction.

Alternatively, you may decide that it better suits your needs to actually use this socket for controlling the system at all times, rather than wiring the PC to the internal RS232 terminals.

Two holes in the back of the unit allow for cable entry and exit, including the cables to the sensors, the external siren and the PC's RS232 interface. The hard-wired serial cable is terminated in a D9 connector at the PC end.

Sensors

Almost any sensor with NO (normally open) or NC (normally closed) contacts can be used with the system. However, you must configure the setup for each sensor (NO or NC) in the Windows-based software.

Basically, you can allocate NO or NC sensors for each zone, but you can't mix NO and NC sensors in the same zone.

When activated (ie, when a sensor trips and the unit is armed), the alarm sets off a piezo siren located inside the case, capable of producing around 119dB of sound. In addition, an external siren and/or strobe can be connected to the unit.

An internal tamper switch will also immediately trigger the alarm if the lid of the case is removed while any of the zones are armed. There are also two alarm outputs (Alarm OutA and Alarm OutB) which can be connected to The *EPE SMS Controller*, March to May '07 issues. These outputs are active high – ie, they switch high when any zone is triggered.

LED indicators

As shown in the photos, the unit is based on two PC board assemblies – a main control board and a display board.

The display board mounts on the front of the unit and carries 18 indicator LEDs. Eight of these LEDs are used to show which zones are armed, while another eight indicate the status of each zone – ie, whether or not it has been triggered.

The remaining two LEDs function as power on/off and data transmit/receive (Tx/Rx) indicators.

The main control board carries a PIC16F877A microcontroller, along with a simple but effective power supply which delivers +5V and +12V rails. This supply also provides a constant 13.6V 20mA (approx.) trickle current to charge the backup battery.

Main Features

HARDWARE FEATURES

- Eight independent zones
- Each zone can be configured to handle NO (normally open) or NC (normally closed) sensors
- Battery backup plus tamper switch
- Internal siren plus output for external siren
- Two door strike and two alarm outputs
- Programmed and armed/disarmed via a PC
- Hard-wired key to disarm unit if there is a power failure
- Optional keypad to arm and disarm unit.

SOFTWARE FEATURES

- Windows-based interface – works with Windows 9x, Me, 2000 and XP
- Independent entry and exit delays for zones (1 to 255 seconds)
- Programmable dialler feature (via a PC and modem)
- Automatic rearming features
- Ability to create three types of groups ('Owners', 'Admins' and 'Users'), each with different access privileges
- Data logging with save, open and print facilities
- Software shows how to configure hard-wired key to match code
- Software is easy to drive.

The main board also carries the RS232 interface (which connects to the PC), along with screw terminal connector's for all the off-board wiring to the sensors, external siren, door strikes and alarm outputs. In addition, there are a number of header sockets to handle the connections between the main board and the display board, and to provide the Alarm OutA and Alarm OutB outputs.

Circuit details

Fig.1 shows a block diagram of the unit. As previously mentioned, it's based on a pre-programmed PIC16F877A microcontroller.

In operation, the PIC micro accepts instructions from the Windows-based software to arm and disarm zones and constantly scans for triggered sensors. It also drives the siren, LED indicator and alarm outputs, and there's provision to control two door strike mechanisms.

Finally, the PIC also relays information back to the PC for monitoring and logging purposes.

Fig.3 shows the full circuit details (minus the power supply). Port lines RB0-RB7 of microcontroller IC1 monitor the sensor inputs via 2.2kΩ input protection resistors. These lines all have 100kΩ pull-up resistors to ensure they don't float.

Further protection is provided by inbuilt voltage clamps inside the PIC micro, so no damage will result if you do accidentally hook up 12V to these inputs. You may need to reset the system if this happens, though. This involves disconnecting both the plugpack and the battery, and then waiting for 30 seconds or so before reapplying power.

Fig.2: this is the main GUI (graphical user interface) for the Windows-based software. The software is easy to drive and you can customise the setup to suit your particular application (full details next month).

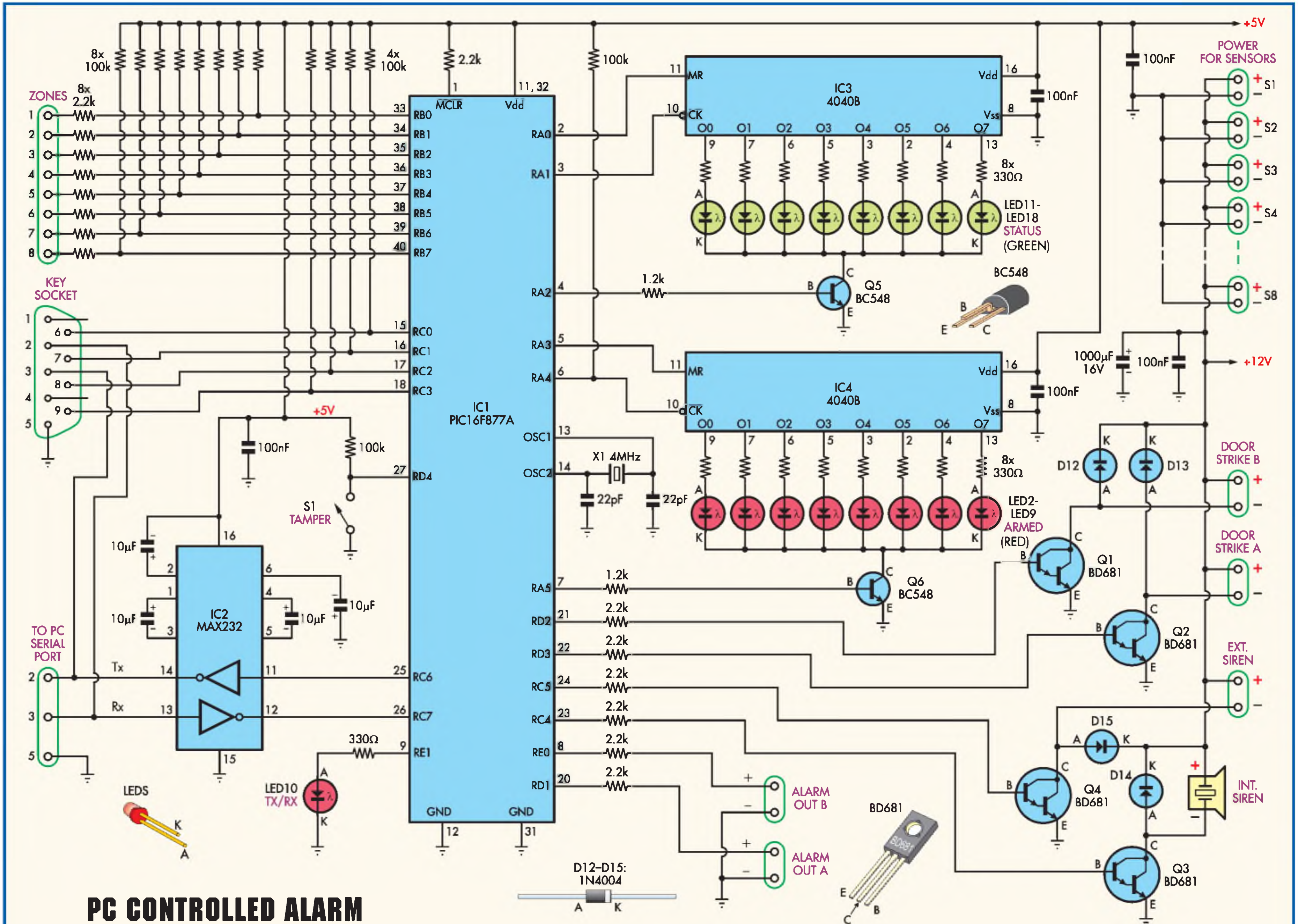


Fig.3: the PIC microcontroller forms the heart of the circuit. It monitors all the inputs, arms and disarms the various zones and drives the status and alarm LEDs via IC3 and IC4. It also drives the siren and door-strike outputs via Darlington transistors Q1 to Q4.

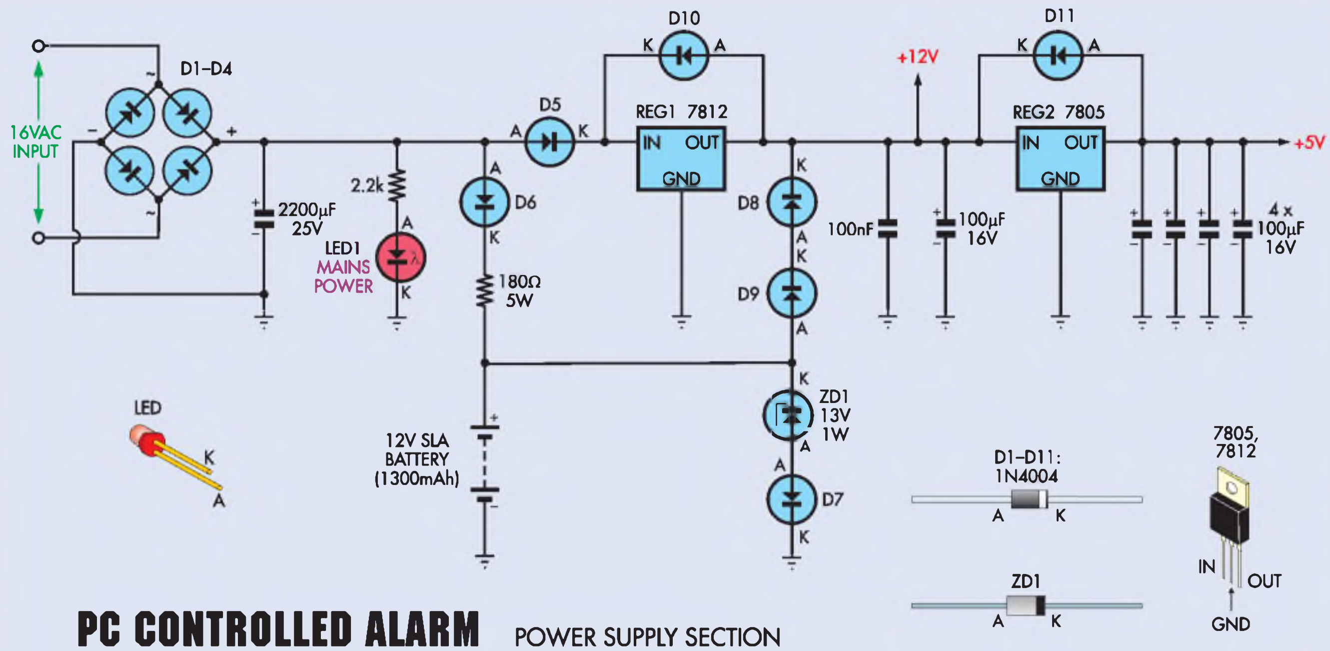


Fig.4: the power supply uses a bridge rectifier (D1-D4) and 3-terminal regulators REG1 and REG2 to produce +12V and +5V supply rails. A 12V SLA battery provides the battery backup and this is charged via D6 and a 180Ω 5W resistor.

Four BD681 Darlington transistors (Q1 to Q4) control the door strikes and sirens via ports RD2 and RD3 and RC4 and RC5, respectively. These each have diodes connected between their collectors and the +12V rail, to protect the transistors from back-EMF spikes – eg, when a door strike turns off.

A word of caution regarding the door strikes – the +12V rail is good for about 1A but only briefly! A door strike will draw around 700mA or so when activated, so don't try to operate both door strikes at the same time.

Microswitch S1 and its associated 100kΩ pull-up resistor on RD4 provide the anti-tamper feature. This line is normally held high when the lid is secured to the unit. However, if the lid is removed, this switch closes and pulls RD4 low. If any zone is armed, this automatically arms all other zones and sounds both the internal and external sirens.

If this happens, all zones must then be disarmed and only 'Admins' and 'Owners' can do this (unless a 'User' has been given full access).

Clock signals for the PIC are provided by crystal X1 (4MHz). The two 22pF capacitors hanging off it ensure correct loading for the crystal, so that it starts reliably.

Two 4040 binary counters, IC3 and IC4, are used to drive the indicator LEDs on the display board. These counters are clocked by the RA1 and RA4 outputs, while RA0 and RA3 provide the reset signals (note: RA4 requires a 100kΩ pull-up resistor due to the fact that this pin can sink current but cannot source it). IC3 drives the 'Status' LEDs (green), while IC4 drives the 'Armed' LEDs (red).

The two counter circuits work in exactly the same way, so we'll just concentrate on the way in which IC3 operates. First, note that transistor Q5 is controlled via RA2 on the PIC. This is the enable line and Q5 turns on (via a 1.2kΩ resistor) when RA2 goes high.

Initially, RA0 briefly swings high to reset the counter, after which (depending on the status of the zones) it is clocked by RA1. During this time, Q5 is off and so LEDs 11-18 are also all off.

Now let's assume that Zones 1 and 4 have been triggered. Zone 1 has a bit value of '1' while Zone 4 has a value of '8'. This means that in order for their corresponding LEDs to be lit, nine clock pulses must be applied to IC3's clock input, so that outputs O0 and O3 go high. IC1's RA2 output then goes high and turns on transistor Q5 to light LEDs 11 and 14.

This arrangement eliminates the need for multiplexing and reduces the amount of wiring required. The associated 330Ω resistors set the LED currents to a safe level.

Alarm and RS232 outputs

Ports RE0 and RD1 provide the two alarm outputs and these go high whenever an alarm condition occurs. These outputs can thus be used to trigger an external circuit that requires an active high (eg, the *EPE SMS Controller*).

RC0 to RC3 are used for the hard-wired key socket. Normally, these inputs are tied high using 4 × 100kΩ pull-up resistors. Inserting the key in the D9 key socket then pulls one or more of these inputs low, depending on the 4-bit code wired into the key.

A 'hard-wired key' (actually a D9 connector wired with a 4-bit code) can be used to disarm the alarm if there is a power blackout.

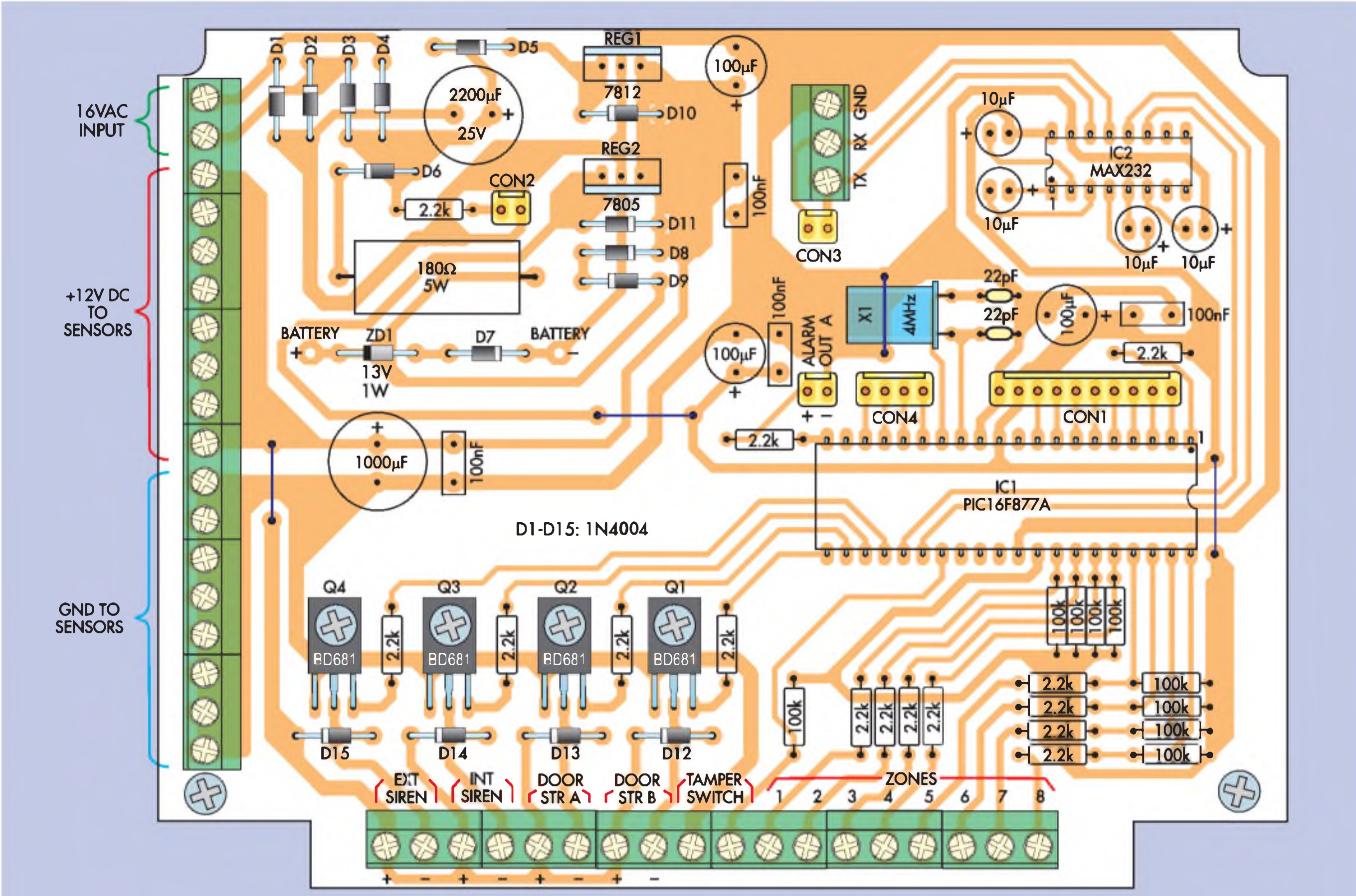


Fig.5: install the parts on the main PC board as shown here, but don't plug in PIC microcontroller IC1 until after the test procedure described in Part 2. Take care with component orientation.

As mentioned earlier, this socket is also wired to the RS232 Tx and Rx lines (in parallel with an on-board screw terminal block).

Data communication – either via the serial port or key socket – is achieved via ports RC6 and RC7. These communicate with the PC via a MAX232 serial data buffer (IC2). LED10 provides Tx/Rx indication and is driven by port RE1 via a 330Ω resistor.

In operation, LED10 normally flashes at varying speeds, regardless of whether or not a PC is connected. In fact, there's a very good chance that the circuit is working correctly if this LED is showing activity.

Power supply

Fig.4 shows the power supply circuit. It's based on 3-terminal regulators REG1 and REG2, which provide the required +12V and +5V rails.

Power is derived initially from a standard 16VAC plugpack rated at 1.25A. This is fed to bridge rectifier D1-D4, the output of which is then filtered using a 2200µF electrolytic capacitor and fed to REG1 via diode D5. In addition, the filtered supply rail from the bridge rectifier is fed via D6 and a 180Ω 5W resistor to a regulator circuit based on Zener diode ZD1 and diode D7. This gives a nominal +13.6V rail to recharge the SLA battery at a current of about 20mA.

The 12V rail from REG1 is used to power all of the peripheral devices that are connected to the alarm panel – eg, PIRs, sirens, strobes and door strikes. The output from REG1 is also fed to REG2 and its +5V output powers the PIC microcontroller and other logic circuitry.

LED1 and its associated 2.2kΩ current-limiting resistor provide power indication. Diode D6 is there to ensure that this LED can only be powered from the mains-derived supply and not by the battery. This serves as a useful indicator that mains power is present.

Diodes D8 and D9 ensure that the battery only supplies power to the circuit in the event of a mains power failure. Here's how it works: normally, the cathode side of D8 sits at +12V due to the output from REG1. D9's anode will at most have 13.2V applied to it under load and so no current flows through D8 and D9 whenever mains power is applied.

However, when the mains power is disconnected, D8 and D9 become forward biased and the battery supplies a nominal +12V rail to power the peripherals and REG2.

Building it

Building this unit is dead simple. Fig.5 shows the parts layout on the main PC board (code 666), while Fig.6 shows the display board assembly (code 667).

Before actually mounting any parts, check the two PC boards carefully for etching defects. It's rare that you will find any problems but it doesn't hurt to make sure. Also, be sure that the cutouts have been made in the corners of the main control board.

These cutouts are necessary for the board to clear the plastic pillars inside the specified case.

Table 1: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
100nF	0.1µF	104	100nF
22pF	NA	22	22p

That done, you can begin the assembly by installing the parts on the main PC board. Install the wire links first, followed by the resistors and MKT capacitors – just check the code tables to decipher their values.

It's also a good idea to check the resistor values using a digital multimeter as they are installed.

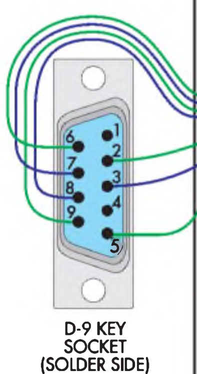
Once those parts are in, you can install the diodes, Zener diode ZD1 and the electrolytic capacitors. These parts are all polarised, so take care with their orientation.

Crystal X1 can go in next. It's installed flat against the PC board with its leads bent at right angles so that they go through the relevant holes in the PC board. A U-shaped wire loop is then fitted over the crystal and is also soldered to its case. This not only secures the crystal in place but also connects its metal case to earth (see Fig.5).

IC sockets are used for the two ICs and these can be installed next. Be sure to install them the correct way around (ie, with the notched ends as indicated), to guide you when it comes to plugging in the ICs later on. IC2 can be plugged in at this stage but leave IC1 out for now – it's installed later, after the power supply has been checked out.

Be sure to install IC2 the right way around.

Now for the two 3-terminal regulators. These must first be secured to



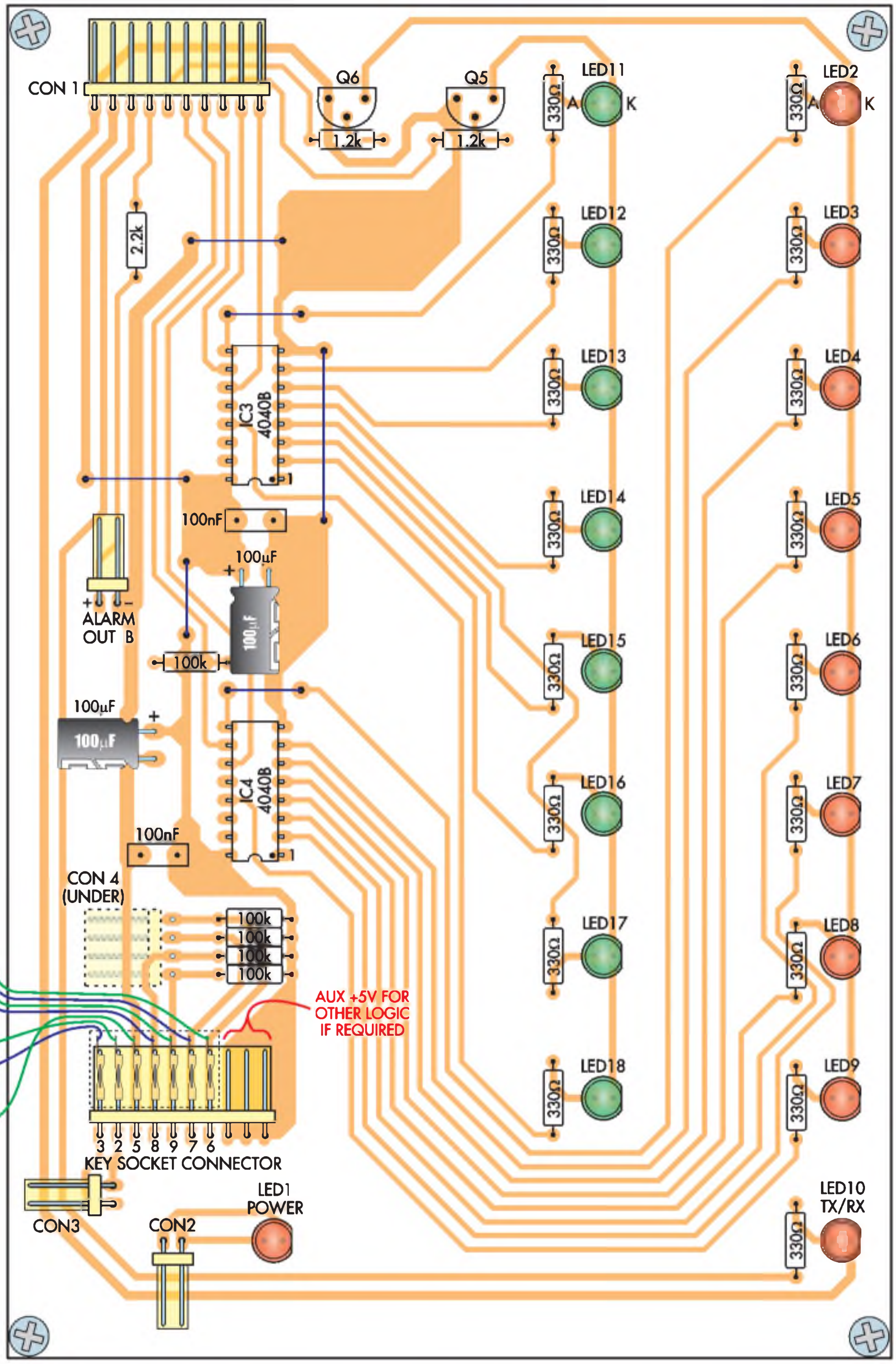


Fig.6: the display board assembly. Note that connector CON4 is mounted on the track (copper) side of the PC board, while the LEDs have their leads soldered after the board has been mounted on the front panel – see text.

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	14	100kΩ	brown black yellow brown	brown black black orange brown
❑	16	2.2kΩ	red red red brown	red red black brown brown
❑	2	1.2kΩ	brown red red brown	brown red black brown brown
❑	16	330Ω	orange orange brown brown	orange orange black black brown
❑	1	180Ω	brown grey brown brown	brown grey black black brown

Parts List – PC-Controlled Burglar Alarm

1 main PC board, code 666, size 151 x 115mm
1 display PC board, code 667, size 123 x 188mm
1 D9 female connector
1 D9 male connector
1 D9 backshell
3 16-pin DIL IC sockets
1 40-pin DIL IC socket
2 TO-220 mini heatsinks (6073B type)
1 100mm length of tinned copper wire (for links)
1 1m length 10-way rainbow cable
6 small cable ties (100mm)
2 large cable ties (300mm)
1 internal siren (optional)
1 16VAC 1.25A plugpack
1 12V 1.3Ah SLA battery
1 microswitch with extended actuator
1 IP65 ABS case, size 240 x 158 x 90mm approx.
1 front panel label to suit
1 4MHz crystal (X1)
4 12mm tapped standoffs
16 M3 x 6mm screws
2 M3 x 20mm screws
16 M3 nuts
4 M3 shakeproof washers
2 PC stakes

Connectors
1 10-way SIL locking pin header, 2.54mm, straight entry
2 10-way SIL locking pin headers, 2.54mm, right-angle entry
2 10-way header plugs, 2.54mm
1 4-way SIL locking pin header, 2.54mm, straight entry
1 4-way SIL locking pin header, 2.54mm, right-angle entry
2 4-way header plugs, 2.54mm
3 2-way SIL locking pin headers, 2.54mm, straight entry
3 2-way SIL locking pin headers, 2.54mm, right-angle entry
6 2-way header plugs (2.54mm)
13 PC-mount 3-way screw terminal blocks (5mm pitch)

Semiconductors
1 PIC16F877A microcontroller programmed with PCCBA.hex (IC1)
1 MAX232 serial transceiver (IC2)
2 CD4040B binary counters (IC3, IC4)
4 BD681 NPN Darlington transistors (Q1-Q4)
2 BC548 NPN transistors (Q5,Q6)
15 1N4004 diodes (D1-D15)
1 13V 1W zener diode (ZD1)
10 5mm red LEDs (LED1-10)
8 5mm green LEDs (LED11-18)
1 7812 12V regulator (REG1)
1 7805 5V regulator (REG2)

Capacitors
1 2200µF 25V electrolytic
1 1000µF 16V electrolytic
5 100µF 16V electrolytic
4 10µF 16V electrolytic
6 100nF MKT metallised polyester
2 22pF ceramic

Resistors (0.25W, 1%)
14 100kΩ
16 2.2kΩ
2 1.2kΩ
17 330Ω
1 180Ω 5W

Table 3: Wiring Connectors

Connector	Leads	Length
CON1 - CON1	10-way	31cm
CON2 - CON2	2-way	35cm
CON3 - CON3	2-way	38cm
CON4 - CON4	4-way	28cm

mini-U heatsinks using M3 × 6mm screws, nuts and shakeproof washers. Tighten the nuts firmly, then install the two regulators as shown in Fig.5 and the photo (don't get them mixed up!) making sure that their heatsinks are well clear of diodes D10 and D11. Note that the two regulators face in opposite directions to each other.

Next, install two PC stakes for the battery '+' and '–' connections. These are located just below the 180Ω 5W resistor, to the left of ZD1 and to the right of D7, respectively.

The main board assembly can now be completed by installing the various screw terminal blocks and PC headers. **Important: the screw terminal blocks must be mounted with their wire access sides facing inwards.** If you mount them the other way around, you will not be able to connect the leads when the board goes in the case.

Display board

Now for the display board assembly – see Fig.6. Once again, start with the links and resistors, then install the capacitors, transistors, IC sockets and PC headers. The two ICs can then be plugged into their sockets, taking care to ensure that they are oriented correctly.

Note that the pin headers on this board are all right-angle types and that CON4 is mounted on the copper (track) side of the board (see photo).

Next, fit 12mm standoffs to the four corner positions, securing them with M3 × 6mm screws. That done, the LEDs can all go in but don't solder their leads just yet. Instead, install them as indicated in Fig.6 (take care with their orientation), then carefully secure the board to the lid of the case using another four M3 × 6mm screws. Make sure none of the LEDs fall out while you are doing this.

Finally, the LEDs can be pushed into their matching front panel holes and their leads soldered.

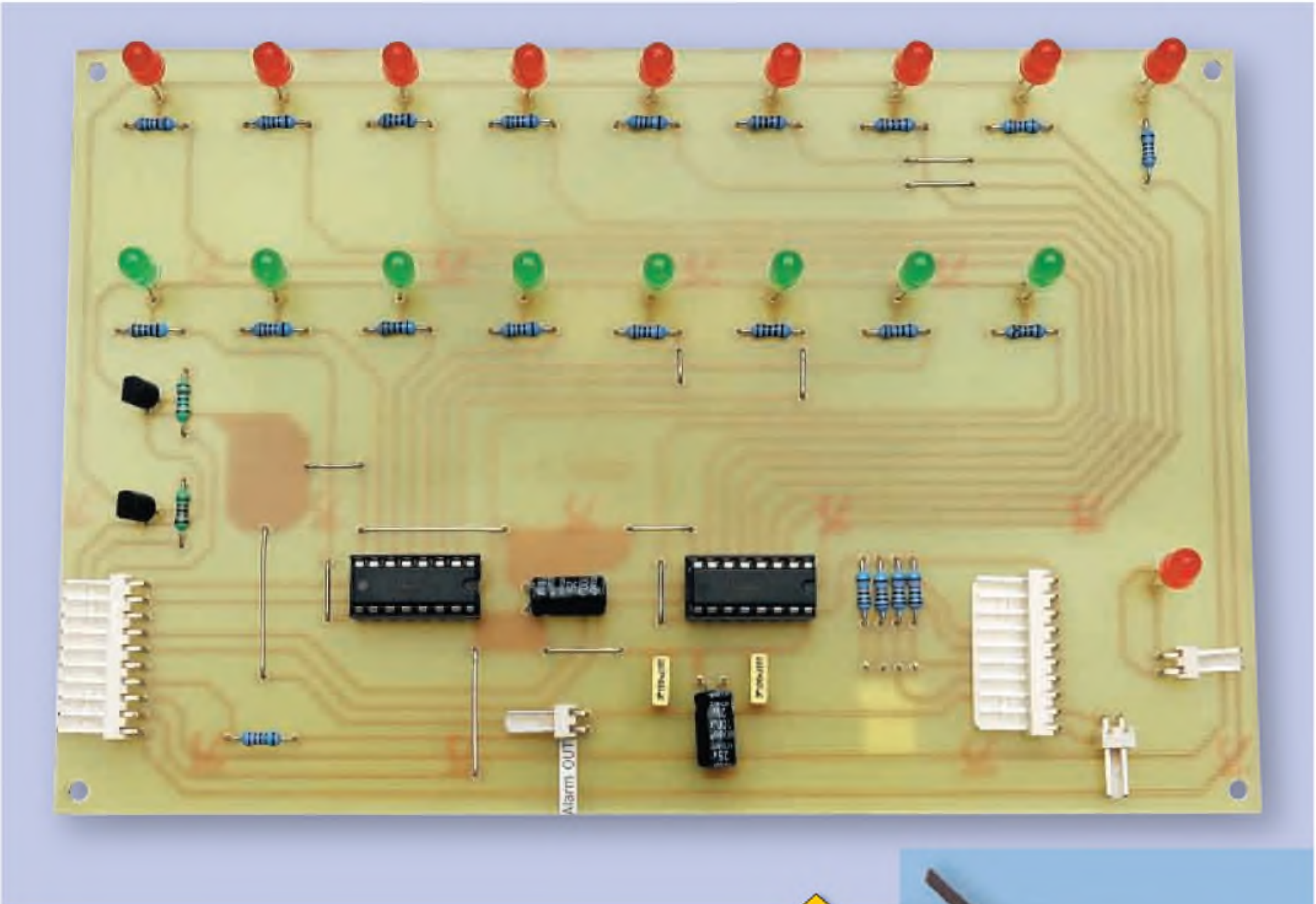
Of course, before installation, you will have to drill the front panel and make the cutout for the keyswitch. Similarly, you will have to drill four holes in the base of the case to take the cable ties that are used to secure the battery, along with mounting holes for the internal siren (if used). Additional holes also have to be drilled in the side of the case (to let the siren sound out).

Finally, two large holes are drilled in the base (to the right of the battery) for the external wiring.

Final assembly

The accompanying photos show how it all goes together. The first step is to secure the battery in position using two 300mm-long cable ties. Make sure these are nice and tight – you don't want the battery to come adrift. That done, you can secure the siren using M3 × 6mm screws and nuts and then install the tamper switch.

As shown in the photos, the tamper switch is mounted on the lefthand side of the case, above the PC board. It's positioned about 7mm below the lip and is secured using two M3 × 20mm screws and nuts. Once it's



This is the fully-assembled display board. Note that this prototype version differs slightly from the final version shown in Fig.6.

in position, bend its actuator arm upwards in an arc, so that the arm is held down when the lid is fitted (ie, to hold the switch open).

The PC board is secured to the base using two screws that go into integral pillars at either corner on the bottom. Another two screws that overlap the top edge of the board go into integral pillars in the centre of the case.

The construction can now be completed by installing the wiring. This mainly involves fitting plug headers to lengths of multi-way (rainbow) cable to connect the two boards together – ie, for headers CON1-CON4. Table 3 shows the details for these cables.

Be sure to connect the leads to the plug headers correctly. It's just a matter of connecting each lead to its matching pin on each header (ie, pin 1 to pin 1, pin 2 to pin 2, etc.

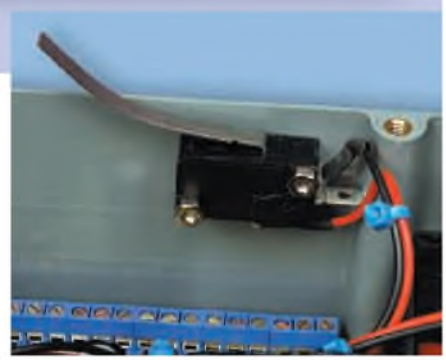
In addition, you have to install the wiring between the D9 female socket and the keyswitch header, after which you can secure the socket to the front panel. You also have to install the wiring to the tamper switch, the internal siren and the battery.

Note that there are three terminals on the tamper switch: COM, NO and NC. You have to connect the two leads from the terminal block to the COM and NC terminals, so that the switch goes open circuit when the actuator arm is held down by the lid.

Use a red lead for the battery positive connection and a black lead for the negative connection. These two leads are soldered at one end to the PC stakes on the main PC board and are fitted with spade clips at the other end to match the battery terminals.

It's a good idea to cover the connections to the PC stakes with heatshrink tubing. This not only insulates them but also stops the wires from flexing and breaking at the solder connections.

Finally, use cable ties to bind the wiring together, as shown in the lead photo. This not only keeps it tidy but also ensures that it folds back neatly into the case when the lid is closed.



The microswitch is mounted about 7mm below the lip of the case. Bend its actuating arm upwards as shown, so that the switch is held open when the lid is in place.

Next month

That's all we have space for this month. In Part 2, we'll give the test procedure, detail the software and describe the hard-wired keyswitch and the optional keypad unit. ***EPE***

TECHNO-TALK MARK NELSON

Light Pipes and Peashooters

There's more happening in lightwave transmission than you'd probably imagine. Mark Nelson looks into optical fibres, even though he knows this can be dangerous

"Kent, sir?" asked Mr Jingle in Charles Dickens's book *Pickwick Papers*. "Everybody knows Kent – apples, cherries, hops, and women." And so with optical fibres; everyone has heard of them, so there's no need to cover them here. Or perhaps there is, as there's plenty new happening in optical fibres.

I was going to cite optical fibre as a classic British invention of which we could be proud, but Wikipedia tells me the underlying principle of light transmission in tubes was first demonstrated by Daniel Colladon (who was Swiss) and Jacques Babinet (a Frenchman) in the 1840s, with Irish inventor John Tyndall giving a public demonstration in 1870. You may remember some scarily tasteless (but nevertheless impressive) room ornaments that illuminated plastic 'waterfalls' in garish pink, blue and orange colours.

Nicknacks

Look around, and you'll find Christmas trees with twinkly fibroid lights and other nicknacks that employ optical fibres, but their primary use is undoubtedly for long-distance, high-bandwidth voice and data transmission. Here we can stand tall and assert British priority. It was in 1965 that Charles Kao (OK, he was born in Shanghai but studied and worked in Britain) and George A. Hockham of Standard Telephones & Cables (STC) first suggested that hair-thin fibres of glass could make a practical transmission medium for communications. This was at a time when all long-distance telephone and data calls went over coaxial cables or microwave radio links and also the same year that Telecom Tower in London was opened by prime minister Harold 'white heat of technology' Wilson.

It took just 15 years to develop a theoretical proposition into an operational reality, and so it came to pass that in 1980 British Telecom installed the first operational fibre optic link in the UK between Walsall and Brownhills in the Midlands (I was a press officer there on the day it opened!). The world's first purpose-designed submarine optical fibre cable was also laid in that year and also by BT, in Loch Fyne (Scotland).

Blinding hazard

Nowadays optical fibre installations are fit-and-forget, but those early 'Lightline' constructions had significant learning curves. The Loch Fyne cable succumbed early on to clouding and had to be replaced, while the first London to Birmingham fibre was repeatedly struck by lightning. Although glass fibres do not conduct electricity, the apparatus in the intermediate electronic repeater stations did and managed to destroy the fibres in the process.

There are other hazards that make optical fibres dangerous, which is why staff who handle them are warned not to look into the ends of any optical fibre. Some fibres are driven by extremely powerful lasers and exposure to this invisible radiation could result in eye damage.

POF!

You might imagine that fibres of glass would be so fragile as to be unusable in cables, but you'd be wrong. When it's as thin as human hair or thinner it can be remarkably flexible and resilient (just think of the fibreglass and resin kits sold for repairing car bodywork). But not all optic fibres are glass and plastic fibres are also used widely.

Plastic has higher attenuation but it is significantly cheaper. This makes it ideal for short-run systems and the obvious choice for high-bandwidth 'backbone' connections between floors within office buildings and also between separate locations in large site or 'campus' situations, particularly with the advent of gigabit networking.

Another burgeoning application for Plastic Optical Fibre (POF) is in automotive control and entertainment systems. Trade publication *Laser Focus World* reports that during the past three years, European car manufacturers have installed 25 million nodes of plastic optical fibre in more than 40 vehicle models. The Media Oriented Systems Transport (MOST) Cooperation industry body was established principally to define standards for a multimedia fibre optic network with standard hardware and software interfaces optimised for in-car applications.

Safety critical

With copper prices rising constantly, POF makes an ideal replacement for copper-wire harnesses in automobiles. It has the key advantage of being easy to terminate, immune to radio frequency and electromagnetic interference, and low in cost.

The most important application of POF in cars is the crucial purpose of passenger safety. In many instances, says the magazine, safety requires communication between sensors embedded in the vehicle and other devices, such as air bags, that are used to ensure safety. BMW, for instance, has developed a POF network operating at 10 Mbit/s for communicating with the air bag sensors, so that if an accident occurs, information from force sensors within the vehicle is interpreted and communicated over the POF network to the individual air bags to control their inflation.

POF is used in some vehicles for in-car entertainment system components such as radio, CD and DVD players, sat-nav systems, Bluetooth interfaces, mobile phone, games consoles and even TV tuners. It is also being proposed for seat-occupancy recognition, with a sensor under each seat identifying whether the seat is occupied. In the event of a collision, air bags would not be deployed for empty seats, saving the expense of repair and replacement.

Peashooter power

It's not only the applications of optical fibre that are changing, but also the structure of the optic fibre itself. Hollow-core fibre is the in-thing now, superceding the solid-core fibre used since the 1970s. Effectively, it's like a peashooter tube or a drinking straw. Pioneered at Bath University, this hollow-core fibre reduces non-linearity and hence distortion of the optical pulses it transmits. Now scientists there have made a discovery that cuts the cost of these next-generation optical fibres.

Initial tests show that the fibre is superior in virtually every respect to previous versions of the technology, making it an important step in the development of new technologies that use light instead of electrical circuits to carry information. These technologies include faster optical telecommunications, more powerful and accurate laser machining, and the cheaper generation of x-ray or ultra-violet light for use in biomedical and surgical optics.

Travelling in air

Professor Jonathan Knight from the university's Centre for Photonics & Photonic Materials in the Department of Physics explains: "In standard optical fibres, light travels in a small cylindrical core of glass running down the fibre length in which the glass causes short pulses of light to spread out in a blurring effect that makes them less well defined. This limits its usefulness in telecommunications and other applications. Hence, fibres in which light travels in air down a hollow core hold great promise for a next generation of optical fibres with performance enhanced in many ways."

The fibres are not easy to fabricate, but their superior performance means that this could have a significant impact in a range of fields such as laser design and pulsed beam delivery, spectroscopy, biomedical and surgical optics, laser machining, the automotive industry and space science. According to Professor Knight, "This brings the day when information technology will consist of optical devices rather than less efficient electronic circuits much closer."

INTERFACE

Robert Penfold

USB INTERFACING

As most readers of this piece are no doubt aware, PC serial and parallel ports are being phased out and replaced by USB ports. The so-called legacy ports are now absent from many PCs, especially the laptop variety. These ports are relatively simple to use with home constructed PC add-ons, because they connect directly to the busses of the microprocessor, and are at addresses in the input/output map.

In the days of MS/DOS and GWBASIC it was easy to read from and write to any hardware in the input/output map, since there were INP and OUT instructions specifically for these purposes. In addition to directly controlling the serial and parallel ports, it was also possible to use the same method to communicate with home constructed expansion cards installed in the ISA expansion slots.

These days, matters are much less straightforward, and there are two main reasons for this. On the hardware side of things, the demise of standard serial and parallel ports, and of the old ISA expansion bus, means that user add-ons cannot be fitted directly into the input/output map of the computer. The PCI slots that replaced the ISA variety do not interface devices directly onto the busses of the microprocessor, and a PCI slot is really a complex bidirectional port that has multiplexed address and serial buses. This makes it impossible to use Inp and Out instructions with user add-ons, and probably rules out any alternative method that offers quite the same degree of simplicity.

Procedural difficulties

Using direct control of the hardware was becoming increasingly difficult anyway, which brings us to the second problem. Even in the days of MS/DOS, direct control of the hardware was not encouraged. It could produce problems with supposedly compatible hardware that was not quite as compatible as it should have been, and there was also a risk of two or more programs using the same hardware simultaneously.

Hardware compatibility is not really an issue these days, but the problem of more than one program at a time accessing the same piece of hardware is taken more seriously. Modern operating systems permit multi-tasking, and it is now the norm for users to have several programs running simultaneously.

It does not matter if you send a job to the printer while another program is still printing a document. The operating system handles the flow of data to the printer, and queues the print jobs so that they are performed one after the other and not all at once.

In normal computing, this way of doing things is highly desirable, since it removes the need for the user to ensure that the data flow to the printer, or any other peripheral, is handled correctly. The operating system should ensure that nothing can go wrong. It makes life difficult for those producing simple PC add-ons, because directly accessing these devices in an arbitrary fashion is no longer permissible. The add-on gadgets have to be accessed via the operating system just like any other peripheral devices, and the correct procedures have to be followed.

It is actually possible to read from and write to devices using Inp and Out instructions when using a modern version of Windows, and this method has been used a great deal in *Interface* articles in recent years. However, this method requires Windows programming languages such as Visual BASIC to be augmented by an add-on that does things in the approved fashion, and communicates with the input/output ports via the operating system. As explained in previous *Interface* articles, there can still be a few minor problems, especially when using the very security conscious Windows Vista, but it is possible.

Drivers

Using USB ports for user add-ons has definite advantages, but there are also major difficulties. The sophistication of this method of interfacing means that simply reading and writing bytes of data to the port using Inp and Out instructions is not an option. On the other hand, there are ways of largely avoiding the complications and making it reasonably easy to commutate with home constructed USB devices. USB devices have to be integrated into the operating system using suitable driver software, and writing programs of this type is a difficult and highly specialised task.

Being realistic about things, most people will have to settle for an 'off-the-shelf' solution, and there are suitable driver programs available. A popular way around the driver problem is to use the Microsoft drivers for human interface devices. These drivers are intended for use with peripherals such as mice and graphics tablets, but it is possible to use them with practically any user add-on.

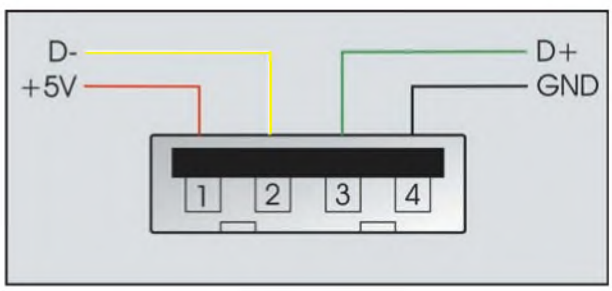
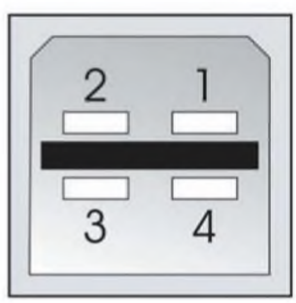


Fig.1. PCs are master devices that have a type A USB socket. Communication is via a three-wire link, with a fourth wire providing a +5-volt supply

Fig.2. (right) USB peripherals are slave devices, and they have the smaller type B socket. Small peripheral gadgets such as digital cameras often have a miniature version of this connector



Firmware

Most of the devices that interface via the legacy ports of a PC are 'dumb' rather than 'intelligent' units. In other words, the only interaction between the computer and a peripheral device is that provided by an application program. The operating system does not communicate with the peripheral device, other than to act as a conduit for the flow of data between the application program and the peripheral.

The situation is very different with USB, where numerous devices (up to 127) can share what is essentially the same interface. The operating system has to establish the number of USB devices connected to the PC's USB ports, their type, and then set up proper communication with each of them.

In addition to decoding and encoding the serial data used by USB interfaces, the peripheral must include a processor and firmware designed to provide the correct responses when the device interacts with the operating system. Once again, this type of programming is fairly specialised in nature, and is probably not something many electronics enthusiasts will undertake for themselves. For most it is a matter of finding suitable 'off-the-shelf' solutions.

USB is definitely an improvement on traditional serial and parallel port interfacing, but there is literally a price to be paid for this progress. Some complex and possibly expensive hardware and firmware is needed to provide a link between a USB port and the electronics of a user add-on, such as a thermometer interface or motor speed controller.

It is likely that the complexities of the basic interface will often leave the main circuit looking very simple by comparison. It is also possible that the cost of the basic interface will be significantly higher than that of the main circuit. With an average project it is certain to contribute a fair proportion of the overall cost.

This contrasts with using the PC's parallel ports, where it is often possible to interface gadgets direct to the input/output lines of the port. Some simple and inexpensive logic circuitry is all that is needed if additional input or output lines are required. While interfacing via an RS232C serial port requires some hardware to provide the serial encoding and decoding, this circuitry is generally quite simple and inexpensive.

Advantages

Using a USB interface certainly makes life difficult for those wishing to interface their own gadgets to a PC, but there are some huge advantages to this type of interface. The original USB specification (USB 1.1) provided a maximum data rate of 11 megabits per second, although only about half this bandwidth was available for a single device. This is not particularly fast by current standards, but is more than adequate for most user add-ons. Modern USB ports comply with the later (USB 2.0) standard, which has provision for much higher data rates. USB 2.0 can provide bursts of up to 480 megabits per second.

RS232C serial ports can be used with very long cables provided the baud rate is low. Even at higher baud rates it is possible to use quite long cables. USB was only designed to handle high speed communication over short distances, which is the requirement for most user add-ons. The maximum cable length for USB is five metres, or three metres when using lower quality cables in a slow mode.

Getting any RS232C serial port device to work properly with a PC tends to be problematic. Although a basic link providing two-way communication requires just three connecting wires, there are numerous terminals on a PC serial port, most of which have obscure functions, and in practice never seem to be needed. There are also the complications of various baud rates, word formats, and types of handshaking.

USB avoids all these complications, and uses a simple four-wire connection. A PC normally has a type A socket, and connection details for this are provided in Fig.1. Peripherals usually have a type B socket, which uses the arrangement shown in Fig.2. The data is carried differentially on the two data (Data– and Data+) lines, and there is, of course, a ground (Gnd) connection.

Unlike conventional serial and parallel ports, USB types have a +5V supply output, and other voltages can be derived from this using DC-to-DC converters. Currents of up to 0.5A can be drawn from a USB 1.1 port, and the maximum output current is 2A for a USB 2.0 port.

However, bear in mind that the maximum current per port is much lower if a passive hub is used to provide several ports from a single port on the PC. With a four port hub connected to a USB 1.1 port there is only 0.5A to share between the four ports, minus the current used by the hub itself. This would give only about 0.1A per port.

This limitation should not occur with a hub that has its own power source, and the full supply current should then be available from each port. Another point to bear in mind is that some portable PCs cannot provide the full supply current from all their USB ports. This is presumably due to the limitations of the computer's power source.

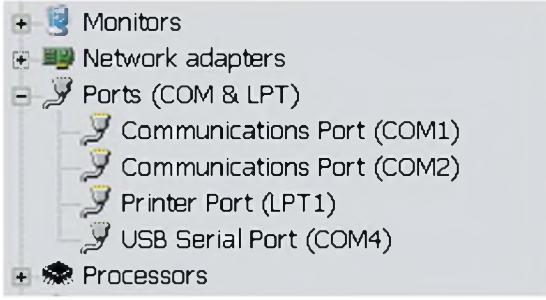


Fig.3. The operating system has assigned COM4 to the USB virtual serial port. With Visual BASIC it can be used just like any other COM port

Software support

With all the hardware in place, producing the software for a USB-based project can be difficult. It will usually require far more expertise than using the legacy ports.

One way around this problem is to use a virtual COM port that is actually a USB device. At its most simple level, this involves buying a USB to RS232C converter and installing the supplied driver software. The serial port will then appear in the Windows Device Manager as a normal COM port, and in the example of Fig.3 it is COM4. Of course, a converter is needed in order to provide serial-to-parallel and parallel-to-serial conversion, but this is easily achieved using a simple PIC-based circuit.

There are actually PC interface boards that combine a virtual serial port and a serial encoder/decoder, sometimes together with additional interface circuitry. All you have to do is tag your own circuits onto the input/output lines of the board, and then communicate with it via the virtual COM port.

Fig.4 shows an EasyDAQ board that provides four digital outputs and also has four relays. In order to set these to the required states it is just a matter of writing the appropriate value to the correct COM port, and this is easy due to Visual BASIC's built-in support for COM ports.

Visual BASIC 6 comes complete with an ActiveX control that makes it reasonably straightforward to communicate with a COM port. This works equally well with real and virtual COM ports, and I certainly had no difficulty in communicating with the EasyDAQ board using this method.

This approach almost certainly represents the easiest way of interfacing to your own circuits via a USB port. Although the serial port ActiveX control is not included with Visual BASIC 2005 or 2008, they are supplied with a component that provides essentially the same features. Thankfully, this component is also included with the free Express versions.

On the face of it, using a USB virtual LPT (parallel) port offers a simpler means of interfacing via a USB port. With this method there is no need for any serial encoding or decoding. It is an approach that has a few flaws though, one of which is that virtual LPT ports often provide something less than a full simulation of a modern PC parallel port. For example, the bidirectional property of the data lines is often omitted. The main problem is that Visual BASIC does not have any built-in support for parallel ports. Consequently there is no easy way of communicating with a virtual LPT port.

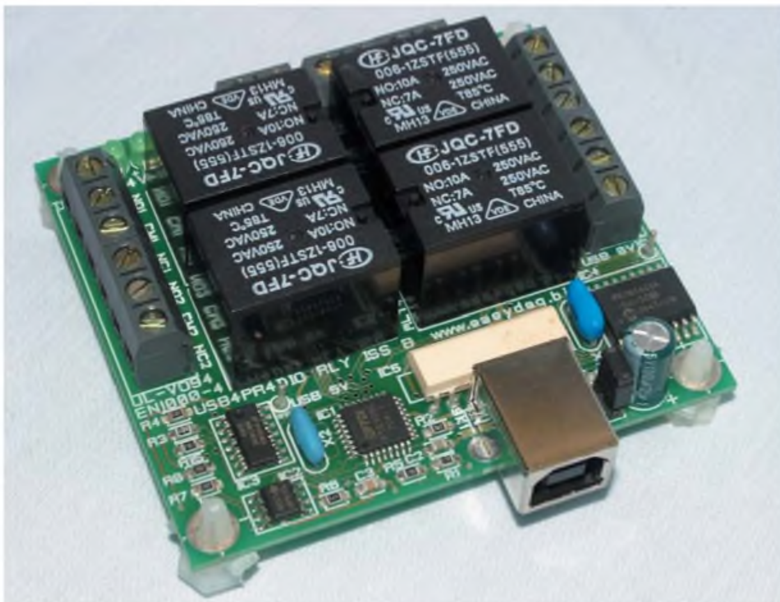
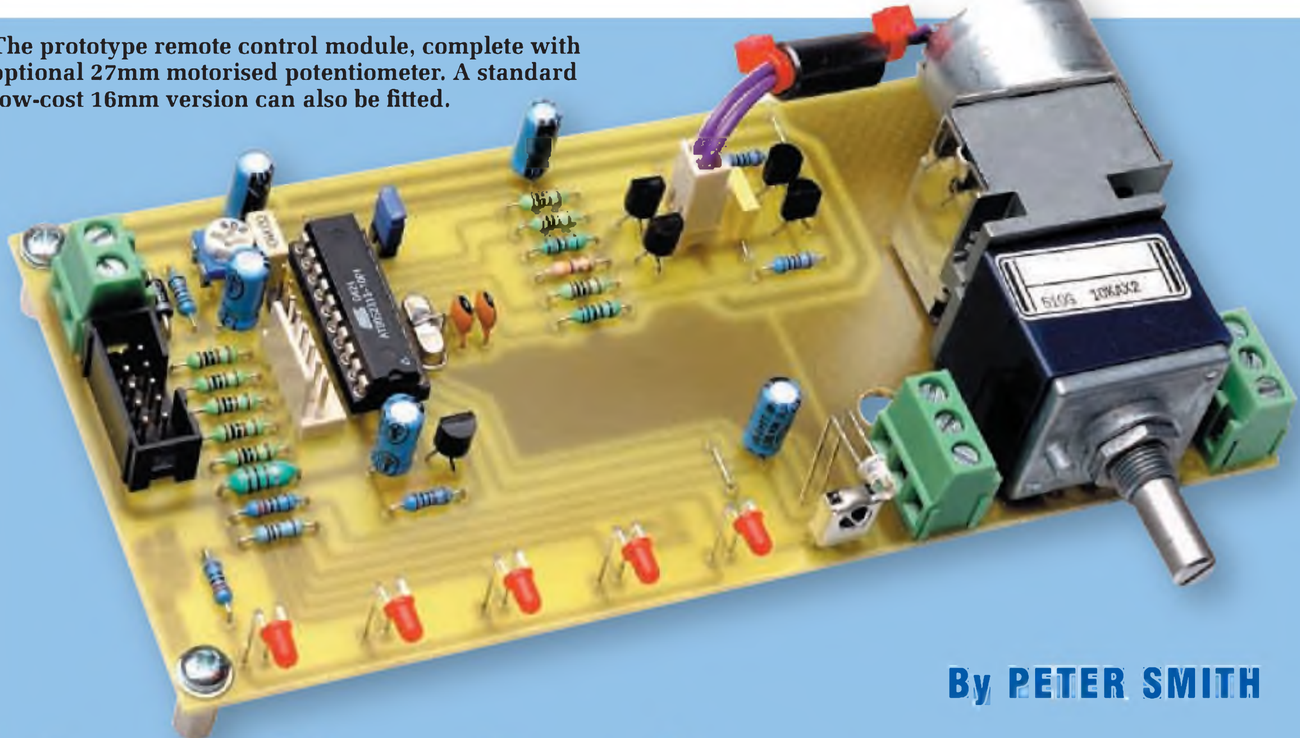


Fig.4. Although it connects to a USB port, this EasyDAQ board can be controlled as if it was connected to a standard serial port. This probably represents the simplest method of USB interfacing

Thanks to Chris Harden of EasyDAQ (**www.easydaq.biz**) for the USB4PRMx card.

The prototype remote control module, complete with optional 27mm motorised potentiometer. A standard low-cost 16mm version can also be fitted.



By PETER SMITH

Studio Series – Remote Control

Works With Any Universal Remote Control!

If you've built our preamp described in February 2008, then this project is a must-have addition. It allows you to control your preamp's volume level and select the music source using any universal infrared remote. As a bonus, we've added support for an audiophile-grade potentiometer for those who want the best.

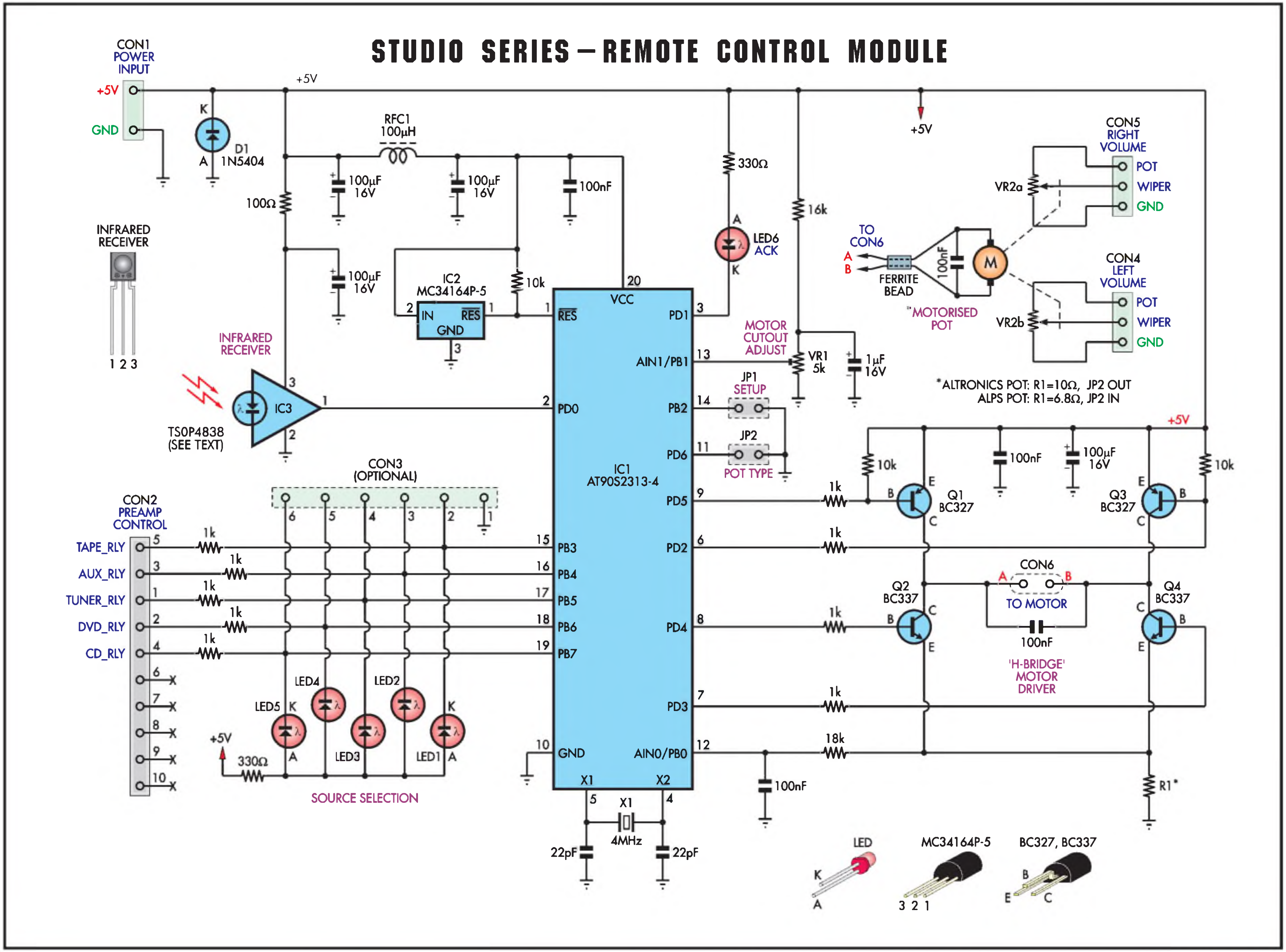
LET'S FACE IT – any sound system is incomplete without at least a remote volume control. The volume control features of this unit are based on a motorised potentiometer. Press the 'Volume Up' and 'Volume Down' buttons on your remote and the pot rotates right and left. It takes about nine seconds for the pot to travel from one end to the other using these controls. For finer adjustment, the 'Channel Up' and 'Channel Down' buttons can be used instead; these cause the pot shaft to rotate only about 1° for each press.

Automatic muting is another handy feature. A press of the 'Mute' button and the pot rotates to its minimum position. Hit the button again and it returns to its original position. Don't want the volume to return all the way? Easy – just hit one of the volume control buttons when the volume has reached the level that you want.

Selecting any of the preamp's signal sources is just as easy. All you need to do is press the associated numeric button on the remote. For example, to select the Tuner input, you'd press '3' and for CD you'd press '5'.

Finally, this design can be fitted with either a low-cost 16mm motorised

Fig.1: the complete circuit diagram for the control module. An AT90S2313 microcontroller (IC1) decodes data from the infrared receiver (IC3) and drives the motorised potentiometer accordingly. Five outputs from port B drive the relay circuits on the preamp (Feb '08) to provide remote control of the music source as well.



STUDIO SERIES – REMOTE CONTROL MODULE

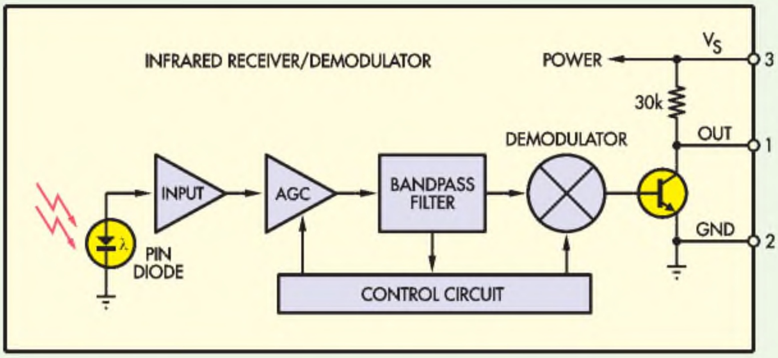


Fig.2: the infrared receiver module contains a lot more than just a PIN (photo) diode. This block diagram of the internals reveals an amplifier, discrimination and demodulation circuits, all integrated in the 3-pin package. After the 38kHz carrier is removed, the data appears on the 'OUT' pin ready for handling by the micro.

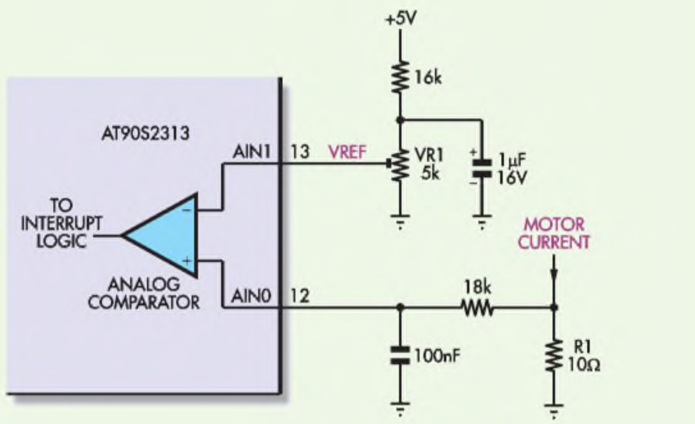


Fig.3: when the pot reaches full travel, a clutch begins to slip, loading the motor and increasing the supply current. The muting function uses a comparator in the microcontroller (IC1) to detect this current increase and switch off the motor. This simplified diagram shows how the comparator is connected.

pot or a more expensive, high-quality 27mm unit. The advantages of the 27mm units include longer life, lower noise and better tracking than their cheaper counterparts.

How it works

As can be seen from the circuit diagram (Fig.1), the design is based on an AT90S2313 microcontroller from Atmel. This device includes 2k bytes of code (FLASH) memory, 28 bytes of RAM and 128 bytes of EEPROM.

The microcontroller is supported by a power supply and several interface circuits, which are responsible for driving the motor, receiving infrared signals and controlling the preamp's relays. Let's look at each section in a little more detail.

Power supply

Looking first at the power supply portions of the circuit, the module expects a regulated 5V (±5%) supply on CON1. A large 3A diode (D1) across the input terminals provides rudimentary reverse-polarity protection for the board.

If the power leads are accidentally reversed, D1 conducts and pulls the power supply rail down to about 1V or so. Assuming you see the smoke signals and react quickly, damage to the board should be minimal, although D1 may not survive and should be checked for a short circuit before reapplying power.

The supply to the micro (IC1) is derived from the +5V rail via a 100µH choke (RFC1), which acts as a simple filter to reduce RF emissions. This is an important consideration for our sensitive audio circuitry.

Separate low-pass filtering is needed for the infrared receiver module (IC3) to keep digitally-generated noise out of its sensitive front-end circuitry. A 100Ω resistor in series with IC3's supply pin and a 100µF capacitor to deck do the job.

An under-voltage sensor (IC2) monitors the supply rail and generates a reset signal for the micro whenever it drops below 4.3V. This function is often referred to as 'brown-out' detection and it ensures that the micro doesn't behave erratically during supply rail transitions.

Incidentally, this design uses an MC34164-5 sensor, rather than the MC34064-5 device. The MC34164-5 has a lower threshold voltage than the latter, needed here to allow for worst-case supply regulation during motor operation.

Infrared receiver

Infrared pulses from the remote control are detected by IC3. In addition to a sensitive photodiode, this device contains an amplifier and other logic necessary to receive and extract the incoming digital data, which is modulated on a 38kHz carrier (see Fig.2).

The demodulated data is pumped into the microcontroller on pin 2. Under program control, it is then reconstituted into byte-wide format using the Philips RC5 protocol specification. Once deciphered, the results can be used to determine which button has been pressed on the remote and the appropriate action taken.

H-bridge drive

Average pot motor current ranges from about 40mA to 100mA, depending on the model used. Start-up current is higher still, and so the drive requirements easily exceed the maximum sink and source capabilities of the microcontroller's port outputs. This necessitates the use of four small-signal transistors (Q1 to Q4) as buffers and drivers, arranged in an 'H-bridge' configuration so that the motor can be driven in either direction.

The transistors operate in pairs. To drive the motor in one direction, port bit PD5 is driven low and PD3 high. This biases Q1 and Q4 into conduction and creates a current path from the 5V rail, through Q1, the motor and Q4 to ground (via resistor R1).

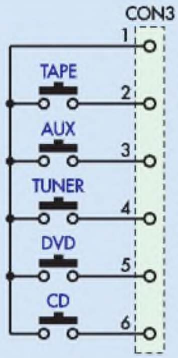


Fig.4: although we think that manual selection switches are unnecessary, we've made provision for them for those who prefer front-panel controls. One push-button switch is required for each source – here's how to connect them to CON3 on the control module. Keep all wiring as short as possible and make sure that the ground connection is insulated from chassis earth.

Parts List – Remote Control Module

- 1 PC board, code 663, size 72mm x 150mm
- 1 2-way 5mm/5.08mm terminal block (CON1)
- 2 3-way 5mm/5.08mm terminal blocks (CON4, CON5)
- 1 10-way shrouded (boxed) header (CON2)
- 1 6-way 2.54mm header (CON3)
- 1 2-way 2.54mm header (CON6)
- 1 2-way 2.54mm plug (CON6)
- 1 4-way 2.54mm SIL header (JP1,JP2)
- 2 jumper shunts
- 1 8mm ferrite sleeve (bead)
- 1 100µH choke (RFC1)
- 1 20-pin gold-plated IC socket
- 4 M3 x 10mm tapped spacers
- 4 M3 x 6mm pan-head screws

Potentiometers

- 1 5kΩ miniature horizontal trimpot (VR2)
- 1 10kΩ log motorised pot (VR1)(*Alps RK27 series) (see text) – or –
- 1 20kΩ log motorised pot (VR1) (†Altronics R-2000)

Semiconductors

- 1 AT90S2313-4 or -10 microcontroller (IC1) programmed with MPOT.HEX
- 1 MC34164P-5 or MC33164P-5 under-voltage sensing IC (IC2) (Farnell 791-908)
- 1 infrared receiver module (TSOP4838 or equivalent) (IC3) (Farnell 491-3190)
- 1 4MHz crystal, HC49S package (X1)
- 2 BC327 PNP transistors (Q1, Q3)
- 2 BC337 NPN transistors (Q2, Q4)
- 1 1N5404 400V 3A diode (D1)
- 6 3mm red LEDs

Capacitors

- 4 100µF 16V PC electrolytic
- 1 1µF 16V PC electrolytic
- 4 100nF 50V metallised polyester (MKT)
- 1 100nF 50V multilayer ceramic
- 2 22pF 50V ceramic disc

Resistors (0.25W, 1%)

1 18kΩ	2 330Ω
1 16kΩ	1 100Ω
3 10kΩ	1 10Ω
9 1kΩ	1 6.8Ω 5%

Additional items

- 2-core shielded audio cable for pot wiring
- Medium-duty hook-up wire for power supply and motor wiring
- 2 x 10-way IDC cable-mount sockets
- 10-way IDC ribbon cable
- 2 small cable ties

Power supply modification

- 1 1N5338B 5.1V, 5W Zener diode

Note: the program file (MPOT.HEX) will be available for download from the *EPE* website (**www.epemag.co.uk**) for those who wish to program their own microcontrollers.

Ready programmed microcontrollers are available from Magenta Electronics – see their advert in this issue

* **www.alps.com**
† **www.altronics.com.au**

To spin the motor in the reverse direction, the opposing transistor pair (Q3 and Q2) is switched on instead. To do this, port bit PD2 is brought low and PD4 high.

Motor hash is reduced using two 100nF capacitors, one of which is soldered directly across its terminals. A ferrite sleeve (bead) in line with the motor's supply leads also helps by blocking high-frequency noise components.

Current sensing

Once the pot's wiper (moving contact) reaches its fully clockwise or anti-clockwise position, a friction type clutch in the gearbox begins to slip. This prevents the motor from stalling, while also allowing the user to manually rotate the pot shaft when necessary.

The muting function depends on the microcontroller's ability to detect when the wiper is 'on the stops'. For the Altronics model, typical motor current is 40mA, increasing to about 50mA when driving the clutch. This handy side effect is put to good use by including a small current sense resistor (R1) in series with the motor driver's ground circuit.

If R1 is 10Ω, 0.4V will be dropped across it during normal rotation and 0.5V when driving the clutch. A low-pass filter comprising an 18kΩ resistor and 100nF capacitor remove much of the motor noise, after which the signal is fed into pin 12 (AIN0) of the microcontroller. Internally, this pin is connected to the non-inverting input of a voltage comparator (see Fig.3), while the inverting input is connected to an external voltage reference on pin 13 (AIN1).

The voltage reference is made adjustable with trimpot VR1, which forms a simple voltage divider with a 16kΩ resistor. When the sense voltage exceeds the reference voltage set by trimpot VR1, the comparator's output swings high, generating a program interrupt. The interrupt handling code then switches off the active transistor pair to stop the motor.

In use, the trimpot is adjusted so that the comparator doesn't trip during normal pot travel. However, when the clutch is slipping, the increase in motor current causes a proportional increase in voltage at the comparator's non-inverting input, causing its output to switch high.

Preamp control

Source switching on the Studio Series – Stereo Preamplifier (see *EPE*

Universal Infrared Remote Controls

The remote control module is designed to work with most universal ('one-for-all') infrared remotes. It recognises the RC5 protocol that was originally developed by Philips, so the remote must be programmed for a Philips (or compatible) appliance before use.

Most universal remotes are provided with a long list of supported appliances and matching codes. To set the remote to work with a particular piece of gear, it's usually just a matter of entering the code listed for the manufacturer (in this case, Philips), as detailed in the instructions.

You'll also note that different codes are provided for TV, CD, SAT, and so on. This allows two or more appliances from the same manufacturer to be operated in the same room and even from the same handpiece.

This multiple addressing capability can also be useful in our application. Normally, we'd program the remote to control a TV, as this works with the control module. But what if you already have a Philips TV (or a Chinese model that uses the RC5 protocol)? Well, in this case, you'd simply use a CD or SAT code instead – the control model can handle any or these!

Let's look at an example. To set the AIFA Y2E remote (see below) to control a Philips TV, you'd first press and hold 'SET' and then press 'TV'. This puts the remote in programming mode, as indicated by the red LED, which should remain illuminated.

Now release both keys and punch in one of the listed Philips TV codes. For this project, code 191 works well. The red LED should now go out and the remote is ready for use. All universal remotes can be programmed in a similar manner but when in doubt, read the instructions! If the first code listed doesn't work with the control module, then try another.

Once the remote has been programmed, the control module must be set up to recognise the particular equipment address that you've chosen (TV, CD, SAT, etc). Details on how to do this are in the setup and testing section.

Although this project should work with almost any universal remote, we've tested the following popular models: AIFA Y2E (Altronics A-1013), AIFA RA7 (Altronics A-1009) and BC3000 (Jaycar AR-1710). For these models, the setup codes are as follows: TV = 191, CD = 651 (but not for BC3000 remote), SAT1 = 424 and SAT2 = 425.

Note that the 'mute' button doesn't work for all codes and in the case of the AIFA Y2E, is missing anyway! In these cases, you may be able to use the '12' or '20+' buttons instead.

Feb'08) is performed by miniature 5V relays, which are in turn switched by PNP transistors.

On the control module, five outputs from the micro (PB3-PB7) are used to drive the preamp's transistors and select between the various signal sources. These outputs are routed to CON2, where they're connected to the preamp via ribbon cable.

Each port line is protected with a 1kΩ series resistor, while LED1 to LED5 indicate which line is low and therefore which signal source is selected.

Optionally, push-button switches can also be wired to each port line via CON3, enabling manual source selection (see Fig.4). To facilitate this function, the microcontroller pulls its inactive port lines high and continually monitors them for a low level (button press).

When a button is pressed, the chosen relay is immediately activated. Just a few milliseconds later, the microcontroller senses the low level and returns the currently active output high while driving the new output low, in effect 'latching' the user's button press.

Assembly

Assembly is relatively straightforward, with all components mounted on a single PC board. This board is available from the *EPE PCB Service*, code 663.

Before you begin construction, check that the holes in the PC board are large enough to accept the motorised pot you are using. The footprint for the standard and optional pots is quite different, so two sets of holes have been provided. If you find that the required row of holes are too small to accept the pot's pins, then they'll need to be drilled out to about 1.2mm.

That done, set the pot aside and following the usual practice, begin by installing all of the lowest profile components. The two wire links and the resistors are a good place to start. Use the overlay diagram (Fig.5) as a guide to component placement.

All other components can then be installed as you see fit, but leave out the microcontroller (IC1), infrared receiver (IC3), LEDs and motorised pot for now; we'll come back to these shortly.

Be sure to mount the five electrolytic capacitors and the diode (D1) around the right way and check that the keyed side of CON2 is oriented towards IC1. Also, be particularly careful not to mix up the two transistor types, or indeed the under-voltage sensor (IC2), as they're all housed in identical TO-92 packages!

Note that the crystal (X1) must be mounted vertically and with minimum lead length. Once in place, connect its metal can to ground by soldering a short length of tinned copper wire between the can and the ground pad underneath (see photo).

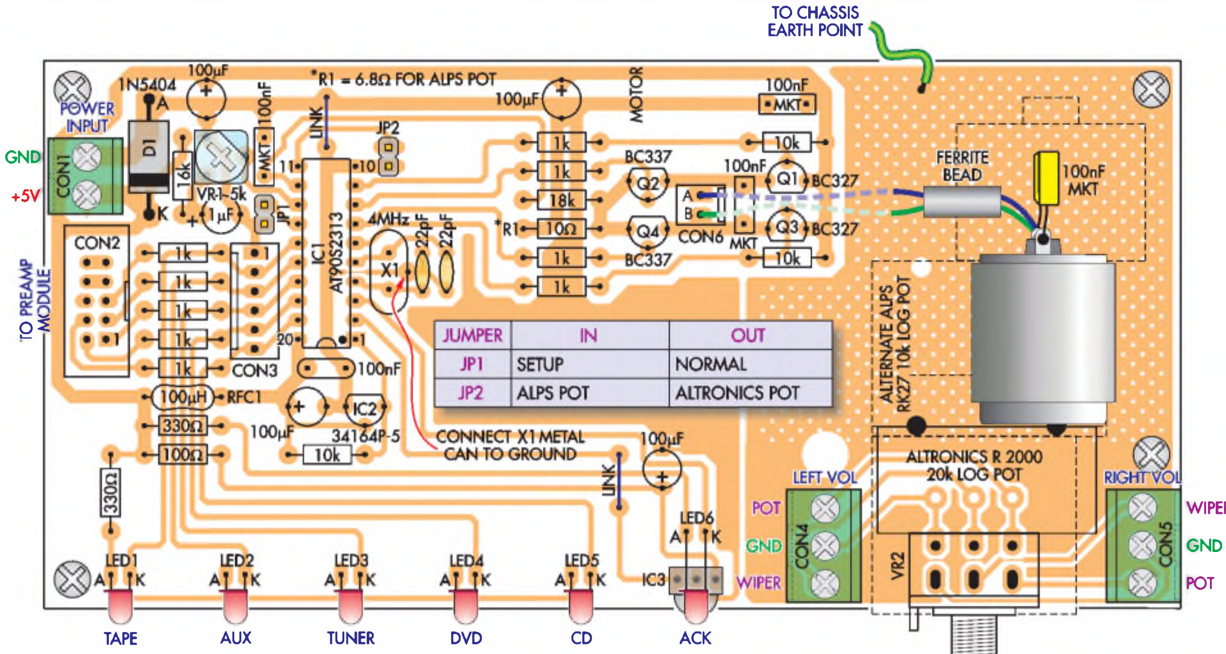
After installing the motorised pot, solder a 100nF capacitor directly across the motor terminals (see photo). Next, solder a pair of medium-duty wires to the motor terminals and pass these through a ferrite sleeve (bead) before terminating in a 2-way plug to mate with CON6. Alternatively, the wires can be soldered directly to the PC board without the header and plug, if desired.

Use a small cable tie or two to hold the ferrite sleeve close to the motor side of the wiring.

Front panel stuff

The remote control module is designed to be mounted directly behind the front panel of a low-profile case. To this end, the infrared receiver, LEDs and pot all mount along one edge of the PC board so that they will protrude through the front panel.

If necessary, trial fit the module into the chosen case to gauge the required lead length and bend for the LEDs and infrared receiver. If you're drilling the



JUMPER	IN	OUT
JP1	SETUP	NORMAL
JP2	ALPS POT	ALTRONICS POT

Fig.5: follow this diagram when assembling your board. Take care not to mix up the two transistor types and the under-voltage sensor (IC2), as they're all in TO-92 packages. Mount the diode (D1) a few millimetres above the board surface for a little extra insurance in case of a wiring error! Below is the fully-assembled unit with the Alps pot.

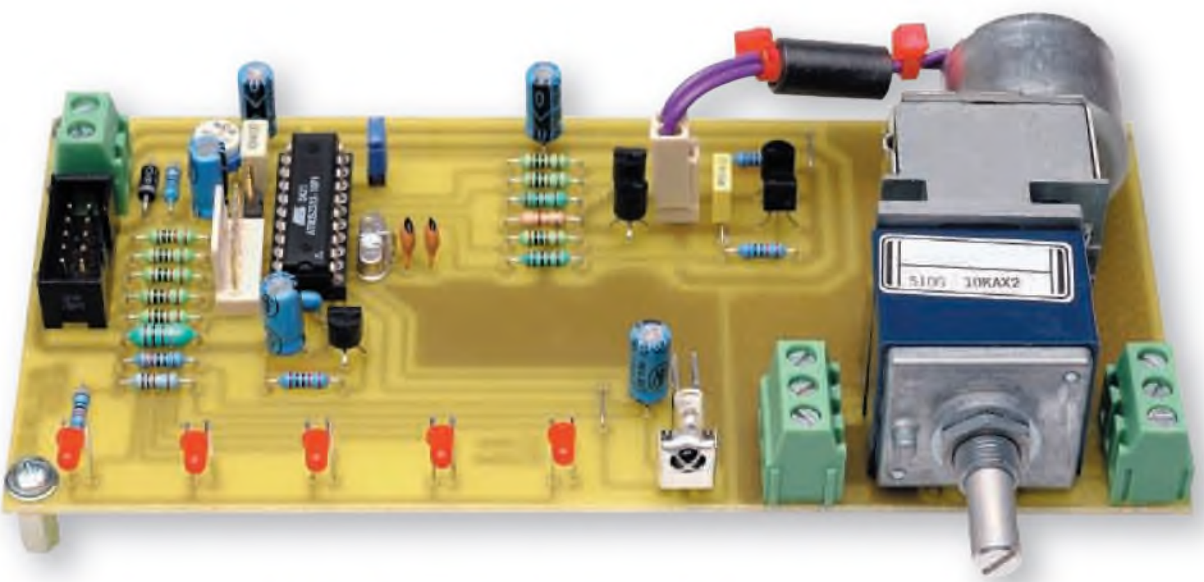
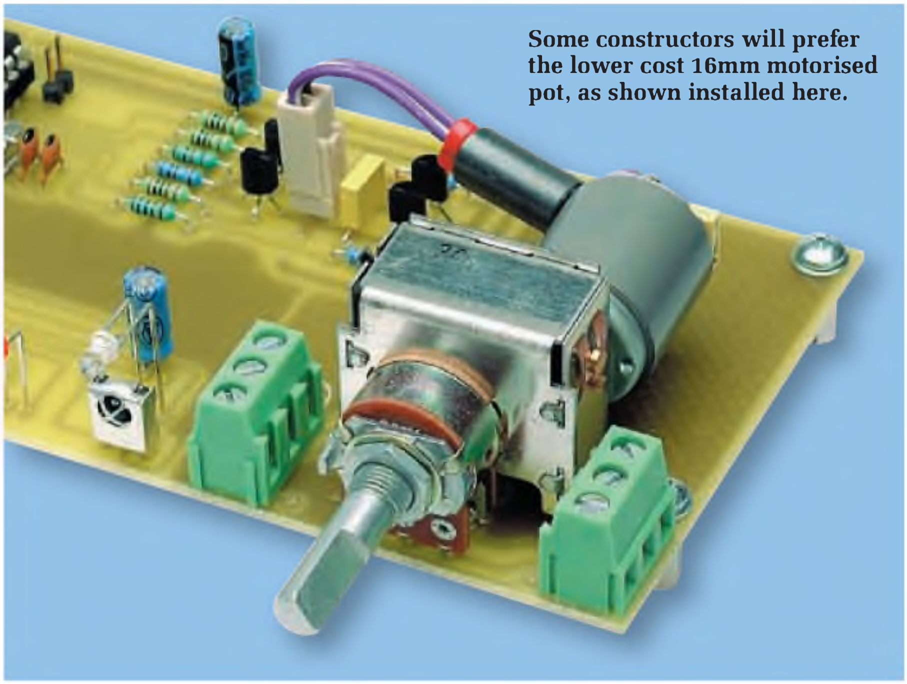


Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	18kΩ	brown grey orange brown	brown grey black red brown
❑	1	16kΩ	brown blue orange brown	brown blue black red brown
❑	3	10kΩ	brown black orange brown	brown black black red brown
❑	9	1kΩ	brown black red brown	brown black black brown brown
❑	2	330Ω	orange orange brown brown	orange orange black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown
❑	1	6.8Ω 5%	blue grey gold gold	not applicable



Some constructors will prefer the lower cost 16mm motorised pot, as shown installed here.

case yourself, then note that the hole for the infrared receiver should be slightly larger than the 'bump' in the package to ensure operation over the widest possible area.

Before drilling the four mounting holes for the module, note that the front boss (face) of the pot should make firm contact with the rear of the front panel. This is very important, as it prevents stress being placed on the pot assembly when the nut is tightened and the pot is manually operated. If necessary, fit one or more additional washers over the pot shaft to bring it in contact with the panel when the board is positioned flush against the rear.

The 100nF polyester capacitor is soldered directly across the terminals of the pot motor, as shown here.

This close-up view shows how a wire link is used to connect the crystal case to a ground pad.

Note that a number of other mounting options are possible, depending on your requirements. For example, the pot could be mounted a short distance from the board, with the shielded audio cable terminated directly at its pins rather than at CON4 and CON5.

Power supply upgrade

Power for the control module can be sourced from the low-noise power supply module described as part of the Studio Series Preamp in the Feb '08 issue. Unfortunately, the module's peak current requirements are a little higher than we'd anticipated, so a minor modification is required to the power supply before it can be used here.

The modification is quite straightforward and simply involves replacing the 100Ω 5W resistor (R1) with a 5.1V, 5W Zener diode. The banded (cathode) end of the Zener must point away from the 7805 regulator (see photo), and its body spaced about 3mm above the board surface. The two PC board holes may need to be drilled out to 1.2mm to accept the larger diameter leads.

Wiring

If a different power source is to be used, it *must* have a well-regulated output of 5V ±5%. A plugpack or other poorly-regulated source is unacceptable and may cause erratic operation or even component failure.

The chosen supply should also power the 5V relay circuit on the preamp board, or at least share a common ground with it. Use medium-duty multi-strand cable for the supply wiring and twist the two wires together to reduce noise and improve appearance.

We suggest using black for ground (0V) and some other colour for +5V – preferably a different colour to that used for the ±15V wiring. The power input connector (CON1) can then be marked using the same felt-tipped pen colour to reduce the chances of cabling mistakes.

Next, hook the 10-way headers on the preamp and control module together using a length of 10-way IDC cable. The plugs and sockets are keyed, so as long as you take care to create a one-to-one connection when crimping on the IDC plugs, all should be well!

Finally, it is *very* important that the motor housing is connected to chassis earth. We suggest running a separate wire from the point marked 'EARTH' on the PC board to the main earth point, rather than relying on the pot to make contact with the metalwork. Note that the motor housing is not connected to the ground (GND) rail on the control module to avoid creating an 'earth loop'.

Setup and testing

To successfully complete the following instructions, you'll need a universal remote control that you have programmed for use with a Philips brand appliance. Refer to the panel titled 'Universal Infrared Remote Controls' before proceeding.

OK, let's check the supply rails. Apply power and measure the voltage between pins 10 and 20 of IC1's socket. Your meter should read 5V ±5% – if not, switch off immediately and look for cabling faults and the like.

Assuming all is well, power off and insert IC1 in its socket, making sure that the notched (pin 1) end is oriented as shown on the overlay diagram (Fig.5). Now insert a jumper shunt on JP1 to place the module in setup mode and power up again. The five

High-Quality Pot Upgrade

In anticipation of this project, several readers suggested that we present a design with a digital, rather than analogue (ie, motorised pot) volume control.

We considered the possibilities of a digital design. It appeared that the best performance could be realised by using a digitally controlled analogue gain/attenuation block. As luck would have it, Burr-Brown (TI) offers a single-chip device that integrates all of the necessary elements and introduces very low distortion. That seemed like the right solution to the audio part of the design (ignoring the additional distortion) but elsewhere it starts to get complicated!

For a start, we'd need some method of indicating the volume settings to the user. We'd also need a means of adjusting the volume. In our opinion, simple 'up' and 'down' buttons don't cut the mustard; you just can't beat a rotary dial for volume!

So at a minimum, we'd need a 'high-spec' digital/analogue volume control IC, a liquid crystal display (or large LED bargraph), a rotary encoder and a microcontroller. Unfortunately, the whole shooting match would be too expensive for most constructors, particularly if it were not made available as a kit.

Anyway, we believe we've struck a good compromise. Our design uses a motorised potentiometer, but we've included provision for either the low-cost Altronics **www.altronics.com.au** pot or a higher quality RK27 series Alps pot. These 27mm Japanese-made pots have a rated minimum life of 15,000 rotations and a maximum gang error of 2dB over the –60dB to 0db range.

Only two small changes need to be made to the board to support either type of pot. To use the low-cost pot, use a 10Ω value for the current sense resistor (R1) and leave out jumper JP2. For the Alps pot, fit a 6.8Ω resistor instead and install a jumper shunt on JP2. That's it – with one caveat, as follows.

No mute?

During prototype development, we were unable to get the muting facility to work reliably with the Alps pot. We found that the motor current tended to vary from pass-to-pass, perhaps suggesting a peculiarity with the gearbox design. It may also have been peculiar to our batch of pots – we can't be absolutely sure! Regardless, this made it impossible to adjust VR1 for reliable cut-off when hitting the end stop.

In the end, we went ahead with support for the Alps pot anyway, as we believe that most constructors who would be willing fork out for this expensive option would also be willing to forgo the muting function, for which they may have little (if any) use.

We understand that the Alps RK27 pots are available from a variety of Internet sites – check for one-off quantities. Be sure to get a 10kΩ type with a '15A' resistance taper and check that the shaft style and length suits your particular application.

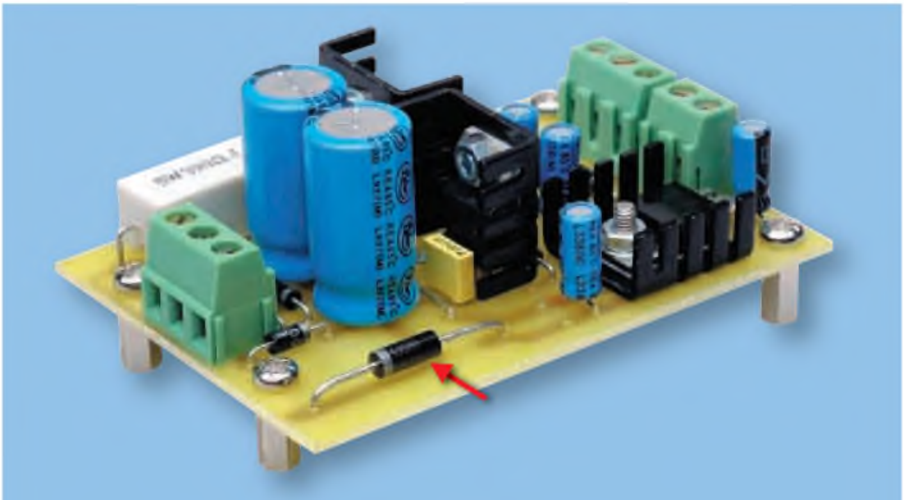
For detailed technical information on the RK27 series, check out the product catalogue on the Alps website at: **www.alps.com**.

red LEDs should flash in sequence the moment power is applied to indicate setup mode.

Now point your remote at the infrared receiver (IC3) and press one of the numeric keys (1 to 9) twice. On the first press, the 'acknowledge' LED should flash once, whereas on the second press, it should flash five times. This indicates that the micro has successfully determined the equipment address and stored it in EEPROM for future use. This completes the microcontroller setup, so power the module down and remove JP1.

Pot'n around

We'll test the motorised pot next, so be sure to insert a jumper on JP2 if you've fitted an Alps pot. Conversely, if you're using the standard Altronics pot, this jumper must not be installed. Exercise the pot by moving it manually over its full range of motion several times. This helps to break in the clutch before we continue with the adjustment procedure.



Replace the 100Ω 5W resistor on the power supply board with a 5.1V 5W Zener diode, as shown here. Note the orientation of the cathode (banded) end of the Zener.

Next, rotate trimpot VR1 fully clockwise and power up. You should now be able to use the volume up/down

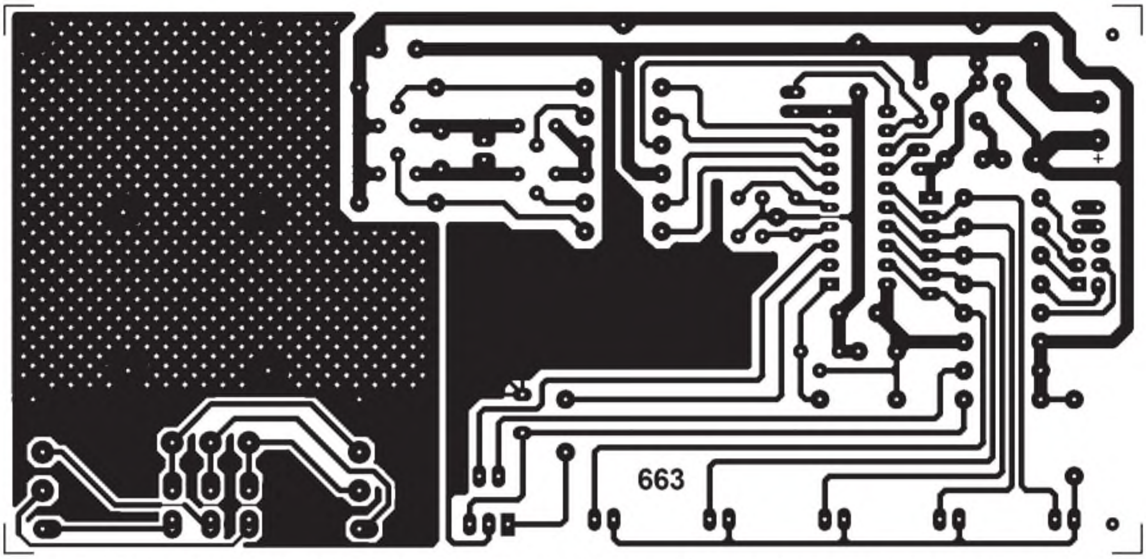


Fig.6: check your board against this is the full-size etching pattern before installing any of the parts.

and channel up/down buttons on the remote to move the pot in both directions. If it moves the wrong way, simply reverse the leads to the motor.

Now set the pot to its mid-position and hit the 'mute' button ('12' on the AIFA Y2E). The pot will rotate anticlockwise for 12 seconds and as soon as it hits the stops, the clutch will start to slip. While this is happening, rotate trimpot VR1 slowly in an anticlockwise direction until the motor cuts out.

Now drive the pot clockwise for a second or so and press the 'mute' button again. This time, the motor should stop as soon as the pot reaches its minimum position. If it stops prematurely or fails to stop at all (ie, the motor runs for the full 12 seconds), try repeating the adjustment. Once the adjustment is correct, pressing the mute button a second time will result in the pot being returned to its original position.

It's important to note that if the cut-out function fails to operate when the pot reaches its minimum position, the motor will continue to run for 12 seconds (the full-travel period). Pressing the mute button a second time will have no effect, as the program has no record of the original shaft position!

Wrap up

Well that's about it. All that's left to do is to connect the two sections of the motorised pot to the preamp using shielded audio cable. Each side of the pot is brought out to a 3-way terminal block (CON4 and CON5) on the PC board to make hook-up relatively easy.

The cable on the lefthand side can be routed through the large hole just to the rear of CON4. As shown on Fig.5, the centre terminal (GND) connects to the cable shields; do not connect the shield to chassis ground! Refer to the preamp project for more details.

Next month's article, we'll show you how to assemble the preamp, headphone amplifier, remote control module and power supply into a very nice slimline case! In the meantime, happy listening!

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RC5 Infrared Protocol – A Primer

Every time you press a button on your remote, a message comprised of the key code and equipment address is composed, encoded and then modulated before being transmitted using a high-brightness infrared LED.

In the RC5 coding scheme, each message is composed of a 14-bit serial stream. A message consists of four parts:

- Start part – 1.5 bits (2 x logic '1')
- Control part – 1 bit
- System part – 5 bits
- Command part – 6 bits

The start bits give the receiver time to 'lock on' to the incoming data. The control bit, also called the toggle bit, is simply a flag to indicate whether the following code is new or repeated. If a new key is pressed, the control bit toggles (changes state) from its previous value, otherwise it remains the same.

The system bits represent the equipment address (TV, CD, VCR, etc), while the command bits are the code for the actual key pressed.

On the physical level, data is transmitted using bi-phase (also known as Manchester) encoding. A logic one is represented by a zero-to-one transition at 1/2 bit time, whereas a logic zero is represented by a one-to-zero transition.

One bit time is approx. 1.778ms, so a complete message is 24.889ms long, with messages repeated at a minimum of 114ms intervals. To reduce interference from other light sources, data is transmitted on a 38kHz carrier.

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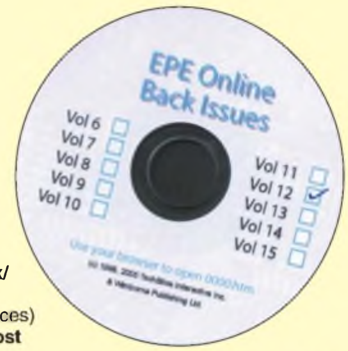

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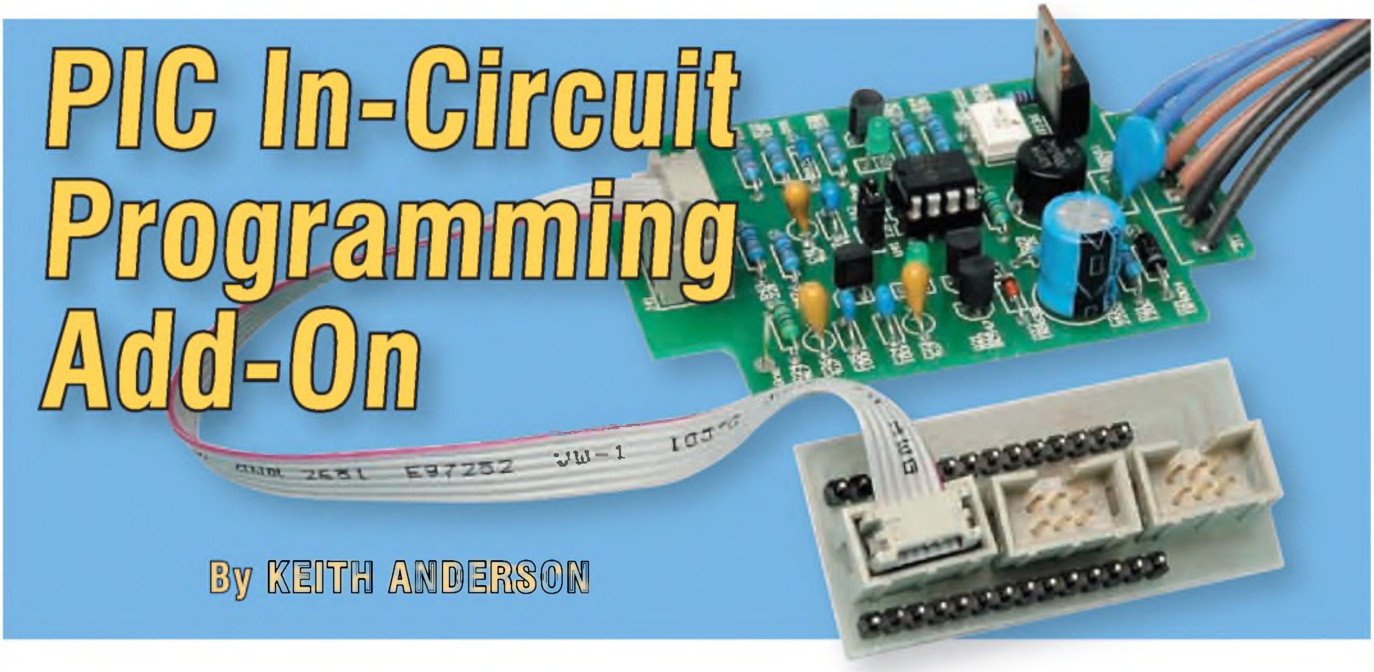
PIC In-Circuit Programming Add-On

By KEITH ANDERSON



Does your PIC programmer have provision for in-circuit programming? Some, such as Microchip's PICSTART Plus don't, but you can add this useful function to your programmer by building a simple adaptor!

OFTEN, THE EASIEST way to program a PIC is to remove it from its circuit and plug it into an appropriate programmer. However, when developing new projects, this can become a real chore, and so professional developers use a range of tools that allow programming and even debugging without removing the micro from the application circuit. Microchip refers to this method of programming as *In-Circuit Serial Programming* (ICSP).

WARNING!

This adaptor was designed and tested for use with Microchip's PICSTART Plus programmer, which allows all PICs to be inserted with pin 1 aligned to pin 1 of the programming socket.

Some low-cost programmers lack this flexibility and require the smaller PICs to be inserted with pin 1 in some location other than the socket's pin 1. This unit will not work with this type of programmer!

While not all low-cost programmers support in-circuit programming, some can be modified to do so. Hobby programmers are usually supplied as kits, so it is often possible to solder wires to appropriate places within the circuit for connection to the application circuit's ICSP header. However, this method is not general to all programmers.

The method used here, is to plug an adaptor into the socket on the programmer. The adaptor picks off the programming signals and makes them available for connection to the application circuit, just like a 'real' ICSP programmer. The programmer still 'thinks' it is programming a PIC in the socket, when in fact it is programming the PIC in the application circuit.

Adding programming support

If your PIC-based project is to support in-circuit programming, then you must include a suitable connector on the PC board to accept the ICSP signals from the programmer. A minimum of five connections is required to carry the ICSP and power/ground connections, which are: DATA, CLK, $\overline{MCLR}/V_{PP}$, V_{DD}, and GND. The suggested connector layout (Fig.1) uses a 6-pin dual-in-line header, with a spare pin available for other uses.

The circuit example in Fig.2 shows how the connector might be hooked into your PIC-based designs. Note that a switch must be inserted in series with the positive supply (V_{DD}) to the PIC, so that either the application circuit or programmer can provide power. By controlling power to the PIC micro, the programmer is able to generate the necessary supply sequencing during the programming cycle.

A 3-pin jumper could be used in place of the switch to save money and minimise use of board space. The switch (or jumper) must be downstream from all filter/decoupling capacitors and positioned as close as possible to the PIC's V_{DD} pin.

ICSP adaptor

The circuit for the adaptor is shown in Fig.3. The large 28-way header (comprised of J1 and J2) plugs into the

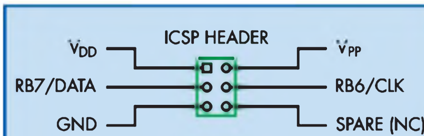


Fig.1: if you want to program your PIC in-circuit, then you must include an ICSP header on your board. Here are the recommended pinouts for the header.

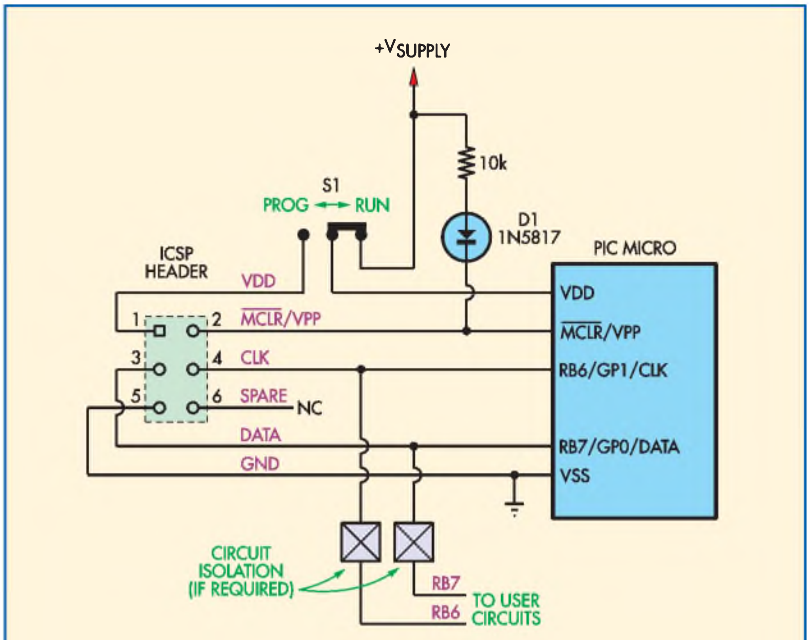


Fig.2: this simplified circuit shows how to include the ICSP header in your projects. If the RB6 and RB7 port bits are used as inputs or to drive low-impedance outputs, then some form of isolation will be required, otherwise the CLK and DATA signals from the programmer will be overloaded. In some cases, this can be as simple as two 1kΩ resistors. If possible, don't use RB6 and RB7 for any other purpose in your design – that way, you won't need to add isolation circuitry.

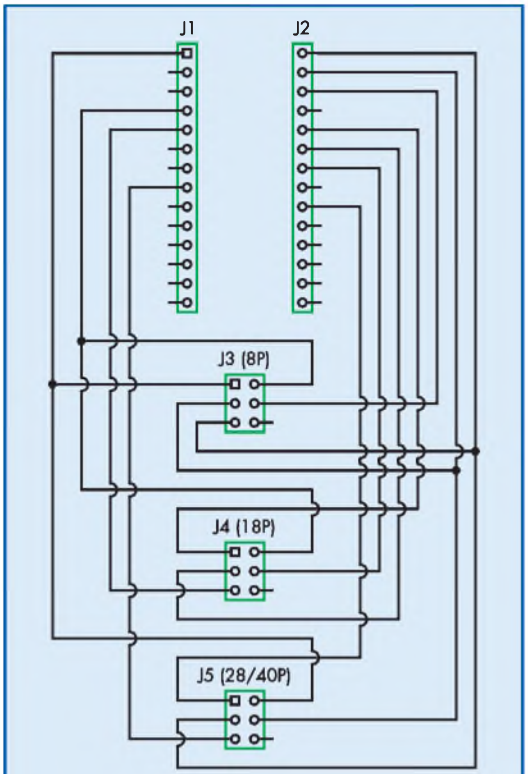
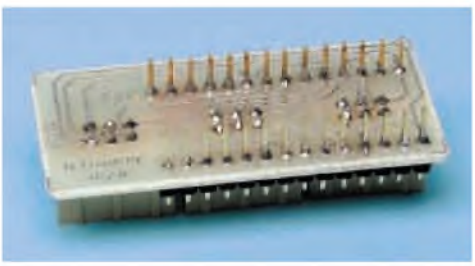


Fig.3: the circuit for the adaptor. Note that the ICSP signals for each family (8, 18 and 28/40-pin) originate from different pins on the programming socket.

programmer's socket, with the ICSP signals made available on one of three 6-pin headers (J3-J5) for connection to the application circuit, depending on the type of PIC in use.

Somewhat fortuitously, Microchip assign the pins required for the ICSP functions consistently, so that most of the range of PICs can be grouped into just three families: 8-pin, 18-pin and 28-pin (to the programmer, 40-pin PICs look like 28-pin PICs).

A 6-pin header is provided on the adaptor for each family type. Connection to the application circuit is made with a short length of 6-way IDC cable, terminated at each end with a 6-way IDC socket. Unlike some ICSP adaptors, the use of a specific header (rather than jumpers or switches) for each family of PICs provides a simple visual indication of correct device selection!



This view shows how the 28-way header pins protrude through the PC board.

Assembly

A PC board (coded 665) is available for this design. Assembly is very simple; just make sure that you insert the 6-pin headers (J3-J5) into the PC board the right way around. The arrow on the header must line up with the square pad (pin 1) on the PC board in each case.

A cunning trick is needed to install the two 20-way SIL header strips (J1 and J2) when using a single-side PC board. Insert each header 'upside down' in its holes, so that the long ends of the pins protrude from the underside of the PC board (see photo).

A little extra pin length can be obtained by pushing each pin through the plastic until the top is flush with the top of the plastic. Obviously, this must be done before the pins are soldered to the PC board. The ICSP cable must not be more than 300mm long, although 190mm is recommended for best results. The prototype was tested with a PICSTART Plus programmer and a couple of representative circuits. ***EPE***

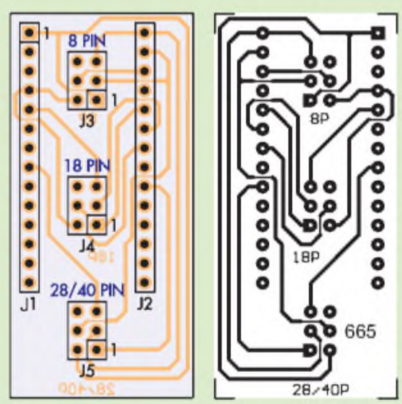


Fig.4: overlay diagram and full-size PC-board pattern for the adaptor. Ideally, the adaptor should be produced in double-sided, plated-through PC board technology, but it can also be assembled on a single-sided board with a little trickery.

MIDI Activity Detector

by David Clark

If you build, repair or regularly set up MIDI (Musical Instrument Digital Interface) systems, you need this easy-to-use, 'quick-check' gadget!

SETTING up a MIDI system is generally a relatively simple matter for someone with a certain amount of experience. Once all the cables are correctly connected, it is usually just a matter of making the correct settings for channel numbers, local on/off, MIDI thru and so on. This, however, only applies if it is certain that all the equipment in the system is working correctly.

Things get a little more complicated when all the 'tweaks' have been tweaked, and the system still doesn't work. Have you missed something, or is something broken?

Using an oscilloscope to check signals in a MIDI system, as with most digital serial communication systems, yields little useful information other than to show whether there is a signal there or not. It is usually impossible to obtain a static display, let alone decipher the meaning of the rapidly changing on/off states if they are present.

Things can be even worse when a PC is a part of the system. For example, some time ago the author spent a long period puzzling as to why his simple MIDI system, which at the time consisted solely of a MIDI controller keyboard and a PC with a soundcard that had a built-in MIDI interface, would not work correctly. The system didn't produce a single sound when the keyboard was played (yes, the loudspeakers were connected!), but did so when playing back some notes that had been programmed into the software sequencer running on the PC.

A 'scope check showed plenty of activity on the 'MIDI out' connector of the keyboard, the 'MIDI thru' tickbox had been correctly selected in the software, and the fake-LED-style indicator in the application showed that MIDI data was being sent from the sequencer. What was happening? A MIDI Activity Detector was needed!

MIDI messages

The MIDI messages that carry musical information between connected devices come in two 'flavours', channel messages and system messages. As the names imply, channel messages are specific to one of the sixteen channels available, and system messages apply to everything connected into the system. Thus, generally speaking, channel messages send information that tells devices when to play particular notes and how they should sound, and system messages can contain tempo, song position and active-sensing information.

Hardware synthesisers and multitrack recorders usually send (and sometimes receive) a lot of system messages. A commonly used system message is the 'clock' message, which, as might be expected, controls the synchronisation between a controlling device and other slave devices.

So it is easy to see how a MIDI cable can show a lot of activity on an oscilloscope and make it very difficult to establish what type of signals are present. To extract diagnostic information, some form of filtering is necessary, and this is essentially what the MIDI Activity Detector does.

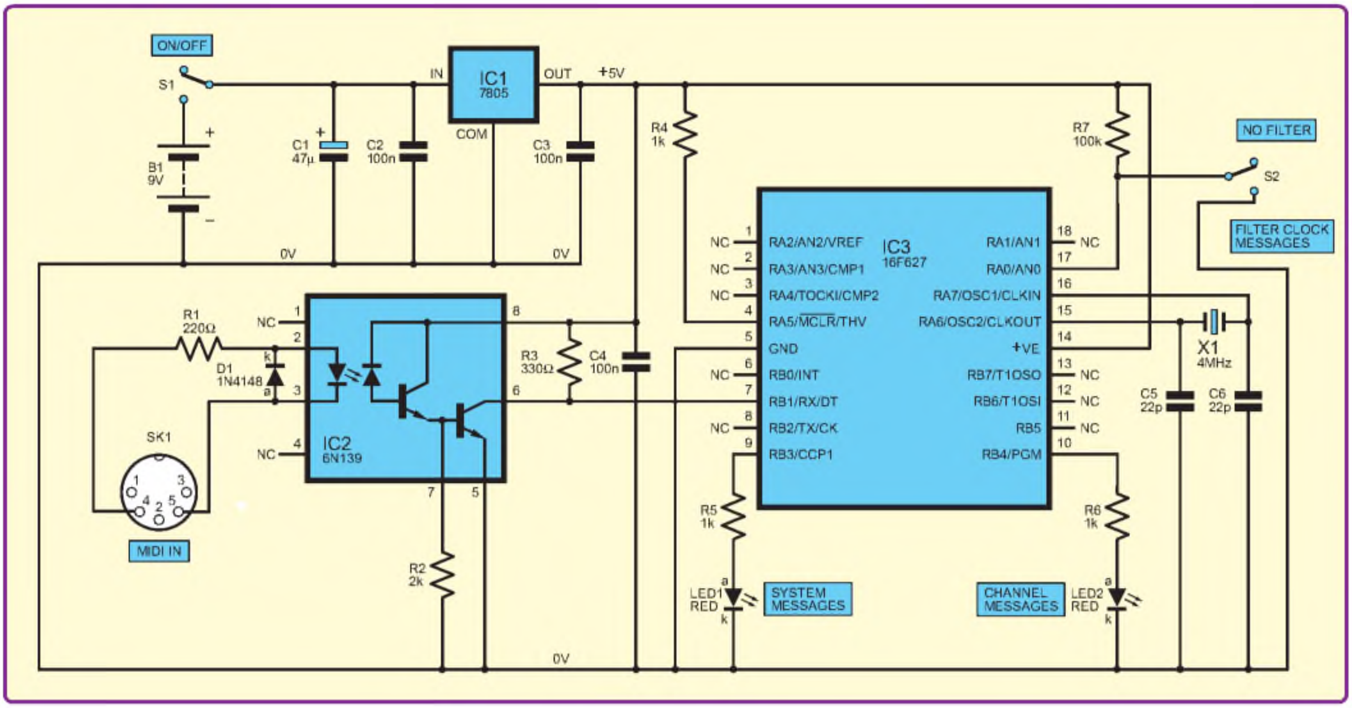


Fig.1: Complete circuit diagram for the MIDI Activity Detector

Useful information

In fact, it is a great deal of help simply to separate channel and system messages. System messages are usually sent continuously, even from a simple keyboard controller that has no in-built sound generator.

An 'active sensing' signal is often found in a MIDI system for example. This is transmitted several times a second from a controlling device, and a receiving device designed to take advantage of this can switch itself off if the active sensing message is missing. This can be particularly useful in saving embarrassment should a cable get pulled out in the middle of a very loud performance and no 'note off' messages can get through – especially when everyone else in the band reaches the end of a song and stops playing!

During fault diagnosis, separating out system messages makes it easy to see if channel messages are created when keys are pressed and released, or a pitch wheel is moved, immediately highlighting the problem if they are missing.

Another system message transmitted continuously, at least when a sequencer and/or multi-track recorder with a 'send MIDI clock' facility is running, is the clock message. Filtering this out of the system messages prevents it masking other system messages that might be of interest: 'system exclusive' messages for example, which are often used to 'dump' configuration data. (Note that it is only the displaying of these pieces of information that are filtered out – no information is removed from the data stream.)

How it works

The full circuit diagram for the MIDI Activity Detector is shown in Fig.1. The circuit is easily described, as all of the manipulation and filtering of the MIDI messages received by the device is done in the software programmed into a PIC 16F627. The MIDI In interface is the standard opto-isolator circuit found in MIDI devices designed to the MIDI standard; utilising in this case a 6N139 (IC2) – see Fig.1.

The circuit around the PIC microcontroller (IC3) is also pretty much

Parts List – MIDI Activity Detector

1 PC board, code 664, available from the *EPE PCB Service*, size 98mm x 76mm
1 ABS plastic box, approx 150mm x 100mm x 55mm
2 SPDT toggle switches (S1 and S2)
1 5-pin 180° DIN socket, panel mounting (SK1)
1 quartz crystal, 4MHz (X1)
1 8-pin DIL, IC socket
1 18-pin DIL, IC socket
1 PP3 battery clip and 9V battery (B1)
4 PCB mounting pillars
12 terminal pins

Semiconductors
1 1N4148 signal diode (D1)
1 78L05, T092 5V voltage regulator (IC1)
1 6N139 Darlington opto-isolator (IC2)
1 PIC 16F627 microcontroller (preprogrammed *)(IC3)
2 red LEDs (LED1, LED2)

Capacitors
1 47mF aluminium electrolytic, 16V (C1)
3 0.1mF polyester, 63V (C2-C4)
2 22pF ceramic, 50V (C5, C6)

Resistors (0.25W, 5% carbon film)
1 220W 3 1kW
1 2kW 1 100kW
1 330W

* Available from Magenta Electronics (**www.magenta2000.co.uk**), see their advert.

Assembly

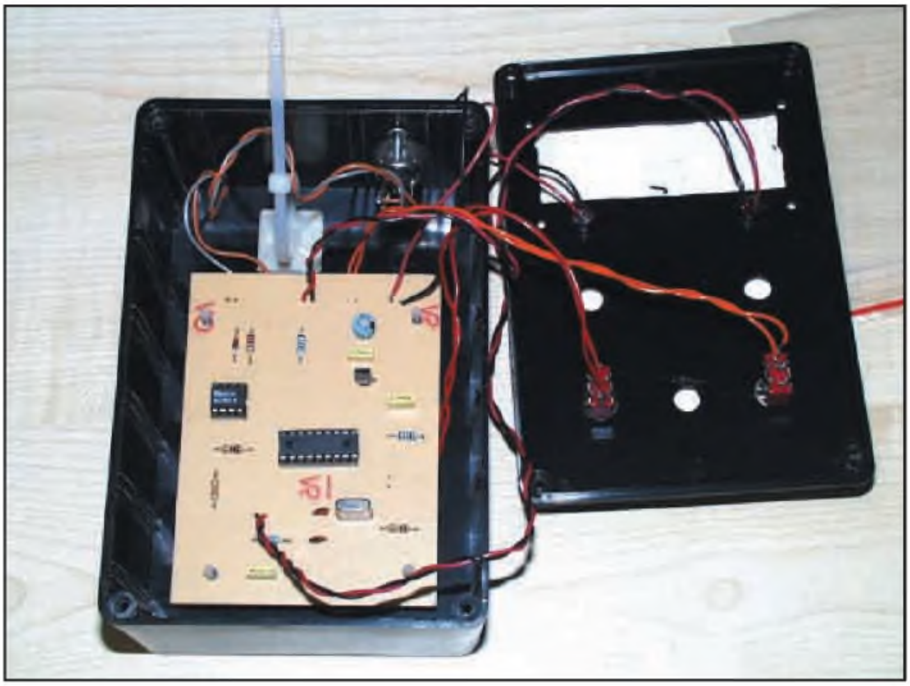
The component layout and wiring details for the MIDI Activity Detector are shown in Fig.2, together with the full-size PCB copper foil etching pattern. Assembly is straightforward; ideally, fix the components in order of increasing height and leave the voltage regulator until last to reduce the risk of electrostatic damage.

For the same reason, it is best to use sockets for the ICs. Only insert them after the PCB and wiring have been given a final inspection, and after the voltage at IC2 socket pin 8 and IC3 socket pin 14 has been found to be the correct 5V when the circuit is powered up.

The wiring details for the off-board components is also shown in Fig.2. The LEDs can be soldered directly to the PCB if the project is not to be housed in an enclosure. Otherwise, a suggested front panel layout for the device is shown in the title photograph.

In use

Simply connect the MIDI out of the device being tested to the MIDI In of the MIDI Activity Detector and switch the clock filter in or out as required.



General layout of components inside the author's prototype model. The lid of the plastic case was 'salvaged' from another project

No prizes!

Incidentally, no prizes for guessing what the problem was with the author's system – the application needed a software update patch just for the sequencer 'MIDI thru' function to work at all! ***EPE***

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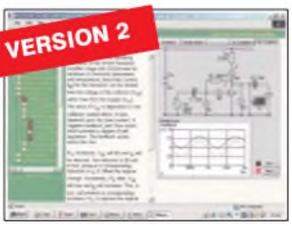
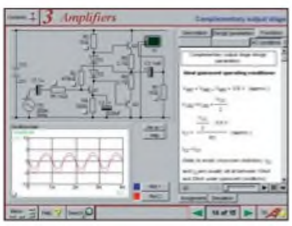


Circuit simulation screen

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

ANALOGUE ELECTRONICS

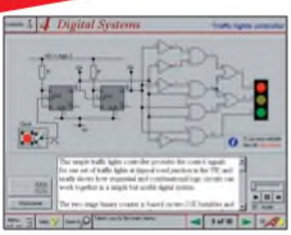


Complimentary output stage

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

DIGITAL ELECTRONICS V2.0

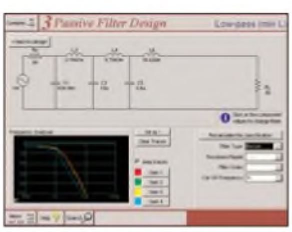
VERSION 2



Virtual laboratory – Traffic Lights

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

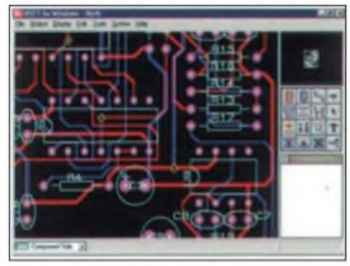
ANALOGUE FILTERS



Filter synthesis

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

ELECTRONICS CAD PACK



PCB Layout

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

ROBOTICS & MECHATRONICS

Case study of the Milford Instruments Spider

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

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

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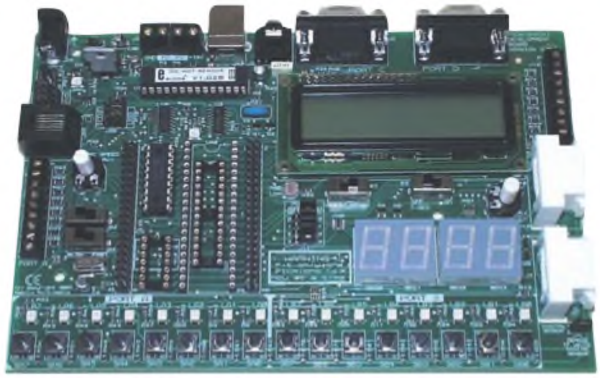

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(Formerly PICtutor)

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● 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

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

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

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

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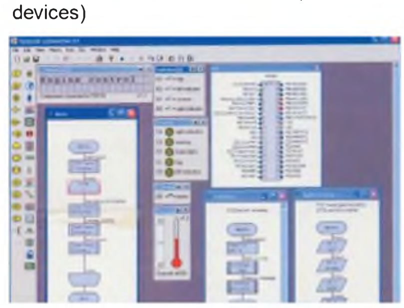
● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

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



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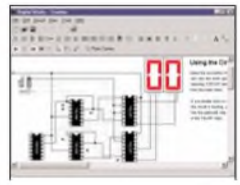

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Teach-In 2008

Part Six – 24-Hour clock, frequency generation and data EEPROM

JOHN BECKER

In the previous parts of this *Teach In 2008* series, we have now told you enough information to create a 24-hour clock. It uses an LCD as the visual output. It is accurate within the tolerence of the crystal.

You have been shown how a one second timing routine can be written. That is taken as the starting point now. Next, its rollover rate is fed to a seconds counter, using the BCD counting method. When that reaches decimal 60, it is reset to 0 and a minutes counter is incremented, in BCD. When that reaches decimal 60, it is reset to 0 and an hours counter is incremented, again in BCD.

When the hours counter reaches 25, it is reset to 0. In principle a similar process could be used to create a calendar clock, but then the process becomes more complicated as different months have different numbers of days to them, and then there is the question about leap years. It is beyond the role of *Teach In 2008* to demonstrate a calendar clock.

You have already been shown how to count in BCD. Now we use seperate BCD counters for the seconds, minutes and hours. The program is shown in Listing 6.1.

The listing is not explained in detail, but you may use the routines in your own programs as library sections, using the copy and paste method.

The circuit diagram and its breadboard layout are shown in Fig.6.1 and Fig.6.2. Assemble the breadboard and connect the LCD. Load the PIC with **TEACH-INF06.HEX**, and run it.

To set the clock to the correct time, press switch S2 to increment the hours, at a rate of one per second. Switch S1 increments the minutes. When hours reach their limit of 24, their value rolls over to zero. When minutes reach their maximum of 60, the value also rolls over to zero. Pressing S3 resets the seconds to zero. Adjusting any setting does not affect the other settings.

The overall timing accuracy is as good as the frequency tolerance of the crystal allows. Again, there are ways to correct the timing to adjust the accuracy, but such are beyond *Teach In 2008.*

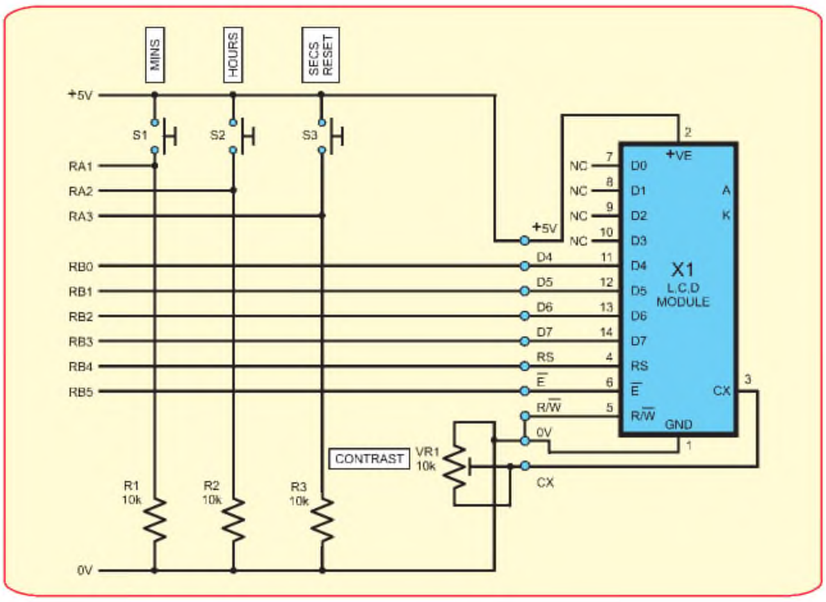

Fig.6.1 Circuit for the 24-hour clock demonstration

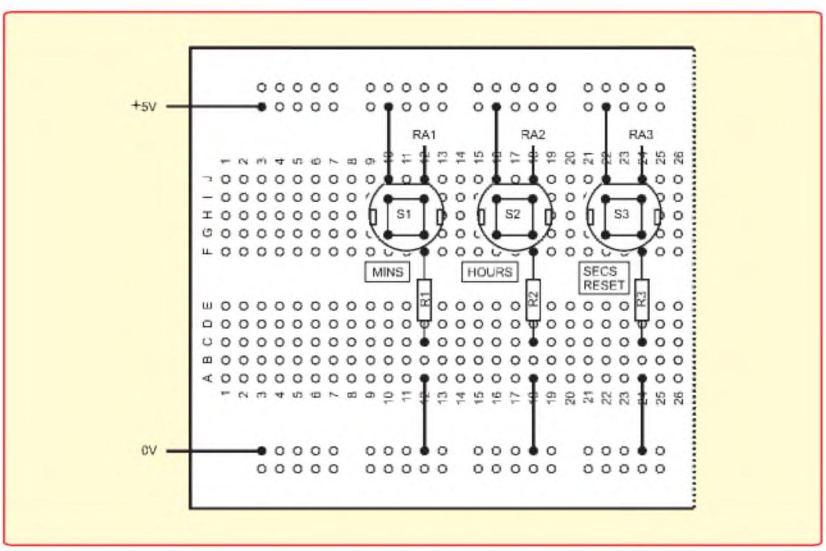

Fig.6.2 Breadboard layout for Fig.6.1

Indirection Register

Part of the program in Listing 6.1 uses what is known as *Indirect Addressing* to access registers. This concept also has profound implications for the ability to minimise the number of sub-routines required by a program.

Indirect Addressing allows the use of generalised routines which do not apply to any specific register files. The file which the routine accesses is specified prior to entry into the routine and can be changed at will to suit different aspects of the program.

The two key commands (or, rather, 'file registers') in Indirect Addressing are FSR (File Select Register) and INDF (INDirect File). The idea of Indirect Addressing is that you place the address of the file that you wish to access in register FSR. Commands to access the specified file address are then made via register INDF.

Not only does this facility allow the same routine to be applied to different calling routines, it also allows a loop to access a sequence of files without having to specify their individual addresses other than that for one of them in the sequence.

In the following example, assume that we have a sequence of files between addresses H'20' and H'2F' (16 files), call them FILE0 to FILE15. Their addresses will have been equated at the head of the program in the usual way, usually via the CBLOCK method, although they could be equated seperately. In reality, only the name of the first file is important in this instance.

Suppose, for example, we wished to clear all 16 of these files prior to another routine and that we shall do it in ascending order using a loop. Prior to entering the loop we get the address of the first file, in this case FILE0, copy it into FSR and reset the loop counter, let's call it LOOPA:

```
        MOVLW FILE0
        MOVWF FSR
        CLRF LOOPA
```

Now all we need to do is use the following simple routine:

```
RESET   CLRF INDF,F
        INCF FSR,F
        INCF LOOPA,F
        BTFSS LOOPA,4
        GOTO RESET
```

Command **CLRF INDF,F** clears the file whose address is held in FSR. Next, **INCF FSR,F** increments the value held by FSR, in other words FSR is incremented to point to the next file we wish to clear (FILE0 in the first instance of the loop, FILE1 in the next). Next, we increment the loop counter, **INCF LOOPA,F**, and test its bit 4 (**BTFSS LOOPA,4**) to see if a count value of 16 (00010000) has been reached (remember we started at 0). If the count is not yet 16, the loop is repeated, **GOTO RESET**. If the count equals 16, the next command after **GOTO RESET** is performed, whatever that might be in a full program.

Another way of doing it (and there are several ways) is:

```
        MOVLW FILE0
        MOVWF FSR
        MOVLW 16
        MOVWF LOOPA
RESET   CLRF INDF,F
        INCF FSR,F
        DECFSZ LOOPA,F
        GOTO RESET
```

You can also use similar constructions to access a sequence of table values (from anywhere within that table) and add them to the values within a sequence of indirectly addressed files, keeping the maximum resulting addition to less than the maximum number of temporary registers that the PIC provides.

In the following example, the first address required in the table is at jump 3. This value is first placed into COUNT (**MOVLW 3, MOVWF COUNT**). We want to start adding the acquired table value to the file starting six bytes beyond

Listing 6.1A

```
MAIN    btfss INTCON,2          ;has a timer time-out been detected?
        goto MAIN               ;no
        bcf INTCON,2            ;yes
        call CLKADD             ;do time
        goto MAIN

CLKADD  decfsz CLKCNT,F         ;increment system clock counter. Is it = 0?
        return                  ;no

        movlw 25                ;reset start value of CLKCNT
        movwf CLKCNT
        call GETKEY             ;check switch status
        incf HLFSEC,F           ;inc half sec counter
        btfsc HLFSEC,0          ;is half second bit clear (= 0)?
        call CLKIT              ;no, it's = 1, so update secs etc
        return                  ;yes, so don't update secs etc

CLKIT   movlw CLKSEC            ;get address of CLKSEC
        movwf FSR               ;move it into indirect reg
        movlw 3                 ;set loop to 3
        movwf LOOP
        clrf STORE1

ADDCLK  incf INDF,F             ;inc units - all in BCD
        movlw 6
        addwf INDF,W            ;if 6 is added is there a digit carry?
        btfsc STATUS,DC
        movwf INDF              ;yes

ADDCL2  movf STORE1,W           ;now check if value > allowed value
        call CHKVAL
        movwf STORE2
        movf INDF,W
        subwf STORE2,F          ;is count =< than allowed?
        btfsc STATUS,C
        goto CLKSHW             ;yes
        clrf INDF               ;no, it's greater, so clear it
        incf STORE1,F           ;and add 1 to time loop & byte
        incf FSR,F
        decfsz LOOP,F           ;dec loop, is it = 0?
        goto ADDCLK             ;no

CLKSHW  call LCD21
        bsf RSLINE,4
        movf CLKHRS,W           ;get hrs
        call LCDFRM             ;format and send it
        movlw ':'               ;insert colon
        call LCDOUT
        movf CLKMIN,W           ;get mins
        call LCDFRM
        movlw '.'               ;decimal point
        call LCDOUT
        movf CLKSEC,W           ;get secs

LCDFRM  movwf STORE2            ;split & format decimal byte for LCD
        swapf STORE2,W          ;get tens nibble
        andlw 15
        iorlw 48                ;ASCII convert it
        call LCDOUT             ;send it
        movf STORE2,W           ;get units
        andlw 15
        iorlw 48                ;ASCII convert it
        call LCDOUT             ;send it
        return
```

Listing 6.1B

```
GETKEY  btfss PORTA,1          ;is S1 (hrs+1) pressed?
        goto CHKSW2            ;no
        incf CLKHRS,F
        movlw 6                ;check if units >9
        addwf CLKHRS,W         ;if 6 is added is there a digit carry?
        btfsc STATUS,DC
        movwf CLKHRS           ;yes
        movlw b'00100100'
        xorwf CLKHRS,W
        btfsc STATUS,Z
        clrf CLKHRS
        goto CLKSHW            ;show time setting
        return

CHKSW2  btfss PORTA,2          ;is S2 (min+1) pressed?
        goto CHKSW3            ;no
        incf CLKMIN,F
        movlw 6                ;check if units >9
        addwf CLKMIN,W         ;if 6 is added is there a digit carry?
        btfsc STATUS,DC
        movwf CLKMIN           ;yes
        movlw B'01100000'      ;59 mins max
        xorwf CLKMIN,W
        btfsc STATUS,Z
        clrf CLKMIN
        goto CLKSHW            ;show time setting
        return

CHKSW3  btfss PORTA,3          ;is S3 (secs) pressed?
        return
        clrf CLKSEC
        bsf HLFSEC,0
        movlw 25               ;reset start value of CLKCNT
        movwf CLKCNT
        goto CLKSHW            ;show time setting
```

FILE0 so the value of 6 is then added to the address of FILE0 and the result placed into FSR (**MOVLW 6, ADDLW FILE0, MOVWF FSR**). We also want to perform the action five times, so a loop (LOOPA) is set up with the initial value of 5 (**MOVLW 5, MOVWF LOOPA**).

The real action then starts at label GETVAL. The current value held in COUNT is copied into W (**MOVF COUNT,W**). The table is called (**CALL TABLE**) and the value held in the table at the location indicated by the value in W is retrieved from the table, being automatically placed into W. The value from the table now in W is then added to the value in the file held via INDF and pointed to by FSR, and the result is stored back into the same file (**ADDWF INDF,F**).

File FSR is now incremented (**INCF FSR,F**), so incrementing the address of the file held via INDF. Count is incremented (**INCF COUNT,F**), and LOOPA is decremented. If LOOPA is not yet zero the process repeats.

```
        MOVLW 3
        MOVWF COUNT
        MOVLW 6
        ADDLW FILE0
        MOVWF FSR
        MOVLW 5
        MOVWF LOOPA
GETVAL  MOVF COUNT,W
        CALL TABLE
        ADDWF INDF,F
        INCF FSR,F
        INCF COUNT,F
        DECFSZ LOOPA,F
        GOTO GETVAL
```

In the 24-hour clock program, the three consecutive registers CLKSEC, CLKMIN and CLKHRS are used. It is they which are accessed by the indirect addressing technique when the clock is in normal running mode, in the routine **CLKIT**.

First the address of CLKSEC is moved into W and copied into register FSR. LOOP is then set with a value of 3. At ADDCLK, the file within register INDF, as pointed to by the value within FSR (i.e. CLKSEC) is incremented. Because we are using BCD counters in this program, a value of 6 is then temporarily ADDed to CLKSEC, still via INDF, and the appropriate storing of the value taken if the result has caused the DC flag to be set.

Next, the value now effectively in INDF (still CLKSEC) is checked to see if it is greater than that permitted, by comparing it with a preset value held in the table at CHKVAL (not shown) (the use of command **subwf** is discussed a bit later).

Following the check and its resulting action as required, register FSR is incremented (to now point to register CLKMIN). If CLKSEC has now been reset to zero, a similar additive process is repeated for CLKMIN, via INDF, which now points to CLKMIN, whose address is now held in FSR.

A similar action for CLKHRS is performed if CLKMIN has become zero, again via FSR and INDF.

In another application, the process could have been repeated by constantly incrementing FSR as many times as are necessary. There are many roles in which Indirect Addressing can be used beneficially. You will see other good examples if you examine Peter Hemsley's BIN2DEC and maths routines.

Commands SUBWF and SUBLW

In the above discussion, command SUBWF was used, which performs a subtraction process. Let's examine the two subtraction commands available with PICs.

PICs have two subtraction commands, SUBLW (Subtract W from Literal) and SUBWF (Subtract W from File). The latter command is used with either the F or the W suffix, e.g. **SUBWF (FILE),F** and **SUBWF (FILE),W**.

One might reasonably have expected that SUBLW would actually mean Subtract Literal from W. This is not the case, the subtraction is that of W from the Literal. Consequently, unless you keep your wits about you, this is a command that you could quite easily use incorrectly. In the following code, the value in the file named DEMO is subtracted from 30 and the result put back into DEMO (the first two lines are just to put an initial value into DEMO):

```
MOVLW 20
MOVWF DEMO
MOVF DEMO,W
SUBLW 30
MOVWF DEMO
```

In this case, the answer is 10 (30 – 20), even though instinctively we might have expected 30 to be subtracted from 20. In this next example, to illustrate SUBWF, again it is the value already in W which is subtracted from the value in file DEMO, the result being returned to DEMO. This is more logical. (Once more the first two commands are just to put an initial value into DEMO.)

```
MOVLW 20
MOVWF DEMO
MOVLW 5
SUBWF DEMO,F
```

The answer put back into DEMO is, of course, 15 (20 – 5).

In these two examples, the value subtracted is less than the value from which it is being subtracted. What happens if the opposite is true?

For a start, if the value subtracted is greater than the value from which it is being subtracted, the byte simply 'rolls over'. We have already shown that decrementing a value of zero results in an answer of 255. Decrementing, of course, is simply a subtraction of 1 from a number and we could, therefore, consider the 0 - 1 situation as being expressed (256 + 0) – 1 = 255.

What we have done by using the addition of 256, is to 'borrow' the 256 in order to achieve the correct 8-bit result. The same roll-over situation applies to subtraction of numbers greater than 1. Thus subtracting 20 from 10 produces an answer of 246 (256 + 10 – 20 = 246).

We are quite used to 'borrowing' in normal arithmetic, so the concept should be familiar to you, although we express the result of subtracting 20 from 10 as equalling – 10. The difference with PICs (and other digital devices) is that we cannot produce a negative answer as such.

What we can do, however, is to use a flag to indicate that a borrow or negative answer situation has occurred. With the PIC, the Carry bit is used for this purpose.

In a subtraction operation we simply test the Carry bit to establish whether or not there has been a borrow.

This, though, is where another 'inverted' concept has to be applied to SUB commands. Whereas with the ADD commands the Carry bit is Set if a carry result occurs, with the SUB commands the Carry bit is Cleared if a borrow occurs, and it is Set if a borrow does not occur.

You could, perhaps, regard the Carry bit as being the bit which is available to be 'borrowed' for the subtraction, hence it remaining set if a borrow is not needed, and cleared if it is.

The following are examples of routines which test the Carry bit in a subtraction operation:

```
MOVLW 30
MOVWF DEMO
MOVF DEMO,W
SUBLW 20
MOVWF DEMO
BTFSS STATUS,C
INCF STORE,F
RETURN
```

The above example will cause STORE to be incremented since a borrow will occur when 30 is subtracted from 20. The next example, 30 - 20, does not result in a borrow, so STORE remains at its previous value:

```
MOVLW 20
MOVWF DEMO
MOVF DEMO,W
SUBLW 30
MOVWF DEMO
BTFSS STATUS,C
INCF STORE,F
RETURN
```

Sound Generation

We now move away from visually demonstrating what's happening with a PIC program and have look at sound generation. A lot of readers like to use sound in various ways as part of their programs.

In essence, the generation of sound is simple, just connect a sound transducer, such as a piezo sounder, between the 0V line and one of the PIC pins, toggle that pin up and down at a suitable rate, and sound is heard. When it comes to tuning that sound to correspomd with a particular musical note, the process starts to become a bit more complicated.

To start off with, let's see what happens when a PIC pin is suitably toggled and it is connect to a small loudspeaker. In themselves, PIC pins cannot provide sufficient current to drive a speaker, a buffer is needed to raise the current available.

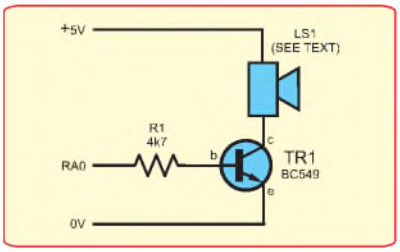

Fig.6.3 Circuit for first sound demo

A transistor can act as this interface buffer for a reasonable level of audio output, and a suitable circuit diagram in shown in Fig.6.3, and a breadboard layout in Fig.6.4. Assemble the board and connect it to the Master Control board described in Part 1. It is suggested that you use a pair of personal headphones connected to the output points indicated as LS1.

Port A can be used as a counter, incrementing it in a loop as we have shown previously, so automatically toggling RA0 to generate the frequency. Let's demonstrate this while still using the 3.2768MHz crystal. Refer to Listing 2.

Load with PIC with the hex file for the program in **TEACHINF01.hex** and listen to the headphones. Assuming that the circuit is correctly connected, you won't hear any sound, it's toggling far too fast, at around 136500Hz. Even if you were to use PORTB as the counter and RB7 as the output, the frequency would still be a bit too high, at around 136500\128 = 1066Hz.

If we use another register as a counter, COUNT0 in **TEACHINF02.asm** (Listing

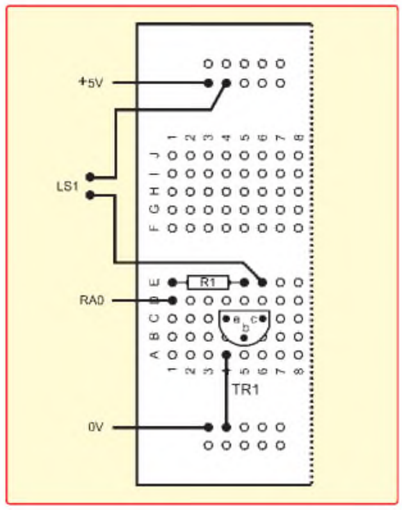

Fig.6.4 Breadboard layout for Fig.6.3

3) incrementing PORTB as that counter rolls over at 256, we get a frequency range of about 1066\2 = 533Hz from RB0, to around 4Hz from RB7.

Between the two methods, we are getting into about the range we need for musical notes. What will be apparent, though, is that if the sound output were coupled to one of the PORTB pins, because the successive outputs each divide the input frequency by two, the resulting 'notes' are each an octave lower than the preceding one.

What we really need then is a variable additive technique, the additive value more accurately determining the note frequency. For a start, let's find a value which will

Listing 6.2

```
; TEACHINF01.ASM 12JUN07 – TEACH IN 2008 PT6
; sound generation demo 1

#DEFINE BANK0 BCF STATUS,5; define STATUS register bit 5 clear as BANK0
#DEFINE BANK1 BSF STATUS,5; define STATUS register bit 5 set as BANK1

        list p=16f628           ; tell MPASM-type programmer to create a
                                ; list (LST) file

        __config  $3F21         ; external xtal (3.2768MHz)

        include p16f628.inc

        ORG 0                   ; reset vector
        goto STARTIT
        ORG 4                   ; Interrupt vector address
        goto STARTIT
        ORG 5                   ; PIC program memory location at which to start

STARTIT movlw 7                 ; needed by some PICs, including PIC16F628
        movwf CMCON             ; so that PORTA is treated as digital port

        BANK1
        movlw b'00000000'       ; all PORTA as output
        movwf TRISA             ; data direction register for PORTA
        movlw b'00000000'       ; all PORTB as output
        movwf TRISB             ; data direction register for PORTB
        BANK0

FREQ    incf PORTA,F            ; inc PORTA
        goto FREQ

        END
```

Listing 6.3

```
STARTIT  BSF STATUS,5
         movlw b'00000000'     ; all PORTB as output
         movwf TRISB           ; data direction register for PORTB
         BCF STATUS,5
         clrf COUNT0
FREQ     incfsz COUNT0,F
         goto FREQ
         incf PORTB,F
         goto FREQ
```

result in a frequency of 440Hz, Concert A in musical terms, putting it out via PORTB,0.

Although a formula could be established, it's actually quite easy to do it with trial and error, trying values and seeing what the result is on a frequency counter. The author has done this countless times in various published projects, operating at different PIC clock rates.

We want to allow you to select a few octaves given a basic note value, and we have just said that a binary count produces various octave relationships. If we take the highest value for A that you are likely to find on any musical instrument, we can aim for 440 × 8 = 3250Hz. So first let's get that frequency appearing at PORTB,0. Refer now to Listing 4 (*TEACHINF03.asm*).

We use two counters, NOTEHIGH1 and NOTELOW1, and the basic values that need to be added to them are held in NOTEMSB1 and NOTELSB1.

With a PIC clock rate of 3.2768MHz, the additive factor has previously been found to be decimal 8447, the MSB/LSB values of that are 32 (h'20') for NOTEMSB1 and 255 (h'FF') for NOTELSB1 (a total hex value of h'20FF' = 8447 decimal).

Setting that into the program will result in the following frequencies at the PIC pins stated:

RB0 3250Hz
RB1 1760Hz
RB2 880Hz
RB3 440Hz
RB4 220Hz
RB5 110Hz
RB6 55Hz
RB7 22.5Hz

If you have a benchtop frequency counter, monitor each pin of PORTB to prove that the stated frequencies are being output, within a few Hertz, as even crystal controlled oscillators only operate at frequencies within given bands of tolerance (as stated previously and in their datasheets).

The respective values for the seven main notes of an octave (excluding sharps and flats) are:

Note	RB0	RB3	MSB	LSB	Decimal
A	3250Hz	440Hz	32	255	8447
B	3944Hz	493Hz	36	248	9464
C	4184Hz	523Hz	39	57	10041
D	4696Hz	587Hz	44	5	11269
E	5272Hz	659Hz	49	108	12652
F	5592Hz	699Hz	52	108	13420
G	6272Hz	784Hz	58	204	15052

Listing 6.3

```
         movlw 32
         movwf NOTEMSB1

         movlw 255
         movwf NOTELSB1

         clrf NOTELOW1
         clrf NOTEHIGH1

LOOPIT   movf NOTELSB1,W       ; get fixed val LSB
         addwf NOTELOW1,F      ; add to counter LSB

         movf STATUS,W
         andlw 1
         addwf NOTEHIGH1,F     ; carry (if any) add to counter MSB
         movf STATUS,W
         andlw 1
         addwf PORTA,F

         movf NOTEMSB1,W       ; get fixed val MSB
         addwf NOTEHIGH1,F     ; add to counter MSB
         movf STATUS,W
         andlw 1
         addwf PORTA,F
         goto LOOPIT
```

Values for the sharps are not given, but their frequencies at RB3 are:

A# 466Hz
C# 554Hz
D# 622Hz
F# 739Hz
G# 830Hz

It is suggested that you attempt to figure out the MSB and LSB values for the sharps, using the values of the main notes as a starting point. You will spot that A Sharp (A#) is between A and B, and will, therefore, have a value somewhere between the two. Once you start thinking analytically, it should not take long to do, and is a good mental exercise!

The two tables in the ASM file can be used to record your results (they are without values for the sharps as shown, but have values for the other notes). The tables, though, are not made use of by this program.

Music Box

Having established the frequencies for musical notes A to G, we now show you how to assemble a simple music box, using switches in place of, say, piano keys for the notes. It outputs notes across one octave. A suitable circuit diagram is shown in Fig.6.5 and its breadboard assembly details are in Fig.6.6.

Load the PIC with hex file **TEACHINF04.hex** and run it. Press any of the keys and the respective note will be heard. Those of you who are musical will know that the first note played usually sets the signature for the remaining notes, but you can only play the respective sharps needed in some cases if you have figured out their frequency generation values. Without those values, pressing a sharp key will produce silence.

Also, of course, musically you really need octaves above and below the one used to give a greater range for any tune. That, though is beyond the capabilities of the simple circuit shown, and of the PIC16F628 as more output pins are needed than it has available.

This is only a simple music box and it is monophonic, so you can only play one note at a time, and the notes have not been provided with any sort of envelope shaping to provide a decay. Such techniques will not be addressed here.

We can next show you how an automatic music box can be created, which plays a sequence of notes when a switch is pressed. Having completed playing the notes, it waits for the next time the switch is pressed, whereupon it plays them again.

PIC Data EEPROM

First, though, we introduce another aspect of PICs, the use of their internal EEPROM (electrically erasable programmed read-only memory). This memory can be written to and read from, not quite in the normal way, but the data stored is effectively permanent. The data is not lost when the power is switched off, unlike that for registers in the 'normal' memory.

There many times that programs can benefit from the ability to store a value or values aquired when running, and for them to be available for access next time the constructed board is switched on and the program re-run.

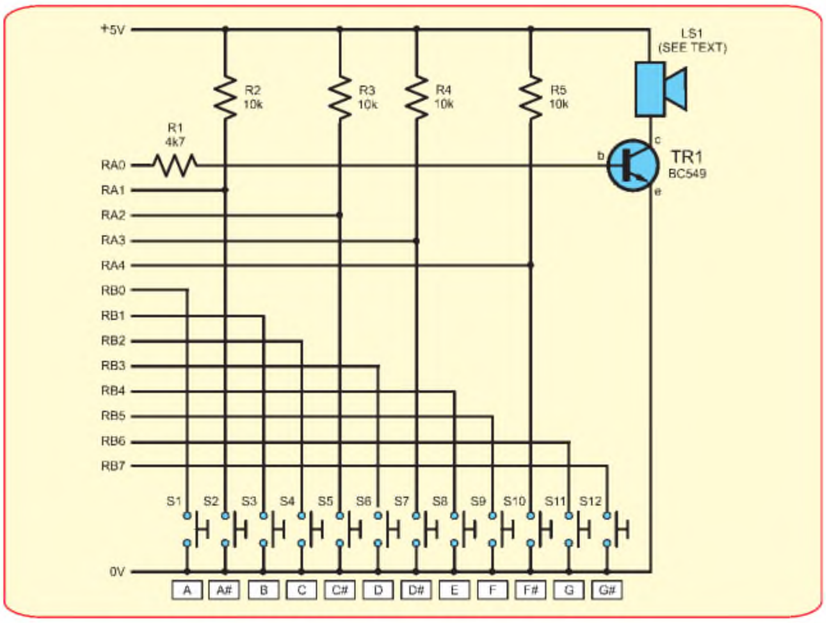

Fig.6.5 Music box circuit diagram

Data can be written to the memory in one of three ways:

- via data statements held in a reserved area at the end of the main commands

- directly as part of the main program during normal running, storing the results of various operations, for example

- by the PIC assembly/programming software through separate routines to those used for normal programming

The second technique can be invaluable when debugging a new program you've written, allowing the resulting values to be stored to EEPROM for checking later via the assembler's EEPROM reading facilities (not all assemblers have this facility, although the *TK3* program does – read its Notes file for information on how to readback a PIC's Data EEPROM.

The routines for writing to and reading from the Data EEPROM from within a program will not be discussed, but we show you how to use those routines in situations of your own. It should be noted that different PIC families have slightly different routines, but such routines for some of them are sometimes available for use as library files from several sources, including *EPE* through past projects. Further data is also on a PIC's datasheet.

Data can be stored using the commands at the end of the program and prefixed by the instruction DE. Any value stored in the EEPROM can be accessed depending on the address value which is called. The range of address values varies between PICs, but for the PIC16F628, there are 128 addresses available, numbered from 0 to 127.

The data is actually placed in a consecutive sequence commencing at PIC address h'2100', which is given as an ORG command prior to the program's data statements (look at the end of the listing). Again be aware that different PICs can have different data storage areas.

Automatic Music Box

The circuit diagram for an automatic music box is shown in Fig.6.5. The breadboard layout is shown in Fig.6.6. Load and run program **TEACH INF05.hex**. Press switch S1 to start the sound playing. There are 13 notes played in sequence. It is a really simple combination of seven notes, starting at A 440Hz and rising to G 784Hz, and then the other way back to A. Sharps are omitted. See the ASM file for the listing.

The 12 notes of a complete octave including sharps have been allocated numbers, as was said earlier, from 1 to 12. The order in which those notes are to be played is stored sequentially in the PIC's Data EEPROM, which is accessed in sequence when switch S1 is pressed.

Two tables, NOTEFREQMSB and NOTEFREQLSB, are called to get the relevant note frequency values. The notes are then generated in the same way as before in the previous program. Now, though, they are played for a fixed duration as set by the value set into CLKCNT in the PLAYIT loop.

Routine NOTELEN then calls the actual note generation in routine LOOPIT, continuously decrementing CLKCNT at each TMR0 roller until the count has become zero. The value for the next note is then retrieved from the EEPROM and is played in the same way.

So the sequence continues until all notes required have been played. This total value is held in the very first available memory location of the EEPROM, and is read at the start of each loop once the switch has been pressed.

Writing to EEPROM

If you examine program **TEACH-INF05.asm**, you will see the routine which allows values to be written to the EEPROM (see Listing 6.5) from within the program. The routine is at Label SETPRM,

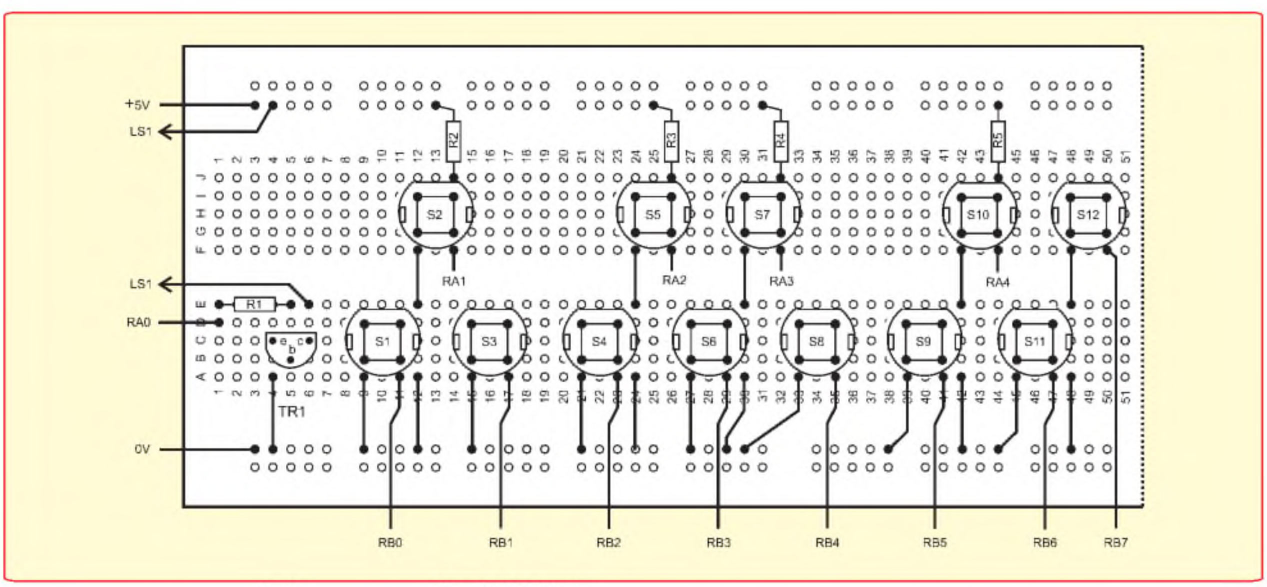

Fig.6.6 Breadboard component layout for the simple music box circuit of Fig 6.5

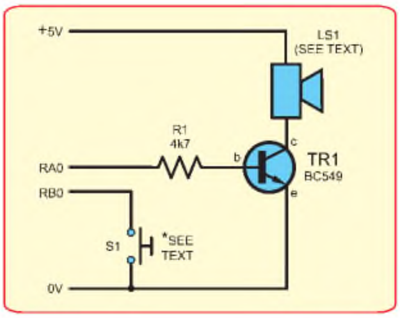

Fig.6.7 Circuit for 2nd music box

which is entered with W holding the EEPROM byte address at which data is to be stored. The data to be stored is held in PROMVAL, which is located in both pages at or above h'70', as equated. Basically, the routine is one which is provided by Microchip in the PIC's datasheet and should not be amended, just used as it is.

So, when wishing to store the result of an operation in the EEPROM, place the value in PROMVAL, put the address at which you want the value to be stored (between addresses 0 and 127) into W, and simply give the command **call SETPRM**. The value is then stored as requested.

The storage takes a bit longer than if using normal PIC memory, but it is only a matter of milliseconds. Be aware that a PIC's Data EEPROM has a limited number of times that it can be written to. Although this is many thousands of times, writing to the EEPROM should be used sparing, and never from within a fast loop. PIC datasheets give the operational lifetimes for such actions. But is worth noting that the author has never had a PIC fail because of giving it too many write cycles.

Something Else To Think About

Although domesticity may not be your strong point, you want to program the controls for a washing machine. There are many factors to consider, such as cycle timing, door opening and closing, flood avoidance, temperature control etc. Can you come up with something that meets all your imagined needs. You have a lot of programming tools at your disposal now.

There's no reason too why you shouldn't speed up the 24-hour clock for the sake of simulation, and set up fictitious temperatures, via the EEPROM maybe, or via some other means.

Correction

Teach-In part 2 (Dec '07) – In Listing 2.1, 2.2 and 2.3, near the top – CLKCNT should be ranged left (in line with STARTIT) and not indented. The CBLOCK and ENDC statements must still be indented as shown.

Listing 6.5

```
;This routine is entered with W holding
              ;the eeprom byte address at which data
              ;is to be stored. The data to be stored
              ;is held in PROMVAL, which is located in both pages at or above h'70'

SETPRM: BANK1
              movwf EEADR          ;copy W into EEADR to set eeprom
                                   address
              movf PROMVAL,W       ;get data value from PROMVAL and
                                   hold in W
              movwf EEDATA         ;copy W into eeprom data byte regis-
                                   ter
              bsf EECON1,WREN      ;enable write flag

MANUAL        : movlw h'55'        ;these lines cause the action required

              movwf EECON2         ;by the eeprom to store the data in
                                   EEDATA
              movlw h'AA'          ;at the address held by EEADR.
              movwf EECON2
              bsf EECON1,WR        ;set the ``perform write" flag
              BANK0

CHKWRT: btfss PIR1,EEIF ;wait until bit 4 of PIR1 is set
              goto CHKWRT
              bcf PIR1,EEIF   ;clear bit 4 of PIR1
              return

;******** READ DATA FROM EEPROM ROUTINE

              ;This routine is entered with W holding
              ;the eeprom byte address to be read.
PRMGET: BANK1
              movwf EEADR          ;copy W into EEADR to set eeprom
                                   address
              bsf EECON1,RD        ;enable read flag
              movf EEDATA,W        ;read eeprom data now in EEDATA
                                   into W
              BANK0
              return

              org H'2100'          ; data eeprom address
              DE 14                ; 0 number of eeprom addresses
                                   needed
              DE 1                 ; 1 note 1
              DE 3                 ; 2 note 2
              DE 4                 ; 3 note 3
              DE 6                 ; 4 note 4
```

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Current Sources

Last month we started looking at current sources in response to a question by ***scott2734*** on the *EPE Chat Zone* (via **www.epemag. wimborne.co.uk**). We discussed the fundamentals of current sources and looked at the most basic current source circuit, which is based on a two transistor current mirror (see Fig.1).

Current mirrors take a reference current input and produce a copy of it; in fact they can produce multiple copies, as shown in Fig.2. This type of circuit is often used to produce bias currents in analogue ICs.

What source voltage?

One of the questions asked by **scott2734** was about the voltage at the output of a current source. The voltage across a constant current source is that required for the current to be at the 'constant' value. In the ideal case the voltage can be any value, but in a real circuit of course, the range of possible voltages is limited.

The circuit in Fig.3 will illustrate how the voltage across a current source may vary. The current source produces a constant 1mA, which flows through a resistor of 1kΩ. This will produce a fixed voltage drop of 1V across the resistor. The other end of the resistor is connected to a voltage source. In a real circuit this could be the supply or, as is more likely, a point in the circuit which is driven to a specific voltage, for example in response to an input voltage signal.

If the voltage source (V_S) in the circuit in Fig.3 outputs 5V then there will be 4V across the current source (recall the resistor drops 1V). If the voltage source outputs 1V there will 0V across the current source, and if the voltage source outputs 0.5V there will be –0.5V across the current source. This is OK for an ideal source, but the current mirror in Fig.1 will stop working once the voltage across it drops below about +0.2V to +0.3V (the transistor's saturation voltage, V_{CEsat}).

For a transistor-based current source there is also, of course, a maximum voltage beyond which it will not work due to stress or breakdown of the device.

Imperfections

The current source circuits used in analogue chips are often more complex than those in Fig.1 and Fig.2, using additional transistors to overcome some of the imperfections in a basic current mirror. One of the key imperfections is the internal resistance of the current source – the basic current mirror does not a give very constant current under changing loads (we discussed internal resistance last month).

The poor internal resistance of the basic current mirror is determined by the output transistor's internal resistance. This is caused by base width modulation, also known as the *Early effect*, which causes a variation of collector current with changing collector-emitter voltage (with fixed base-emitter voltage).

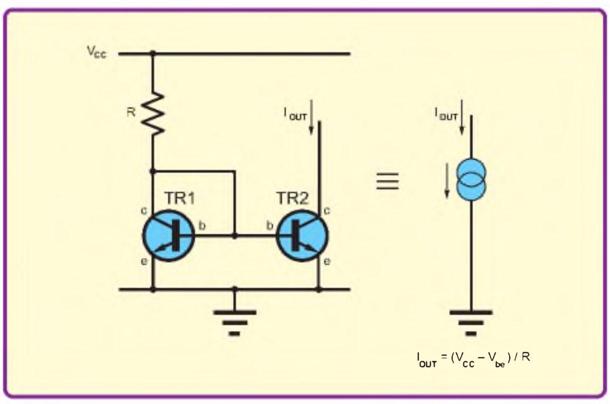

Fig.1. Current source based on a current mirror

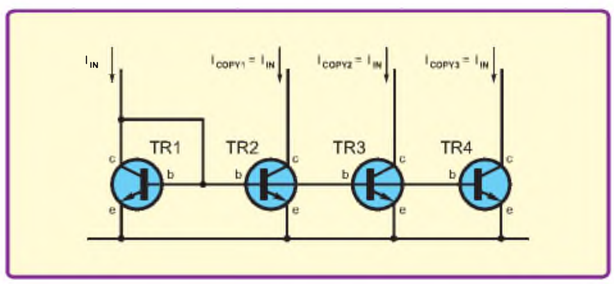

Fig.2. A current mirror can make multiple copies of a current

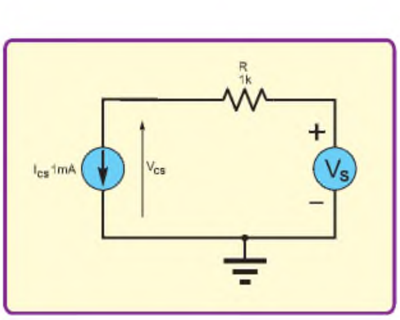

Fig.3. Voltage across a current source

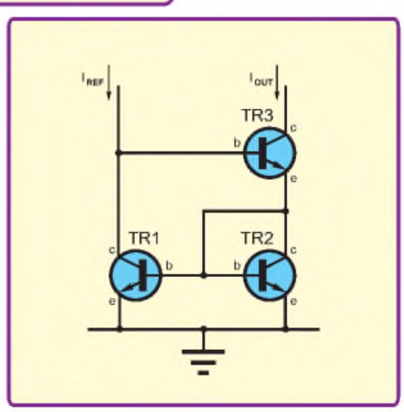

Fig.4. Wilson current source

Wilson current mirror

One improved circuit is known as the *Wilson current mirror* after its inventor, George Wilson. The performance of the basic current source can be greatly improved by adding an extra transistor to compensate for the Early effect (see Fig.**4**).

Any voltage variations at the output largely occur across TR3; whereas the mirror transistor's (TR2) collector is held nearly constant at V_{BE} (TR3's base is at $2V_{BE}$). More accurately, the Wilson current mirror has a subtle negative feedback mechanism which results in high output impedance. Remember that good current sources have very high internal resistance, the opposite to good voltage sources.

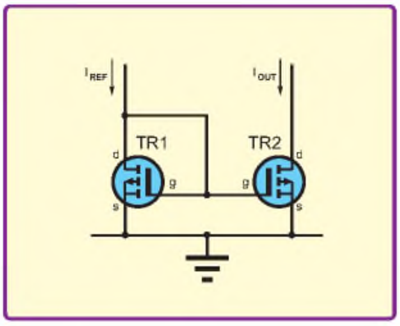

Fig.5. Basic MOSFET current mirror

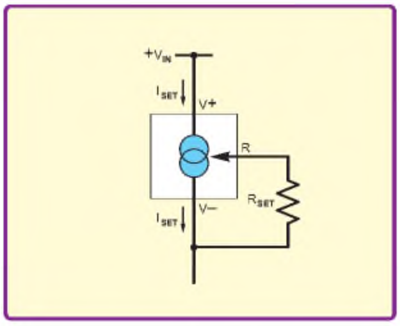

Fig.6. Basic LM134 current source circuit (from National Semiconductor datasheet)

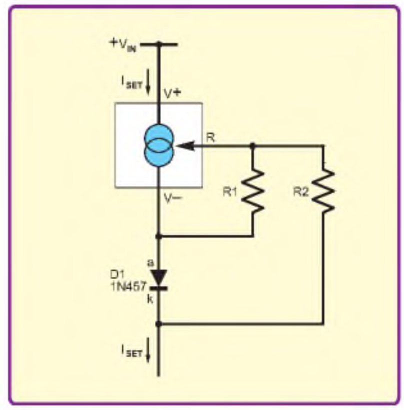

Fig.7. Basic LM134 current source circuit (from National Semiconductor datasheet)

The mirror current from TR2 passes through TR3 to the output. TR1's collector is at a nearly constant voltage of $2V_{BE}$, allowing the reference current to be established via a resistor from the supply, as in Fig.1. The minimum output voltage from this circuit is larger than the basic current mirror and is equal to V_{BE} plus V_{CEsat}, rather than just V_{CEsat}.

Current sources and applications

Current sources can also be built using MOSFETs. The most basic circuit is shown in Fig.5. This produces a more accurate copy of the input current than the basic bipolar transistor current mirror (Fig.1) because it does not have to 'steal' any base current from the reference current (the gate current is effectively zero). Like the basic bipolar mirror, this circuit suffers from poor internal resistance and again, more sophisticated circuits are available which perform better in this respect.

Last month we mentioned that in addition to bias circuitry in analogue ICs, there may be a number of applications of current sources of interest to readers. These include LED drivers, ramp generators and battery chargers. We will now look at a couple of these in a little more depth. There are also a number of special function ICs based on current sources, including LED drivers, which we will consider later. For other applications, you may wish to use a general purpose current source such as the LM134.

The LM134 from National Semiconductor (**www.national.com**) is a 3-terminal adjustable current source with a 10,000:1 range in operating current and a voltage range of 1V to 40V. No separate power supply connections are required, so it is described as a true floating current source.

The current is set using an external resistor (see Fig.6 for the basic circuit). For currents in the range 2µA =< I_{SET} =< 1mA, at 25°C, the value of I_{SET} is given approximately by $I_{SET} = 0.0677/R_{SET}$. Consult the LM134 datasheet for more detailed information on selecting R_{SET}.

The basic circuit configuration generates a current with a +0.33%/ °C temperature dependence. Zero drift operation can be obtained by adding one extra resistor and a diode, as shown in Fig.7. Consult the LM134 datasheet for details on the selection of R1 and R2 for this circuit. The temperature sensitivity of the LM134 means that it can also be used as a temperature sensor.

If a constant current flows into a capacitor (as in Fig.8) then the voltage across the capacitor, V_C, rises as a linear ramp; compare this with the exponential charging curve which occurs when a capacitor is charged via a resistor from a fixed voltage source. The voltage across the

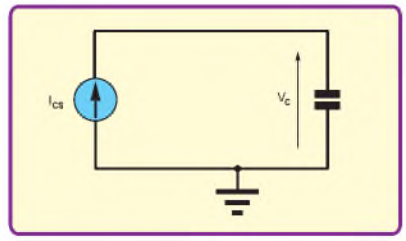

Fig.8. Current source charging a capacitor

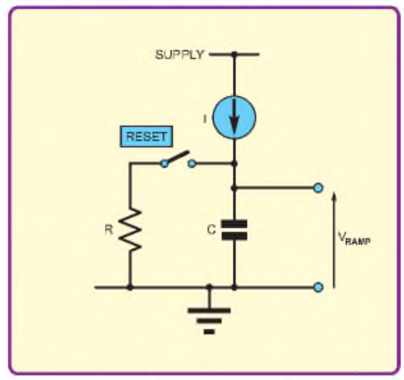

Fig.9. Charging a capacitor

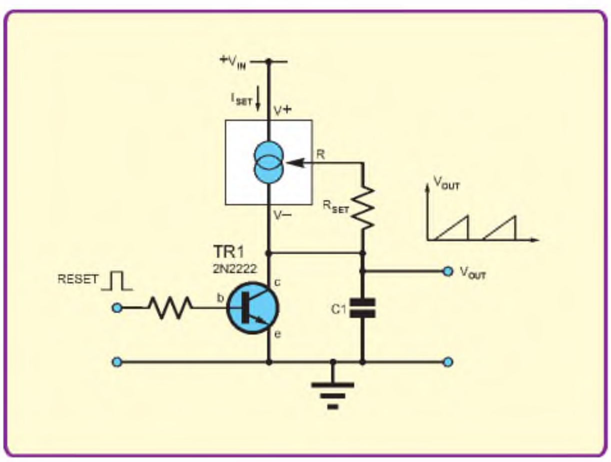

Fig.10. Linear voltage ramp generation using the LM134 current source (circuit from National Semiconductor datasheet)

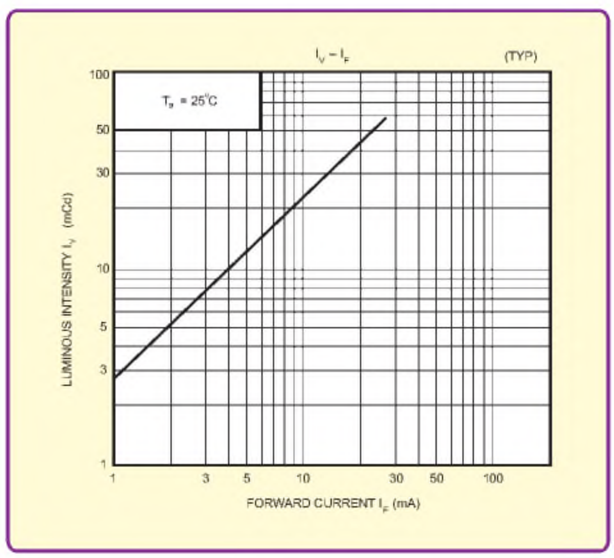

Fig.11. Comparing LED light output vs current (Toshiba TLOU1002A(T12))

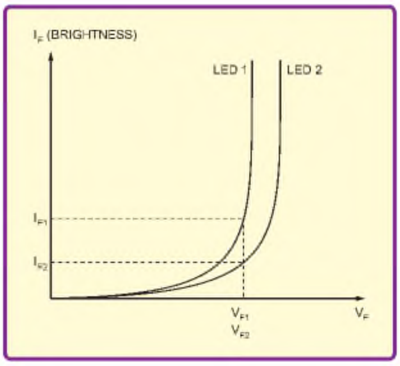

Fig.12. Possible characteristics of two individual LEDs of the same type. With the same forward voltage the LEDs may have different forward current and hence different brightness

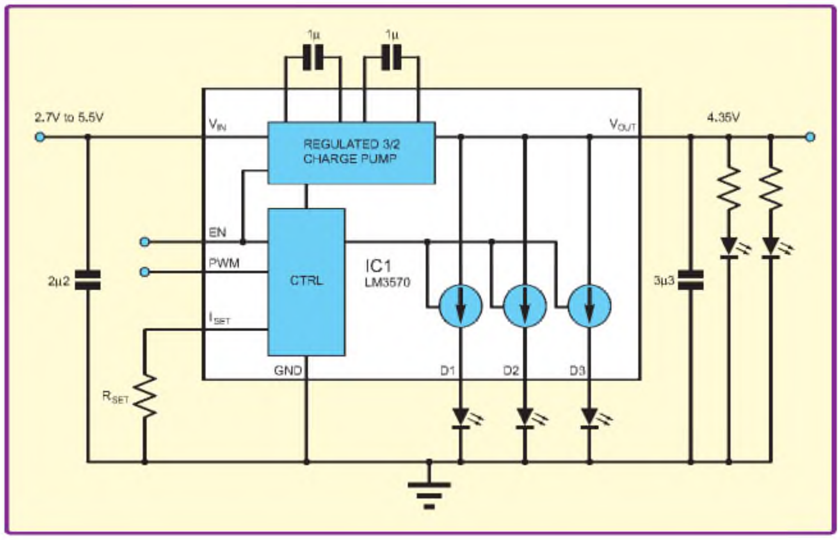

Fig.13. LM3570 constant current LED driver (circuit from National Semiconductor datasheet)

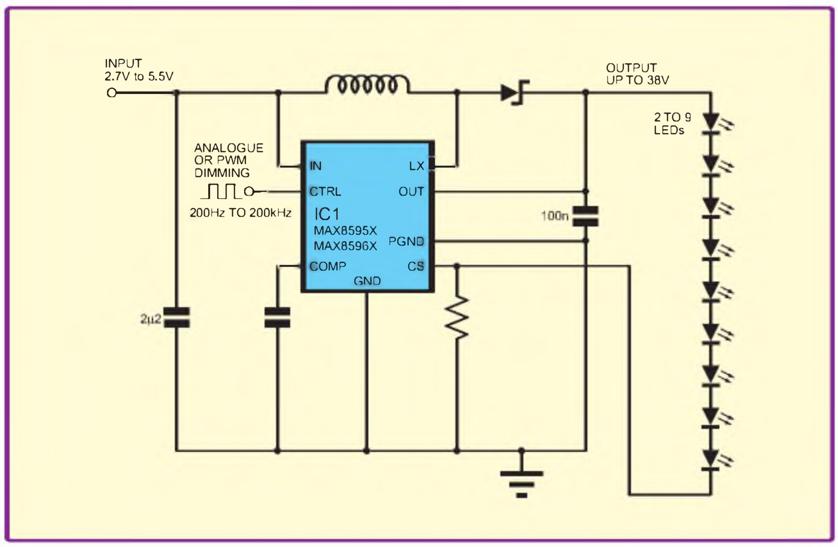

Fig.14. MAX8595 LED driver IC (circuit from Maxim datasheet)

current-charged capacitor in a real circuit will continue to rise until the voltage across the current source prevents it from operating.

Practical ramp generator

In Fig.9 is shown a more practical ramp generator circuit concept. Here the power source is a conventional voltage supply, allowing us to a use a transistor current source. In this circuit, the output voltage (V_{ramp}) will ramp up from zero until the voltage across the current source is too small for it to operate, at which point it will level off.

If we want to generate another ramp we will need to discharge the capacitor, this is implemented using a switch with a current limiting resistor in Fig.9, although typically a transistor will be used. Fig.9 is still only a concept; Fig.10 shows a practical linear voltage ramp generator utilizing an LM134 current source.

LEDs are current controlled devices – the light brightness is just about linearly proportional to the forward current. This is illustrated by Fig.11, which is taken from a Toshiba datasheet (**www.semicon.toshiba.co.jp**). In many applications it is important to have even brightness across multiple LEDs. Typically, we want all the LEDs to have the same brightness so that we create an aesthetically pleasing display or evenly distributed illumination.

It is the *current* through an LED, not the voltage, which sets the brightness. Two individual LEDs of exactly the same type will produce the same illumination with the same forward current (I_F), but may have different forward voltage drops (V_F) at this current. The variation in voltage drop between individual devices may be in the range 0.1V to 0.3V for typical LEDs. This is a key fact that needs to be considered when designing LED drive circuits. This is illustrated in Fig.12, which shows the possible forward characteristics for two LEDs of the same type.

It follows, from the previous discussion, that the best way to drive multiple LED is from a constant current source, with the current set to give the required luminous intensity. There are numerous constant-current based LED driver ICs available. There are two approaches to achieving even brightness, one is to use multiple current sources which are accurately matched to give the same current, and the other is to use a current source with a large voltage range that can drive the same current through multiple LEDs in series.

LED drivers

One example of an LED driver IC is the LM3570 low-noise white LED driver from National Semiconductor (**www.national.com**). This device is targeted at applications such as wireless handsets and other portable devices using a display and keypad. It provides three constant current sources, to drive up to three white LEDs for display lighting. The current matching of these sources (0.3% typically) ensures that the lighting will be even.

The IC also provides a regulated 4.35V output voltage, which can be used for other LEDs not requiring such well matched brightness. Pulse width modulation (PWM) can be used to control LED brightness. Fig.13 shows a typical schematic for the LM3570.

Another LED driver IC is the MAX5895 from Maxim Integrated Products (**www.maxim-ic.com**). This device generates a relatively high voltage to allow multiple LEDs to be driven in series from a single current source. It includes a switched mode power supply which generates up to 38V. It can drive from two to nine (white) LEDs.

The current level can be adjusted using a control voltage, or the brightness can be modified using pulse width modulation. Fig.14 shows a typical MAX5895 circuit taken from the Maxim datasheet.

As with any switched mode power supply IC, the MAX5895 requires careful PCB layout and component selection. Consult the datasheet for details.

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PIC N' MIX

MIKE HIBBETT

Our periodic column for your PIC programming enlightenment

Real Time Clocks

In this month's article, we take a look at how to go about including a real time clock feature in a PIC microcontroller project. It's an odd term, *real time clock*, and was probably coined because most digital electronic circuits contain a number of different clocks. *Real time* means that the clock is tracking normal time, in hours, minutes and possibly seconds and milliseconds.

The typical uses for such a clock in a PIC-based design can be varied, from simply displaying the current time to perhaps controlling a piece of equipment at periodic times during the day, or recording the time at which an event took place.

Maritime navigation

Our fascination with knowing the true, current time grew out of a maritime necessity for safe navigation; knowing the correct time and the position of the stars enabled sailors to accurately determine their longitude. Get the time wrong, and you could end up on the wrong continent, or worse. Over the years, our appetite for greater and greater time accuracy has accelerated, although such precision is rarely necessary in our normal working lives, unless you are planning the next mission to Europa!

For our typical microcontroller-based projects, the requirements are likely to be somewhat more mundane. An accuracy in the order of a few seconds every month is likely to be perfectly acceptable.

There is another requirement that often goes hand-in-hand with projects using a real time clock – power consumption. They often find themselves in remote locations, are battery powered and so maintaining as long an operating life as possible between recharges or battery replacement is an important issue.

You could, of course, simply purchase a real time clock integrated circuit, such as the DS1672 from Maxim, and use that in your circuit. No reason why not, but that would make for a very short article, and miss out on the features already provided by Microchip on many of their processors. It's a journey round an often overlooked peripheral, a rarely used instruction and an interrupt.

At this point, you might be thinking: 'Why do we need to do anything special? We know how fast the processor is running, why not simply use a timer to generate a one second count?'

The problem with this is that the main oscillator is not particularly accurate, at least by the standards of maintaining the current time and date. The main oscillator also draws a relatively high current, which will limit battery powered projects significantly.

Timer 1

Fortunately, Microchip provide a solution to this – a low power oscillator circuit that can drive the Timer 1 peripheral. The oscillator comes out of the PIC on two pins, to which you connect a special crystal called a *watch crystal*. The crystals are typically supplied in small tube like containers, and are available in a few well known frequencies – the most common being 32.768kHz.

They are constructed in a very different manner to normal microprocessor crystals, being cut in the shape of a tiny tuning fork. They are very accurate, and require a very low drive current – and are easy to break if over driven. This style of crystal is referred to as 'AT cut' by the manufacturers and distributors.

Microchip are very good at re-using peripherals across it's processor range, so if you look at pretty much any PIC16 or PIC18 device's datasheet, the section on Timer 1 will probably include a low power oscillator function, often functionally equivalent across the processor range.

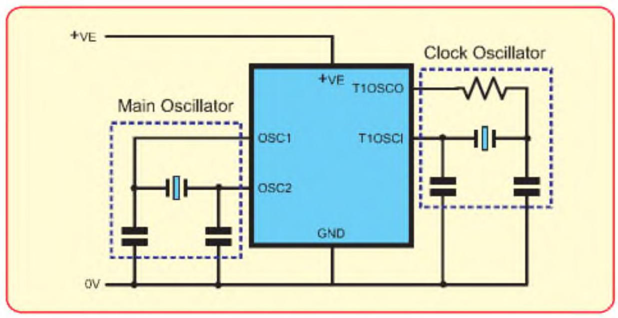

Fig.1. Typical oscillator setup

This low power oscillator is used in addition to the main oscillator, meaning that in some cases two crystals are required, depending on how fast or accurate you want your software to run. Fig.1 shows a typical circuit using two crystals. You can use 22pF capacitors around both crystals; note the resistor in series with the T1OSCO pin. This is required to limit the drive to the watch crystal.

In a 5V circuit, this resistor probably wants to be about 680Ω; you can reduce

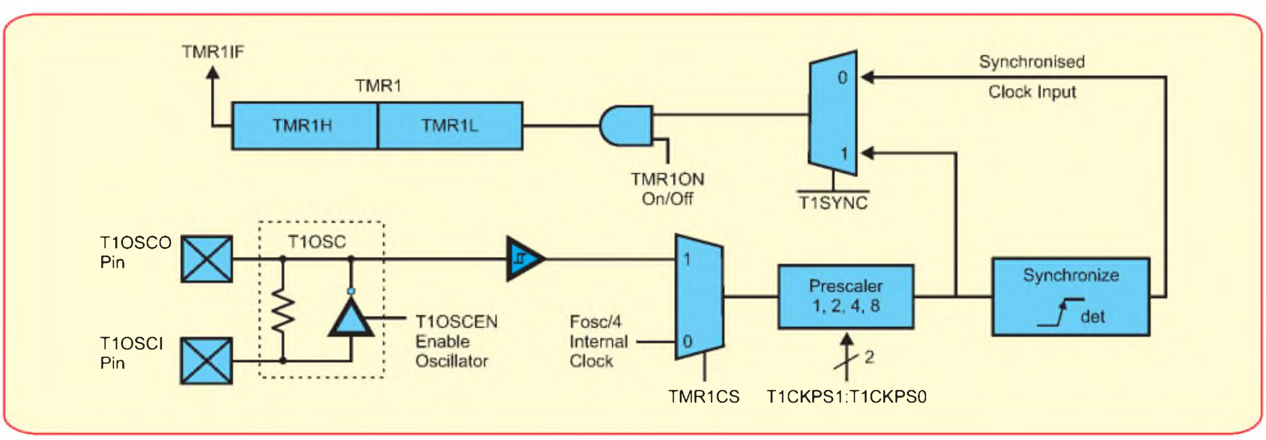

Fig.2. Timer 1 block diagram

this to 100Ω to 200Ω if you are using a lower supply voltage. The generally accepted rule is: try it and see. There are no hard and fast rules about designing oscillator circuits.

Actually, there is one common rule: tie the ground connection of the oscillator circuit directly to the processor's ground pin and **do not** connect any other components to the ground track. Low power oscillators are very susceptible to noise that can be caused by current flowing through its ground connection, so always provide a track from the crystal to the ground pin with nothing else using it. Also, try to keep the crystal, capacitors and resistor as close as possible to the pins on the processor, again to reduce interference from circuit noise.

Watch crystal oscillators take a very long time to start oscillating when power is applied – in some cases, as long as two seconds! Bear that in mind when writing your software to drive it, and either give a good delay following power up or wait a few seconds before actually using it.

In Fig.2 is shown the typical setup of the Timer 1 peripheral, in this case as found in the PIC16F877. The inverter and resistor symbols shown in the bottom left corner of the diagram are the key components (fitted inside the PIC as part of the silicon) which coupled with the crystal, capacitors and limiting resistor fitted externally make up the complete oscillator.

Various signals shown on the diagram control how the oscillator works and how it links into the timer peripheral. T1OSCEN, for example, turns the oscillator on or off. This signal is a data bit inside one of the SFR registers (T1CON in the case of the PIC16F877).

From the diagram in Fig.2, one can see the options that we need to understand and configure to get the oscillator running as we wish – T1OSCEN to enable the oscillator, TMR1CS to select the oscillator as the source of the timer's counter, T1CKPS to select a prescaler value, T1SYNC (the meaning of which is unclear at this point) and TMR1ON to enable the timer register to start counting as clock pulses come in. TMR1IF is the interrupt flag that gets set when the timer overflows from FFFF to 0000. Yes, I'm afraid so – to get the best out of a clock application, we are going to need to resort to interrupts.

Pre-scaling

First though, let's think about how we want to set the timer up. Let's consider an example where we want a simple digital clock, which shows the hours and the minutes only. Knowing that we will use the interrupt to cause the software to increment the time, it would be beneficial to have the interrupt occur at one minute intervals, reducing the amount of work the software has to do (we will see why shortly.)

Assuming we are using a 32.768kHz crystal, and knowing that Timer 1 is 16 bits wide, how frequently will it overflow? Simply divide 32768 by 65536 to give 0.5, or once every two seconds. We only need the interrupt to go off every minute, so can we get any slower? Yes, we can use the prescaler to divide the clock frequency down. The possible division values are 1, 2, 4 or 8. If we choose 8, that gives us an interrupt that goes off every 16 seconds.

That's not bad, but a 16 second 'tick' is not very useful – we need to count up in 60 second intervals, not 16! The solution is to pre-load the timer with a value other than zero. If we load it with a value of 4096 and reload that value every time the interrupt goes off, we will have a period of 15s – much easier to deal with, since we just count four of them and then increment the minute counter.

Let's look at how that translates to program instructions. Fig.3 shows a subroutine to perform the initialisation and enable the Timer 1 interrupts.

```
initTimer1Clock
    ; Set the prescaler to 8,
    ; enable the oscillator,
    ; disable synchronisation,
    ; select the external oscillator,
    ; leave the timer switched off.
    movlw   B'00111110'
    movwf   T1CON

    ; Pre-load the timer register
    ; with a value of 4096 decimal
    clrf    TMR1L
    movlw   0x010
    movwf   TMR1H

    ; enable Timer 1 interrupt
    bsf     STATUS, RP0
    bsf     PIE1, TMR1IE
    bsf     INTCON, PEIE

    ; Enable global interrupts
    bsf     INTCON, GIE

    ; Now, start the timer running
    bcf     STATUS, RP0
    bsf     T1CON, TMR1ON

    return
```

Fig. 3. Timer initialisation code

Interrupt

Of course, we now need an interrupt routine to handle the interrupt, occurring once every 15 seconds. When the interrupt occurs, the processor stops whatever it was doing – no matter where it is in the main program – and starts executing program instructions from the *interrupt vector*. This is simply a fixed location in memory, location 4 in the PIC16F877. When writing an interrupt routine it is vital to do three things: save the contents of the W, PCLATH and STATUS registers; restore them when your interrupt code has completed and finally end the routine with a RETFIE instruction (return from interrupt).

You must follow this procedure, otherwise, when the processor returns to where it left off, the W and STATUS register will have changed unexpectedly and your program will crash. Saving and restoring the content of these three registers is quite a tricky programming problem, so Microchip have kindly supplied an example solution in the datasheet. They rely on three user registers at addresses 0x7d, 0x7e and 0x7F.

Our interrupt needs to do very little other than count to four, increment the time and reload the timer with 4096. The complete code is shown in Fig.4.

And that's all you need to keep a real time clock running. In your main program

```
    ORG     4

INTERRUPT
    ; Save the W, PCLATH and STATUS registers
    ; in user registers
    movwf   0x7D
    swapf   STATUS, W
    clrf    STATUS
    movwf   0x7E
    movfw   PCLATH
    movwf   0x7F
    clrf    PCLATH

    ; reload the timer value with 4096
    clrf    TMR1L
    movlw   0x010
    movwf   TMR1H

    ; Clear interrupt occurred flag
    bcf     PIR1, TMR1IF

    ; Count to 4, i.e. 1 minute.
    ; We use register 0x7C to hold
    ; the count variable.
    incf    0x7C,F
    btfss   0x7C,2
    goto    intDone

    ; 1 minute has passed. Update the clock
    ; - your clock incrementing code goes here

intDone
    movfw   0x7F
    movwf   PCLATH
    swapf   0x7E, W
    movwf   STATUS
    swapf   0x7D,F
    swapf   0x7D,W
    retfie
```

Fig. 4. Timer interrupt code

you can simply display the contents of the clock periodically, knowing that it is being kept updated by the interrupt routine.

Sleeping time

The only missing part to the puzzle is how to best minimise the current consumption. With the main oscillator running, your PIC device is probably consuming several milliamps – which will flatten a battery in a few weeks. Microchip provide a solution to this with the SLEEP instruction.

When this instruction is executed the processor will switch off its main oscillator, and therefore stop executing instructions. The current consumption will now drop significantly – down to tens of microamps.

In this state, the processor will remain inactive until the clock oscillator (which still runs in SLEEP mode) causes a timer interrupt. The main oscillator will then wake up and start executing instructions again.

If you place the SLEEP instruction inside a loop within your main code, you can wake up, perform some very quick display updates and return back to sleep. The complete 'main loop' code for this example is shown in Fig.5.

There are a couple of problems with the above design. The first is that the choice of

```
Main
    ; call a function to
    ; clear the display
    ; - your code goes here

    ; setup the timer
    call    initTimer1Clock

loop
    ; go into low power mode
    sleep
    nop

    ; We woke from a interrupt,
    ; so update the clock display
    ; - your code goes here

    goto    loop
```

Fig.5. Clock 'main loop' code

capacitors may need to be experimented with to give exactly 32.768kHz. The second problem is in the design of the software. When the interrupt routine reloads the timer, it does so after a short delay while the main oscillator powers up. While this is not a significant problem in many cases, better performance can be had using the comparator peripheral – but that's a subject for another day.

Other sources

There are other ways to maintain a real time clock. The frequency of the mains power supply is very accurate over time, and could be used as a 50Hz timebase (in the UK, at least). A very accurate source of time can be obtained from a GPS receiver, although these are expensive and power hungry solutions. Why bother, however, when you can manage with a simple crystal?

The current 'standard' for time is derived from microwave emissions from the element Caesium-133, accurate to within one second in 30 million years. The SI Standard second is based on the averaging of over 500 atomic clocks, all running slightly differently due to gravitational time dilation. The net effect of this seems to be that there is no such thing as a perfect clock, since the length of a second depends on where you are (or your proximity to another object).

In our hunt for better and better definitions of the basic unit of time, one wonders what the relevance of it all is to the majority of us. 100 years ago one might have said to a friend, "I will visit you next Tuesday afternoon". 20 years ago one might have said, "I'll see you at 3pm". Now, we can hear people say "I'll be home in 25 minutes". In another 100 years, will we be saying "I'll be home in three minutes and 10 femtoseconds"? One hopes not, although that's a problem for another generation!

READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly.

WIN AN ATLAS LCR ANALYSER WORTH £79

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

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★ LETTER OF THE MONTH ★

Web browser security

Dear EPE,

I read Alan's *NetWork* article on web browser security with interest. I am *not* a defender of Internet Explorer myself. It has more security holes in it than a dartboard. I actually migrated to Firefox many moons ago, and it is a much superior piece of software that has yet to crash on me. Unlike IE which crashed often.

I am very much into PC security and have, over the last five years, tested and used just about every available piece of software out there. This year I have installed Zone Alarm Professional, AVG Anti-Virus, AVG Anti-Spyware and AVG Rootkit. I have had little if any problems at all. I dumped PC tools Spyware Dr due to the fact it is no longer the product it was when purchased last year!

However, after consultation with a relative, who is in the security business for a living, he advised I try out Kaspersky Internet Security suite version 7.0, which is a free download for a trial of thirty days.

To say I am impressed is an understatement. The install was smooth and simple after following the instructions, which most don't, trying to install over already installed firewalls. It has more facilities and controls than any other product I have used.

The most interesting parts are how it will tell me what URL I am connected to on-boot up, even before browsing. This was a revelation. I had found I was connected to eleven sites that were collecting information on a regular basis. I suppose you realize that Real Player is, in fact, clever Spyware that sends confidential information every time you use it to play a film clip or a song? I still use it, but have managed to stop this feature now.

Also, when I first installed Kaspersky the scans detected thirty seven infections and Trojans.

Just to check, I re-installed PC Tools Spyware Dr and ran AVG and Avast, *none* of them detected what Kaspersky did. All of the infections were handled and for the first time I feel I have complete control of my computer. Most of the infections were low level threats, but the interesting point is that most of them were sending data. Most firewalls are designed around blocking stuff coming in, although some still gets through. But Kaspersky managed to detect those that were all about sending data out!

Couple this with an hourly automatic update with virus definitions and a special purchase offer this month of only £18 and I consider it an absolute bargain. Kaspersky is fast becoming the standard package.

I know you tout a lot for Avast and IE but there are better products out there and you need to try them all. To be fair, Kaspersky does require some experience and a thorough reading and understanding of the supplied manual, so it will not be 'popular' with the standard surfer who is too lazy or too thick to read a book, but hopefully that is the minority.

Doug, via email

Alan replied to Doug:

Many thanks for your letter, which obviously took a lot of time to put together, I appreciate it.

I covered the subject of anti-virus s/w in November 2007 *Net Work* – I decided that Avast was long in the tooth, it was better than nothing at the time, and it was free for home use – but I did recognise its shortcomings and I sought a modern replacement. In fact, I tested a number of packages, and I highlighted several that readers could try out for themselves. Actually, I had high hopes and tried hard to get on with a Kaspersky trial on my laptop and I still do not dispute its ability to unearth deeply buried viruses. I was very impressed with an initial scan (90 trojans), and I said as much in the magazine review.

My argument against it was usability, especially the blizzard of constant popups that made no technical sense at all to myself, let alone the average user. I found them relentless and in the end I found the product's usability annoying, so eventually I settled on the far more straightforward product from F-Secure – the annual licence for which covers three machines and seems to be best value (an attraction for those running multiple PCs), although it is not perfect.

I must disagree that anyone who struggles with any such products is lazy or thick! – especially when confronted by Kaspersky's deeply arcane popup warnings, which I found did nothing to boost my confidence. Personally, I find F-Secure works well sitting in the background and is non-intrusive. I will scan maybe weekly with Spyware Doctor – it is too processor intensive to run in the background on my machines.

I do realise my view is subjective and everyone tends to be defensive about their preferred choice, but until Kaspersky becomes friendlier to use I would tend to recommend it to power users having time on their hands. I am of course familiar with others, eg Grisoft's AVG and Panda Anti Virus, and I used the free ZoneAlarm firewall in the 1990s on W98 machines. Zone Alarm does intercept outbound traffic, which I often found would interfere with many legitimate programs until exception rules were configured. I accept it's another complication that experienced users will take in their stride and I don't disagree that it is useful to know what is reaching out onto the Internet. However, very many users don't want to know, they just want a system that they can be confident in and that works transparently and safely.

As will be appreciated, it isn't possible to run comprehensive reviews on all products in such limited page space, but I gave readers a flavour of current trends. I really appreciate your interest in my column.

Alan Winstanley, via email

Small projects

Dear EPE,

I have many years experience of building and making various electronic types of equipment, and now that my older lad is doing this at school, I have noticed something lacking in the new approach to electronics.

It would be nice if you could run articles on small projects, possibly using 20 components or less, as they used to in old *Practical Wireless* many many years ago. I know they were always of interest to me and appealed because of the low cost involved and good explanation of how they worked. They could be built in an hour on the kitchen table; I was never very good at the maths side of electronics, but practically I became very good by building and experimenting. I have always been able to carry on in electronics where others, more qualified, but less experienced people have found it hard to survive.

I can remember building a rain alarm for my mother fitted inside an old Tupperware container from such an article. Not using printed circuit boards and ICs, but doing it the old way using perforated board and hand wiring up the individual components, which I believe helps students identify with the components better and teaches them how to layout parts and acquire patience. I can remember building many circuits then dismantling them, cleaning the board and building another.

This instant build on PCBs doesn't seem to have the same effect as hand wiring something and having it work; there was always a greater sense of achievement and also lower cost for a one-off circuit.

Maybe, you could cater a little for the youngsters out there, as we all know how hard it is to hold their attention for long nowadays. Small projects may get yet another generation into the dying art of electronics and get their brains thinking in a more inquisitive manner. I know PICs and micros are the future, but the transistors of the past are what made them. Let's not let the youngsters forget it and get them interested again, maybe run a competition for simple student circuits.

Steve Payne, via email

Previous Editor Mike replied:

Thanks for this, we do find that most students want to get into programmable (ie PIC type) projects these days. We did however publish a range of *Back To Basics* projects – admittedly on PCBs – in our *Electronics Teach-In* book – see our *Direct Book Service* for ordering details.

Mike Kenward

PIC name origins

Dear EPE,

I recall that, several issues of *EPE* ago, readers speculated about the meaning and origins of the expression *PIC*.

At the time I looked at the photos and concluded that a *PIC* was a rather large electronic circuit. I had also looked at the photo of an advertiser's *PIC oscilloscope* and concluded then that a PIC was a type of electronic equipment.

However, I have recently concluded that a PIC is not a complete electronic circuit but a single IC! From that point it became obvious to me that the 'P' stood for *Programmable*. What could be more natural than the first developer of an IC which could perform a range of functions should name it a 'programmable integrated circuit', or a PIC.

Although I agree that mathematics is a language and that circuit diagrams, flow charts and computer programs also constitute important languages, I also believe that spoken and written languages are important and useful; the names of pieces of technological equipment and parts thereof give vital information about what they can do and how they are made.

I have noted that contributors to *EPE* make a real effort to make use of the English language in order to communicate meaning. I for one am extremely grateful for this.

M.P. Hopkins, via email

Thanks MPH, I too originaly shared your view of the term PIC, then Microchip advised me that I was wrong, as I said in Part 1 of Teach In 2008. *All of us at* EPE *believe that we should communicate meaning clearly through what we write.*

Waste time?

Dear EPE

Regarding a letter from Tony Jaques of Manchester (Dec '07) about saving power and his apparent thoughts of it being a waste of time. I sugguest he reads his gas and electricity bills, particularly the price per kWh (electricity unit). Taking my own bills as examples – gas (for heating) is at 4.266p (first so many units), then 2.173p per kWh as opposed to elctricity at 9.32p per kWh. (source British Gas and Southern Electric).

So Tony's 'unintentional heating' is more expensive than deliberate heating, even allowing for boiler efficiency. His question of 'where is the saving?' – look in his bank account, it will be worth switching off and that is without any environmental reasons on top.

Brian Ellison, via email

Thanks Brian

PIC random byte generator

Dear EPE,

I have been looking at the code for the random number generator from the **PICnMix/mplab-art4-step1.zip**. The function **rand_seed** in the file **random.asm** reads:

```
rand_seed
   global rand_seed
   movlw  rand_seed_1
   movwf  shiftReg1
   movlw  rand_seed_2
   movwf  shiftReg2
   movlw  rand_seed_3
   movwf  shiftReg3
   movlw  rand_seed_4
   movwf  shiftReg4
   return
```

This would move the value of the address into the **shiftReg** variable (create a pointer). This should read:

```
rand_seed
   global rand_seed
   movfw  rand_seed_1
   movwf  shiftReg1
   movfw  rand_seed_2
   movwf  shiftReg2
   movfw  rand_seed_3
   movwf  shiftReg3
   movfw  rand_seed_4
   movwf  shiftReg4
   return
```

ie move file, *not* move literal?

Also, the project won't load properly into MPLAB, is this due to PicKit2 debugger being enabled?

'Col', via email

Mile Hibbett replies:

Thanks for spotting that mistake Col, you are quite right. Of course the program does work and produces random numbers, it's just that you would never be able to change the start point for the random number generator. Your change is exactly what I would have intended.

I've just tried loading the project files into MPLAB, and it builds fine. Perhaps you are concerned about an error message saying that the PicKit2 debugger is not connected? You can ignore that message, but to make it go away select Debugger->Select Tool->None from the main menu.

Mike Hibbett, via email

Energy saving

Dear EPE,

In the Dec '07 *Readout* you requested comments on Tony Jaques' observations on energy efficiency. If the house is heated by thermostatically-controlled electrical resistance heating, his views are essentially correct. However, except for local areas over short periods, electrical resistance is not a rational way to heat a dwelling. It is just wasting energy.

In most power grids, marginal power (the next kW) is provided by the combustion of fossil fuels. The maximum thermal efficiency of a fossil fuelled power plant is just under 60% (one in Wales, I believe). Then there are transmission losses. But, condensing home furnaces burning natural gas, propane, or domestic fuel oil (or even coal slurries) can achieve thermal efficiencies of 95% or more.

Although the initial cost of such furnaces is considerably more than simple electric 'baseboard heaters', with current energy prices they will pay for themselves in savings in utility costs in only a year or two.

Incidentally, I have used propane heating for the last 20 years. In the US, natural gas is the preferred heating source in the west, fuel oil in the northeast, and propane in the southeast, but it varies locally. 'All electric' homes were promoted by builders in the 60s to allow them to offer low prices, but vanished with the 'energy crunch' of the 70s.

Ed Grens, USA, via email

Thanks Ed, energy conservation is a matter that is very much with us.

FPGAs

Dear EPE,

I would like to start by saying that *EPE* is an excellent magazine that always contains a wealth of very interesting articles, and is produced to a very high standard. Although I have only subscribed since May 2007, there has never once been any mention of Field Programmable Gate Arrays (FPGAs) within your pages.

It seems a shame that these devices offer such huge potential and yet you don't mention them or utilise them in any projects. Is it the fact that many are supplied in either ball grid array (BGA) or quad flat-pack (QFP) form and are seen as too difficult to utilise by the hobbyist? Surely there are ways around this?

Their cost cannot be seen as a hurdle either, as many can be purchased for the same price as a PIC micro. As an example, Xilinx can supply a superb starter kit for the Spartan-3E FPGA for a mere £85! This could form the basis for an excellent tutorial.

Can I suggest that you cover these in a future series with some sample projects?

Paul Towle, via email

Thanks Paul, personally I've never played with FPGAs but we'll keep your suggestion in mind.

Mike's retirement

Dear EPE,

Reading in the Feb issue of Mike Kenward's retirement as editor, I would like to express my most sincere personal thanks and appreciation to him for the professional excellence of his endeavours throughout his many years as editor with *EPE*.

Edwin Chicken MBE, BSc MSc CEng FIET, G3BIK.

Thanks Edwin, your sentiments will be shared by everyone who has come to know Mike, either personally or through EPE.

I have known Mike since about 1972 when I took my first design into Practical Electronics *which at that time was under its founding Editor, Fred Bennett. Mike was then Fred's assistant. I continued to have periodic contact with Mike for many years, during which time he took over the Editorship of* Everyday Electronics, *and eventually became its owner and expanded it to become* Everyday Practical Electronics (EPE). *I joined him on* EPE *in 1994.*

You may care to read the potted history of EPE *in the Resources section of our website at* **www.epemag.wimborne.co.uk**.

It is Matt Pulzer who takes over the Editorship of EPE, *although Mike will remain in overall charge. I have known Matt for maybe 14 years, from the time when he was editing our sister publication* The Modern Electronics Manual. *I am certain that he will continue to maintain* EPE's *excellence. I am pleased to be working with him again.*

I too send my best wishes and thanks to Mike.

Net Work

Alan Winstanley

The full eight megs!

For those of us lucky enough to live in a broadband-enabled area, in my experience the quality of service available seems to have reached a plateau. Many ADSL (asymmetric digital subscriber line) broadband users are stuck with a theoretical 8Mbps (megabits per second) service delivered via a decrepit copper telephone line, which in my case is from an era of shared phone lines and rotary dial telephones.

Following a number of complaints about deceptive advertising practices, the weasel words 'up to' now feature more prominently in TV and newspaper advertising. For most of us, then, 'up to 8Mbps' means more like 2 or 3Mbps in practice. You can try an excellent online speed checker tool at **www.broadbandspeedchecker.co.uk**. This speedometer-style display tests both your upload and download speeds and it confirmed suspicions, namely that 'up to 8Mbps' download speed is actually 1.9Mbps.

Consequently, the service offers just one quarter of the utility and value of the theoretical full speed. Put another way, a broadband tariff costing £18.50 per month is more like £74 a month in terms of potential usefulness. And it's even more expensive due to bandwidth throttling, discussed later.

Of course, ADSL is inherently restricted by technology: the further away from the exchange, or the poorer the quality of the line, then the lower the available speed, especially as we are usually handicapped by a network of copper wires rather than fibre optics. My heart sinks when trying to download a large file and the transfer rapidly tumbles to sub-dialup levels of 20 or 30kbps – especially at night, or when kids are surfing the net.

The large influx of ADSL subscribers has also contributed to a general reduction in speed. The term *contention ratio* describes how many users have to share one broadband 'pipe'. A residential or consumer ADSL service is 50:1, while a business tariff offers 20:1 contention, with more to go round.

Meltdown

We're lucky though. Regular *EPE* contributor the Rev. Thomas Scarborough in Cape Town, South Africa reminds me that Internet access is in chaos, if not meltdown, in his part of the world, and the speed and reliability of access are about as consistent as his church's monthly receipts.

I had to check back a long way until I found a copy of my *Net Work* (August 2005) column – in which I described how broadband finally arrived against all odds here in my worklab. At the time, there was a big question mark over whether ADSL would ever be installed: BT had devised a system of 'trigger levels' and only when sufficient numbers of interested subscribers were reached would BT think about updating their exchanges to carry broadband traffic.

Nowadays, it seems that everyone and their dog has broadband. Back in 2005, I enthused about the excellent service that Tiscali had provided in enabling my phone line on time (if not early), ensuring documents were sent very promptly in the post, and delivering a free but undesirable ADSL modem. I wrote how *'Tiscali was to be congratulated on providing a very efficient and informative upgrade service...Tiscali's entire upgrade process could not be faulted...'* I wrote, through spectacles made all the more rosy by the surreal experience of always-on 512kbps broadband finally arriving in the rural outbacks of England.

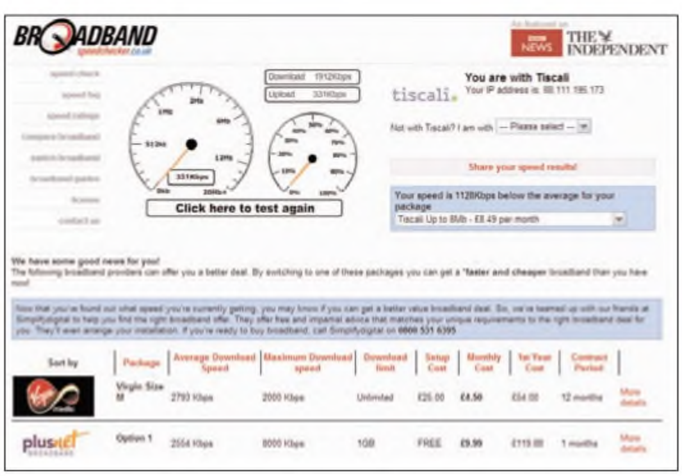
Contrast this with a recent email I received from a Tiscali user who was moving premises, and wanted to relocate further up the road. Tiscali completely botched the transition, and all they delivered were broken promises: a process that should have taken five days eventually took a month, after which the customer cancelled Tiscali altogether.

At full throttle

The effect of falling speeds has become more noticeable in recent months, and is partly caused by the practice of bandwidth 'throttling' by ISPs such as Tiscali and Pipex (in turn owned by Tiscali). Try downloading a large 200MB music file during peak periods, and Tiscali's network will tighten the thumbscrews to the threshold of total frustration. The reason they give you a free router is so that you don't feel so bad when you kick it. Sometimes, I've given up trying to fetch such files and left them to download overnight, which is a throwback to the dark days of dialup.

The technology of bandwidth throttling and network control is effected using systems such as P-Cube, now owned by Cisco – for a good insight, try the old P-Cube website at **www.p-cube.com/indexold.shtml** and check the Flash demo. The P-Cube technology lets ISPs differentiate between types of traffic by deep-analysing the packet traffic. Bandwidth can therefore be prioritised. Online gaming, streaming audio/video audio or peer-to-peer traffic can be 'throttled back' by the ISP in order to optimise the meagre bandwidth. A recent network upgrade to the throttling technology backfired and Tiscali, deluged by disgruntled subscribers, quickly back pedalled and reversed the system upgrade.

Some may view bandwidth throttling as penalising subscribers in terms of their time needed to do anything useful with the service. From experience, at peak times, a large file download could be throttled down to a mere 30kbps which is just 1.5% of the line's practical capacity: put another way, an £18.50 monthly rate (for just 1.9Mbps) jumps to the equivalent monthly rate of £1,233 for bandwidth at peak throttled periods! Note that technology such as the P-Cube also paves the way for charging subscribers dependent on the type of traffic they generate, with music downloaders or gamers being penalised even more.



broadbandspeedchecker.co.uk offers a car speedo-style speed test or upload and download speed, and then suggests alternatives to try

Next month, I will continue on the same theme, highlighting some pitfalls and showing how to research new providers and get the best deal. You can email me at: **alan@epemag.demon.co.uk**

DIRECT BOOK SERVICE

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

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

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Electronics Teach-In + Free CD-ROM

Mike Tooley

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

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

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

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

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CD-ROM

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

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PROJECT CONSTRUCTION

IC 555 PROJECTS
E. A. Parr

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

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

POWER SUPPLY PROJECTS
R. A. Penfold

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

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

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

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

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

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold

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

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

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

135 pages **Order code BP392** **£5.49**

TEST EQUIPMENT CONSTRUCTION
R. A. Penfold

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

The following designs are included:-

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

104 pages **Order code BP248** **£4.49**

COMPUTING

COMPUTING FOR THE OLDER GENERATION
Jim Gatenby

Especially written for the over 50s, using plain English and avoiding technical jargon. Large clear type for easy reading.

Among the many practical and useful ideas for using your PC that are covered in this book are: Choosing, setting up and understanding your computer and its main components. Writing letters, leaflets, invitations, etc., and other word processing jobs. Keeping track of your finances using a spreadsheet. Recording details of holidays and other ideas using a database. Using the Internet to find useful information, and email to keep in touch with family and friends. Making 'back-up' copies of your work and checking for viruses. How to use Windows XP to help people with impaired vision, hearing or mobility.

Provides the basic knowledge so you can gain enough confidence to join the local computer class.

308 pages **Order code BP601** **£8.99**

THE INTERNET FOR THE OLDER GENERATION
Jim Gatenby

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

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

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

RADIO

SETTING UP AN AMATEUR RADIO STATION
I. D. Poole

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

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

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

EXPERIMENTAL ANTENNA TOPICS
H. C. Wright

Although nearly a century has passed since Marconi's first demonstration or radio communication, there is still research and experiment to be carried out in the field of antenna design and behaviour.

The aim of the experimenter will be to make a measurement or confirm a principle, and this can be done with relatively fragile, short-life apparatus. Because of this, devices described in this book make liberal use of cardboard, cooking foil, plastic bottles, cat food tins, etc.

Although primarily a practical book with text closely supported by diagrams, some formulae which can be used by straightforward substitution and some simple graphs have also been included.

72 pages **Order code BP278** **£4.00**

25 SIMPLE INDOOR AND WINDOW AERIALS
E. M. Noll

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

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

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

AN INTRODUCTION TO RADIO WAVE PROPOGATION
J.G. Lee

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

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

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

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

THEORY AND REFERENCE

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

This book gives the "big picture" of digital electronics. This indepth, highly readable, up-to-the-minute guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate.

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

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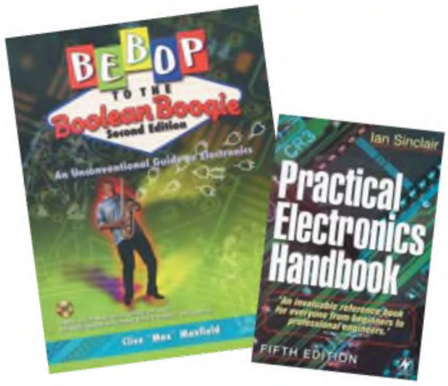

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Ian L. Sanders

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GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

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96 pages **Order code BP239** **£5.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

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EPE EVERYDAY PRACTICAL ELECTRONICS

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ELECTRIC MOBILITY BUGGY MONITOR

EPE resident design engineer John Becker recently bought a battery-powered mobility buggy – and within hours of first using it he was working on an upgrade! This project provides instrumentation to measure everything from journey distance and speed to the ambient temperature in Fahrenheit or Celsius. The compact unit is PIC controlled and uses a 2-line x 16-character LCD.

PC-CONTROLLED BURGLAR ALARM

Following on from this month's hardware section, find out how to program and operate *EPE*'s sophisticated, all-areas alarm system.

PREAMPLIFIER SYSTEM INTEGRATION

Next month we'll bring together all the components of our low-cost, high-performance stereo preamp – the preamp module itself, a matching headphone amplifier and an infrared remote control module – all powered with a suitably low-noise power supply.

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A interface board with 5 digital input & 8 digital output channels. In addition, there are two analogue inputs & two analogue outputs with 8 bit resolution. All communication routines are contained in a Dynamic Link Library (DLL). You may write custom Windows (98SE, 2000, Me, XP) applications in Delphi, Visual Basic, C++ Builder or any other 32-bit Windows application development tool that supports calls to a DLL.
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With a total of 33 input/outputs: including analogue / digital and + 1PWM output. Connection to the computer is galvanically optically isolated, so that damage to the computer is not possible thus providing a high level of secure implementation. Supplied with test software & examples.
K8061 Kit £48.95
High Power LED Driver
Power up to four 1W or two 3W high-power LEDs (not incl.) Delivers accurate constant current required by most high-power LEDs, built-in rectifier for easy connection to AC source, compact size, short-circuit protected, no heatsink required.
K8071 Kit £4.95
VM143/1W for 1W LEDs £7.55
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Remote Control by Telephone
Turn up to three devices on or off over the telephone. It is also possible to check the condition of a switch (open or closed). A major advantage of this circuit lies in the fact that audio signals are used to tell whether a specific output has been turned on or off. Operation is protected by a user defined code, which is simply keyed in from the telephone keypad.
K6501 Kit £29.95
USB DMX Interface
Control DMX fixtures using a PC and USB interface, test software and "DMX Light Player" software is included, a DLL is provided to write your own software. Stand-alone test function that outputs all 512 channels at a time, with adjustable levels. Supplied with case, lead & CDROM
K8062 Kit £46.95
VM116 Assembled £49.95
Remote Control Transmitter
For use with the K8057/VM109 2-channel RF receivers. Generates unique 32-bit code more than 1,000,000,000 unique codes code can easily be changed for safety purposes choose continuous or 'burst' transmission LED indicator.
K8059 Kit £8.95
Remote Control Receiver
Two relay contact outputs for use with K8059 and VM108 two channel RF codelock transmitters, toggle or pulse function selectable per output, can learn a unique 32-bit code from the transmitters, store up to 31 transmitters, LED indicators for outputs and functions.
K8057 Kit £12.55
Remote Control Transmitter
Compact 2-button IR keychain remote compatible with most Velleman IR receivers, 2 powerful IR LEDs for a range of up to 15m, 16 channels (allow use of multiple transmitters in one room), easy channel configuration, no jumpers required.
MK162 Mini Kit £6.25
Remote Control Receiver
Two channels with relay output (24VAC/DC 1A max.) ultra compact channel and reception indication through LEDs toggle / pulse selection for each channel learn mode for channel ID all settings are stored in EEPROM compatible with most Velleman Kit IR remotes.
MK161 Mini Kit £7.95
3-30V 3A Power Supply
Suitable as a power supply for all common Velleman kits using a stabilised DC voltage between 3 and 30V, 3A max. Of course this power supply unit can also be used for other purposes. By replacing the trimmer by a potentiometer, it may even be used as an adjustable power supply unit. Supplied with heat sink.
K7203 Kit £19.95
Sound to Light Unit
Low, mid and high channels. Sensitivity adjustment per channel. LED indication per channel. Attractive translucent enclosure. Microphone included. Noise suppressed according to EN55015
K8017 Kit £27.55
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Operate your lighting simply by clapping your hands. Good immunity against surrounding noises, '1-clap' or '2-clap'-mode selection, '2-clap'-mode features built-in safety turn-off timer (approx. 5h), output relay 'pulse' or 'toggle' selection.
MK139 Mini Kit £7.95
Voice Changer
Make your voice sound like a robot, add vibrato effect, use the 'pitch'-buttons and make your voice sound lower or higher, built-in microphone and power amplifier with volume control, just add a speaker.
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