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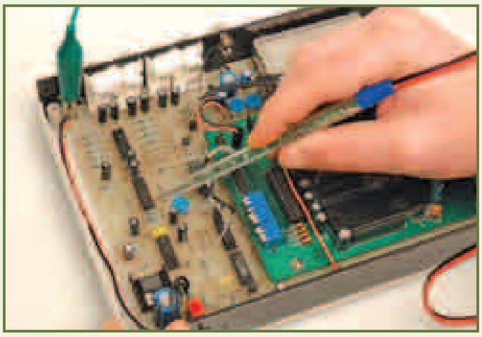

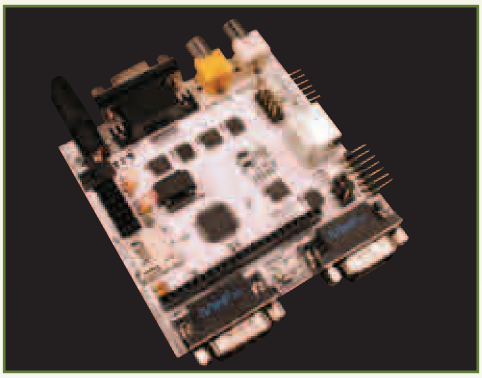

Our August 2009 issue will be published on Thursday 9 July 2009, see page 72 for details.

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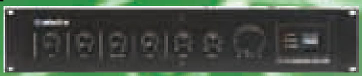

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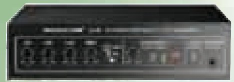

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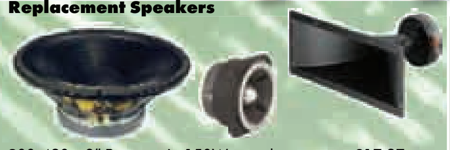

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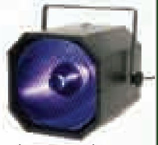

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Energy harvesting

Recently, I was browsing a trade publication (Electronic Product Design) when I came across an interesting phrase – energy harvesting (EH). It was new to me, but I suspect we are all going to hear about it over the coming decade. EH or 'energy scavenging' is the use of ambient energy to power small electronic devices, gadgets and systems. While each individual example may not represent much of a leap forward in fundamental engineering, as a design approach it will offer novel, even revolutionary answers to problems.

Old and popular EH solutions are the bicycle light dynamo and solar-powered calculator. More up-to-date and sophisticated designs include wireless powering of remote sensor networks and battery-dependent devices such as mobile phones and laptops. Future designs will even make use of 'body' generators that take power from walking and other human motion to charge personal stereos or any of the myriad of electron-thirsty gadgets we carry with us – a 21st century take on self-winding mechanical watches.

As I discussed in a recent Editorial, batteries are certainly vital and do have their place in electronics, but they are costly, bulky and their toxic contents can present serious disposal problems – 30 billion button batteries were sold last year, and who knows how many AA and larger batteries find their way into landfill. If this new technology enables us to use fewer and smaller batteries, or take advantage of essentially 'free' energy, then it promises a more convenient and less polluted world.

Last month, I asked for advice on interfacing non-Windows computers, and I am pleased to report a positive response. Chris Harden, from Easydaq, pointed me to the website of his company's range of UK-manufactured inexpensive interface products. Mac OSX and Linux fans can browse Easydaq's hardware at: www.easydaq.biz (see Readout).

AVAILABILITY

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

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

PROJECTS AND CIRCUITS

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

COMPONENT SUPPLIES

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

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NEWS

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

Sony's X-series Walkman

Barry Fox reports on Sony's new launch

IT IS now thirty years since Sony put the word Walkman into dictionaries round the world. Although Sony's analogue cassette players were hugely successful, the Company made a hash of the digital transition. Mini Disc never took off and Sony's Digital Walkmen were very user-unfriendly, largely because Sony insisted on using its proprietary compression system (ATRAC) with very unpopular software (SonicStage) and Digital Rights Management (MagicGate/OpenMG).

In 2001 Apple grabbed the opportunity to launch the user-friendly iPod and Sony has been playing catch-up ever since. The new X-Series Walkman is Sony's best yet, largely because ATRAC, SonicStage and MagicGate/OpenMG have been ditched. In a further admission of defeat at the hands of Apple, free PC software lets the user drag and drop music and movies by USB link direct to the Walkman from iTunes (provided the content is DRM-free).

Product Manager Wesley Dearing says "We are now back to doing what we do best".

Sony's launch event was not a good sign though. To put some buzz into the worldwide unveiling, Sony hired a disused Jubilee Line tube train station, deep under London's Charing Cross. A tube train was shunted in and X-Series Walkmen installed for the press and public to try. One of the big selling points of Sony's new iPod-busting Walkman is 'Wi-Fi connectivity for easy YouTube streaming, Podcast direct downloading and Internet browsing'. The player also receives FM radio.

Unfortunately, Sony forgot that there is no Wi-Fi or FM radio cover in an underground tube tunnel. So the demonstrators had to keep explaining why the new Walkman's special features would not work.

PICS WITH THE WORLD'S LOWEST SLEEP CURRENT

Microchip has announced the world's lowest power sleep current for 8-bit microcontrollers (MCUs). The PIC18F46J11 and PIC18F46J50 MCUs feature Microchip's new nanoWatt XLP eXtreme Low Power Technology, which enables typical sleep currents of less than 20nA. The new nanoWatt XLP technology gives designers the flexibility to customise their applications for the lowest power consumption through multiple internal wake-up sources, such as real-time clock and calendar alarm; brown-out resets, interrupts and watch-dog timers, all while maintaining I/O states.

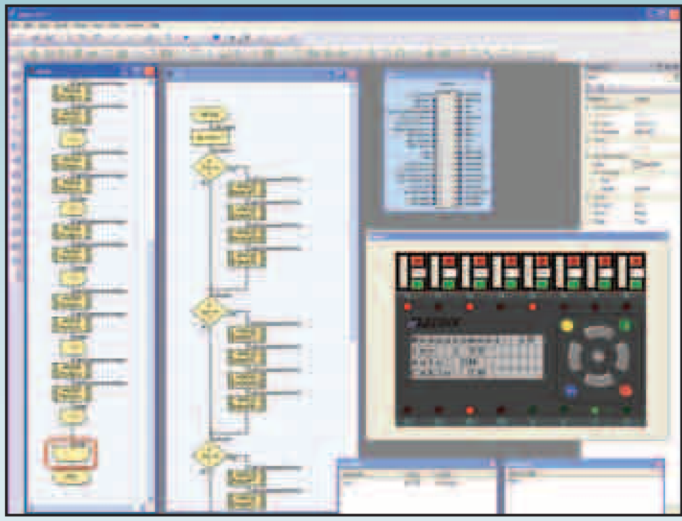
The general purpose PIC18F46J11 MCUs enable designers to easily and inexpensively add new features to a variety of applications, while maintaining extremely low power and small size. The PIC18F46J50 devices include full speed USB 2.0 for designs requiring connectivity, for remote field upgrades or the downloading of data. Both MCU families include a unique mTouch sensing peripheral, which lowers system cost by enabling capacitive touch user interfaces.

Additionally, a Peripheral Pin Select (PPS) function gives designers the flexibility to map the desired digital peripherals to I/O. With all of these features, the new MCUs provide the peripheral set of a typical 64- or 80-pin device in only 28 or 44 pins. Numerous applications can benefit from the extreme low power and peripheral integration of the PIC18F46J11 and PIC18F46J50 MCUs, across consumer, industrial, automotive and medical markets.

Designers looking to evaluate the new PIC18F46J11 devices can use the PIC18 Explorer Board (part number DM183032, $99.99) and Plug-In Module (part number MA1 80023, $25). The PIC18F46J50 MCUs are supported by the new PIC18F46J50 FS USB Demo Board (part number MA1 80024, $45), which also plugs in to the PIC18 Explorer Board.

The six PIC18F46J50 USB 8-bit family members are available now for general sampling and volume production. The 28-pin package options for the PIC18F24J50, PIC18F25J50 and PIC18F26J50 MCUs are: QFN, SSOP, SOIC and SPDIP. The 44-pin package options for the PIC18F44J50, PIC18F45J50 and PIC18F46J50 MCUs are: QFN and TQFP.

For more information, visit **www.microchip.com/XLP**.

MIAC with free graphical programming software

Matrix Multimedia tell us they have recently launched a flexible controller for the hobbyist and industrial markets – the MIAC is a rugged PIC microcontroller designed to allow those with no programming experience to develop highly functional control systems. The free software supplied with MIAC allows users to design a program using standard flow-chart icons, simulate the program on-screen, and then download the program to the MIAC using a standard USB lead.

The MIAC unit itself is packed with features, including eight analogue or digital inputs, four 10A relays, four motor outputs, keypad, LCD display, and a CAN bus interface, which enables networks of MIACs to be developed. The unit is powered by an advanced 18 series PIC and is also compatible with all third-party PIC compilers.

The MIAC and Flowcode 3 graphical programming software is priced at just £120 ex VAT, (€135, US $180), making MIAC one of the best value for money controllers on the market, say Matrix.

Matrix Multimedia is a leading producer of development tools for the electronics industry. The company's products include Flowcode, E-blocks, ECIO, Locktronics and MIAC. Over the last 16 years, Matrix has developed a broad portfolio of development software and hardware allowing engineers, hobbyists and students to learn about, design and build electronic systems.

For more information contact Matrix Multimedia, The Factory, Emscote street South, Halifax, HX1 3AN. Tel: +44 (0)1422 343924. Web: **www.matrixmultimedia.com**.

HAPPY BIRTHDAY PCB-POOL

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NanoMarkets report highlights printed batteries

NanoMarkets, a leading industry analyst in Virginia, USA, has announced the release of *Printed Battery Markets: 2009 and Beyond*. The report contains the latest analysis and market projections from NanoMarkets' ongoing research of the 'thin' batteries market.

NanoMarkets has reached a stage where printed batteries are now a viable technology. Thanks to advances in materials and manufacturing, there are products on the market that utilize them. However, the conventional wisdom a few years back was that RFID was going to be the killer application for printed battery technology.

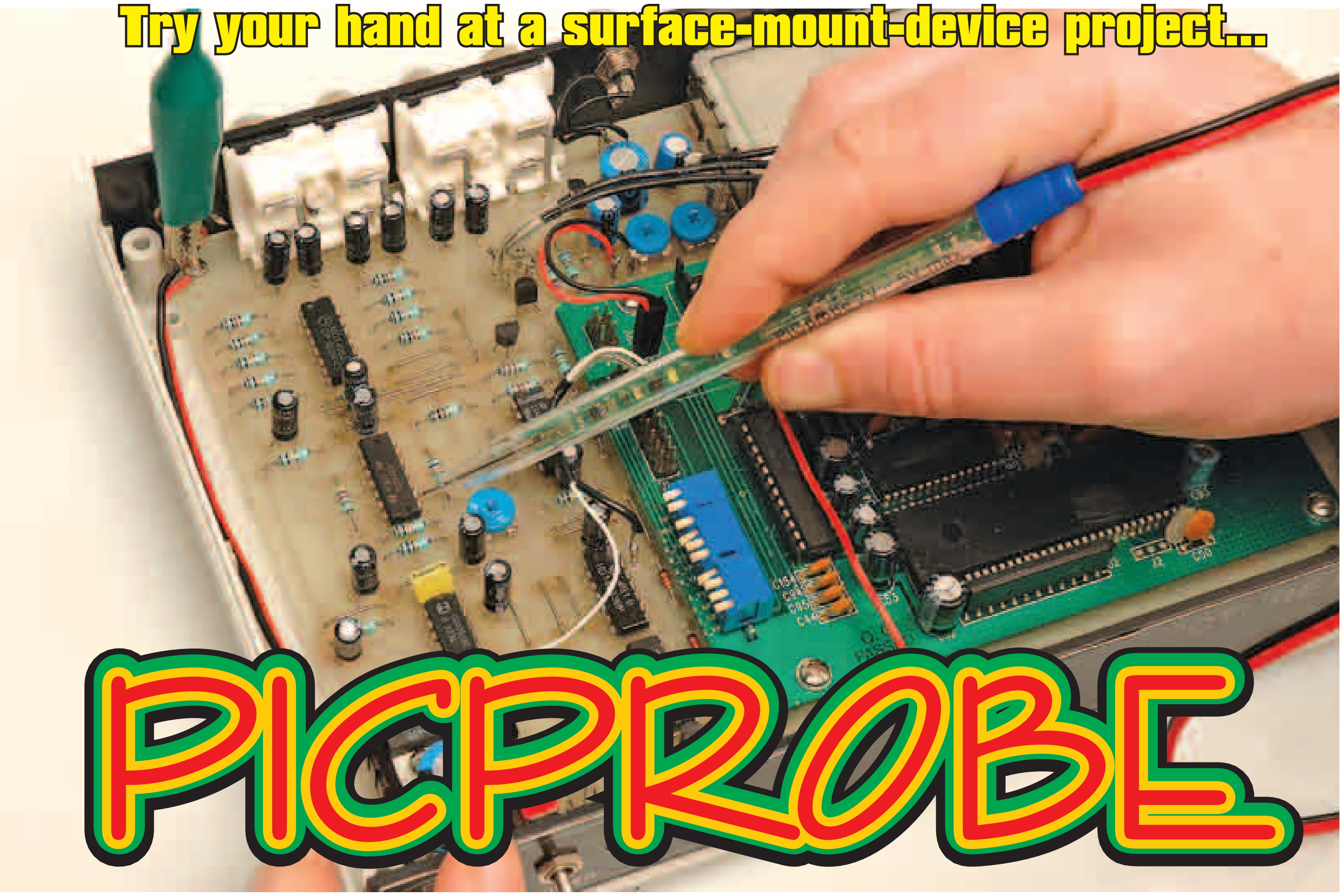
That has not happened because of printed RFID's slower than anticipated market acceptance. While printed RFID will still be an important application for printed batteries, the real story today is powered smart cards, which are an increasingly important technology for the credit card industry and consumers. Smart cards is an area where printing is already used as the manufacturing process. Being able to integrate the power source in the production of smart cards is extremely attractive for manufacturers.

Meanwhile, the story of printed batteries has shifted from being about their own opportunity to what it is that printed battery technology can enable. By 2015, NanoMarkets sales of products that utilise printed batteries will total $1.5 billion in revenues, with the value of the batteries themselves amounting to more than $200 million.

While this should be seen as encouraging, NanoMarkets believes that more printed battery firms will have to follow the lead of Power Paper and look to develop applications for their batteries, rather than just produce the batteries themselves since remaining as a battery supplier will likely spell the demise of many firms. This strategy will offer potentially bigger markets for printed batteries manufacturers to tap into, but it also means a potentially significant shift in the focus of the business models and the need for additional finance.

The new NanoMarkets report analyses and quantifies the opportunities for printed batteries for the period 2009 to 2016. The report contains detailed eight-year forecasts of both printed batteries and the products that are powered by them. It also contains assessments and projections of the technologies emerging in this area; both the battery chemistries and the printing technology and profiles of the leading companies in this space, including Btu Spark, Enfucell, Planar Energy Devices, Power ID, Power Paper, Prelonic Technologies, Rocket Electric, VARTA and VTT. Applications covered include RFID and smart packaging, electric shelf labels, smart cards, sensors, cosmetic and pharmaceutical patches, smart bandages, sensors and others.

Details of the report are available at **www.nanomarkets.net**.



A PIC-based logic probe that fits inside a ballpoint pen case!

THIS PROJECT CAME ABOUT through the recent trend in electronics towards lower operating voltages. If you look around at the latest chips being offered from semiconductor manufacturers, you will see that most are designed to operate on 3.3V or less.

Having produced a few designs with 3.3V components recently, I discovered that my old favourite test tool, the logic probe, wouldn't operate below 5V. I looked around my usual electronic suppliers, but couldn't find anything that would work on less than 5V. So I decided to design and build one myself.

The first requirement was to make it work over as wide an operating voltage as possible, so that it could be used on the old legacy 5V systems and down to some of the latest processors at 2.8V. The second requirement was low cost.

I took a look inside the existing probes I had, only to find them full of analogue components, some of which were now obsolete.

Micro size

The quickest and easiest approach seemed to be to build something around a small microcontroller, so I went on the hunt for anything that was small, cheap and worked on a wide supply voltage. I ended up at the Microchip website looking at our old friend, the PIC.

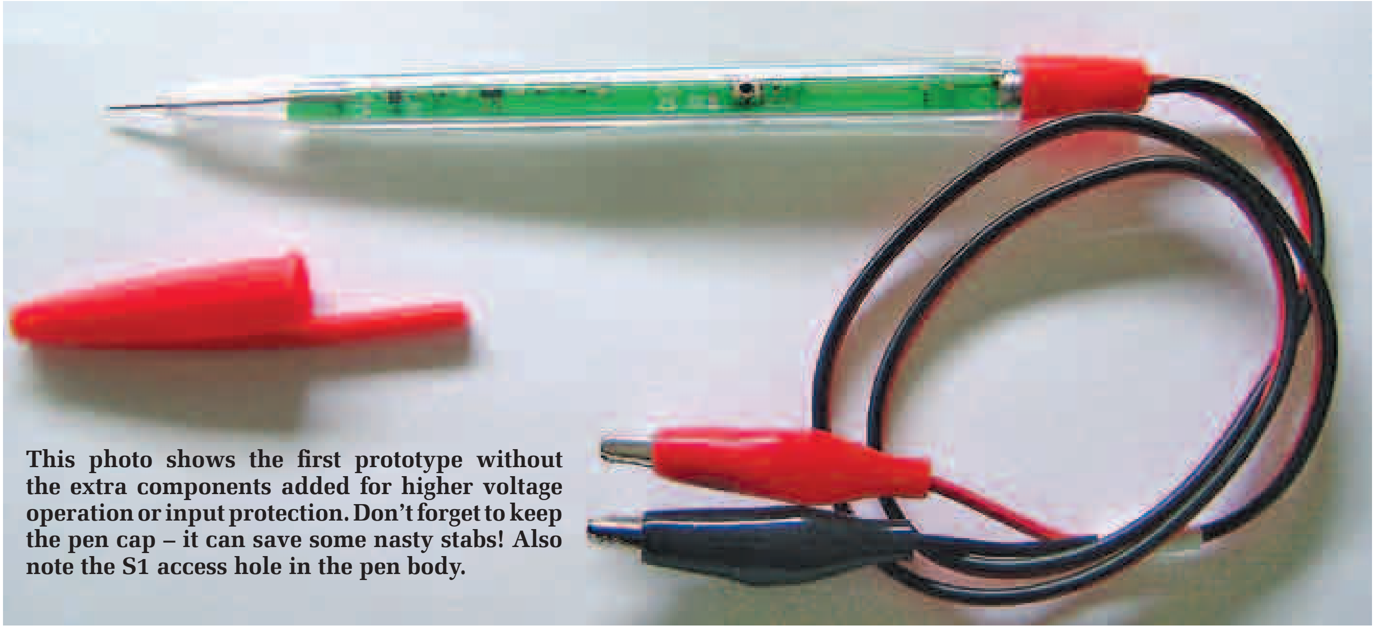
One of the microcontrollers in their ever-expanding family is the 10F20x series, which is available in DIP-8, SO-8 or SOT-23-6 packages. The SOT-23-6 was my choice, because these are tiny and easy to put inside some type of pen as a housing.

from an original
by Ross Purdy

The next mission was to find a housing for the design. Many years ago, I built a logic pulser into a white board marker pen from a magazine article. So, I decided to check out the local stationery shop for ideas. If I could find, say, a pen moulded in clear plastic, then I wouldn't need to drill holes to view the LEDs. This would not only make it easier to build, but it would look pretty cool as well!

I found a 10-pack of ballpoint pens that looked about right and cost only £1.00, making for a very cheap case – including an end cap to protect the 'needle' probe. The pens were a bit on the small size, allowing for a PC board only about 5mm wide and 100mm long, but it was the height that I was more concerned with.

I cut out a dummy piece of circuit board, glued a few bits on and found that the micro and LEDs would fit easily down the barrel of the pen. With the micro and housing sorted out, at-



This photo shows the first prototype without the extra components added for higher voltage operation or input protection. Don't forget to keep the pen cap – it can save some nasty stabs! Also note the S1 access hole in the pen body.

tention was now concentrated on the functionality required.

First and foremost was a good sharp tip that you can use to probe the tiny pitch devices that are becoming increasingly common. A sewing needle seemed to fit the bill quite nicely here. I also wanted to have a pulse stretching or latching function to view and change very quick pulse transitions, so a switch would be required to change modes and clear the pulse latch when required.

Modifying the design!

You can see from the circuit diagram (Fig.1) that there isn't much to the PICprobe design. However, it does have some differences to the author's original circuit and project.

Since there would be a lot of hobbyists who might want to use the probe for testing devices with higher voltages, provision for an optional 5V voltage regulator has been added to the PC board design. This involved including the pads and tracks for a 5V SMD (surface mount) regulator (78L05, REG1). Due to the miniscule power drawn by the circuit, the regulator should be quite happy working up to its maximum input voltage of 30V.

If you only want low-voltage operation, the regulator can be left out and a link added to connect the DC in and DC out pads (where the regulator would be). The regulator input and output filter capacitors can remain – they won't do any harm and may even do a bit of good in decoupling a supply.

We've specified 100nF capacitors because we have found these are the easiest to get in SMD and in small quantities. But there would be some benefit if one of the two 'downstream' capacitors (ie, between the regulator output and ground 0V) could be larger – in fact, as large as you can get in SMD.

The second change was in the input circuit. The PIC only has six pins, two of which are the power supply. GP3 (pin 6), the probe input, can withstand a maximum of 13.5V. In the vast majority of circumstances this would be more than adequate, but once again, we've 'gilded the lily' somewhat by adding a pair of diodes (D1, D2) across the input (one each to the positive supply and ground 0V) along with a series resistor. This protects the input from accidental higher voltages and for the price is a worthwhile addition.

This is very handy in case you touch something at a higher potential than the power supply. If you don't need this protection, the diodes can simply be omitted. The 4.7kΩ resistor could be retained, or replaced by a wire link if you wish. It won't matter either way.

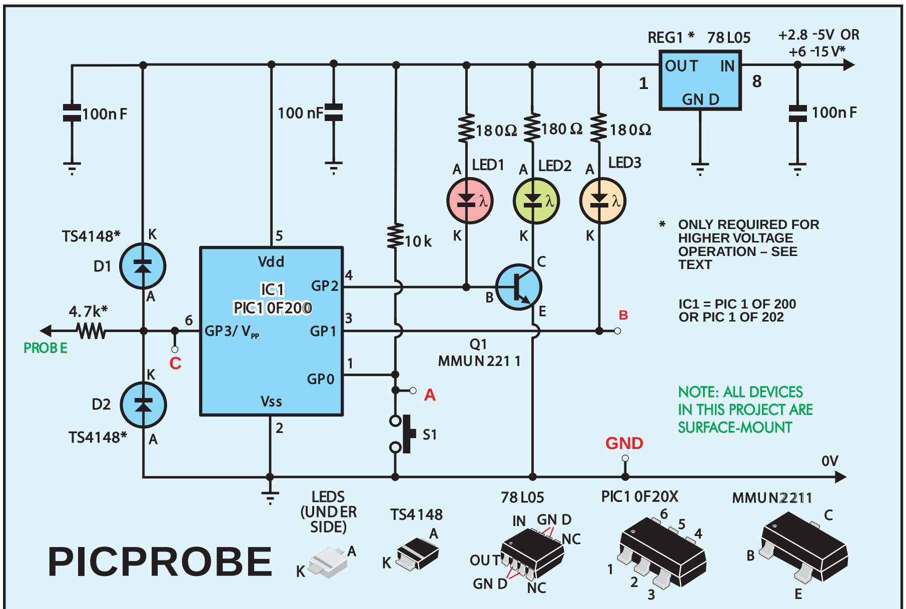


Fig.1: the circuit can be built in two versions – the one shown here, suitable for general purpose work or without REG1, suitable only for low-voltage work. Note: points marked A,B, C and GND on the circuit are 'pads' on the circuit board for programming the PIC *in situ*.

The SMD LEDs are really bright, especially in normal lighting. This photo clearly shows them glowing, even though they have been 'swamped' by the very bright photo flash we used for the photo.

Circuit details

Surface-mount LEDs, so tiny that they are almost impossible to find if you drop them on a carpeted floor (trust us!), are directly driven from the PIC's GP2 (red LED) and GP1 (orange LED) outputs. The green LED is driven by the inverse of GP2, using transistor Q1.

Even though Q1 is shown on the circuit as a standard *NPN* type, it's a bit more complicated than that. It is actually a 'resistor equipped transistor' which has two internal resistors: a series resistor to its base (B) and a pull-down resistor to its emitter (E). These 'RET' devices are great for use as digital inverters.

GP0 is normally held high by a 10kΩ resistor connected to the positive supply. It's also connected to a pushbutton switch (S1), which grounds the input when pressed.

Which PIC?

The circuit (Fig.1) shows a PIC10F200 as the microcontroller, but you can also use a PIC10F202. The program was originally written for the 200, which has 256 bytes of program, 16 bytes of RAM, and one 8-bit timer.

Note that neither the PIC10F204 nor PIC10F206 will work in this circuit – you must use the 200 or the 202.

Operation

The probe has three LEDs and a pushbutton switch (S1). The red LED is turned on for a logic 1 at the probe tip, while the green LED turns on for a logic 0.

The orange LED works in one of two modes – pulse stretch or latched. In pulse stretch mode, the orange LED will pulse for 50ms every time there is a change on the probe input. This makes very small pulses at the probe tip viewable. If the orange LED stays on permanently in this mode, then the probe tip is changing at a rate greater than 50ms.

In latched mode, the orange LED will turn on and stay on with any change on the probe tip. This is handy for detecting very infrequent changes. The latch is cleared and the LED turned off when the switch button is pressed.

The pushbutton switch has three functions: (1) changing orange LED mode, (2) clearing the latch and (3) enabling a pull-up resistor on the probe tip.

To change modes you press and hold down switch S1 button for two seconds. After two seconds the orange LED will blink to indicate the mode is about to change. When the button is released, the mode is toggled. In latch mode, a single press of the button will immediately reset the latch.

If the button is pressed when power is first applied, a pull-up resistor on the probe tip is enabled. Normally, the pull-up is disabled, which makes the input impedance very high. In this configuration the LEDs will flash randomly until the probe is connected to the target test point.

This is very useful for tracking down floating circuits on the target under test. If this is not an issue, then enable the pull-up and the tip will go to a 'soft' logic 1. The only way to reset the pull-up is to re-power the probe.

Software

Internally, you don't get much room to play with in this tiny PIC. Because the device is so small and the task relatively simple, the software was written in PIC assembler using the PIC IDE 7.5 tool kit, which is available free from **www.microchip.com**. The IDE gives you an editor and assembler and is quite easy to learn.

As this micro has no interrupts and very little resources, it doesn't take long to master, but as I found out, there are a few traps for the unwary. The first thing to master is the internal oscillator and its calibration, if required.

When the device is manufactured, it has a MOVLW instruction loaded into the last byte of the memory. On power reset, the micro starts at the last address and executes the MOVLW instruction. This loads a calibration value into the 'W' register and is factory set. The program counter then rolls around to 0 and starts executing the user's code.

The problem comes when you erase the device and lose the MOVLW instruction. If you want a 4MHz calibrated

Parts List – PICPROBE

1 double-sided PC board, code 717, available from the *EPE PCB Service*, size 106mm × 5mm – see text
1 clear plastic ballpoint pen case, with top and cap
1 35 to 40mm long darning needle
1 500mm length thin figure-8 cable, red and black
1 small red alligator clip
1 small black alligator clip
1 ultra-miniature (SMD) momentary action pushbutton switch

Semiconductors
1 PIC10F200 or PIC10F202 (SMD), 8-bit FLASH microcontroller, programmed with PicProbe.hex (IC1)
1 MMUN2211 (SMD) *NPN* resistor-equipped transistor (Q1)
1 red SMD LED (LED1)
1 green SMD LED (LED2)
1 orange SMD LED (LED3)
2 TS4148 SMD diodes (D1, D2)
1 5V SMD positive regulator (see text) (REG1)

Capacitors
3 100nF SMD

Resistors (all 6035MD)
1 10kΩ 1 4.7kΩ 3 180Ω

oscillator, then you need to read the last byte and write it down, then manually put it back in. All this seemed unnecessary as I wanted it to run as fast as possible. As the first instruction, I loaded 'W' with 0x7E, which makes the oscillator run at its fastest speed.

Internal timer

The next item to master is the internal timer. This is a bit tricky, as the micro has no interrupts to trigger asynchronous events. The timer is free-running and you can only read the timer register and compare it with a constant. Any write to the timer will clear it and start timing again, so you can't use any read-modify-write instruction.

This was a trap I fell into. I have run the timer at 50ms per overflow (counts from 0x3d to 0 in 50ms then is reloaded with 0x3d). If you check and branch when the timer is zero you can have a routine which is executed at a regular period for timing tasks.

The program begins by setting the oscillator configuration, port pin configuration (inputs or outputs), starting the timer, and resetting the LEDs.

As the processor has no interrupts the only way to monitor the probe tip is to poll it. This is done in the main loop and the smaller the main loop (or the quicker it executes) the smaller the pulse transition that can be detected. This is one limitation of the design, but in practice it doesn't appear to be a problem.

The main loop moves the state of the probe input to the red/green output, checks the status of the mode change flag and looks for the timer to reach zero.

On the button

Every 50ms, the time function is called. The job of the time function is to check that the button (S1) has been held down for two seconds and to update the orange LED in either pulse or latch modes.

First, we will look at the button down timer. To do this, we have a variable called CNT0 which is preloaded with 40. Every time the time function is called, we decrement CNT0 if the button is pressed. If it is not pressed, we reset CNT0 back to 40.

The only way CNT0 can make it to 0 is if we have 40 consecutive calls to time with the button pressed (40 × .05 = 2 seconds). When CNT0 reaches 0 we set a flag (BDOWN) to signal to the main loop that the mode change function needs executing.

The orange LED is handled with different pieces of code depending on the mode set. The flag LATCH determines the mode.

Every time the red/green LED changes state we set a flag (CHANGE). This flag is read by the time routine.

In pulse-stretch mode, the orange LED is turned on when CHANGE is set and then CHANGE is cleared. If CHANGE is not set, the orange LED is turned off. This means that the minimum time that the orange LED is on will be 50ms, which is more than enough for your eye to see.

Latch mode is similar, in that when CHANGE is set the orange LED is turned on, but is not cleared until the button is pressed. This is detected using the BPRESS flag.

Mode changing uses a separate function labelled 'cngmode'. When this function is called it will blink the orange LED using simple delay loops until the button is released. When the button is released, the LATCH flag is inverted and the routine exits back to the main loop.

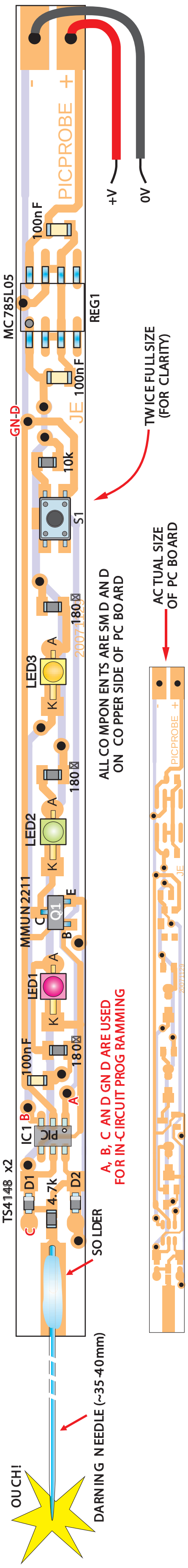
Construction

If this is your first SMD (surface-mount device) project, you will find there is a rather radical difference between handling, fitting, and soldering these devices and conventional components. For a detailed explanation, we refer readers to pages 16 and 17 of the January 2009 issue.

The other big difference in this project is the size (or lack thereof!) of the PC board. Like the SMDs themselves, it is tiny.

The double-sided printed circuit board component layout and full-size board are shown in Fig.2. The board is available from the *EPE PCB Service*, code 717. This board does not have plated-through holes, so you will need to make some 'links' between the two copper layers of the board. These are easy to make using short lengths of tinned copper wire.

This board measures just 106 × 5mm and should be a relatively snug fit inside the pen case. Don't push it all the way in to check, though – you may not be able to get it back out again.



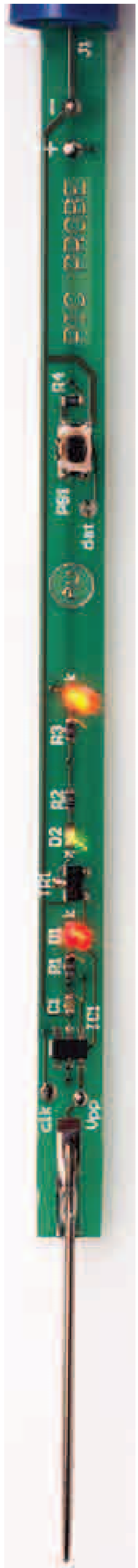


Fig.2: install the parts on the PC board as shown in this twice-size overlay. Note that this assembly differs slightly from the accompanying photo, which shows the author's prototype (ie, no regulator or input protection diodes for working at higher voltages).

PROGRAMMING THE PIC CHIP

If you're not building the PICprobe from a kit, you must first program the 10F200 or 202 micro with the file **PicProbe.hex**.

The software files are available for *free* download via the *EPE* Library site, access via **www.epemag.com**

Since the micro is a surface-mount device, programming it presents added complications. It must be done in-circuit, but before the board is fully populated. This section explains how to do this.

You need both a V_{PP} voltage source of around +13V and a normal +5V supply. If you have decided to use the 78L05 regulator, then you can derive the 5V supply from that. If you have chosen to omit the regulator, you will need to apply +5V to pin 5 of the PIC micro and 0V to pin 2.

The micro must first be soldered in place, making sure that the orientation is correct. If you are using the regulator, solder that in too, then solder both the positive and negative supply leads to the board.

Special pads to access pins 1, 3 and 6 of the PIC have been provided on the board specifically for programming. These are labelled, respectively, 'A', 'B' and 'C' on the component overlay. The pad labelled 'GND' can be connected to the external programming circuit shown above right.

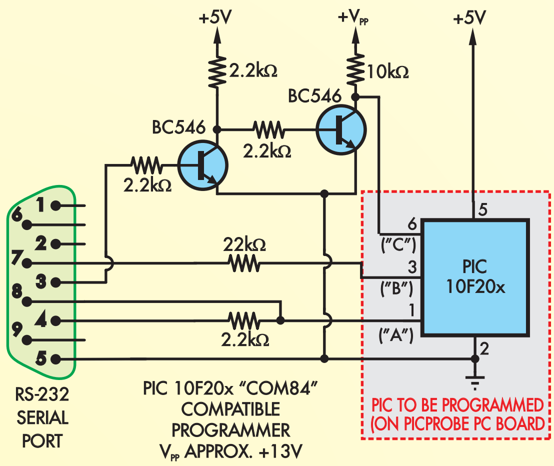
You may solder wires to these pads for the programming phase and later, when the micro has been successfully programmed, remove these wires. Back-up pads for the links required in normal operation have also been provided on the PC board.

The type of programmer we recommend is the 'COM84' style programmer, whose schematic appears above. A computer's serial port will be required and the software to use is WinPic, available free to download from **www.hamradioindia.org/circuits/winpic.php.**

We used the WinPic version compiled on 9 December 2005, but other versions should be similar.

After soldering the wires to the A, B and C pads, you should breadboard this circuit.

The two BC546 *NPN* transistors are used to switch on and off the higher programming voltage, which for normal programming should be between 12.5V and 13.5V at pin 6. Adjust your input V_{PP} voltage level to within this range. There will be a small voltage drop across the 10kΩ resistor in series between V_{PP} and the collector of the BC546/pin 6.



When the Tx line (pin 3) of the serial port is low, the voltage at pin 6 of the PIC10F20x should be around 0V. When it is high, it should be between 12.5V and 13.5V. The WinPIC software will automatically switch this voltage on or off as required.

To access the serial port, we used a serial cable with an IDC 10-pin header attached, as in the photograph below.

Once you are satisfied that the circuit is working correctly, you may connect the serial cable to your computer's COM1 port.

Now you should run the WinPic programmer. You must first select the COM84 programmer for the serial port in the 'Interface' tab. While you are there, check that the interface is working correctly by clicking on the 'Initialise!' button. If everything is working correctly, you should get the message 'Interface tested OK'. If not, double check your wiring.

Now go to Device -> Select . . . and select the PIC10F20x as your device.

You should now be able to erase, program and read the micro. To load the firmware, go to File -> Load and select the PicProbe.hex file. Then choose Device -> Program to program the micro.

If this worked, go to Verify to check that the firmware has been programmed correctly.

We are assuming you're building the PICprobe from a kit – ie, the micro is already programmed. If you are not, you will need to programme the IC as described above.

You need to decide if you want to use your logic probe for low-voltage work only (as in the original design) or for general purpose, higher voltage work. If it is for low-voltage work only (ie, 5V or less), you can leave out the voltage regulator and place a link between its input and output positions.

The first step in the assembly is to carefully solder the SMD devices to the PC board – but don't install the PIC just yet. To install these parts, you will need a soldering iron with a fine pointed tip and a magnifying lamp. A pair of self-closing tweezers can be used to hold each device in position as it is soldered.

Once these SMD parts are in, solder on the probe tip, the switch and the external connection wires. As mentioned earlier, the tip is a sewing needle. These are often nickel-plated, which makes soldering a bit difficult. Test it first – if it is difficult (or impossible) to get solder to take, you may need to file off a small section of the nickel plating.

The size of the 'probe' is up to you – and the type of work you'll be doing. We'd be inclined to use a small darning needle, as these tend to have less of a point (so you won't get stabbed!) but are still fine enough for the vast majority of work.

The needle we used was about 35mm long and so far, hasn't been missed from the sewing box.

Don't forget that the power wires (polarised figure-8 cable) need to pass through the pen top-cap, so it is wise to do this now, rather than later. You'll need to drill a hole in the end of the cap to accommodate the wires.

The last component to be fitted should be the PIC chip, as this allows you to check the LED operation *before* soldering the PIC (IC1) in position. To do this, connect power and in turn short the cathode (K) of each LED to ground (0V). Each should light in turn (you won't do any harm to transistor Q1 doing this).

As you do this, also check that the colours are correct: red towards the probe, orange in the middle and green towards the switch. If your LEDs light, it's a pretty good bet that you haven't made any mistakes or shorted out any SMD pins.

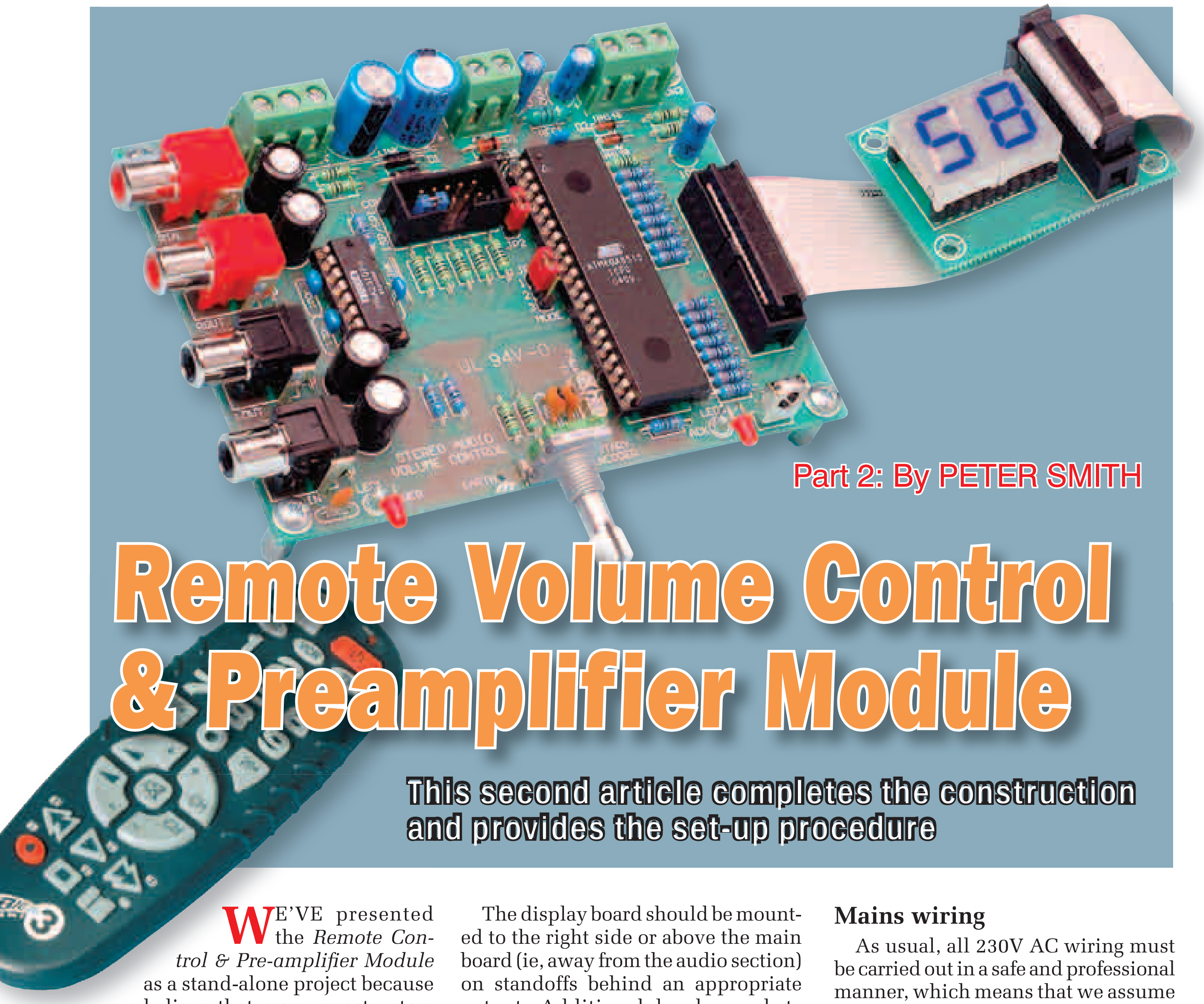
Next, remove power, wait a few minutes and then solder the PIC (IC1) to the board, taking care with its orientation. That done, apply power again – the LEDs should be flashing in an apparent random fashion, but only one should be lit when you touch the probe tip to the positive supply and then to 0V (which, of course, equates to a logic high and logic low).

Assembly is now complete – all you have to do is drill a 2mm hole in the pen case, as shown in the photo, to access pushbutton switch S1, then slide the completed PC board into the case until the switch is right under the hole. ***EPE***

Where Do You Get It?

Jaycar Electronics (**www.jaycarelectronics.co.uk**) sell a kit of parts for the PICPROBE.

Their kit includes a double-sided PC board with plated-through holes and all parts, including a preprogrammed micro, but not the pen or the needle (Cat. KC-5457).



Part 2: By PETER SMITH

Remote Volume Control & Preamplifier Module

This second article completes the construction and provides the set-up procedure

WE'VE presented the *Remote Control & Pre-amplifier Module* as a stand-alone project because we believe that many constructors will want to build it into an existing case. It is designed to fit flush behind a front panel, hence the LEDs and the rotary encoder are located along the front edge of the board. However, all of these devices can be mounted independently on a panel and hard-wired back to the PC board via short flying leads if desired.

Note that if the infrared receiver includes an external metal shield (see photo), then steps must be taken to ensure that it is insulated from any metal chassis or front panel. We suggest a short strip of insulation tape on the inside of the front panel, with a hole cut out to match the hole in the panel. Do not rely on the paintwork to provide insulation!

The display board should be mounted to the right side or above the main board (ie, away from the audio section) on standoffs behind an appropriate cutout. Additional header sockets (or cutdown 40-pin IC sockets) can be stacked vertically to increase the display height for a flush fit. Both the red and blue displays look great with tinted filters!

As mentioned last month, three different power supply configurations are possible. You could also power the unit from an existing regulated DC source if available. The minimum requirements are: ±15V at 20mA and +5V at 120mA.

Note that the two (analogue and digital) supplies must share a common ground. This means that if they're located on physically separate PC boards, their grounds must be cabled separately to the single 'GND' input at CON1.

Mains wiring

As usual, all 230V AC wiring must be carried out in a safe and professional manner, which means that we assume that you already have the relevant expertise or can obtain assistance from someone who has. **Most importantly, the assembly must be housed in an earthed metal enclosure. The mains earth must be properly connected to this chassis. This can be achieved via a double-ended 6.3mm spade lug fastened securely to the base with an M4 x 10mm screw, shakeproof washer and two nuts – see Fig.16.**

A basic wiring layout is shown in Fig.14. The mains section of the wiring will obviously need to be amended if the module is to coexist with a power amplifier, which will at least share the mains input socket and power switch.

Note that if using a separate, chassis-mounted transformer, alternative arrangements must be made for mains fusing. This is best achieved by using an IEC socket with an integral fuse.

Once all the mains wiring has been completed, go back and double-check that each connection is secure and well insulated. If necessary, use heat-shrink tubing to completely cover any exposed terminations. That done, use your multimeter to check continuity between the earth pin of the mains plug and any convenient point on the chassis that is devoid of paint.

This check *must* be repeated later when the case is assembled. At that time, use your meter to check that all panels of the case are earthed – without exception!

Low-voltage wiring

As a first step, disconnect the mains cable to prevent mishaps while working under the 'hood'. You can then complete the assembly by running all the low-voltage wiring.

If a separate transformer has been used, its two secondary (15V AC) windings must be terminated at the transformer input (CON1) of the power supply board. Twist the wires together and keep them as short as possible to reduce radiated noise.

Next, connect the +15V, –15V and GND outputs at CON2, and +5V at CON3 on the power supply to the matching inputs at CON1 and CON2 of the Remote Volume Control & Preamp Module. Note that the GND output at CON3 on the power supply is not used.

Use only heavy-duty hook-up wire for the job. Take great care to ensure that you have all of the connections correct – a mistake here may damage the control module. We suggest four different cable colours to reduce the chances of a mistake.

If you want to control left/right balance from the front panel, then you'll also need to install a pushbutton switch. This will enable you to use the rotary encoder for both volume and balance adjustments. The terminals of the switch are simply wired between the BALANCE and GND inputs at CON3. Having said that, balance adjustment is a rare requirement after initial setup (which would be done via remote control), so most constructors will not need this switch.

The module also provides a second switch input at CON3 labelled CHANNEL. This is intended for a possible future multi-channel upgrade and should not be connected, as it currently has no function.

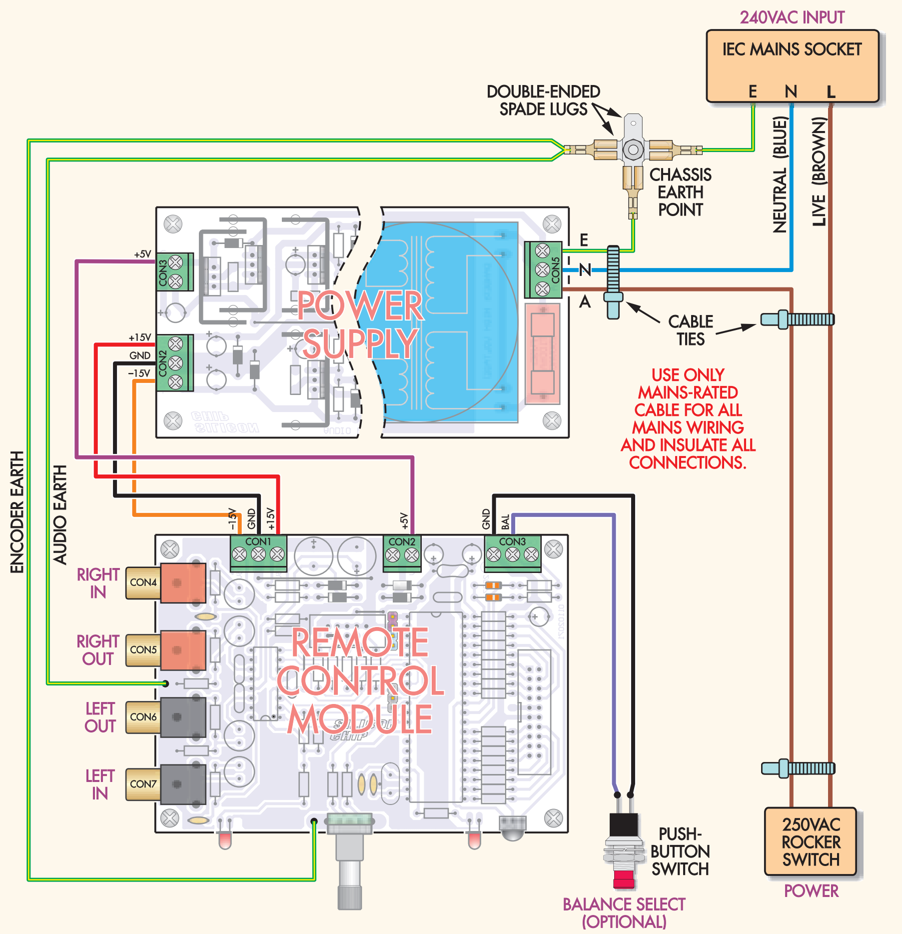


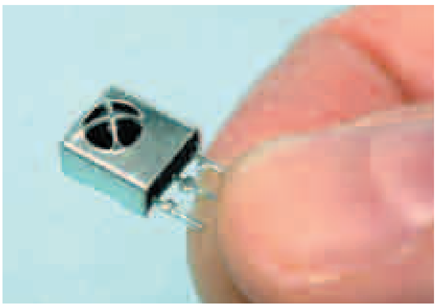
Fig.14: follow this basic diagram when hooking up your module. Use heavy-duty hook-up wire for all of the low-voltage power supply connections. For the mains side, use only mains-rated cable and be sure to keep it well away from the low-voltage side. A few strategically placed cable ties will keep everything in position, even if a wire should happen to come adrift.

Use good quality shielded audio cable for all the audio connections. Terminate one end of the cables in RCA phono plugs for connection to the control module's inputs and outputs. Depending on your requirements, you may wish to fit chassis-mount RCA phono sockets at the other end and mount these on the rear of your case.

Finally, you'll need to make up the cable for the main board to display board connection. This is simply a length of 20-way IDC ribbon cable terminated with 20-way plugs at each end (see photos). We used a 12cm length for the prototype, but we reckon it could be at least twice as long without causing any problems. Avoid routing the cable close to the analogue section of the control module.

Earthing

So far, you should have just two wires connected to the chassis earth point – the mains earth wire from the IEC socket and a second wire to the 'E' input (at CON5) of the power supply. Now run an additional mains-rated green/yellow earth wire from the pad just to the left of



If your infrared receiver module has a metal shield like this one, then be sure to insulate it from the front panel as described in the text.

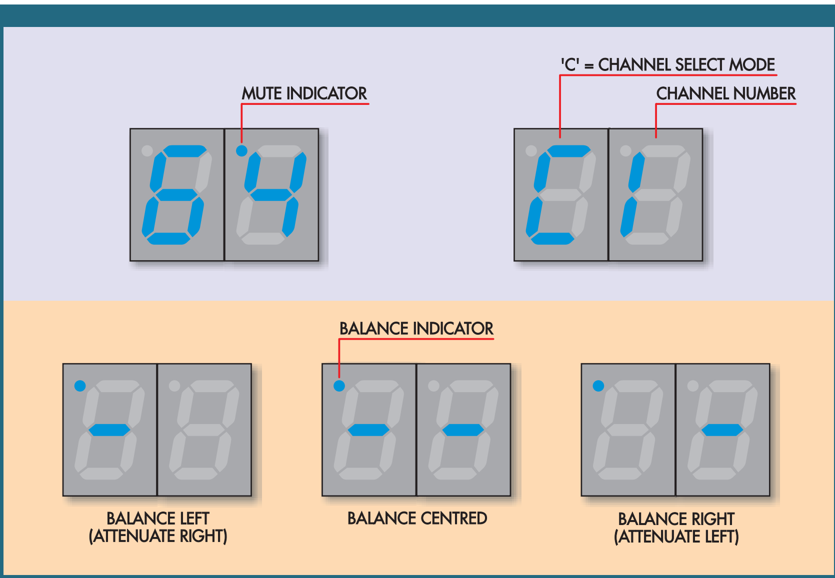


Fig.15: the 2-digit readout displays volume and balance on a 0-85 scale, and flashes an indicator when muted. Note that the channel select mode is for a possible future upgrade and can be ignored at present.

the rotary encoder to the chassis earth point. This solidly earths the body of the encoder to protect the microcontroller from static discharge.

To earth the audio ground, run another wire from the chassis earth point to the free pad situated between CON5 and CON6 on the control module, again using mains-rated green/yellow wire. Both earth wires should fit into a single spade crimp terminal to mate with the free end of the chassis-mounted lug – see Fig.14.

This earthing method will reduce the chances of creating an audible 'earth loop' in your system, but success is not guaranteed! For example, if your power amplifier also earths the audio signal, an earth loop will exist once the two are hooked together. This may or may not be a problem.

If you notice more hum in your audio system after connecting the preamp, then try disconnecting the earth wire to the control module. **Never, ever, disconnect the mains earth from the chassis!**

Testing

Before applying power for the first time, bear in mind that the mains input end of the power supply circuit board is live! Accidentally placing a finger under the board or contacting the mains input terminal block (CON4) screws might well prove fatal! Therefore, it is important that the power supply board is securely mounted in a chassis – not floating around on your bench.

Assuming the board is correctly installed, apply power and use your multimeter to measure the three rails at the supply outputs (CON2 and CON3). If all is well, the +15V, –15V and +5V rails should all be within ±5% of the rated values.

Now measure between pins 10 and 12 and then pins 10 and 13 of IC1's socket on the control module. You should get readings just below the ±15V levels measured earlier. Finally, check between pins 5 and 4; again, the reading should be just below the earlier +5V measurement.

Now switch off and allow about 30 seconds for the 1000 F filter capacitors to discharge. You can then insert IC1 and IC2 in their sockets, making sure that the notched (pin 1) ends line up with notches in the sockets!

Before moving on, you must now program the microcontroller (IC2) if it's blank – see the Microcontroller Programming panel.

JUMPER	IN	OUT
JP1	SETUP	NORMAL
JP2	0.5dB STEPS	1.5dB STEPS

Table 1: jumpers must be installed on both JP1 and JP2 during initial set up.

JP3 POSITION	INTERFACE ON CON8
1-2	ISP (DEFAULT)
2-3	SPI (FUTURE MULTI-CHANNEL UPGRADE)

Table 2: jumper JP3 should be installed in the 1-2 position.

Initial setup

Once construction and testing are complete, a simple set up procedure must be followed to prepare the module for use. Before beginning, make sure that you've set up your remote control as per the information presented last month in the Universal Infrared Remote Controls panel.

First, check that the power is switched off, then install jumper shunts on JP1 and JP2 (see Table 1) and JP3 pins 1-2 (Table 2). **A jumper must also be installed on CON8 pins 1-3 (see Fig.7 (last month) and photos) at all times, except when the microcontroller is being programmed.** Note that if this jumper is missing at power up, the display will flash an error code of '90'.

Now apply power while observing the 'Ack' LED. It should flash five times to indicate that the unit is in set-up mode. The 7-segment display should be blank, except for the the 'mute' indicator continuously flashing.

Next, point your remote at the on-board infrared receiver (IC3) and press the numbers '1' or '2' twice. It's significant which of these numbers is chosen. A '1' enables display blanking, meaning that the display will go blank eight seconds after each volume or balance adjustment. Conversely, '2' disables this feature, causing the display to be always on.

On the second press, the 'Ack' LED should flash five times again, indicating that the code was received and the chosen equipment address (TV, SAT, AUX, etc) successfully saved. You should now power down the unit and remove the set up jumper (JP1) only. This procedure can be repeated in the future should you wish to change the equipment address or display blanking option.

In use

As mentioned previously, volume span is effectively 127dB (–95.5dB to +31.5dB). As the PGA2310 supports 0.5dB gain steps, there are 255 steps from minimum to maximum volume. To fit this on a 2-digit readout and make it more intelligible, the level is scaled down to a 0 to 85 range by dividing it by three. The result is accurate to 1.5dB, so you'll need to adjust the volume/balance by three points before you see a change in the readout. Note that '64' corresponds to 0dB (unity) gain –

Microcontroller Programming

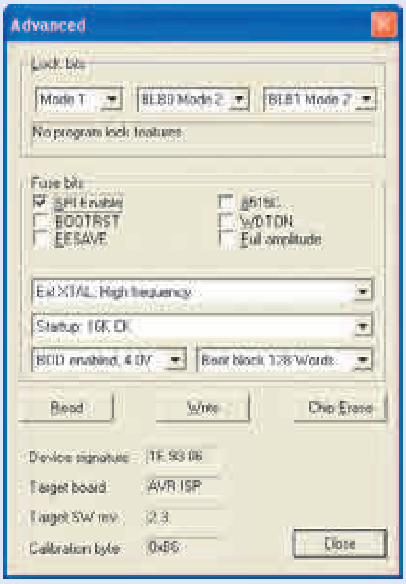


Fig.17: here's how to set the fuse bits in AVR Prog, as used with the AVR ISP Serial Programmer. Once you've set all of the options exactly as shown, click on the 'Write' button.

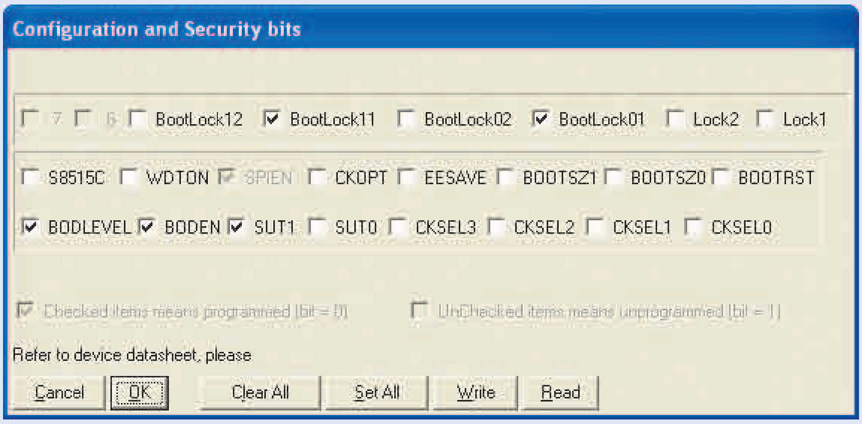


Fig.18: the parallel port programmer uses PonyProg, which has an entirely different fuse configuration menu. Again, copy this example and hit the 'Write' button.

IF YOU'RE BUILDING this project from a kit, then the microcontroller (IC1) will have been programmed and you can ignore the following information. Alternatively, if you've sourced all the components separately, then you'll need to program the microcontroller yourself. A 10-way header (CON8) has been included on the PC board for connection to an 'in-system' type programmer. Temporarily remove the jumper between pins 1 and 3 of CON8 to allow connection of the programming cable. Also, make sure that there's a jumper between pins 1 and 2 of JP3.

Once you have a suitable programmer, together with the necessary cables and Windows software to drive it, all you need to complete the job is a copy of the microcontroller program for the *Remote Volume Control & Preamplifier Module*. This can be downloaded from our website in a file named 'DAVOL.ZIP'. This archive contains the file 'DAVOL.HEX', which needs to be programmed into the micro's program (FLASH) memory. Just follow the instructions provided with the programmer and software to complete the task.

Finally, the various fuse bits in the ATmega8515 must be correctly programmed, as depicted in Figs.17 and 18. If you miss this step, your module may behave erratically.

values below this attenuate the input signal, whereas those above it amplify.

To increase or decrease the volume, hit the 'Vol Up' or 'Vol Down' buttons on your remote, or turn the rotary encoder. With jumper JP2 installed, each press (or click of the encoder) moves the volume by just 0.5dB. If the remote's button is held down so that it automatically repeats, the adjustment steps jump to 1.5dB after one second.

Some audio systems may not require the fine 0.5dB adjustment steps. To increase the steps to 1.5dB for every button press or click, remove jumper JP2. In this case, holding down the remote's buttons makes no difference to the step size, which always remain at 1.5dB.

On balance

To adjust the balance between the left and right channels, use the 'Ch Up' and 'Ch Down' buttons on your remote instead. Alternatively, press the optional front-panel 'Balance' button and use the rotary encoder. Each press or click adjusts the level by 0.5dB, regardless of the state of JP2. However, holding down the remote's button for more than one second will case a temporary shift to 1.5dB adjustment steps.

When in balance adjustment mode, the left inverted decimal point flashes (see Fig.15). Two dashes on the LED displays indicate that the balance is centred.

Hitting the 'Ch Down' button moves the sound stage left. On the first two presses, a single dash is shown in the left digit position, indicating the direction of 'movement'. Likewise, one or two presses of the 'Ch Up' button from the centred position results in a single dash in the right digit position.

Subsequent presses display a number indicating the relative attenuation level of the opposing channel. For example, if the current volume level is set to 50 and the balance is favouring the left side and reads 5, the actual levels are: left = 50, right = 45. After four seconds of inactivity, the unit automatically reverts to volume adjustment mode. To bypass the four-second delay and immediately exit balance mode, use the volume up/down buttons on your remote or press the 'Balance' button again.

Both channels are simultaneously adjusted when the volume is increased or decreased, maintaining the balance separation. Note that when either channel reaches the maximum volume setting (ie, 85), further commands to increase the volume are ignored.

When one channel reaches the minimum volume position (0), further commands will continue to decrease the volume in the other channel until both are at minimum, if they are not identical. Increasing the volume from

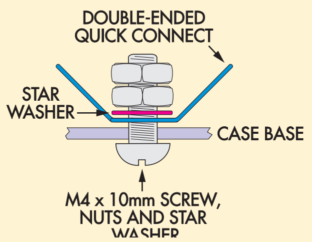


Fig.16: the mains earth lead must be securely attached to the base of the metal chassis. Here's how to assemble a suitable earthing point for attaching two spade lugs. The two nuts lock the assembly in place.

this minimum position restores the original balance seperation.

Muting

Muting is achieved by hitting the 'Mute' or '12' buttons, depending on your model of remote. Hitting the mute button a second time immediately restores the original volume level and simultaneously increases it by one step.

Note that pressing 'Vol Down' while muted does decrease the volume level shown on the display, but it doesn't turn the muting off. This allows you to wind down the volume to a respectable level first – perhaps when you've been caught out with the wick wound up far too high! Muting is indicated by the flashing of the second inverted decimal point (Fig.15, top left), which will continue to flash even during display blanking (when enabled).

Multi-channel upgrade

Finally, we've reserved buttons 1-6 and the optional 'Channel' front-panel switch for a possible future multi-channel upgrade. This would allow up to five simpler slave modules to be daisy-chained off CON8, all under your command via remote control! Pressing any of these buttons causes 'C1' (meaning 'Channel 1') to appear on the display – but has no other function at present (Fig.15, top right).

That's it – your new Remote Volume Control is ready for use. Sit back and enjoy the music. ***EPE***

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Not Just For Cellphones

TechnoTalk

Mark Nelson

SIM cards, which give mobile phones their memory and unique identity (or anonymity if you prefer), have other uses too. This month, Mark Nelson explains how they could be the vital enabler for a new range of M2M communications devices for our homes and workplaces.

SIM cards are such an essential element of mobile messaging that it might appear perverse that they could have a role to play in static (non-mobile) communication. Nevertheless, they are forecast to take on a major role in the fascinating new world of machine-to-machine communication (M2M for short).

So what is M2M all about, and what will it mean to electronicists like you and me?

Massive markets

Simply stated, M2M enables machinery to talk to computers by exploiting four entirely separate developments. Mobile data networks are now more robust, the SIM card data modules are cheaper and more mature, business benefits are more clearly understood and competition means that equipment suppliers and network service operators are determined to extract (and offer) the maximum value possible. Rob Conway, chairman of the GSM Association enthuses that there is a commercial opportunity to embed SIM cards into 750 million new devices between now and 2014.

But what exactly are the benefits? Are they mission critical or merely nice to have? The Business Services division of mobile operator Orange, a leader in this field, claims that "from vehicle tracking to stock control, machine-to-machine solutions give you visibility into what's happening, as it happens without having to be there in person. By enabling remote equipment such as cameras, copiers, containers and even payment machines to interact with your information systems, you have the vital, real-time data you need to make quick decisions and manage your internal processes more efficiently."

Keeping track

Already Vodafone SIM cards are used in TomTom satnav systems to enable users to receive location-specific traffic updates and other local information.

SIM cards installed in vending machines already provide suppliers with live data on stock and cash levels. The catering industry relies on SIM cards attached to refrigerators and freezers to monitor the safe keeping of the contents, while office equipment and industrial machinery use SIM cards to report faults and enable engineers to carry out remote diagnosis. SIM cards are also installed in some car park advance information signs and security systems (CCTV and burglar alarms).

Cash machines and retail point-of-sale equipment use SIM cards, as do real-time outpatient healthcare monitoring systems. SIM cards enhance driver safety and vehicle security for road haulage companies and enable large fleet operators to keep track of their vehicles (and drivers).

Consumers like you and me will increasingly encounter SIM card-enabled devices. Visa has announced that it will make 2012 the first cashless Olympics, with plans to install thousands of electronic readers at venues. These will likely use SIM cards for data transfer, as will the ticket barriers that London Underground will upgrade to M2M in time for the games. Travellers with O2 mobile phones will be able to pay their fare and pass through these barriers simply by swiping their handset past a contactless receptor.

Smart meters

By far the largest SIM card application planned so far, however, is the smart meters that will be installed in every British household under the 2008 Energy Act. By the end of 2020, some 26 million households (and 19 million business sites) will have their gas and electricity meters modified or replaced to communicate directly with their energy suppliers, removing the need for meter readings and estimated bills.

Smart meters will provide entirely accurate bills, the government explains, and a clear, in-home display will provide domestic customers with information that could help them use less energy, promoting greater energy efficiency. Research indicates that peak-time demand for power falls by five per cent when customers are able to monitor 'live' how much their energy use is costing them.

Smart meters would enable power companies to offer separate peak-time and off-peak tariffs, which might reduce energy consumption by discouraging electricity use during peak periods, but could also lead to many families facing higher fuel bills. Benefits include knowing exactly how much power appliances consume, for instance televisions left on standby. With luck, USB data ports will be incorporated in these meters, leaving plenty of opportunity for *EPE* contributors and other clever designers to provide add-on devices for interpreting the data in innovative ways and using it control other devices.

100 Uses for a dead cat

Well not quite, but what about other uses for a spare SIM card? Unlike certain smart cards used in ticketing and payphone applications, it appears that SIM cards cannot be reprogrammed, which makes them pretty useless for data storage (or other) projects. On the other hand, they are ideal for use in 'static mobile' telephones. Once an expensive luxury, mobile phones having the same form factor as a desk telephone are now quite affordable and are ideal for locations where you need a proper phone without the hassle (or cost) of a landline.

An example of these is the Telular Phonecell SX5d, stocks of which can be found on UK eBay for £20 or so. Be aware that there are several products with similar names; you want the UK model that works on the GSM mobile system. It accepts most UK SIM cards (except those from the '3' network) and can be used for phoning and texting wherever a normal mobile handset will operate.

Another brand to look for is the Nokia Premicell, which is a mobile adapter for any standard telephone (or switchboard). You connect your phone to the 'black box' and then you can use any phone (even a black Bakelite one) in your car, holiday chalet, site office, caravan or boot sale pitch. Some Premicells will work with telephones equipped with rotary dials. The price of these versatile units on eBay is generally between £20 and £50, but it is important to know what you are buying (check out the model number and type it into Google to find a data sheet).

Both the Nokia Premicell and the Telular Phonecell use a battery recharged by a mains power pack. Each model has a built-in antenna and can be connected to a variety of external aerials. Note that if you buy a dedicated SIM card for your Premicell or Phonecell it is important to make at least one call with it every six months. Inactive cards tend to be disregarded by the networks and you might lose any call credit.

WHAT EXACTLY IS A SIM?

A Subscriber Identity Module (SIM) is the element that authenticates and identifies mobile subscribers on the network they are using. A memory chip stores this information and other data on a removable 'SIM card' that can be transferred from one telephone, computer dongle or other telephony device and inserted in another.

Data stored on SIM cards can include Integrated Circuit Card ID (ICCID), International Mobile Subscriber Identity (IMSI), Authentication Key (Ki), Local Area Identity (LAI) and Operator-Specific Emergency Number. The SIM also stores other carrier-specific data such as the SMSC (Short Message Service Centre) number, Service Provider Name (SPN), Service Dialling Numbers (SDN), Advice-Of-Charge parameters and Value Added Service (VAS) applications, as well as the subscriber's own stored contact list.

Solar Water Heating System Controller

Part 2

By EDWARD CHASE MA(Cantab) CEng MIMechE

Save on energy bills with no CO2 solar energy

Last month, we covered the design of this project and this month we cover assembly, testing and calibration.

Assembly

PCB layouts are shown in Fig 4, and 5. Ready-made unpopulated PCBs are available from the *EPE PCB Service*.

Insert the IC sockets first and then all other components, leaving the largest ones, like C6 and relays, till last. Capacitor C6 should be bent over and laid flat against the PCB to save board height.

For CON2, 4, 5, 6, 7 and 8 lock the adjacent parts together before inserting them. Insert two wire links (J1 and J2) in the main and one (J3) in the LCD PCB, plus any others needed to replace optional components.

Leave the battery till last, and do not insert JP2. Beware – as soon as the battery is soldered in there is the possibility of damaging high currents from it if soldering is performed near it, or if the PCB is laid on any metal surface, even with JP2 removed.

The main board is double-sided, but the holes are not plated through on the *EPE* version, so ensure that you solder the leads of components to the top and bottom tracks where applicable. Leave a small gap under the component if there is a track on the top connected to it. This enables you to feed solder up against the leads.

The 28-pin IC socket is harder to solder for this reason, so buy the turned pin type that has a plastic body that does not sit flush with the PCB. If you are not sure about the joint or track quality, test it with an ohmmeter between the top and bottom tracks and component pin. In particular, check that the long 0V track is continuous (not over etched) as any break in this will make later fault finding difficult.

Space is provided on the PCB for the seven lightning protection diodes, but better protection will be obtained if these are all soldered to a small piece of stripboard several metres away from the controller in series between PV/ICsens1 and the controller. Use soldered joints and short connections on this board for minimum impedance (not screwed terminals) and generous spacing. Solder a short lead though the main PCB to connect the top and bottom tracks if D9 is not fitted there.

Drilling guide

You will find 16 pilot holes not connected to pads provided on the LCD PCB. Four are for LCD mounting only. The remaining 12 are for guiding box drilling: four for PCB mounting, four for switches and four for the corners of the LCD cutout. Place the bare PCB onto the underside of the box lid with

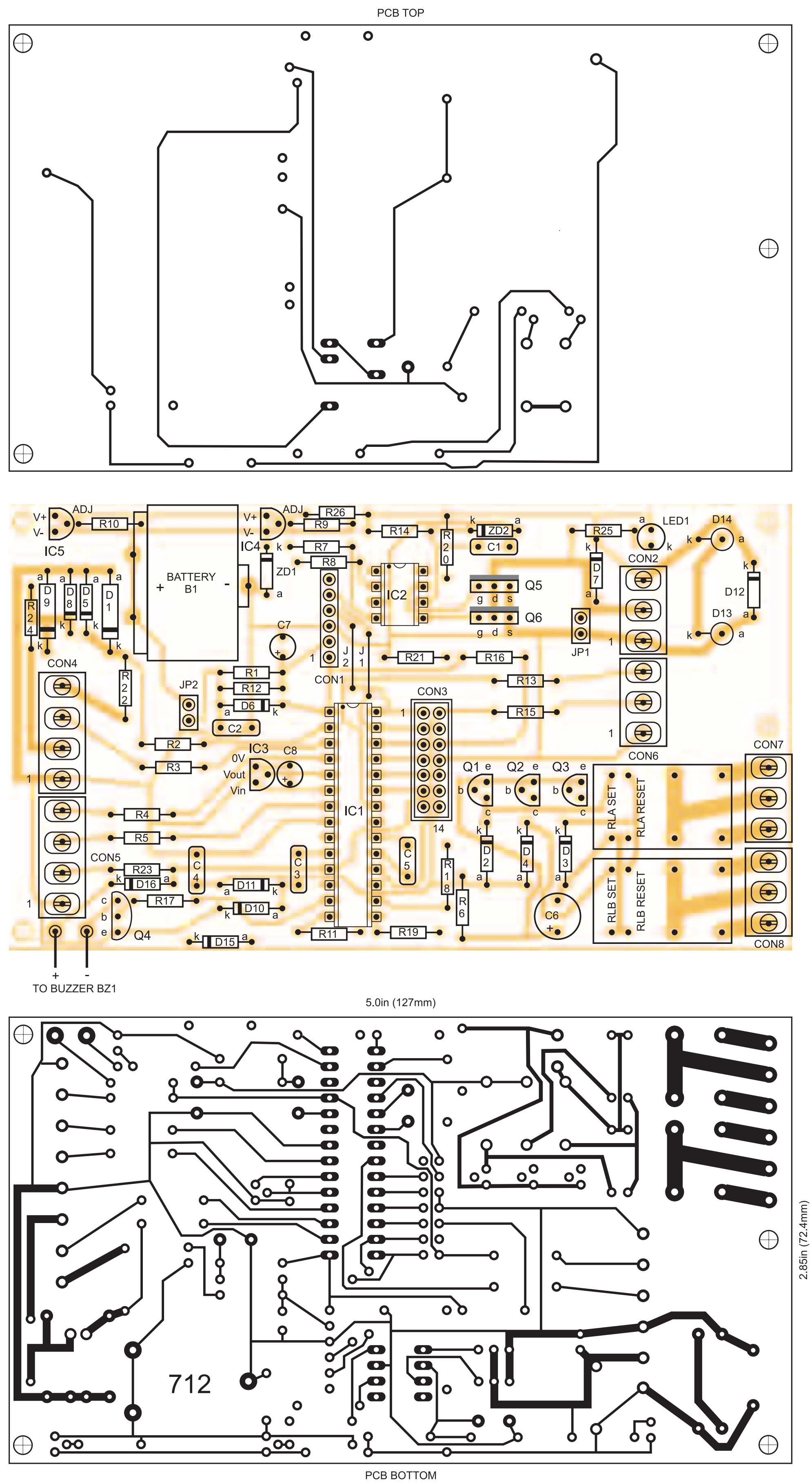


Fig.4. Main double-sided PCB for the Solar Water Heating System Controller

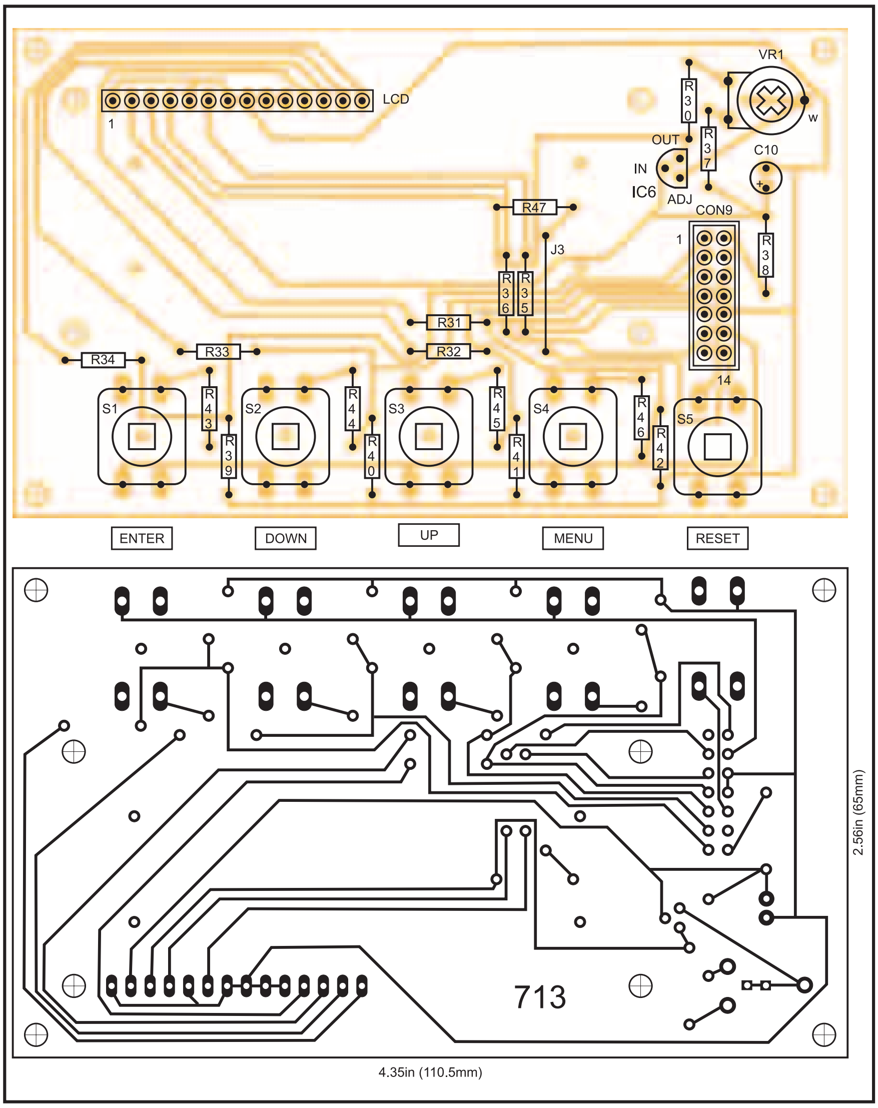


Fig.5. LCD PCB for the Solar Water Heating System Controller. Components R38, R47, S5 and VR1 can be fitted to the back side – see text.

A suggested front panel label is shown in the title picture.

Use the main PCB as a guide to drill four holes in the bottom of the box. One hole is not in the PCB corner, as this provides better insulation between that screw and the relay contacts. Drill holes in the back of the box (for hidden wires) or sides at the two ends for the sensor and other external cables. Add/enlarge holes to let the buzzer sound out.

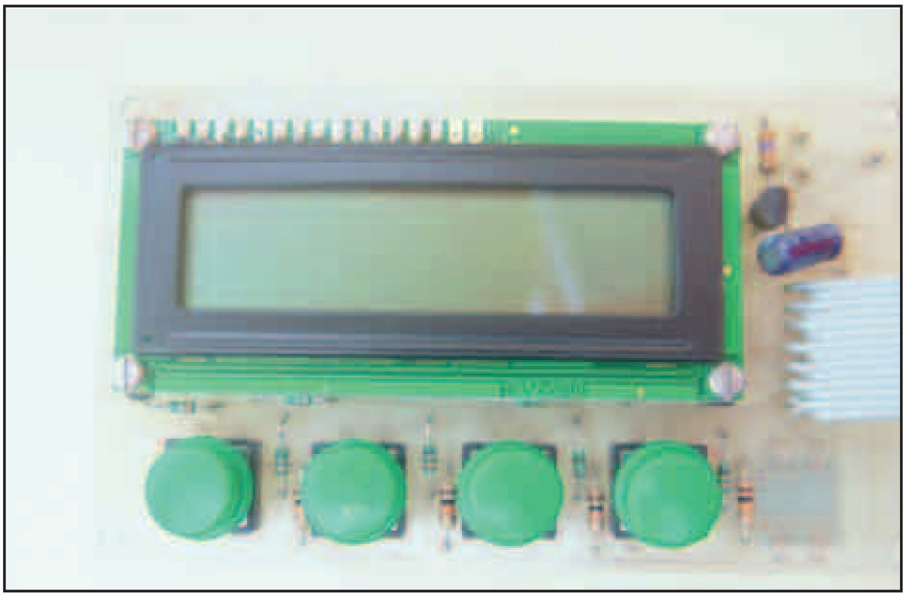
LCD PCB

Solder all components into the LCD PCB, leaving the LCD till last. Make sure no component touches any metallic parts on the back of the LCD. CON9 is optional, as you can solder the ribbon cable straight to the PCB. If CON9 is fitted, solder R38 on the track side of the PCB, as well as the reset switch and VR1, if you want to operate them by opening the box rather than having holes drilled into the front panel. Track sided mounting is recommended as they are rarely needed in normal use. Resistor R47 also goes on the track side. Capacitor C10 may need bending over a little to clear the box lid, so leave its leads long. Use short wire offcuts to link the LCD to the PCB.

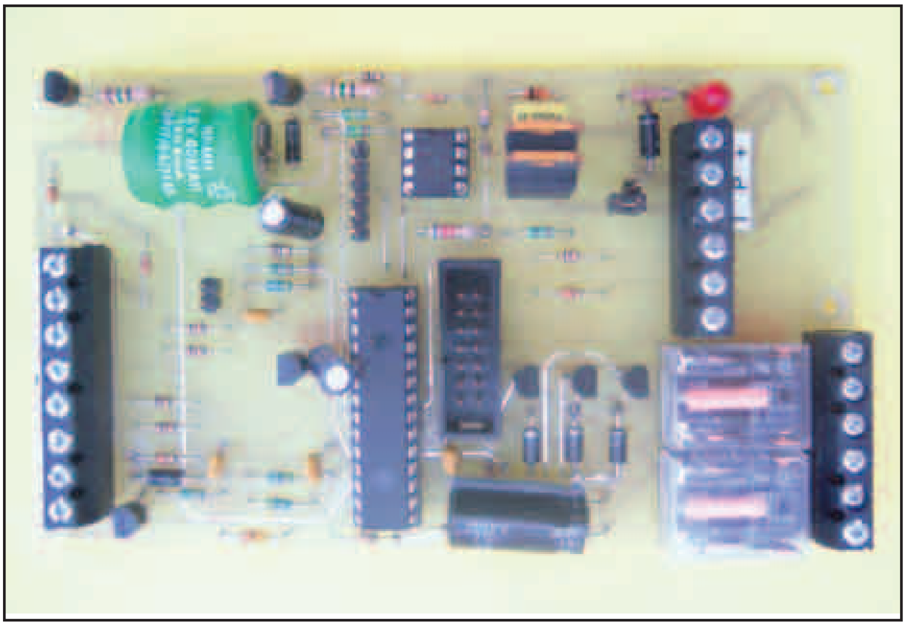
Check carefully for any solder bridges on both PCBs as the track spacing is small in places.

Connect pin 1 of the ribbon to pin 1 of both PCBs' sockets and arrange for the cable to neatly exit the connector from the correct side of the plug. Insert the plugs into the PCBs before assembling the tracks facing you, the four switches centralised left to right and the PCB centralised vertically. Part drill into the lid through these 12 holes. After assembling the PCB, check that your hardware matches these holes, adjust their positions if needed and increase their sizes to suit. The reset switch and VR1 positions are not marked, so add your own holes if you need them, using a small hole for access with a fine tool.

The LCD spacers should be of such a length that they allow the switch buttons to protrude through the box lid when the LCD is up against the lid; 3 to 4mm spacers for the display connection to PCB suited the prototype, made from a 10mm pillar cut in half and filed down, and using 2.5mm diameter screws. 10mm spacers filed down to 9mm with 3mm screws were used for fitting the PCB to the box lid.



The LCD PCB for the Solar Water Heating System Controller



The main PCB – the lightning protection diodes have not been fitted to this board

the plugs, put the PCBs loosely into the box and then hold the cable up against the plugs to see the alignment and length needed. No twist is needed in the cable; 110mm is the right length for the specified box, but adjust it for your box if different.

Mount the main PCB on pillars, about 3mm long, on the base of the box. Make sure none of the mounting screws connect to any PCB track. It is best to finally install the PCBs into the enclosure after the testing and calibration explained below has been completed.

Mount the buzzer in the box using double-sided adhesive pads. The prototype's one was too large to attach to the specified box's sides, so it was stuck to the top of the components on the main PCB.

The relays have separate N/O and N/C contacts. These are connected together by the PCB to make a changeover contact, but you can separate them into two contacts using track cuts if you need to. Make sure the cuts are wide enough to withstand the voltage you apply.

Panel sensor

For the panel sensor (ICsens1) select wire that is able to withstand the temperature of your panel. Standard PVC cable is unlikely to be suitable. You could use a short length of high temperature wire, such as PTFE insulated, next to the panel and less expensive cable for the rest of the run, but ensure for joint reliability that the join is in a protected area and not outside your house. This joint is a good place to put the lightning protection board. Use screened twin-core cable, such as microphone cable.

The datasheet for the MCP9700A recommends a ≥0.1µF ceramic decoupling capacitor across the + and – leads or 1µF if in a high interference environment. Such interference is unlikely but, as it's difficult to get to the sensors to modify them later, especially on the panel, we recommend that a 1µF capacitor is fitted to at least ICsens1. Leaded capacitors are easier to work with and give stronger solder joints, but high temperature ones are expensive so, for ICsens1 at least, use surface mount ones of 1205 size (3mm long) or larger and able to withstand 125°C.

Solder the capacitor half way up the untrimmed sensor leads with the leads on the ends rather than underneath the capacitor, so the overall sleeving holds the joints together. Preheat the capacitor slowly to 100°C before soldering to reduce the chance of cracking it. Make sure the joints are solid. See the sensor photograph, which shows a sensor with two separate single-core PTFE cables.

Slide three pieces of heatshrink tubing over the three wires of the cable, with the central one longer. This is slipped right under the capacitor to prevent shorts between the capacitor and the centre wire. Add one larger, longer piece of sleeving that goes over everything.

Solder the three wires of the cable to the sensor, with the screen to the sensor pin 3, slide the heatshrink up in place with the larger one firmly to the base of the sensor package and shrink all four pieces. Check you can place the side sensor face onto a flat surface without the sleeving preventing it. Then dip the whole sensor into a pot of thin varnish to cover all the heatshrink. Wipe any excess off the flat faces of the sensor, as these need to be kept flat, and leave to dry. When dry, repeat for a second coat.

Other sensors

For the other sensors use the same approach; however, you can use 0.1µF leaded capacitors here, so two of the sleeves can slide up over the capacitor wires. There is no need to varnish these (unless mounted in a damp place, remembering that condensation may make even a normally warm place damp if it goes cold sometimes). A more waterproof design would be needed if you are going to immerse a sensor in liquid, eg by epoxying the whole sensor with sleeving into a metal tube with closed ends.

For ICsens1 glue one of the flat faces to the surface to be measured with epoxy glue. Make the faces as close as possible, and securely fix the cable to something so it cannot put any strain on the sensor, even in high winds. It

Connecting the supression capacitor across the sensor leads

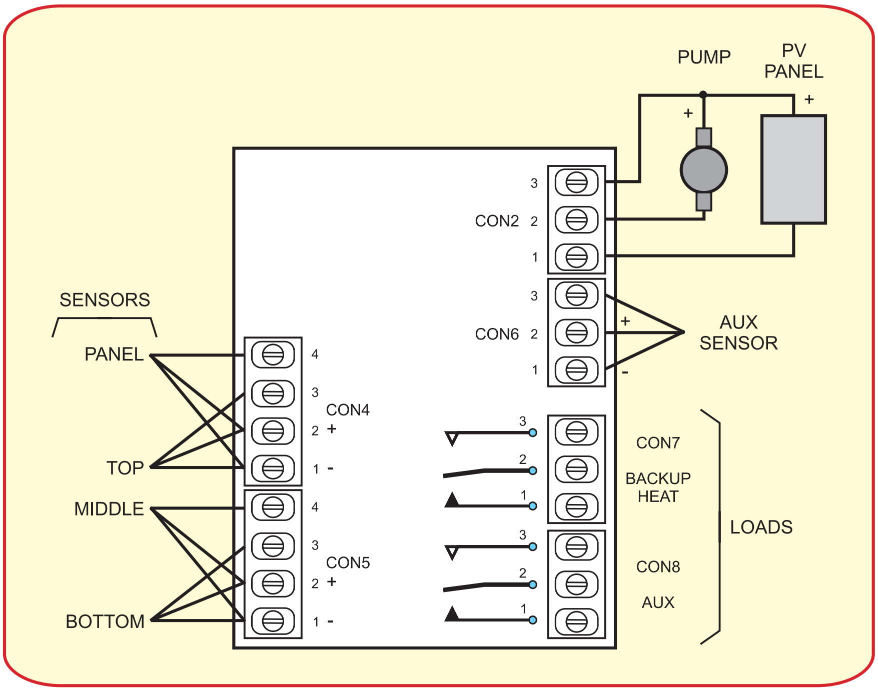


Fig.6. Wiring to the main PCB

may be there for 20 years, so make it very secure. Sleeve over the cable with UV-resistant conduit, or run it well behind the panel so the sun cannot degrade it.

Wrap the sensor with insulation so the air temperature round it and the first few cm of cable is at roughly the same temperature as the surface to be measured. The sensor is more sensitive to its lead temperature than the package temperature, so the cable must be exposed to the heat too. For pipes, the sensor can be fixed with a jubilee clip or tiewraps (if not too hot) to the pipe so glue is not needed, but heat transfer compound and insulation, as above, is recommended. Do not over tighten.

Solartwin panel

On the back of a Solartwin panel mark a point half way across the panel and 100mm down from the top edge. Cut a 25 × 60mm (with 25mm being the vertical dimension) plug from the insulation with a craft knife, taking care not to score the metal collector plate of the panel under the insulation. Prise it out with a blunt knife. Push a 5mm drill bit parallel to the plate 25mm in under the foam in one corner of the hole to make a pocket for the sensor and ensure there is flat metal to slide the sensor up against.

Reinsert the insulation plug after gluing the sensor, with the wires running along the collector plate face then exiting along the side of the plug. Tape over the plug and wires with duct tape so there are no gaps showing. Panels by other than Solartwin may need similar treatment, but many have pockets built in to easily mount a sensor.

If you can't get to the panel rear then you may need to attach the sensor to the hot outlet pipe as close as possible to the panel, but add a resistor of about 150Ω across the –ve and pump pins on CON2 so that a trickle of water flows all the time there is a good PV voltage, even if the FETs have not demanded the pump to be fully on. Test it on a medium sunny day to ensure that the pump never quite stops as long as there is enough sun to heat the panel to more than say 40°C; adjust the resistor accordingly.

This ensures that hot water in the panel reaches the sensor so it can read its temperature correctly. The downside is that permanently sending current to the pump considerably lessens charging current under low light conditions. Modifying the software to pulse the pump on regularly and briefly to move some panel water to the senor position would be better.

Hot water cylinder

Assuming the HWC has the usual sprayed on polyurethane foam insulation, the HWC sensors can be installed by cutting out 25×60mm plugs of foam from this insulation. Push a 5mm drill bit under the foam as before. Squeeze some heat transfer compound into the pocket and onto the sensor face and push the sensor into the pocket with the flat side against the cylinder. Reinsert the foam plugs and securely duct tape over the plugs and wires. Gluing the sensors on is not essential here, as there are no high winds to contend with, as long as the wiring is securely held.

The best positions for the sensors are:

- Top, at the transition between the domed top of the HWC and the cylindrical sides.
- Middle, half way up, or at a level that will give you enough hot water when the backup heating that uses this sensor operates. Not lower than the lowest pipe on the backup heating coil.
- Bottom, 25mm above the level of the cold inlet pipe, but not vertically above it.

Any pipes and bosses in the HWC walls can cause local vertically rising or falling water currents at a different temperature to the normal temperature at that HWC level. So mount any sensors at least 100mm sideways away from such points.

Testing

With the LCD PCB disconnected and leaving out the ICs from their sockets and the removable jumpers, connect a current-limited supply of 15V to 18V to the PV input of CON2. Check that the battery charges up and that there is 10V on IC2 socket pin 6. The voltage drop across resistor R26 should be around 180mV, which represents 18mA charge current to the battery. Check it under a range of supply voltages and battery charge states to ensure IC4 and IC5 are correctly keeping the current constant.

Adjust R9 and R10 equally to get the desired current for the battery you are using, don't go below 10Ω. Do not exceed 18mA even if C/10 for your battery type is higher, or IC4 and IC5 may be overstressed. 18mA suits the specified 150mAh battery as not all the current goes to the battery once JP2 is on. Disconnect the supplies and JP2 between each of the steps below, particularly when connections are made.

Check the battery voltage is at IC1 socket pin 20 with JP2 on. Connect the LCD PCB and check the battery voltage is on one of IC1 socket pins 25-28 when an appropriate button is pressed.

Insert the ICs. Programme the PIC at

this stage, if not already done, using CON1. Reconnect the supplies and the LCD should display text, if not adjust VR1 till it is readable. Press reset if needed to start the processor, although it should start correctly upon inserting JP2. If you can't get the contrast high enough try changing D10 and D11 to Schottky types, such as 1N5817, to reduce the –2V rail to about –2.5V.

Check for 2.5V at IC1 pin 5 and that the voltage across R1 is 20-50mV, or 10-30mV with the LCD off after midnight. This current is quite sensitive to battery voltage. Higher voltages across R1 than this means you have a fault.

Connect at least a panel and bottom sensor to CON4-6, with resistors to Sensor –Ve for unused sensors. It is easiest to test with loose sensors on short wires rather than ones installed on the panel and HWC. The LCD should then display temperatures with LO for any unused sensors. If the panel sensor is heated up to more than the bottom sensor or about 65°C, depending on which mode the software is in, the LED should light indicting that IC2 can turn the pump on.

Be careful if you use a soldering iron to apply heat as it's easy to overheat the sensors. Check the pump LED goes off when the panel sensor is cooled again. It should also go off if the sensor is 65°C to 80°C but the PV supply is reduced below about 6V, indicting that the PIC is correctly responding to 'low light' levels. But note that it may also go off anyway if the supply is below about 4V as IC2 may not correctly function at such low voltages and does not need to. Check that the LCD indicates the correct PV voltage, remembering that it displays in decivolts, ie volts divided by ten.

Note that it may take the software up to 60 seconds to cycle round to the correct point to activate these on/off transitions, so conduct the tests slowly.

Optional current reduction

For the lowest possible supply current, at the expense of the LCD contrast getting too low as the battery voltage/charge reduces, increase the value of R47 to the highest possible value that gives a readable display at a low battery state, such at 3.3V. Replace the resistor or solder resistors in parallel to it on the PCB track side to bring it's value to a suitable value in the range 470Ω to 4.7Ωk.

Go back to the assembly stage and install the PCBs into the case.

If testing a complete system after connecting it all up bear in mind that every day has different weather and day length, so your measurements may vary day to day. Also remember that the PV voltage varies depending on whether the pump is on or off. The pump may load the voltage down many volts, see Table 1 last month.

For sensor error messages on the LCD, a LO indication is a sign of a short circuit sensor or wiring, or open circuit on positive supply, or an equivalent for on-board components. An HI indication means open circuit earth wiring, or maybe a faulty sensor.

Connecting up

Connections to the pump panel and sensors are shown in Fig.6. Any + or – terminal can usually be used for any sensor, but if lightning suppression is fitted, on or off board, do not connect any sensor other than ICsens1 to CON4 terminal 1 or 2. Unused sensor inputs should be linked to Sensor –Ve on the connectors with a 1 to10kΩ resistor.

For the backup heating you need to work out how to connect it in. On many gas heating systems it will need the changeover contacts of RLA connecting in across the HWC thermostat or central heating controller. Google for Honeywell X and Y Plan circuits to see how most are wired. ***Beware:*** *they are usually at mains potential, so observe precautions below about mains.*

If lightning protection is on board, only allow the panel sensor + and – supply to be connected to CON4; use CON5 for the top sensor supply.

Connecting to other types of solar system

On solar systems with 6V nominal PVs, such as the latest Solartwin, replace R14 and D14 with links and remove ZD2. With the lower gate drive voltage the FET on resistance will be a little higher, but will still be low enough for a typical solar pump.

On non-PV driven systems the positive or mains live end of the pump will be driven from a fixed voltage, so there will be no light level input to drive the kWh calculation and to adjust the clock, so connect a small 12V PV of about one watt to CON2 terminal 1 and 3, and do not connect the pump supply to terminal 3.

The PV should be loaded to ensure its voltage output tracks the heat level of the sun, as mentioned in Part 1. If the controller is not enough load, add a resistor in parallel. Remove the LED as it could overload a one watt PV. A very small, efficient 6V to 20V mains power supply could be used to charge the battery if this small PV has inadequate output and a smaller capacity battery is also then possible. Remove R26 or its link and feed this fixed voltage straight into IC4 and IC5.

For mains pumps, drive a mains capable solid state relay from the FETs. You can even eliminate the FETs, diode OR the two IC2 outputs together and drive the relay from the diodes with the relay cathode to 0V, but R14's value may need reducing to allow enough current into the relay, and ZD2 may need uprating.

On more complicated solar systems, the Aux sensor and relay could be used to control secondary pumps or

Main PCB mounted in the case

motorised valves. With a little ingenuity almost any sort of solar system can be accommodated.

Electrical safety

For installations connected to mains or subject to lightning risk it is possible under fault conditions, although unlikely, that exposed metal parts or parts with thin insulation like sensor leads could acquire a dangerous voltage. Thus, it is essential to properly earth the 0V rail in this controller for those installations.

Connect a mains earth solidly with thick wire to all the PV– and Sensor –ve terminals of CON 2, 4, 5 and 6 so that all sensors and the PV panel are earthed where they connect to the controller PCB. Also, ensure every screw through the box has plenty of insulation between it and tracks. Use plastic screws and washers if needed and do not use a metal box. Mains wiring must be separated from other wires. Do not connect the FETs to more than about 100V, even if you substitute higher voltage ones off board.

Calibration

The controller should work adequately well on a Solartwin system without any calibration. However, with other systems it is best to do some calibration and even on Solartwin ones improved performance may be obtained with calibration.

Calibration of the sensors is built into the software. Place all sensors closely together in a warm place at 50-70°C. Then, using the menu, adjust the variable Temp_scaler by deducting/adding about 1 for each degree hot/cold they indicate until all sensors read the same. This takes care of any differential errors and should bring the absolute level, which is less critical, to within 1°C. If you have an accurate thermometer you can also set the absolute to read correctly with respect to this known standard. Better than +/–1°C is achievable, but it only displays to the nearest degree.

Check them at room temperature, although accuracy is not needed there. Check again at near 0°C if you are using any freeze prevention functions, eg on the auxiliary sensor. A small change in the software calculation could be attempted if you can't get it to calibrate correctly at both 0°C and 60°C, ie build a temperature offset into the software to complement the slope change already there by adjusting Temp_scaler. But the sensors should calibrate accurately enough without resorting to that. Or you can select one sensor that does correctly calibrate as it is likely you only need one to go down to 0°C. Check the panel sensor at 110°C - 120°C too if you use an evacuated tube panel.

With a known fixed voltage on the PV supply check the displayed PV voltage. Adjust PV_scaler in direct proportion to any error.

For time calibration, three settable variables can be increased/decreased to slow/speed up the clocks. You need a PV connected to do this check. Check the time on the maintenance display after a period of slightly under one day and adjust Time_interrupt by adding two for each three minutes fast each day. Check it before midnight as it auto corrects then and so it will upset your calibration measurement.

Once that is correct to within 1 to 2 minutes per day (although five min is acceptable in most situations) check the Mins int (internal delay based minute counter) just before the 59 mins point and check that the normal time reading is also at the same minutes. Add/subtract about 21msec to Timing_delay_fine for each minute fast/slow Mins int is per hour. Timing_delay_coarse will not need changing unless Timing_delay_fine goes over 250 or under 0.

Over the course of a year check the displayed adjusted time against real time and note down the error every couple of months. Work out the average error and change Minute_offset and/or DST to suit at the end of the year. Any erratic timing is a sign the Dawn_light_level threshold is incorrect or that you are getting a lot of spurious light on the PV at night.

Day to day running

When the unit is first powered up following PIC programming, use the option on the LCD to revert to the default values, after which a time setting screen appears. Use the up/down buttons to set the displayed hour of the day to the nearest hour. The normal screen will appear after a few seconds with no button presses, cycling around the temperatures. After a week the clock will have self adjusted to nearly the right time. Always double press the buttons as there are regular short periods when the button detect routine is paused to allow other code to execute, so it occasionally misses the first press. Pressing the Menu button at any time will bring up the set variables screen again, where you can enter your own preferences.

Each time the unit is reset or powered up again following a flat battery there is the option to revert to the default values, but don't take this option as the defaults will already be stored in EEPROM and you may have modified them to your own values. The hour needs setting again. In the bottom right of the LCD it will display + for pump on, 0 for pump off and – if the system exports heat.

At night the measurements are slowed down for power saving, so during each hour the Aux relay will only change state once and the buzzer sound for a few minutes at most. Rewiring D16 anode from IC1 to the 3.6V rail instead would lead to the buzzer being available permanently if you require it.

Fail safe

In the event of a persistent overheat or panel sensor failure an emergency macro comes in and sets the pump running continuously as long as there is some sun, with a warning message to warn you to investigate why the event occurred. The clock and kWh measurement will stop and only a reset will restore normal operation.

Please don't get the impression from this that controller failure is likely, it's just the author's professional caution that has led him to build in some fail safe features as, unlike for most *EPE* projects, this one has to run reliably for 10 to 20 years of continuous use. The prototype has not failed in over a year of running so we hope you will have many years of energy efficient and flawless running out of this controller.

Disclaimer

The controller has been designed to work with Solartwin systems, amongst others, but the design is not endorsed by Solartwin so they may not honour their warrantee on their components if they can show that the use of this controller affected the system's reliability.

It seems extremely unlikely that there will be any such effect on the components as no extra voltages are being applied to the pump than normal. Indeed, the use here of lightning protection could improve reliability. Panel reliability could, however, be slightly degraded if your connections are not well made as this could stop the pump running and overheat the panel more often than normal. ***EPE***

It's cheap and simple to build, operates completely una

Simple Dat
Weather S

ttended, and will run for years on a set of AA batteries

If you need to record weather data at a remote location, there are very nice professional logging weather stations out there that do the lot, with solar panels for power and the ability to record rainfall, temperature, humidity, barometric pressure, wind speed and direction and sunlight hours.

While it would be nice to have all that capability, I had a need that was a lot simpler. Like many people, I only wanted to record rainfall and temperature. More importantly, I couldn't justify the cost of the professional systems, which typically run to four figures.

There are plenty of hobbyist weather stations out there too – and at much better prices. They appear very capable, but none can log data unattended for an extended period (well, I did find one, but even it was hundreds of pounds).

A bit of research convinced me that it wouldn't be too hard to build my own, including a suitable rain sensor.

So that's just what I did!

ta-Logging Station

Part 1 – by Glenn Pure

ON THE ELECTRONICS SIDE, I decided a low power microcontroller was the way to go. With the right device and a bit of care in design, current consumption has been kept down to an average of around 10µA, meaning a set of three AA batteries should last for years – virtually their shelf life, in fact.

In terms of logging capability, with half-hourly readings, it is capable of storing just under a year's worth of rainfall and temperature records, utilising the 64 kilobytes of on-board EEPROM memory. The firmware can easily be modified for reading at more frequent intervals. With a six-minute logging frequency, it has over two months capacity. At the other extreme, with hourly recording, it will store almost two years of data.

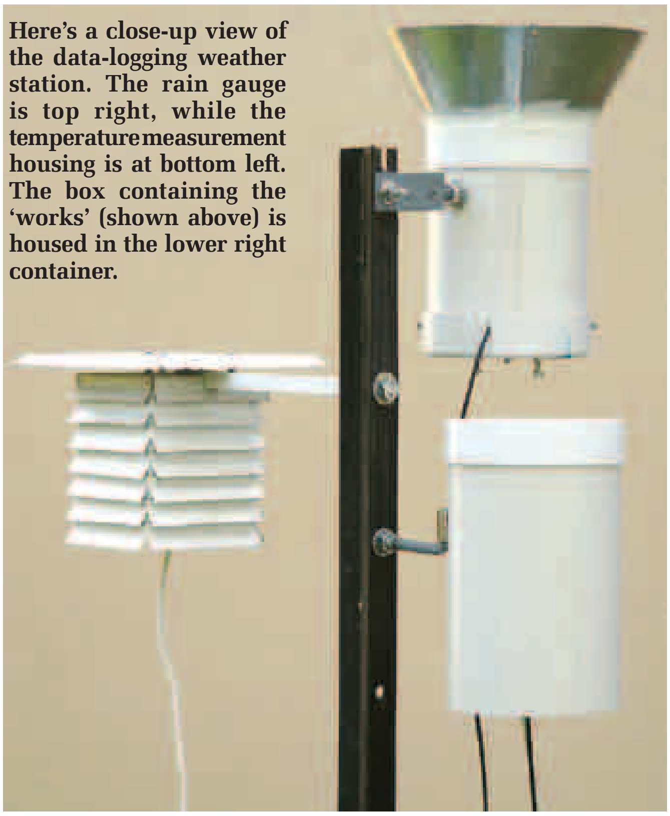
The data is accessed through an on-board RS232 interface, enabling easy downloading straight to a laptop or desktop computer. If, like me, you don't own a laptop, there is a simple solution. The controller is cheap and easy enough to build that you can make two and simply swap one out and take it home to dump the data at your leisure.

In fact, the most time-consuming part about the project isn't the electronics – it's the hardware. Building the rain sensor will probably take the most time and effort. But if you don't have the time or inclination, at modest cost you can even solve that little problem too.

While unsuccessfully looking for a suitable commercial weather station, I found a good quality rain sensor for $90 (US) that will interface with the weather station. More on this next month.

Circuit description and operation

The Data Logging Weather Station circuit diagram is shown in Fig.1. As mentioned, the circuit is based around a microcontroller (IC1). Since low power consumption and simplicity were paramount, a PIC16F88 'nanowatt' microcontroller was chosen.



Here's a close-up view of the data-logging weather station. The rain gauge is top right, while the temperature measurement housing is at bottom left. The box containing the 'works' (shown above) is housed in the lower right container.

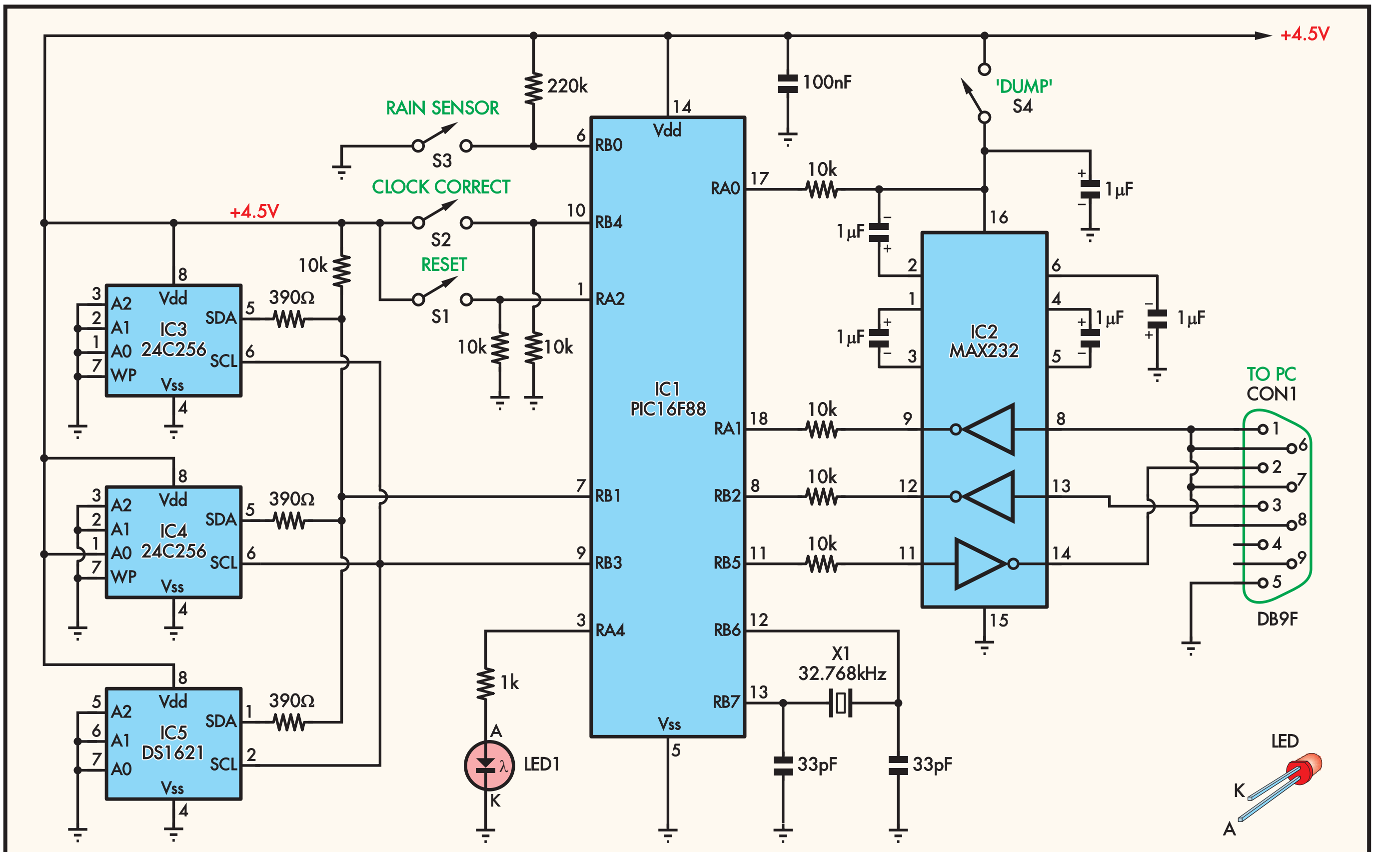
This has pretty-much all the peripheral interfaces needed already integrated into the device, including an on-board oscillator, a serial interface driver and A/D converters. While the A/D converter was used in an earlier version of the design for temperature sensing, it's not actually needed in the final design because analogue temperature sensing was abandoned.

Instead, sensing is done by a Dallas DS1621 digital sensor (IC5). This greatly simplified the circuit, which previously required an accurate voltage reference for the A/D converter and a circuit to switch this on and off. Better still, the DS1621 is an I^2C bus device (like the two 24C256 serial EEPROMs – IC3 and IC4), which further simplified design and software development. The DS1621 has a low-power standby mode when not in use, further helping to save power.

Lines of communication

These devices require two lines for communication – a clock line and a data line. The data line is normally held high by a 10kΩ pull-up resistor. An active device pulls the data line low when it needs to during transmission. Hence, if two devices attempt to transmit at the same time, the worst that can happen is that they can pull the shared data line low.

This is unlikely to present any risk of damage, but could lead to unpredictable power consumption in some cases. Therefore, three 390Ω resistors were included in series



DATA LOGGING WEATHER STATION

Fig.1: there are just five ICs and a handful of other components in the Weather Station circuit.

between the PIC (pin 7) and each of the data lines to the three I^{2}C devices.

The PIC actually has a synchronous serial port for I^{2}C bus interfacing, but this hasn't been used here because it has more limitations than benefits. Instead, the I^{2}C interface is implemented fully in the firmware of the weather station.

The asynchronous (RS232) serial port on the PIC is connected through a standard MAX232 serial interface driver (IC2), providing suitable voltage levels for serial communication. The MAX232 part of the circuit is manually switched on and off by the user (using switch S4) when a data dump is needed.

Getting this part of the circuit to work proved more difficult than it might seem, because even when switched off, the MAX232 would sometimes stay in a partially running state. It appeared to be drawing power parasitically through its three I/O connections to the PIC. Resistors (10kΩ) between the PIC and each of these I/O lines solved that particular problem.

The RS232 interface is set up for 2-way communication, but only transmission from the PIC is built into the firmware, since this is all that is needed. However, the capability is there for the device to receive serial communication for anyone who wanted to extend the capabilities of the design.

Interfacing the rain sensor is simple. The rain gauge is a tipping bucket type and operates by closing a switch momentarily each time the bucket empties. The PIC detects this through an interrupt and increments an internal rain counter by one.

The rain sensor input (S3) on the PIC (RB0 pin 6) is normally held high by a 220kΩ resistor when the switch is not closed. A high value resistor was used because there is a small risk that the tipping bucket could stick in the centre

The control box from the rear, showing the battery pack (three AA cells) and the five-pin DIN connector, along with the hanger bracket at the top.

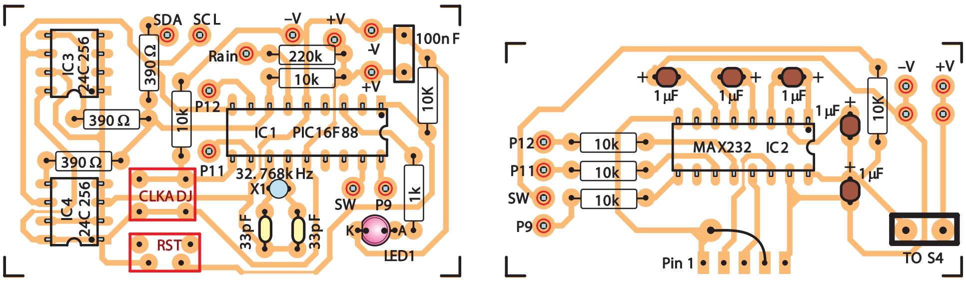


Fig.2: two PC boards are used: (1) a main board, containing the PIC16F88 (IC1) and the two 24C256 serial EEPROMs (IC3 and IC4); and (2) an RS232 interface board, which holds the MAX232 (IC2). The DS1621 is not mounted on a PC board, but is housed inside the temperature measurement container.

position and keep the switch closed. If this occurs, the battery would quickly drain if a smaller (say 10kΩ) pull-up resistor had been used instead.

There are two extra features included in the circuit. One is a small pushbutton switch (S2) on the PC board that is only accessible when the case is open. This is used to calibrate the clock in the controller.

You may wonder why this is needed. To achieve low power consumption, the PIC spends most of its time 'sleeping'. Even though the 16F88 has an on-board oscillator that could potentially run a real time clock, this shuts down when the device sleeps. Hence, an external crystal oscillator, using a 32.768kHz 'watch' crystal was needed. The PIC keeps driving this crystal, even when it is sleeping.

Although these crystals are pretty accurate, they aren't perfect and can be out by maybe five seconds a day. In the worst case, over a year, this can add up to an error of half an hour. Details on using switch S2 can be found in Part 2, next month.

A second pushbutton switch (S1) is accessible from the front panel. This is used to reset the weather station.

'Reset' in this case does not mean a hardware reset of the PIC. Instead, the reset button is used to zero the address pointer for the EEPROM memory. The user would normally do a reset after data is dumped, so that all the memory in the device becomes available again for logging.

If a reset is not done via this button, the weather station will keep logging from where it last left off. This will happen even if the device is powered down or re-boots itself due, for example, to a fault condition.

There is no way to wipe the EEPROM memory in the weather station. This has been done deliberately to enable data to be recovered, even if the address counter has become corrupted. If a data dump is performed just after a reset, the entire contents of the EEPROMs will be dumped – all 64kB or 16,384 records (four bytes per record).

Normally, only the records up to the last one recorded will be transmitted through the serial port during a data dump. The way the data is recorded also enables breaks in the recording to be detected if a full data dump needs to be done – but more on that later.

The weather station is very reliable and I've never had a need to do a full data dump (except for testing) but the feature is there just in case.

Finally, there is an LED on the front panel to indicate status. This flashes very briefly every four seconds during normal operation. It comes on permanently during a data dump, and it quickly flashes three times when a reset is performed by the user.

A high-intensity LED is used to improve visibility, since it is only on for about three milliseconds each flash – again, this was done to help keep power consumption down.

Pin	I/O port,bit	Allocated to…
1	Port A,2	'Reset' switch input
2	Port A,3	(unallocated analogue input or digital I/O)
3	Port A,4	LED output
4	Port A,5	(unallocated, digital I/O)
6	Port B,0	Rain sensor switch input
7	Port B,1	I^2C bus data line (SDA)
8	Port B,2	RS232 port receive (input)
9	Port B,3	I^2C bus clock output (SCL)
10	Port B,4	Clock calibration switch input
11	Port B,5	RS232 port transmit (output)
12	Port B,6	Clock crystal
13	Port B,7	Clock crystal
15	Port A,6	(unallocated, digital I/O)
16	Port A,7	(unallocated, digital I/O)
17	Port A,0	Data 'dump' request input
18	Port A,1	RS232 'communication ready' input

Four I/O pins on the PIC are not used at all, including an analogue input for the A/D converter. Hence, there is scope to expand the capability of the weather station for those who may need additional sensing.

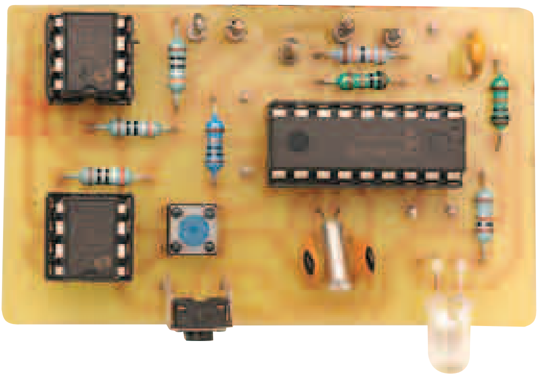
The above table summarises the I/O pin usage on the PIC.

Putting the controller together

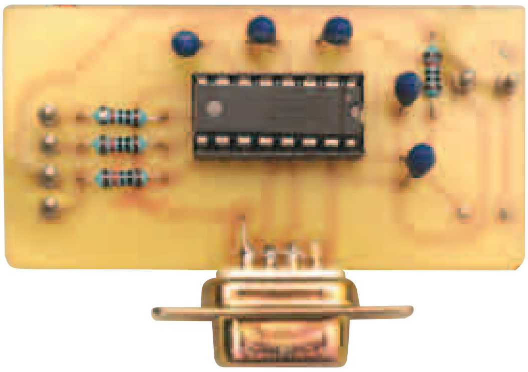
The project is assembled in a small plastic utility box (second smallest size is used). Looking first at the externally visible parts, the front panel of the box has holes for the LED and the Reset switch, plus a larger cutout for the DB9 female serial port connector. There is also a single-pole, single-throw slide switch (S2), used for powering up the MAX232 when preparing for a data dump.

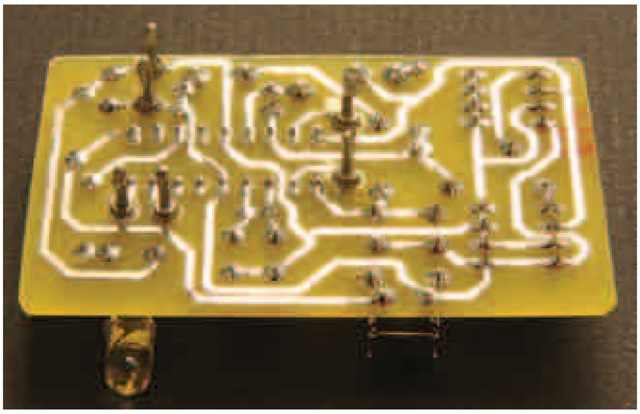
The battery holder (3 x AA) is stuck to the back of the box with double-sided tape and the wires from this run through two small holes in the box. The only battery holder I could find for three AA cells was one with a plastic cover and an on-off switch.

Unfortunately, the case opens on the opposite side to the switch. Hence the switch is inaccessible when the case is stuck to the utility box – and in fact, the switch actuator had to be cut flush with the surface of the battery case to enable mounting. Since the switch is now inaccessible, to minimise the risk of failure, I broke open the battery case behind the switch and soldered a link across the terminals to bypass it (so the switch is effectively permanently on).



Here are the two PC boards, shown slightly over-size for clarity. They match the diagrams shown left. Note that there are also connections underneath the boards – the underside of the main PC board is shown below.





Of course, a 4 x AA flat battery holder could also be used with either a dummy cell or shorting wire replacing one of the four cell positions. If you use this method, don't forget which cell you've replaced or you could end up putting one into the shorted position.

One end of the utility box has a socket for connecting the temperature and rain sensors. The temperature sensor (IC5) requires four connections (Vcc, ground, data and clock), while the rain sensor has a two-wire connection (ground and signal).

A five-pin DIN audio connector was chosen for the task, with the ground connection shared between the temperature and rain sensors. A range of other socket types would be suitable, including separate sockets for the temperature and rain sensor if this is desirable. The main consideration should be ensuring a reliable connection.

Inside the box, there are two PC boards, on which all components are mounted except the slide switch S4, for dumping data, and the rain and temperature sensors.

The PC boards slide into the mounting slots provided in the utility box, with the component side of both facing towards the socket that connects the temperature and rain sensors. Solder pins have been included on the PC boards for the interconnections that are needed.

Those pins on the main controller (PIC) board that are needed for connection to the MAX232 board should be mounted on the copper side of the board so that they point towards that board, enabling easier connection.

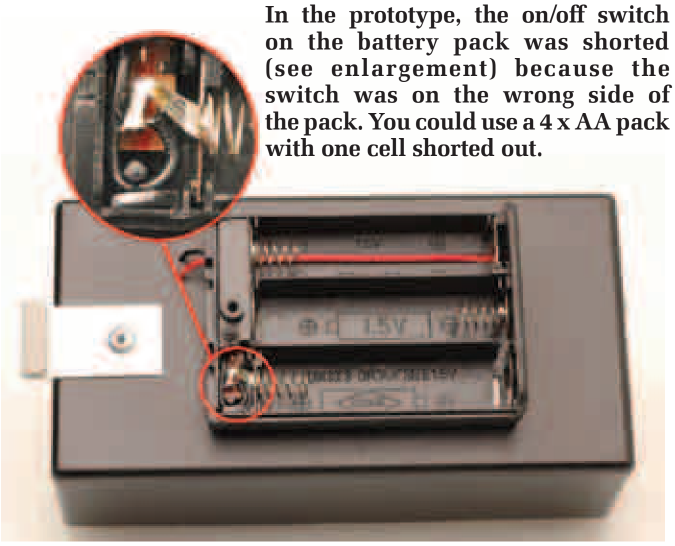
Six connections are needed between the two boards (including +V and ground). The overlay of both boards (Fig.2) makes it clear where the interconnections should occur ('SW' to 'SW', 'P9' to 'P9' and so on).

There are two sets of positive and negative connection points on each board. One of the sets on the MAX232 board (which should face out from the copper side) is for connection to the battery pack, while the second set connects power to the PIC board.

The second set of power connection pins on the PIC board is for the temperature and rain sensor socket. The MAX232 board also has two pins marked 'to switch' on the overlay, which need to be run to 'dump' switch S4.

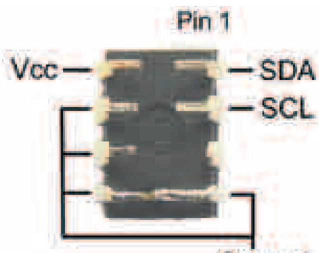
Assembly is straightforward. As usual, watch for correct orientation of polarised components – besides the ICs, the only ones are the five electrolytic capacitors on the MAX232 board and the LED on the main board.

There is one PC board link – sort of, anyway. The in-line

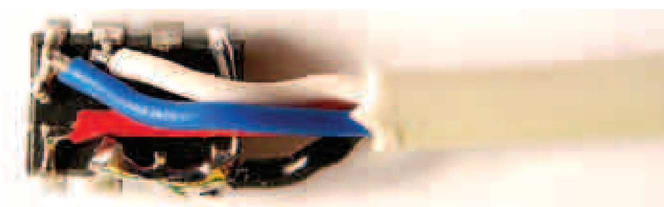


In the prototype, the on/off switch on the battery pack was shorted (see enlargement) because the switch was on the wrong side of the pack. You could use a 4 x AA pack with one cell shorted out.

The DS1621 temperature sensor chip is soldered to the end of a four-wire lead as shown on the left and in the photo below. If using telephone or alarm cable, it makes sense to use red for +ve, black for -ve and the blue and white wires for data.



IC5



Parts list – Data Logging Weather Station

1 PC board, 63 x 37mm, code 718 }
1 PC board, 63 x 32mm, code 719 } Available from the *EPE PCB Service*
1 130 x 68 x 43mm plastic utility box (UB3)
1 ~500mm length of 100mm-diameter PVC sewer pipe (150mm length for rain sensor and 200mm length to house the controller)
3 PVC end caps to fit 100mm sewer pipe
1 180 x 360mm piece of 0.4mm galvanised steel sheet (for primary funnel)
1 260 x 15mm piece of 0.4mm galvanised steel sheet (for secondary funnel bracket)
1 80 x 125mm piece of 0.6 to 0.8mm thick aluminium sheet (for tipping bucket)
1 100 x 50mm piece of 0.6 to 0.8mm thick aluminium sheet (for secondary funnel)
1 95 x 25mm piece of 0.6 to 0.8mm thick aluminium sheet (for tipping bucket bracket)
2 M4 x 20mm machine screws and nuts, corrosion resistant
4 M4 x 12mm M4 machine screws (corrosion resistant) plus 1 nut
1 small piece of fine wire gauze (for primary funnel; also used on discharge holes below the tipping bucket)
2 100 x 8mm galvanised steel bolts, plus nuts and washers for each (to make mounting brackets for rain sensor and controller housing)
1 steel strip, 70 x 25 x 3mm, for rain sensor mounting bracket
1 20 x 8mm galvanised steel bolt, plus nut and washers to suit (for rain sensor mounting bracket)
1 length of stainless or galvanised steel wire, 50mm long 1-2mm diameter
Assorted pop rivets
1 AA battery clip (for three AA batteries)
1 1m length single-core shielded audio cable
1 1m length 4-core alarm cable
1 3 x 2mm disc-shaped rare earth magnet (or two 3 x 1mm magnets)
1 DB9 female socket (in-line solder type)
1 5-pin panel mounting DIN socket and line plug to match (plus mounting screws for socket)
1 right-angle PC-mount momentary close pushbutton switch (mini tactile) (S1)
1 PC-mount momentary close pushbutton switch (mini tactile) (S2)
1 glass-encapsulated magnetic reed switch (S3)
1 SPST slide switch and mounting screws (S4)
21 PC solder pins
1 18-pin IC socket
1 16-pin IC socket
2 8-pin IC sockets
1 32.768kHz watch crystal (X1)

Semiconductors
1 PIC16F88 microcontroller (IC1) programmed with 'weather station.hex'
1 MAX232 serial (RS232) interface driver (IC2)
2 24C256 or 24LC256 serial EEPROMs (IC3, IC4)
1 DS1621 temperature sensor (IC5)
1 5mm super bright red LED

Capacitors

2 33pF ceramic (C1, C2)	(code 33 or 33p)
1 100nF ceramic (C3)	(code 104 or 100n)

5 1µF tantalum bead or sub min elect. (C4-C8)

Resistors (0.5W, 5%)

3 390Ω	(colour code orange white brown gold, 5%	or orange white black black brown, 1%)
1 1kΩ	(colour code brown black red gold, 5%	or brown black black brown brown, 1%)
7 10kΩ	(colour code brown black orange gold, 5%	or brown black black red brown, 1%)
1 220kΩ	(colour code red red yellow gold, 5%	or red red black orange brown, 1%)

Optional parts
1 steel star picket (1.2m long)
Aluminium and galvanised (or Colorbond) steel sheet to make a louvred housing for temperature sensor
1 galvanised steel bolt, 100 x 8mm (and two nuts and washers to suit) for mounting the louvred housing
1 DB9 serial communication cable for computer connection

See part II of this project (next month) for more details on materials for the separate temperature housing

DB9 socket solders directly on to the MAX232 board, with the edge of the board pushed between the two rows of pins on the socket. Pads are provided on the solder side of this board for pins 1-5 of the socket.

Pins 6, 7 and 8, which sit on the component side, also need to be connected. A single pad and hole in the PC board is provided for this, just near pin 6 of the DB9. A wire link should be soldered into this pad and, on the component side, bent and soldered to pins 6, 7 and 8 (see photo). Don't connect pin 9 of the socket.

Wiring the DS1621 temperature sensor

The DS1621 temperature sensor (IC5) comes in an 8-pin DIP package. For use with this project, it is mounted on the end of a cable, so it can be placed in a housing or other suitable location where the temperature is to be measured.

There are a few possible cable choices, including a length of 4-core alarm cable, telephone cable or Ethernet LAN cable. A length of about a metre was used for the prototype and this worked well. Constructors could probably extend this length, but no testing has been done on longer lengths. The cable only needs to handle a digital signal at about 60kHz, so it shouldn't be too demanding.

We're getting a bit ahead of ourselves (mechanical details will be presented next month) but this shot shows how the control box is 'hung' inside a PVC pipe with the hanger bracket riveted to the PVC pipe cap 'lid'.

Fig.3: it's up to you which software you use for data logging – there's a mountain of it out there, a lot of it freeware. This screen grab shows the 'Eltima' RS232 software, which the author uses. More on this next month.

The wires on one end of the cable are simply soldered directly to the appropriate pins on the DS1621. Follow the wiring diagram and the photograph, which shows the underside of the DS1621.

All DS1621 pins except pins 4 and 5 are trimmed before soldering so that they can be bent flat onto the back of the device without touching one another. Bending them back like this gives a more compact final result.

After soldering, coat the DS1621 and the end of the cable in two-part epoxy. Try to keep the amount of epoxy to a minimum – the more there is, the more bulk that has to heat up or cool down each time the temperature changes, thereby reducing responsiveness.

Protecting the DS1621 like this should be fine for most uses. But be warned: experience has shown that it won't tolerate extended immersion or prolonged exposure to wet or damp environments.

If high water-resistance is needed, pot the DS1621 in silicone sealant (again, minimising the amount used) then use a short length of adhesive lined heatshrink tubing over this. After heating the heatshrink (and while the adhesive is still melted), pinch the open end closed until the adhesive re-hardens (use gloves or you could burn yourself!).

It's a good idea to apply white paint to the coated sensor to reflect any radiant heat that may reach it. If you don't do this, you may measure heat from sources other than the surrounding air.

The temperature sensor is accurate to 0.5° Celsius and is not adjustable.

NEXT MONTH
Full construction details for the rain gauge and temperature measurement housing

XGS Video Games Development System

by Mike Hibbett

Reviewing Nurve Networks' XGS PIC-Based Video Games Development System

THE XGS is a system designed to enable hobbyist programmers to develop their own video games and applications on a small printed circuit board. You may have seen adverts for it in this magazine; this month we got our hands on one to try it out.

Nurve Networks, founded by Andre LaMothe, has been designing and selling a variety of video and FPGA development systems since 2001. Video game development is something of a passion for Andre; as he has written several popular books on the subject, and his enthusiasm comes across in the documentation supplied with the kit.

The XGS is a new product from Nurve, released at the end of last year, and is a clear evolution from previous product offerings. There is a huge amount of information supplied, in the form of a 300-page printed manual, several electronic books and over one hundred relevant datasheets and application notes. Unlike other microprocessor development boards that you can purchase, Nurve Networks has invested a lot of effort in providing very detailed information and tutorials that will help you learn how to design and write your own video applications and hardware, not just tinker with someone elses.

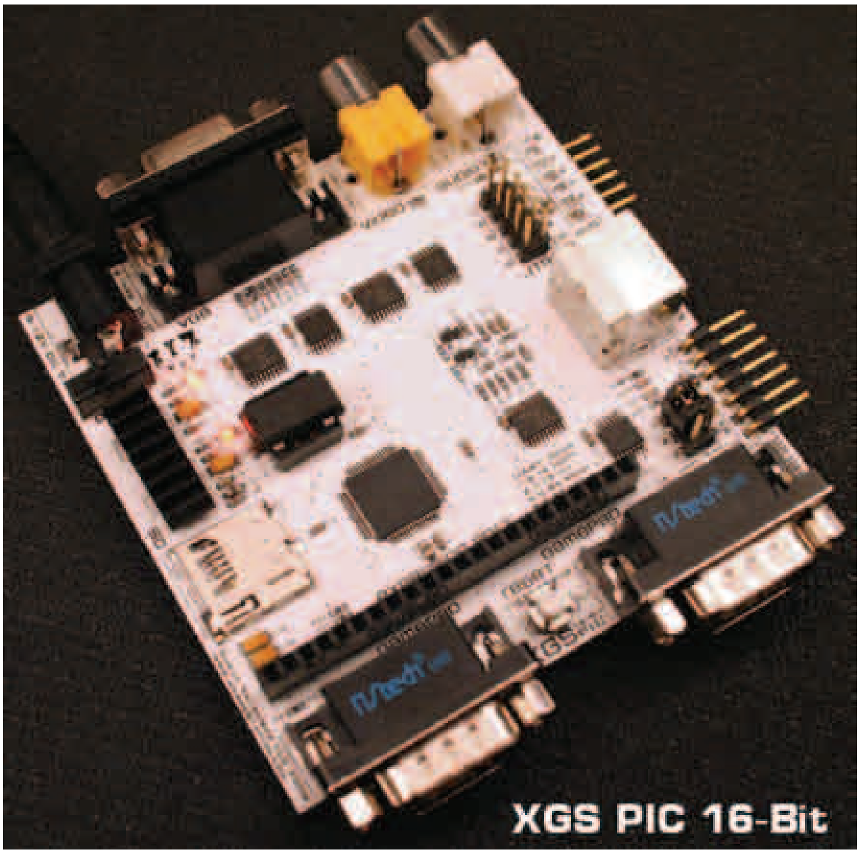
Contents

So what's supplied in the kit? The photo above right shows the main contents, excluding the DVD. The heart of the system is a small double-sided PCB (measuring 80mm × 80mm) fitted with a PIC24HJ256x206 Microchip processor. Those of you who have been following the recent *PIC n' Mix* series of articles will recognise this processor as one of the same family – it's a 16-bit processor that can run at up to 80MHz.

Unlike the part used in the *PIC n' Mix* articles, this device is the more powerful and feature-loaded part, which we would have preferred to have used, but for the fact that it is difficult to solder. But then that is why kits like these are of interest – they have done all the hard work in providing you with a small PCB fitted with everything you need to develop your own design. The kit also comes with a standard PicKit 2 programmer, which is the means by which new programmes are downloaded onto the PCB.

A 1GB MicroSD Media card is supplied, which you can use with the MicroSD card reader fitted to the PCB, accessible using the Microchip flash filesystem software. Phono leads are provided to connected to a television for video and sound output. A cheap games controller, modelled on the PS2 controller, nicely emphasises the 'games' aspect of the kit.

A simple RS232 adaptor enables you to connect a serial device or PC to the



board. That's a simple yet nice touch, as it means you have a lot of connectivity without needing to dig out a soldering iron or visit your local electronics store to purchase exotic connectors.

A 300mA 9V DC unregulated power supply is also provided, fitted with US style mains pins. This comes as standard on kits supplied to Europe too, so it isn't of much use, but these power supplies are very cheap and readily available.

A close-up of the PCB is shown in the photo above. There are two DB9 connectors for controllers (allowing for two player games, if you purchase a second controller), phono connectors for video and sound output and a VGA connector for connecting to a standard LCD or CRT monitor.

A 6-pin PS/2 keyboard connector is also provided. While most keyboards are now fitted with USB interfaces it is still possible to purchase PS/2 style keyboards, and at a very low cost. The PS/2 interface is a very easy to use protocol, and suitable software is provided.

A MicroSD Media card socket offers the ability to access Gigabytes of cheap flash storage. Finally, a 22-way 0.1-inch header provides a very easy to access expansion port, bringing plenty of useful I/O signals to the outside world.

This PCB makes for an ideal, general purpose development platform – not just for video games.

User guide

It's nice, in this digital age, to get a printed manual. This one is a high quality 300-page spiral bound book that covers the technology and techniques for generating video on a microcontroller, how to use the various interfaces on the PCB, and software tool installation and use. It also delves into some more advanced game-specific techniques such as 'tiling', which enables you to generate complex scenery with limited memory resources.

Bear in mind that the term 'complex' is relative – this is a very simple video system. You're not going to be writing the next DOOM3 graphics system on this platform, but rather re-creating games from the 1980s arcades. Don't be put of by this, however. Few of us have the skill and knowledge to fully understand today's complex graphics algorithms, but with this system it is possible for anyone to fully understand and develop their own games. That in itself is quite an achievement, and can be enormous fun, and very satisfying.

The style of the book is quite informal and often in the first-person, so it gives the sense that the author is in a one-to-one conversation with you. The book has not been well proofread, which can sometimes cause confusion, but overall the author's passion for the subject comes across strongly, and you cannot help but soak up some of it. It's an enjoyable read, which is unusual for a user manual.

DVD

The DVD holds all the source code described in the manual, including demonstration applications that can be quickly downloaded onto the PCB. All the software tools (mainly Microchip's MPLAB v8.15 and PIC24 C compiler) are supplied. Even the full schematics of the board are provided, which will make hacking the board, or designing your own add-on PCBs easy.

There are several other 'eBooks' in PDF format, including Andre LaMothe's *The Black Art of Video Game Console Design*. It's an unusual, but very entertaining book, with the first 510 of 900 pages covering the development of electronics from the ground up – all the way back to semiconductor theory! Like the XGS user manual, it is written in a very open, relaxed style and the passion of the author comes across quite strongly. A passion that is rather infectious!.

Software

Although much of the low level software provided has been written in assembly language, all of the demonstration code and tutorials assume use of the C programming language. There are no tutorials on the C language (they had to stop somewhere!) so if you are not comfortable with programming in C, then you should consider getting a few books on the subject first.

Nurve are working on a BASIC compiler for the XGS, but to obtain the best results from this tiny system we would advise that C, with a little assembly, is the best route to take.

The software is presented in simple, logical blocks within the user manual, which makes it very easy to cut and paste into your own applications.

NTSC verses PAL

Having been developed in the US, it should come as no surprise to learn that all the example programs have been written to comply with the

NTSC video standard. For those of us in countries that use PAL or SECAM, the video will still sync on our televisions but the display will be in monochrome.

Nurve haven't, at present, any plans to produce PAL video drivers, but are expecting that someone in the XGS community will develop a suitable driver and make it available publicly. The hardware is fully capable of supporting PAL – it's just waiting for someone with an XGS system and a PAL television to do the work.

Colour video can be generated, however, over the VGA connector. VGA is (thankfully) a global standard and the video driver for it has been provided. Although limited to 64 colours (two bits per red, green and blue channel) it is still quite an accomplishment for colour to be generated by a simple PIC processor and the results look great.

Sound

The sound output is limited, as it relies on simply toggling a single I/O pin to generate audio frequencies. The results are, however, quite good, and perfectly suitable for use with simple games. Various techniques for generating audio are covered in the user guide, with enough information for users to be able to experiment with better techniques.

Pricing

The XGS PIC 16-bit discussed in this article can be ordered online from the Nurve Networks website at **www.xgamestation.com**. Orders are shipped only from the USA at present. Pricing is $159, plus $45 USD shipping costs (to the UK).

Conclusion

For anyone interested in experimenting with video generation, but who does not want to start tinkering with hardware yet, this is an ideal system. The wealth of information provided is more than sufficient to educate you in video game development, and even if you get bored with video, the PCB is an ideal general purpose PIC24 development platform.

Some may be wondering why this is better than simply purchasing a Nintendo DS lite and a homebrew card – you can develop far more complex video games on that. And the cost would be slightly less too. You would be right, if all you want to do is write video games. But that is not the purpose of this kit; it's about learning and being able to write games *from the ground up*, where it's just 'you and the hardware'.

There is a certain satisfaction, when watching a bitmap animation wandering across a scene, that every pixel has been generated under your control, every signal change on that video cable occurred through the compulsion of your software. In delivering that buzz and satisfaction, the XGS is unique.

If this has raised your interest in the generation of video by a simple processor then take a look at our *PIC n' Mix* column in previous issues, where we covered the subject. There is also an opportunity in this month's *PIC n' Mix* to win the XGS system reviewed in this article, although it will require getting out your soldering iron! ***EPE***

Recycle It!

BY JULIAN EDGAR

Making an adjustable loud screamer

This month, we're re-visiting our old friend, the 12V phone charger. As shown in Dec '08, it's easy to give these chargers an adjustable output voltage. However, it's also easy to make them perform a completely different function – and here we use two to make a loud 'screamer'.

IN ADDITION to a couple of 12V car phone chargers, you'll also need a small speaker for this project. You can use any salvaged wide-range speaker, but in keeping with a mobile-phone theme, we used a boxed speaker from a hands-free car phone system. You can often pick these up at the same time as phone chargers.

Cost? Well at garage, car boot sales and the like, expect to pay only a few pounds for the lot. But what can you do with these bits and pieces? One answer is to make a very loud pulsing screamer.

Components

In this system, the two phone chargers perform different functions. The first is modified to produce a pulsing output voltage, which in turn powers the second charger. The second charger is modified to produce the audio output tone, which is fed to the speaker. And the speaker? Well, it makes the loud noises!

The modifications to the charger boards are very easy and it takes only a few minutes to get the screamer up and running.

In addition to the chargers and the speaker, you'll also need a selection of capacitors. You'll only end up using two of them, but having a range available makes it easy to get the sounds you want.

Building it

The first step is to modify one of the chargers to produce the pulsing output. Begin by removing the printed circuit board from its cigarette lighter plug enclosure, then remove the output filter capacitor. This is the electrolytic capacitor that's usually located near to the output leads (a typical value is 680 F). Just desolder it and place it in your parts drawer – you never know when it might come in handy for some other project.

The next step is to replace the timing capacitor. It's dead easy to find – it's the smallest disc-shaped capacitor on the printed circuit board and typically has a value of 100nF. Carefully desolder this capacitor and temporarily replace it with a 100 F electrolytic capacitor (this can be tacked to the copper track side of the board).

Note that electrolytic capacitors are polarised, so be sure to connect the negative lead of this capacitor to the ground (–V) track of the circuit board. You might have to do some track tracing to make sure you get this right.

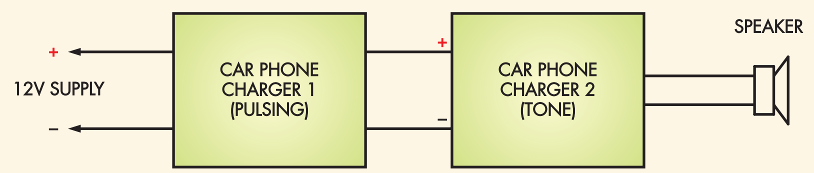


Fig.1: the pulsing screamer uses two slightly modified 12V phone chargers and a speaker. The first charger pulses the second charger, which in turn produces the audio frequency that's reproduced by the speaker.

A sound charger

The next step is to modify the other charger so that it will produce the sound (ie, an audio tone). As before, start by removing the output filter capacitor and placing it in your parts drawer. That done, remove the timing capacitor and temporarily replace it with a capacitor of around 1 F.

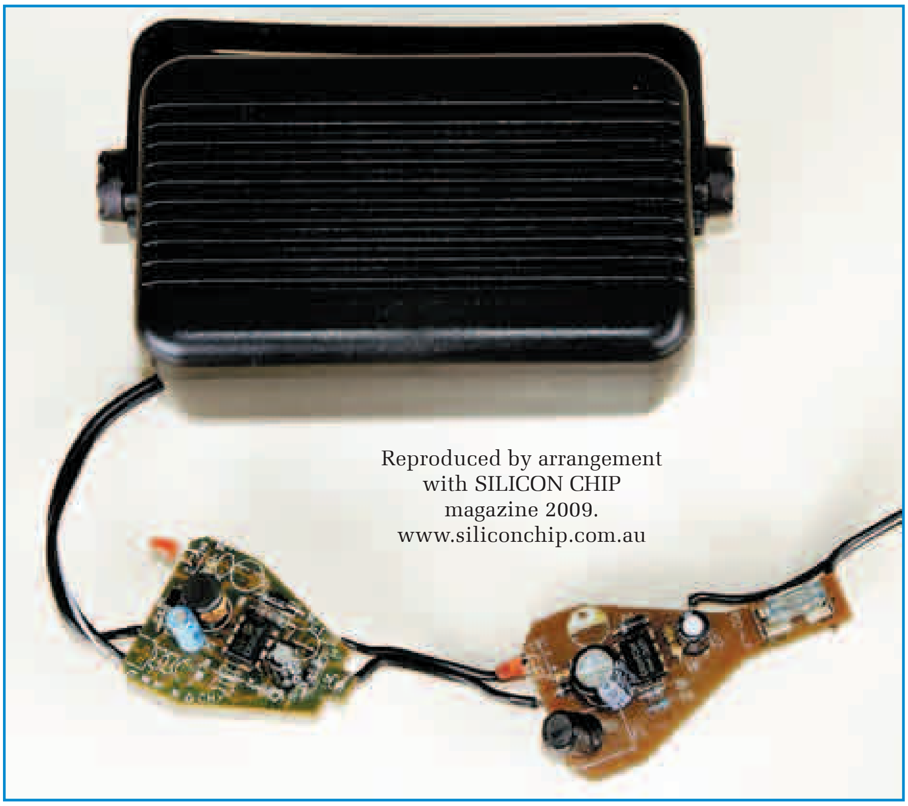
Next, connect the outputs of the 'pulsing' charger to the power supply inputs of the 'tone' charger, making sure that the polarity of the connections are correct – see Fig.2. You can then connect the speaker to the 'tone' charger's output terminals.

Testing and Tuning

Now for the 'smoke test' – connect 12V power to the 'pulsing' charger and listen. It's likely that the sound will not be quite as you want it – it may be too low in pitch and pulsing too slowly, for example (or vice versa).

That's easily fixed. To speed up the pulsing, decrease the value of the timing capacitor in the 'pulsing' charger. Similarly, to increase the pitch (frequency) of the sound, decrease the value of the capacitor in the 'tone' charger.

By making some simple capacitor changes, it's possible to have anything from a deep, slowly pulsing foghorn to an ultra-piercing, frantically pulsing screamer – and everything in between! When you're happy with the sound, solder the selected capacitors in place.



The pulsing screamer is easily made from two modified car phone chargers and a speaker. In this case, we used a (brand new) speaker from a hands-free kit which we picked up at a garage sale, but any wide-range speaker is suitable.

Now run the system for a while (you might want to wrap the speaker in a pillow!) and check the temperature of the two ICs. They are likely to be warm, but they shouldn't be too hot to touch. If they are, install a 5Ω 5W resistor in series with the 12V supply to the system. This will drop the audio output, but the ICs will run cooler.

Incidentally, when testing, always power the system using the voltage that will be used in the final application. This is because the pitch and pulsing frequency will vary with supply voltage. Note that depending on the value of the capacitors used, the circuit will work down to about 4V.

Making it louder

If you want to increase the loudness of the output, solder a bridging wire across the inductor on each circuit board (the inductor is placed near to the output and is simply a coil of wire). A second bridging link should also be installed across the output diode on each board (see Fig.2).

The prototype was configured to produce a very loud 200ms burst of 300Hz sound at one-second intervals – so it was configured more as a 'growler' than a 'screamer'! This involved using a supply voltage of 12V, a 470μF capacitor in the 'pulsing' charger and a 47μF capacitor in the 'tone' charger. In addition, the inductors and output diodes were bridged on both chargers, as described above.

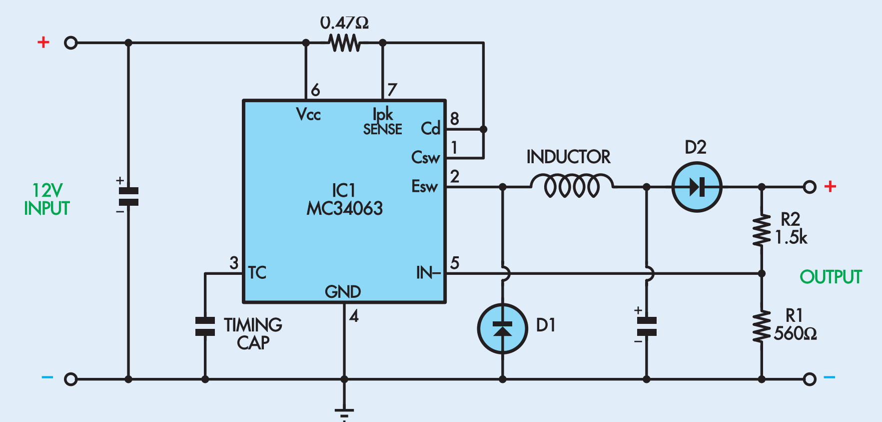


Fig.2: here is a typical circuit for a 12V phone charger. The primary modification is to alter the value of the timing capacitor to dramatically lower the frequency at which the charger is operating. Shorting the output inductor and output diode increases the output level.

Housing your screamer

Many hands-free speakers use boxes that are held together with screws, allowing the enclosure to be easily opened. If that's the case, the two modified chargers can be insulated (eg, by being wrapped in electrical tape) and then placed inside the enclosure, one each side of the speaker basket.

Alternatively, the chargers can be housed in a separate case. ***EPE***

Rat It Before You Chuck It!

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

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

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

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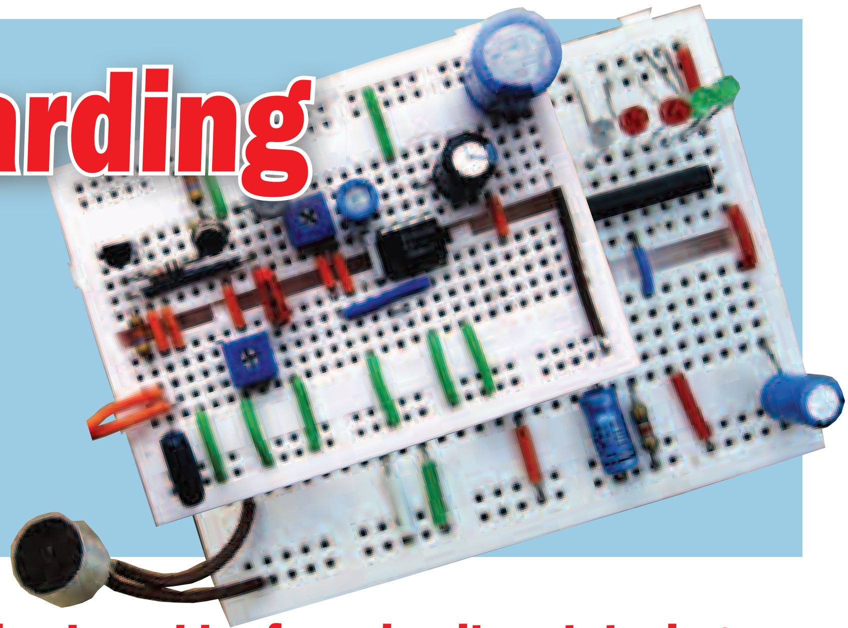
Breadboarding Projects

by Dr Malcolm Plant



A beginner's guide to simple, solder-free circuit prototyping
Part 10: AM Radio and Sound Sensor

Project 17:
AM Radio

ALTHOUGH radios are common enough and cheap, why not make your own from a few readily available components? For example, the design shown in Fig.10.1 is uncomplicated thanks to the two integrated circuits, IC1 and IC2, and it will receive radio stations transmitting amplitude modulated (AM) radio frequencies, delivering your selection to a small loudspeaker.

Circuit details

The central component for the first building block is integrated circuit IC1, a 'radio on a chip'. Essentially, its purpose is to amplify the small voltage generated across the tuned circuit comprising the LC combination; that is, variable tuning capacitor VC1 in parallel with inductor L1.

When the radio is 'tuned in' to a station by adjusting VC1, a small alternating voltage is generated across the tuned circuit. This is processed by the rest of the circuit to extract the information carried by this carrier wave.

IC1 requires a 1.5V supply voltage, which is provided by transistor TR1, resistor R1 and potentiometer VR1, used as a variable resistor. Adjustment of VR1 alters the supply voltage and determines the sensitivity of the circuit.

Capacitor C2 couples the signal from the radio frequency amplifier and detector stage to the second building block, a low-power audio amplifier based on IC2, which powers a small loudspeaker, LS1. Potentiometer VR2 acts as a volume control.

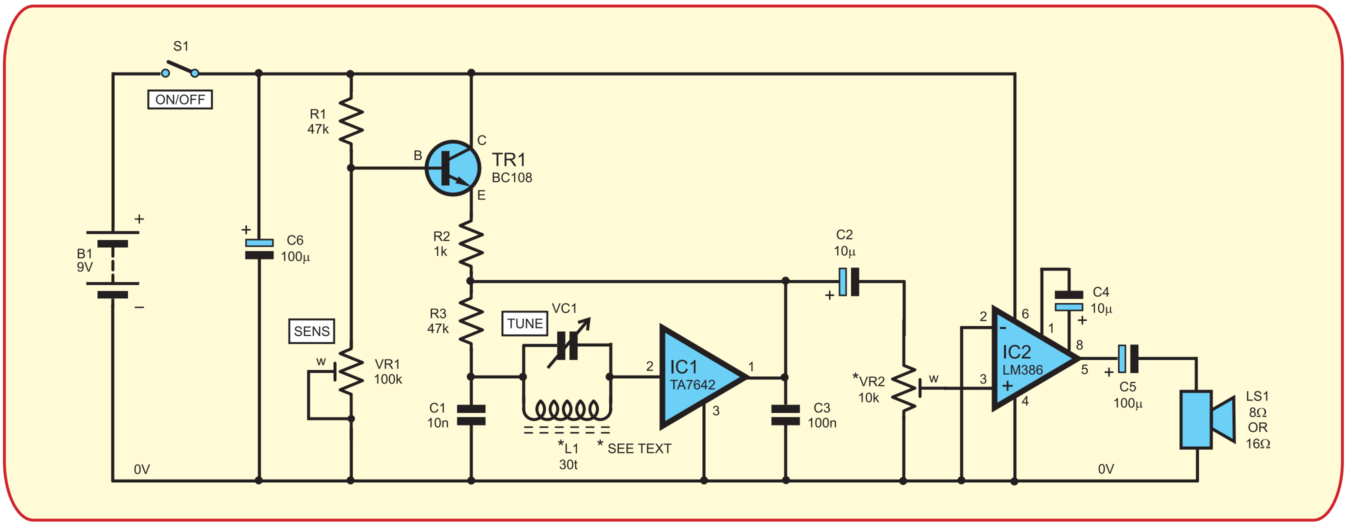
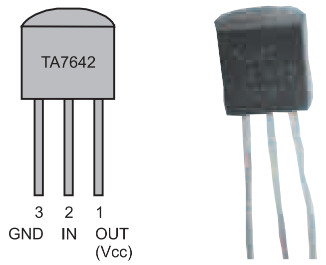


Fig. 10.1. Complete circuit diagram for the 'breadboard' AM Radio

Component Info

IC1, type TA7642 AM radio IC

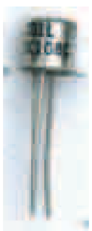


With the flat face facing you the pin functions are shown above.

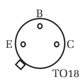
VC1, variable capacitor

In this circuit, the two terminals may be connected either way round. Usually sold as a 'transistor radio tuning capacitor'.

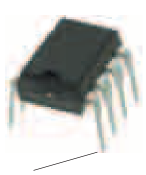
TR1 type BC108 (*NPN*)



Seen from below, the emitter lead is next to the small metal tag. Clockwise from the emitter are the base, and collector leads.



IC2, type LM386 audio amp



PIN 1

Viewed from the top, an indented dot and a 'half-moon' shape at one end indicate pin one. The pins are numbered anti-clockwise ending at pin 8 opposite pin 1.

The miniature tuning capacitor and ferrite 'aerial' wired to the terminal block TB1

Components needed...

AM Radio

Integrated circuit, IC1: type TA7642 AM radio IC
Integrated circuit, IC2: type LM386 low power audio amplifier
Transistor, TR1: type BC108 or similar in a TO18 style package
Ferrite rod coil (aerial), L1: 30 turns 0.2mm enamalled copper wire; ferrite rod, 50mm ×10mm dia. – or medium wave ferrite aerial
Variable (tuning) capacitor, VC1: value between about 100pF and 500pF when adjusted to its maximum value. (Usually sold as, 'miniature transistor radio tuning capacitor')
Loudspeaker, LS1: miniature 8Ω or 16Ω impedence
Capacitors, C1 to C6: values 10nF polyester (C1); 10µF 16V radial elect. (C2, C4); 100nF polyester (C3); 100µF 16V radial elect. (C5, C6)
Potentiometers, VR1, VR2: values 100kΩ (VR1) and 10kΩ (VR2), miniature preset types
Resistors, R1 to R3: values 47kΩ (R1, R3); 1kΩ (R2). All 0.25W carbon film
Switch, S1 (On/Off): single-pole, single-throw (SPST)
Battery, B1: 9V plus connecting leads
Protobloc, wire links and a two-way screw terminal block (TB1)

Breadboard

The Protobloc component layout for the AM Radio circuit is shown in Fig. 10.2. To make the coil, L1, you will need to wind about 30 turns of enamelled copper wire onto the ferrite rod.

The tuned circuit, L1 and VC1, should be connected up using a two-way section of terminal block, as shown, and the two common 0.6mm leads plugged into to the breadboard.

Notes

- To set up the circuit, turn VR2 to maximum volume, which in this breadboard layout is fully anticlockwise. Then adjust VR1 until the radio just stops oscillating. This is the position of maximum sensitivity. VR2 can then be adjusted to provide a suitable volume.
- Tuning is done with the variable capacitor, VC1. Note that the receiver is directional, so the coil should be rotated for best reception of a particular station.
- You might like to experiment with winding fewer turns of wire when making L1, so as to receive short wave transmissions.

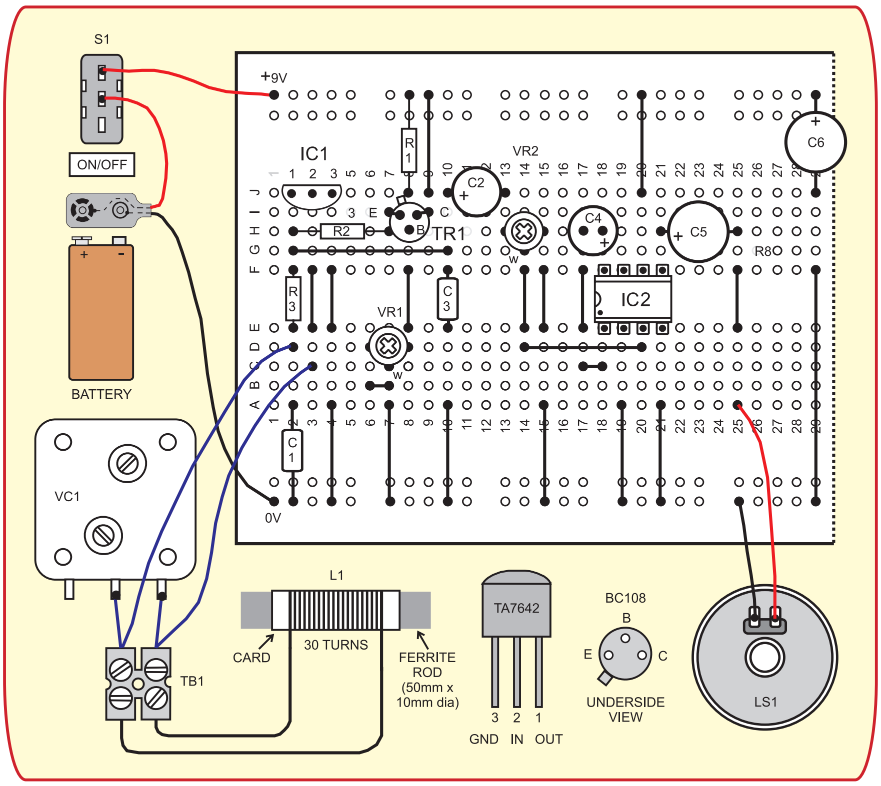
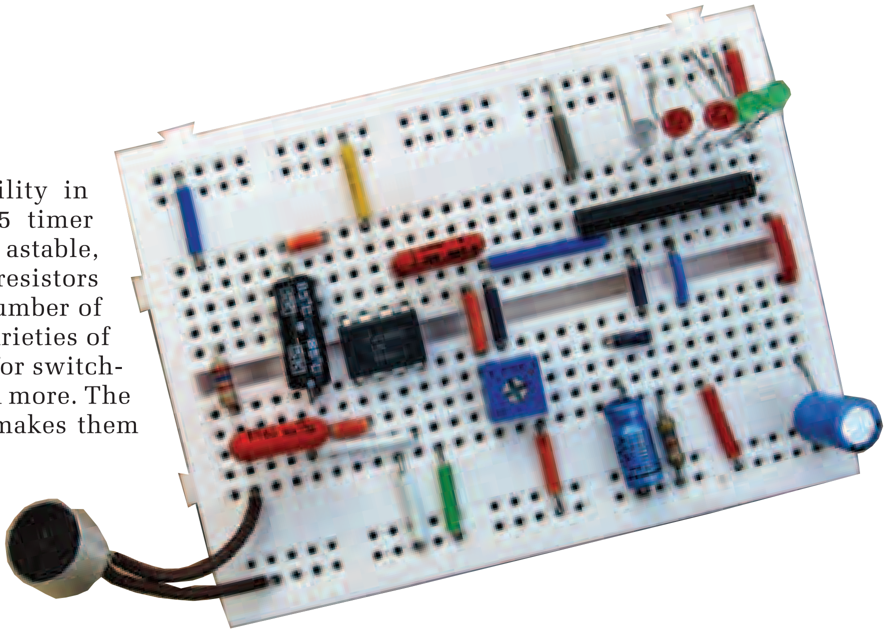


Fig. 10.2. Assembly and wiring for the AM Radio on Protobloc

Project 18:
Sound Sensor



SOME integrated circuits offer flexibility in circuit design. For example, the 555 timer can be operated as a monostable or an astable, depending on the configuration of external resistors and capacitors, thereby lending itself to a number of applications. Similarly, the 741 and other varieties of operational amplifier (op amp) can be used for switching or audio amplifier applications and much more. The flexibility and cheapness of these two ICs makes them popular with hobbyists.

A dedicated cause

Other ICs, such as the LM386 audio amplifier, have a more specific use. Among the many ICs that are designed for specialist applications is the LB1413N, which features in this project. The designated purpose of this IC (IC2 in Fig.10.3) is to provide a visual indication of the strength of a DC or AC input signal on a row of five LEDs.

In this case, it is the strength of an input signal from a microphone, it works as a sound level meter, or a volume unit (VU) meter. This means that for this application IC2 is used in the AC mode, whereas for the *Moisture Meter Mk2* project (May '09) IC2 was used in the DC mode.

The full circuit diagram for the Sound Sensor shown in Fig.10.3 uses two ICs. IC1 is an audio amplifier type LM386 in a standard dual-in-line (DIL) package, but IC2 has a single row of pins spaced by 0.1 inch (2.54 mm) and its package is not surprisingly called a single-in-line (SIL) package. This second IC is designed to provide an indication on five LEDs of the strength of a varying signal; it is an LED meter doing much the same thing as a VU meter in a hifi system.

Components needed...
Sound Sensor

Integrated circuit, IC1: type LM386 low power audio amplifier
Integrated circuit, IC2: type LB1413N LED level meter in a 9-pin SIL package
Electret microphone insert, MIC1: sub- or ultra-miniature omni-directional
Light emitting diodes, LED1 to LED5: two green, two red and one blue; suggest 3mm dia. types
Capacitors, C1 to C5: values 100nF polyester (C1, C3); 10µF 16V axial elect. (C2); 22µF 16V axial elect. (C4); 100µF 16V radial elect. (C5)
Potentiometer, VR1: value 10kΩ miniature preset type
Resistors, R1, R2: values 2.7kΩ (R1) and 4.7kΩ (R2). Both 0.25W 5% carbon film
Switch, S1 (On/Off): single-pole, single-throw (SPST)
Battery, B1: 9V plus connecting leads
Protobloc and wire links

Hot point

If you are expecting to light the five LEDs continuously for a prolonged

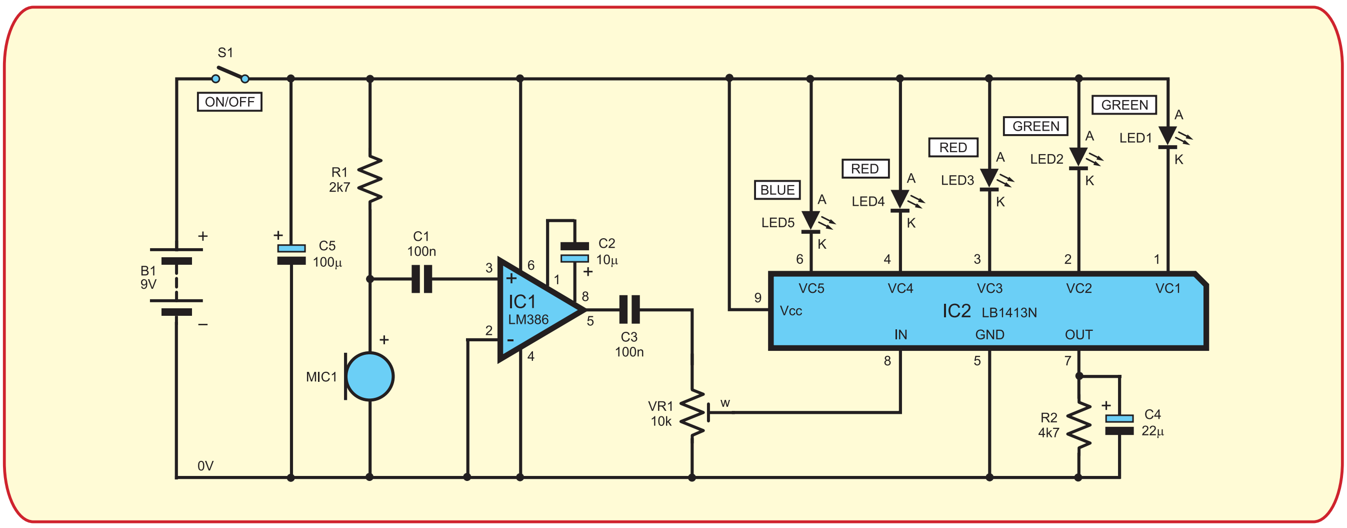


Fig. 10.3. Complete circuit diagram for the Sound Sensor

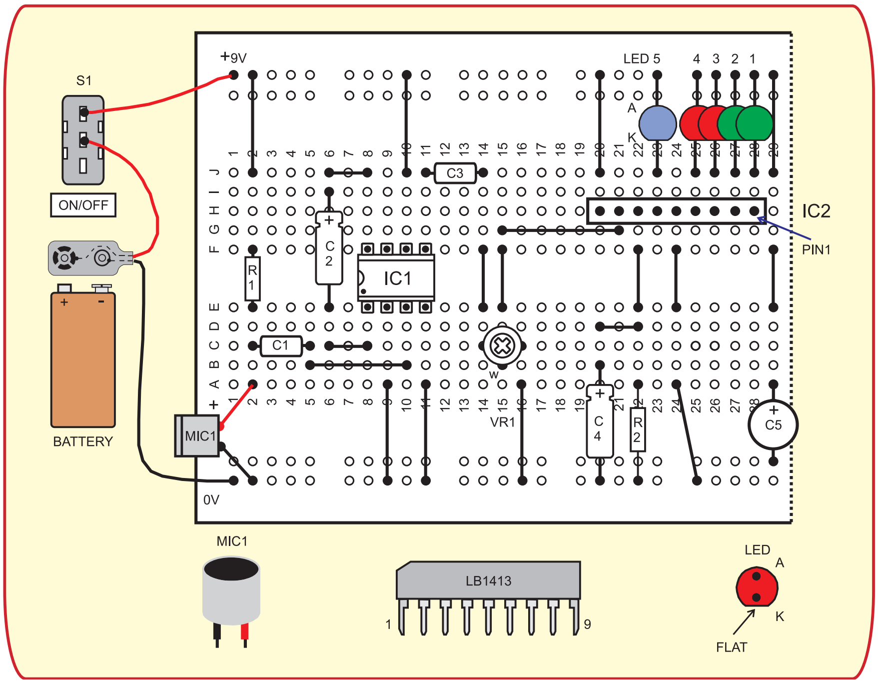


Fig. 10.4. Assembly for the Sound Sensor on Protobloc

length of time, do ***not*** exceed the 9V supply voltage; most of the power is consumed within IC2. It is recommended that when using a higher power supply voltage, that you insert a resistor in series with the LEDs to restrain the power consumed within the IC package – see Fig.10.5.

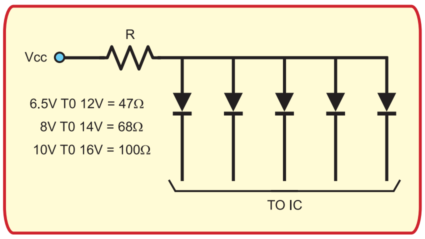


Fig. 10.5. If using a higher supply voltage, insert a resistor in series with the LEDs

Notes

- C4 and R2 determine the time constant of the circuit. That is the responsiveness of the display, so it is worthwhile experimenting with their values.
- Since the signal from the microphone is amplified by IC1, the circuit is very sensitive. Indeed, it will respond to a pin dropping.
- The pins on IC2 are rather short, so this IC needs to fit snugly close to the Protobloc.

Please Take Note

Last month, in the *Lightning Detector*, IC2 should be a 7661 device. The circuit is corect.

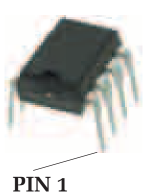
Next Month: Festive Lights

Component Info

IC2, type LB1413N LED level meter

Reading from the chamfered end, the pins are numbered 1 to 9

IC1, type LM386 audio amplifier



Viewed from the top, an indented dot and a 'half-moon' shape at one end indicate pin one. The pins are numbered anti-clockwise ending at pin 8 opposite pin 1.

LED1 to LED 5, 3mm green (2), red (2) and blue (1) light-emitting diodes

The longer lead is the anode, the shorter lead is the cathode.

MIC 1, electret microphone

Solder short lengths of 0.6mm dia. insulated wire to the solder pads. One pad is connected to its case so make sure this lead is connected to 0V.

Construction brief

To ensure trouble-free assembly, you should try and follow these basic guidelines

Always use single-core 0.6mm diameter plastic-sleeved wire for wire links, not thicker. The ends of the wire should be stripped of plastic for about 8mm. The use of thicker wire can permanently damage the springy sockets underneath each hole.

Never use stranded wire; it can fray and catch in the sockets, or a strand can break off and cause unwanted connections below the surface of the breadboard.

It is very important to make sure that the bared ends of link wires and component leads are straight before inserting them into the breadboard. Kinks in the wire will catch in the springy clip below the socket and damage it if you have to tug to release the wire from the holes.

Make sure that the arrangement of components and wire links is tidy, with components snugly fitting close to the surface of the Protobloc. This usually means providing more link wires than is perhaps necessary, so as to avoid having wires going every-which-way across the board.

Never connect the battery leads to the top and bottom rails of the breadboard until you have carefully checked that all the component connections correspond to those on the circuit diagram.

Some components, such as switches and relays, do not have appropriate wire leads for insertion into the Protobloc. If you have access to a soldering iron, solder short lengths of single-core 0.6mm diameter plastic-sleeved wire to the terminals of these components.

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

DEALING with components that only have two leadout wires should be very easy, since there is not a great deal that you can get wrong. It is simply a matter of fitting the component into position, trimming the wires to length, and soldering it to the circuit board.

In many cases it really is that simple, and nothing more is involved when dealing with twin-lead components such as resistors and small inductors. With some other types, however, there is one slight complication, which is that the components must be fitted the right way round. In most cases there will not be any dire consequences if a mistake is made and one of these components is fitted the wrong way round, but the finished project is unlikely to work properly until the error is corrected.

In a minority of cases, and particularly where rectifiers are concerned, there is a real possibility of components being damaged, and possibly in a spectacular fashion. It is sometimes acceptable to use a 'suck it and see' approach, with trial and error being used to find the correct method of connection, but in general this method is not a good idea. It is better not to connect any component unless you are sure of the correct method, and to rigidly adhere to this approach until you have the ability to sort out the risky situations from those that pose no threat of damaging anything.

One-way traffic

Most semiconductor components have more than two leadout wires or pins, and the only common exception is the diode. The diode is the simplest form of semiconductor, and it is a sort of electronic valve. It allows an electric current to flow in one direction, but blocks any significant flow in the other direction.

Connecting a diode with the wrong polarity allows a current flow in the wrong direction, while blocking any flow of current in the right direction. This more or less guarantees that the circuit will not work properly, and in some circumstances can have disastrous consequences. Diodes designed for use at high currents in power supply circuits are usually called 'rectifiers', and getting one or more of these fitted the wrong way around is almost certain to result in some damage, and could even be dangerous.

Despite their simplicity, diodes can be problematic when building electronic projects. In fact, some types of diode are notorious in this respect, with even experienced constructors finding that the polarity markings of a diode are sometimes less than clear. In some cases,

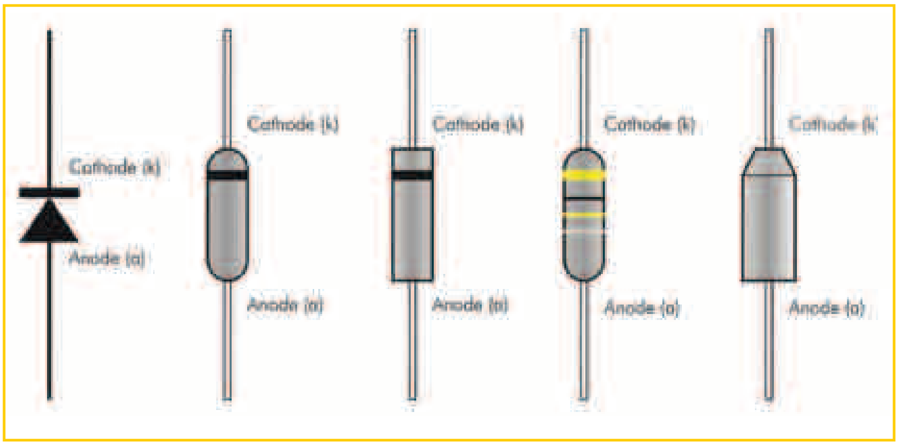


Fig.1. The diode circuit symbol (left) together various methods of identifying the anode and cathode leads of the actual components. All these methods are very loosely based on the circuit symbol

the markings give the impression that they have been deliberately designed to be confusing, and in a few instances the polarity markings are totally absent. In general, normal diodes cause relatively few problems. They are usually in the form of small tubular components in glass or plastic encapsulations that look a bit like miniature resistors. The circuit symbol for a diode, together with various physical representations for this type of component, are shown in Fig.1.

The two terminals of a diode are called the 'anode' and 'cathode', and these have the abbreviated forms of 'a' and 'k' respectively. The circuit diagrams in *EPE* include the 'a' and 'k' markings, but they will not necessarily be included in circuit diagrams published elsewhere. A '+' is often used in place of the cathode marking, possibly accompanied by a '–' instead of the anode marking.

None of these additional legends are actually required, since the polarity is indicated by the diode symbol itself. However, these extra markings should be helpful to those of limited experience with circuit diagrams and circuit symbols.

Banded together

A band marked around the body of the component near the cathode (k) lead is by far the most common method of indicating the polarity on a diode. It can be helpful to remember that this band corresponds to the bar at the cathode end of the diode's circuit symbol.

There are two common exceptions to this method of marking the polarity of a diode. One method tends to cause a certain amount of confusion by retaining the usual band, and augmenting it with additional bands. The type number of a diode, as with most semiconductors, is normally marked on the body in minute lettering. A different approach is adopted with multi-band diodes, which use a system of colour coding based on the system used for resistors.

As far as I am aware, this system is only used for diodes that have a '1N' prefix. Three or four bands are used to indicate the three or four digit serial number that follows the prefix. No multipliers are used with this system, which works on the simple basis of one band per digit of the serial number.

The band that indicates the cathode end of the component is supposed to be much wider than any of the others. However, in practice, the polarity is often something less than obvious, and careful scrutiny of the bands might be needed in order to determine which lead is which.

The other alternative method of polarity marking is mainly used for rectifiers, and it has the body of the component tapered slightly at the cathode (k) end. This thinning of the component corresponds quite well with the arrowhead part of the circuit symbol. Rectifiers are mostly much larger than ordinary diodes, and have thick leadout wires that can safely accommodate high currents.

Most of the unusual encapsulations that were used in the past have now become obsolete. The few remaining high power rectifiers that have exotic encapsulations usually have the polarity clearly marked with (say) a diode circuit symbol.

Light work of it

The light emitting diode (LED) is probably the type of diode that has provided the most problems over the years, together with a great deal of correspondence from readers of this magazine. An LED is a true diode, and unlike a simple filament bulb it will only light up if it is connected to the power source with the correct polarity.

Unfortunately, there is no truly standardised method of indicating the polarity of a LED. By far the most common method of indicating the polarity of a LED is to have the cathode leadout wire a few millimetres shorter than the anode lead (Fig.2). It is likely that the vast majority of LEDs conform to this method, but a minority of these components either do things the other way around, or have two leadout wires of equal length.

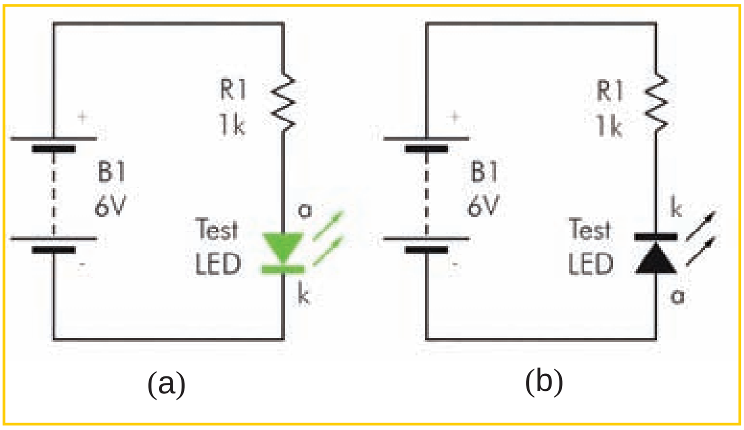


Fig.3 (above). The LED will light up when connected as in (a), but not when it is connected with the polarity shown in (b). The circuit will work with any battery voltage from 3V to 12V

Fig.2 (left). The cathode lead of an LED is usually a few millimetres shorter than the anode lead. This method is not totally reliable though

Fortunately, there is usually an additional means of indicating the polarity, which is to have the cathode side of the body flattened slightly. It is not possible to guarantee that there are no exceptions to this rule, and with LEDs there always seems to be some components that flout the conventions.

However, I have never encountered any LEDs that have the flattening next to the anode leadout wire. On the other hand, I have used numerous LEDs that have no flattening of the case, and a few that also have two leadout wires of equal length.

It would clearly be helpful to have a 'sure-fire' method of determining the polarity of a LED without resorting to some form of electronic testing. Although a variety of methods have been suggested over the years, none of them have proved to be totally reliable. There is an additional problem these days, which is simply that modern LEDs are available in a wide range shapes and sizes. As a result of this, the normal methods of determining LED polarity are not applicable to many real-world components. With the fancier types of LED it is usually necessary to consult the supplier's component catalogue. This should provide a connection diagram.

With LEDs, it is usually all right if the 'suck it and see' method is used to find the correct method of connection. Getting an LED connected the wrong way around should not result in any damage. The reverse breakdown voltage of a LED is usually quite low, and will probably be breeched if the component is connected with the wrong polarity. Excess voltages usually zap semiconductors almost instantly, but this is an exception, and the component should not come to any harm. The driver circuit for the LED will ensure that an excessive current cannot flow. Of course, in some circumstances it could be difficult to correct matters if you do not get it right at the first attempt. You certainly need to know the correct method of connection before dealing with a large number of LEDs.

It is a good idea to check the polarity of LEDs before connecting them into a circuit, and virtually every multi-range test meter has a facility for checking the polarity of diodes. Unfortunately, LEDs have relatively high forward threshold voltages, and this factor makes it impossible to test them using some meters. Where a suitable test meter is available, it certainly represents the easiest way of checking the polarity of LEDs when some doubt exists. A simple test circuit can be improvised if a suitable test meter is not available, and the simple arrangement of Fig.3 will suffice.

There are other types of diode, such as the Zener and variable capacitance ('varicap') varieties. Zener diodes are used in simple voltage stabiliser circuits, and at one time they featured in many projects. These days they are relatively rare, with plenty of low-cost integrated circuits offering better ways of obtaining a regulated supply. Variable capacitance diodes are mainly used in radio equipment, and are little used in general electronics. Anyway, both types of diode are normally housed in the same encapsulations as other small diodes, and have their polarity indicated using the standard methods.

Diac

There is actually another two-lead semiconductor component, and this is the diac. The main use of diacs is in mains power controllers where they are used to trigger a switching device called a triac.

Diacs are sometimes included in the same section as diodes in component catalogues, but they are not diodes. A diac provides essentially the same characteristics with a supply of either polarity, which is essential since these components are mainly used in AC circuits. A diac can, therefore, be connected either way round.

High capacity

Apart from diodes, the only other common two-lead components that must be fitted with the right polarity are electrolytic capacitors, and certain other high value types such as the tantalum variety. Lower value types can be fitted either way around, and generally have quite high maximum operating voltages. Polarised capacitors tend to have quite low maximum operating voltages, so it is important to obtain components having an adequate rating in this respect, and to fit them the right way round. Getting it wrong in either case can result in a spectacular failure, often with the component bursting its casing!

Determining the polarity of electrolytic capacitors is usually very straightforward, because the components are marked with '+' and (or) '–' signs. Additionally, axial lead types usually have a small indentation running around the '+'end of the body (Fig.4). Many printed circuit mounting (PCM) electrolytic capacitors have a similar indentation, but this is of no practical significance.

Tantalum capacitors used to have a method of colour coding to indicate the value and polarity, but this system is now obsolete. The value is simply written on the body, together with a '+' sign to indicate the polarity.

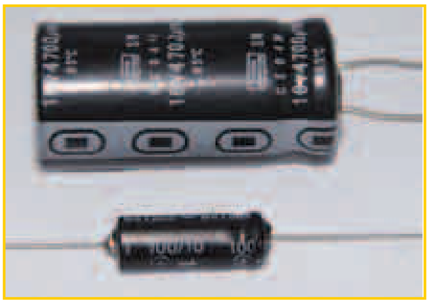
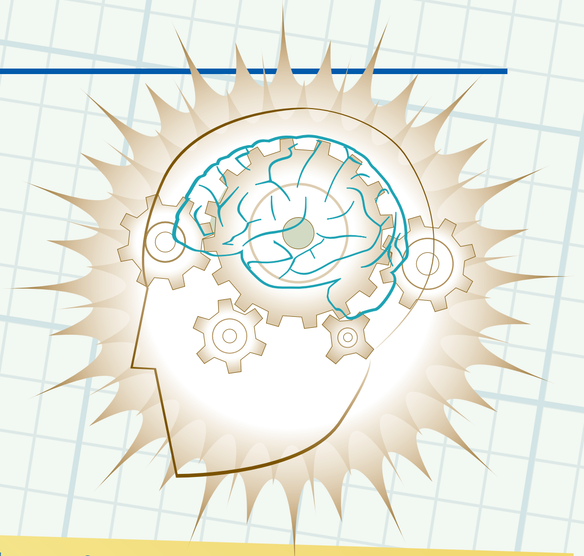


Fig.4. An axial electrolytic capacitor (bottom) has an indentation around the body at the positive end. PCM electrolytic capacitors have a similar indentation, but it is of no importance. Both types are marked with '+' and (or) '–' signs as well

Ingenuity Unlimited

Our regular round-up of readers' own circuits



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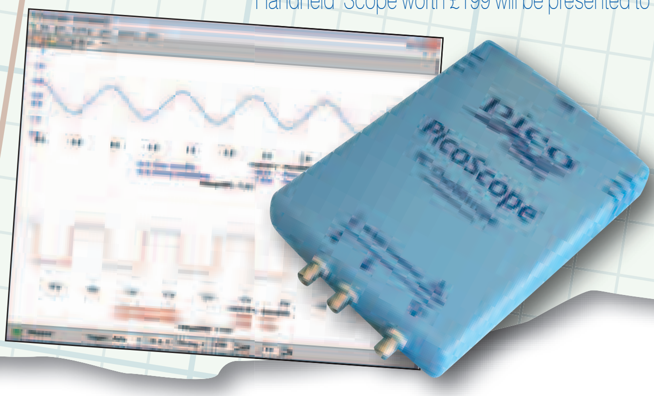

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The circuits shown have NOT been proven by us. **Ingenuity Unlimited** is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and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

Your ideas could earn you some cash **and a prize** !

Heating Oil Storage Tank Burglar Alarm –

Avoiding a drain on resources

This project was driven by the need to provide some form of alarm to combat the attempted burglary or inappropriate interference with the heating oil within my black plastic storage tank located at the rear of my back garden. With the ever increasing cost of heating oil, it has become quiet common for thieves to furtively remove the contents of home heating oil storage tanks.

These thieves gain access to the tank and dismantle the outlet pipework in order to drain the oil into drums or, in some cases, they pump the oil into a road tanker posing as a legitimate heating oil supply contractor. There have also been cases where the thieves crudely punch/drill a hole in the plastic storage tank in order to drain the heating oil.

A general security problem with home oil tanks is that fitting padlocks on the filler cap is not practical on the plastic type tanks and even if it was, this will not prevent dismantling of the outlet pipe work or punching/drilling through the tank wall to enable illegal draining.

Design concept

What is needed is a type of alarm which reacts when the burglar comes within the proximity of the tank and is initiated after a few seconds. This basic requirement is met by the sensing 'spotlight' which many people employ to illuminate their front door

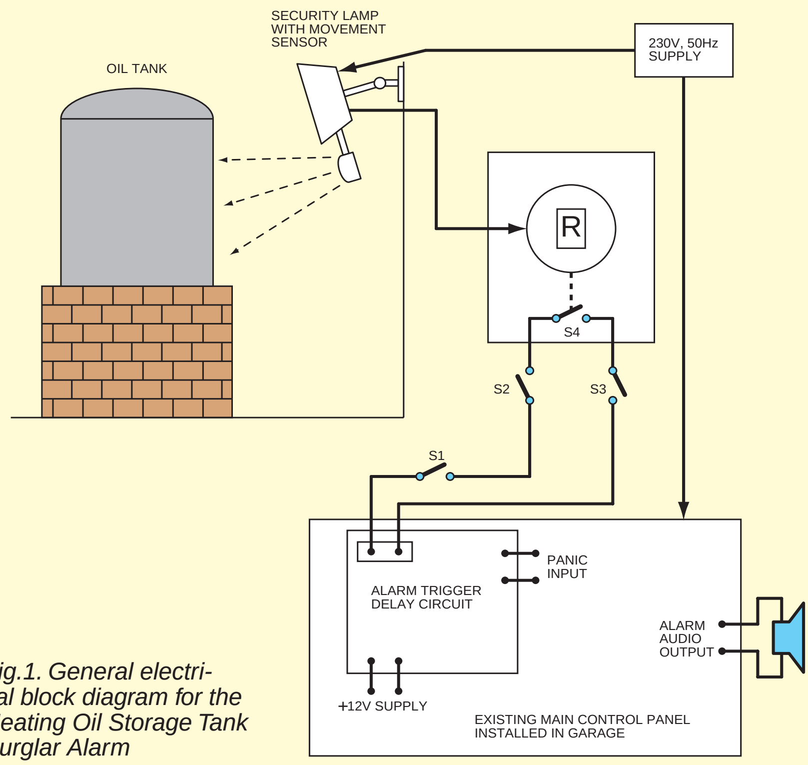

Fig.1. General electrical block diagram for the Heating Oil Storage Tank Burglar Alarm

or drive when a person approaches. These units can be obtained from any of the big DIY stores and come with adjustable 'ambient light' and 'lamp on duration' features. Also, there is a common type which is fitted with a switched mains supply, which is intended to feed an auxiliary spotlight when the master lamp is triggered.

This switched supply can be used to energise a mains relay with voltage-free contacts which, in my case, is then used in a conventional 'loop' type alarm system, as utilised on the windows and doors in my garage.

If the oil tank can be approached from a number of directions, then it is a simple matter of installing a number of the 'spotlamps' and connecting the auxiliary outputs in an OR format. The 'ambient light' adjustment is set such that the lamp will be triggered at any time of the day or night and the 'lamp on duration timer' is set for about three seconds. If the tank is close to bushes, which the wind can move or if cats/dogs/birds cross the lamp sensor beam path, then the alarm will be triggered falsely.

For this reason, I have incorporated an additional timer circuit which is set for about six seconds. This means that even if the lamp is falsely initiated by the wind or an animal, then it must stay in this condition for at least six seconds before the main alarm is initiated. This arrangement has virtually eliminated 'nuisance alarms' The system has been working without functional problems for over a year and can be applied to many other security requirements around the home.

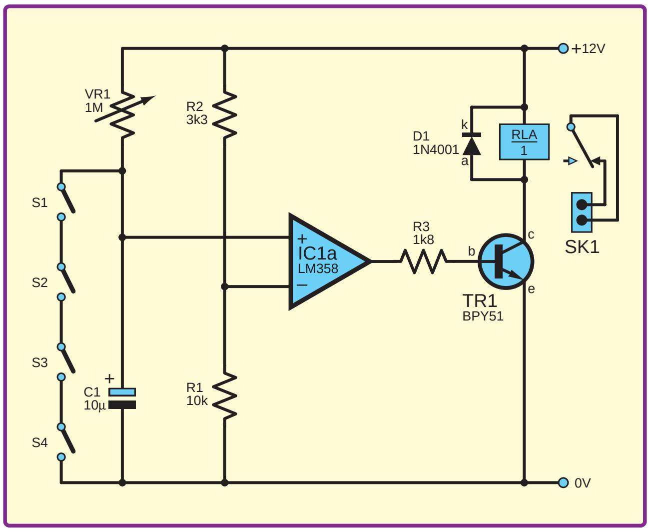

Fig.2. Trigger delay circuit diagram for the Heating Oil Storage Tank Burglar Alarm

Delay circuit details

The overall electrical connection diagram is shown in Fig.1. When the security lamp sensor is activated, the master lamp switches on and the mains auxiliary output energises the relay, which opens switch S4 and initiates the alarm trigger delay circuit (Fig.2). Magnetic switches S1 to S3 previously existed as part of the garage alarm system I have and any of these switches, when opened, will also initiate the alarm trigger delay circuit.

The operation of this is straightforward, in that if switches S1 to S4 remain open for more than six seconds, then capacitor C1 will charge via potentiometer VR1 until the voltage on the non-inverting pin of the LM358 op amp is greater than the 9V level on the inverting pin, as set by resistors R1 and R2. When this happens, the op amp output swings hard positive, which switches on transistor TR1, thus energising the small 12V PCB relay.

Diode D1 protects TR1 from reverse voltages (back-EMF). The voltage-free contact associated with the PCB relay is then used via connector CNI to latch on the 'Panic Input' audio alarm, which is a part of the original garage burglar alarm system.

George Caldwell, Drumahoe, Londonderry

Filters circuits Part 1

Frequent *EPE* forum contributer ***Paul Goodson*** posted the following plea for help with filters on the *EPE Chatzone* (**www.chatzones.co.uk**):

I am trying to make some band-pass filters in the audio frequency range (20Hz to 20kHz). I would prefer to use the single supply op amp LM324 if possible. There is so much dissimilar information out there it's driving me mad!

There doesn't seem to be any consistency in the way the op amp is configured or any values associated with the components. Also, the equations are a little above me at the moment! Probably as there never seems to be any working example shown with the component values as above! I was just hoping to find some better information with a working schematic that I could build and use as a push start.

Filters are circuits that pass signals at certain frequencies (in the pass band), while rejecting signals at other frequencies (in the stop band). A frequency that divides the pass band from the stop band is a *cut-off frequency*.

It is perhaps not surprising that Paul has found it difficult to find his way through the available information on filters, because there are indeed many circuit configurations. Even with the same circuit structure, it is possible to find component values to be different for the same stated cut-off frequency because other characteristics of the filters are different. Furthermore, full analysis of filter circuits requires some advanced mathematics, so anyone who has not studied mathematics or engineering to university level will probably struggle with the more mathematical treatments of the topic.

Fortunately, you do not have to use advanced maths to design and make use of filter circuits. The well known filter configurations have been extensively studied and boiled down to 'recipes' for finding component values. Traditionally, this was done with the help of books containing tables of values, but now, as you might expect, there are software tools that can do even more of the work for you.

To make appropriate choices, even designing filters from 'recipes', it helps to know the relevant terminology (including some terms relating to the mathematics) and something about the different filter characteristics and circuits available, so that is what we will be looking at now in *Circuit Surgery*. This month we will look at basic terms and filter characteristics and next month we will look at some popular filter circuits. However, before we start, we will take a quick look at the choice of op amps.

Op amp choices

The LM324 mentioned in Paul's post is a low power, quad operational amplifier from National Semiconductor (**www.national.com**). The LM324 series are op amps designed for single power supply operation and which have true-differential inputs that remain in the linear mode with an input common-mode voltage down to 0V DC.

These op amps are mainly aimed at DC applications, where large common mode input ranges may be problematic. This would include transducer amplifiers and DC gain blocks, but, of course, they can be used in all conventional op amp applications, including filters.

If you are aiming for a filter circuit with very high audio performance then it would probably be better to use an op amp specifically designed for this purpose. One example is the LME49740 quad, high performance, high fidelity, audio op amp, again from National Semiconductor. However, unlike the LM324 the LME49740 requires split (positive and negative) power supplies.

LME49740 is aimed at AC applications and is comfortable with capacitively coupled outputs. For the LM324, the datasheet states that a resistor should be used from the output of the amplifier to ground to prevent crossover distortion. This is due to the need to provide sufficient bias current for its class A output stage.

Filter types

Filters constructed from just resistors, capacitors and inductors are called *passive* filters, whereas filters that employ active devices such as transistors or op amps are called *active* filters. Circuits using just resistors and capacitors (*RC* circuits) cannot be used to make high performance filters due to their 'soft' response and the high attenuation of the signal they cause.

Very good filters, with sharp cut-offs, can be made using *RLC* circuits; but inductors are often bulky and expensive, are limited by the non-ideal characteristics such as series resistance, and are susceptible to magnetic pickup of interference. Using the properties of negative feedback, circuits using just resistors and capacitors, together with op amps can provide the same response as an RLC circuit without the aforementioned problems.

Filters can be classified according to the pass band: low-pass filters let low frequencies through; high-pass filters let high frequencies through. Band-pass filters let a specific range of frequencies through. Bandstop filters reject a specific range of frequencies. A notch filter is a bandstop filter with a very narrow stop band, which can be useful for rejecting a specific unwanted frequency. The graphs in Fig.1 illustrate ideal filter responses.

For an ideal filter, the transition from pass band to stop band occurs at a single frequency. Ideal filters are sometimes called 'brick-wall' filters due to the vertical shape of the response curve. For real filters the transition from pass band to stop band occurs over a range of frequencies (see Fig.2), thus we need to define specifically what we mean by 'cut-off frequency'. The cut-off is often defined to be the point where the filter's gain is –3dB with respect to the pass band gain. The stop band

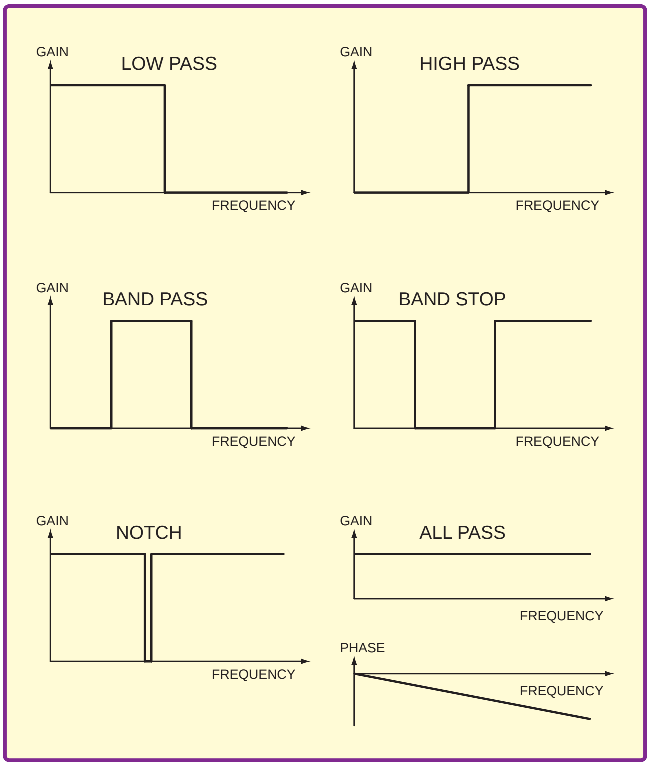

Fig.1. Ideal filter responses

may also be specifically defined in terms of reduction in gain, although there is not a ‘standard’ gain reduction for stop band as there is with the –3dB point for cut-off. The range of frequencies between the pass and stop bands is the transition region, or skirt.

Filter cut-off

The reason for choosing –3dB to define filter cut-off is that it represents the point at which half power is delivered to the load, compared to the nominal full power output in the main part of the pass band. The definition of the decibel is based on the logarithm of the power ratio of two signals P1 and P2, such that the power ratio in decibels is given by $10\log_{10}(P2/P1)$dB.

If we are expressing power gain (eg of an amplifier) then P1 would be the input power and P2 the output power. For measuring a power quantity relative to a reference, P1 would be the reference level and P2 the value we are measuring. So for filters, P1 (the reference point) would be the nominal pass band full power output and P2 would be the output at the frequency of interest. For half power output we have P2/P1 = 0.5 so in decibels this is $10\log_{10}(0.5)$dB which is –3dB.

The vertical axis on filter frequency response graphs, (eg Fig.2), which shows filter gain or attenuation is usually scaled in decibels, which as we have just seen is a logarithmic scale. For a gain A, the value in decibels is $20\log_{10}(A)$dB. Note the factor of 20 which is used here for signal voltage or current, rather than the factor of 10 which is used for expressing signal power in decibels. The horizontal (frequency) axis of the graph is also usually logarithmic (eg the scale is marked 1Hz, 10Hz, 100Hz, 1kHz, etc at even intervals). These times ten-steps are referred to as decades.

If the gain (or attenuation) in the pass band does not vary much with frequency it is described as flat. In some filters the pass band gain has distinctive ripples as frequency varies; the depth of these ripples is usually measured in decibels. The stop band may also have ripples.

Filter slope and phase lift

The slope of the frequency response in the transition region, and possibly the stop band indicates how quickly the filter’s gain drops as the frequency moves away from the cut-off. The slope is measured in dB per octave, or dB per decade, this value is called the fall-off or roll-off. The fall-off may be different near and far from the cut-off, thus we can describe both initial fall-off and ultimate fall-off. Note that an octave is a range of frequencies in which the higher frequency is twice the lower (the same term is used in music). As already mentioned, a decade is a range in which the upper value is ten times the lower.

The variation of phase shift with frequency is also an important characteristic of filters. Phase shift relates to the time delay of signals passing through the filter. If the delay is different at different frequencies the signal will be distorted. Constant delay corresponds with a linear increase of phase shift with frequency. The terms constant-delay, or linear-phase are used to refer to filters that are ideal or have very good performance in this respect.

Mathematics

The full mathematical treatment of filters uses what are known as complex numbers to represent both signals and circuit characteristics. Unlike ordinary numbers, which have just one value, complex numbers have two values (referred to as the real and imaginary parts). This two-dimensional quality essentially enables complex numbers to fully represent both the frequency and phase attributes of a signal or circuit, something which a single value (for say a voltage or frequency) cannot do.

When analysing filters using complex numbers we find critical (complex number) frequencies at which the response of the filter is zero or infinity. These points are called *zeros* and *poles* respectively. If it seems a bit strange to get infinite output response from a filter, remember this occurs with complex numbers, not with the ‘ordinary’ values.

We can translate the complex frequencies of the poles and zeros to the real frequencies shown on the frequency response graphs, such as in Fig.2. We then find that at the pole and zero frequencies the response graphs change slope. For a simple case, these frequencies correspond exactly to the cut-off frequencies (–3dB point) or break frequencies at which the response turns up or down.

Poles cause the gain of the filter to decrease with increasing frequency, with the eventual rate of decrease being 6dB/octave or 20dB/decade. Zeros cause the gain of the filter to increase with increasing frequency, with the rate of increase being 6dB/octave or 20dB/decade at sufficient distance from the zero. Poles make phase shift more positive by 90° per pole and zeros make phase shift more negative by 90° per pole.

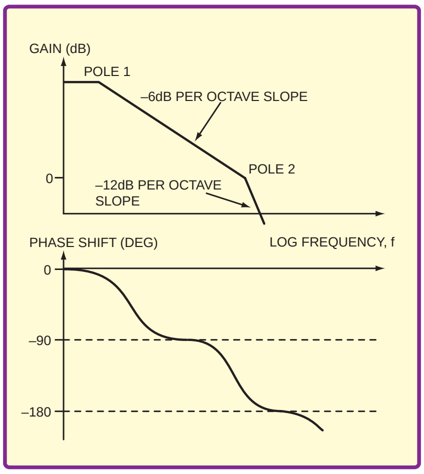

Fig.3. Frequency domain response showing poles and phase

The effect of poles is illustrated in Fig.3, which shows a low-pass response with two break frequencies determined by the presence of poles. The order of a filter equals the number of poles or zeros, whichever is greater. The order also relates to the ultimate fall-off:

1st order	6dB/octave	20dB/decade
2nd order	12dB/octave	40dB/decade
3rd order	18dB/octave	60dB/decade

and so on.

The time domain response of a filter can be characterised by applying a step input signal. The following characteristics may be identified (see Fig.4):

- Rise time – time to get from 10% to 90% of final value
- Overshoot – percentage of maximum value over final value
- Ringing – decaying oscillations as output settles to final value
- Settling time – time to get within a certain small percentage of final value

Filter design is a compromise between requirements such as pass band flatness, sharpness of cut-off, delay flatness (phase linearity), rise time, overshoot, etc. There are standard filter types which provide particularly good characteristics in specific areas. Examples include the Butterworth filter, which has as flat pass band; the Chebyshev filter which has sharp cut-off; and the Bessel filter, which has a flat delay response.

We will look at this in more detail next month as well as describing some op amp based filter circuits.

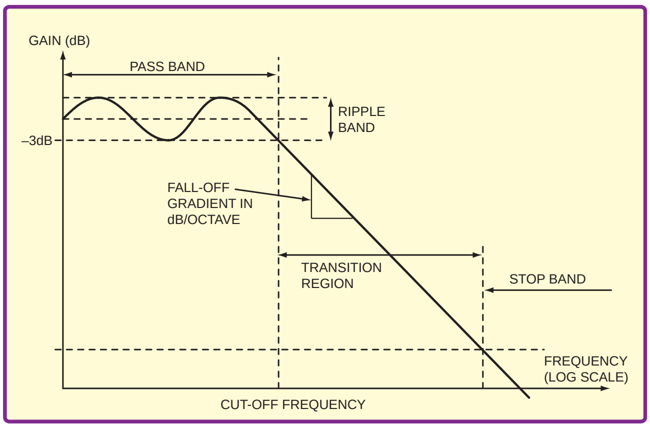

Fig.2. Frequency domain response

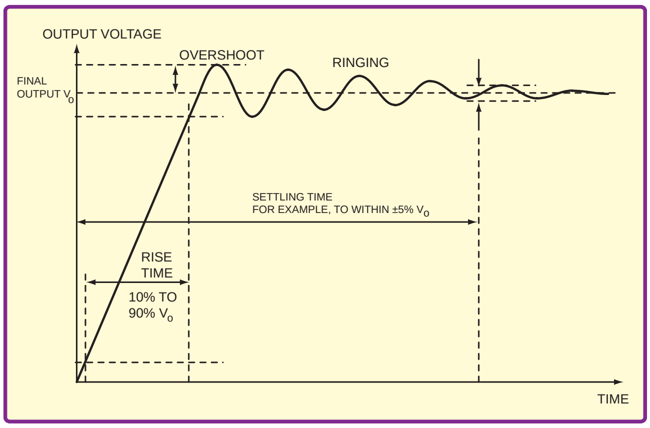

Fig.4. Time domain response

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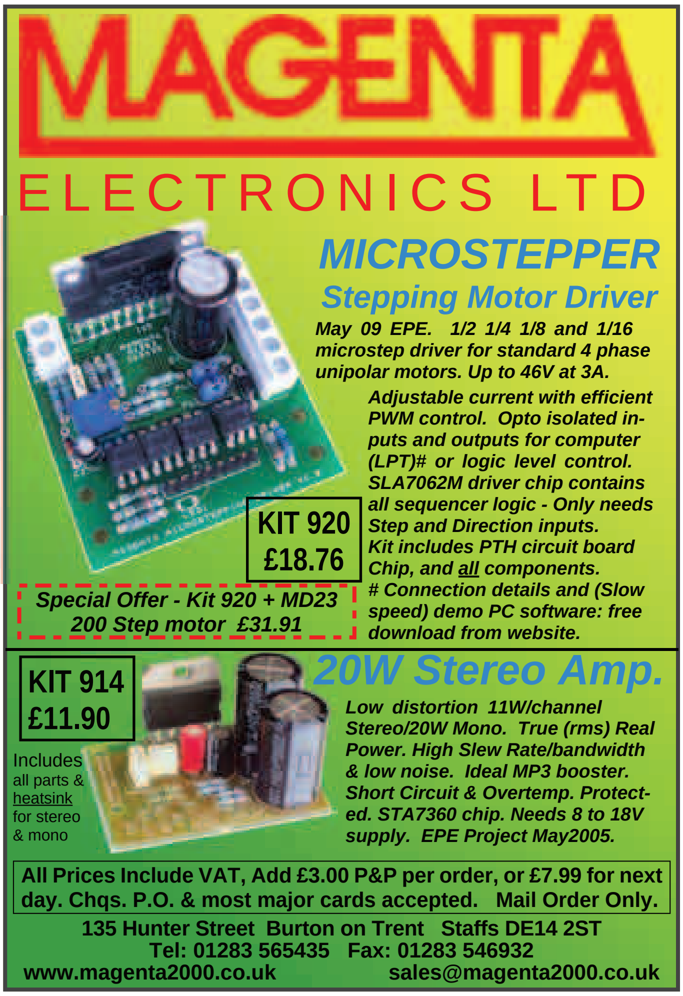

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PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Keyboard Interfacing

We are taking a break this month from video generation to take a look at interfacing to a full sized computer keyboard using the PS/2 interface. There is a point to this detour – as our video articles have developed over the last few months, we have aimed towards building an RS232 video terminal device – and that will need a keyboard. We won't go into the details of that project right now, but knowing this helps explain the sudden change of direction; and interfacing to a PS/2 keyboard is quite an interesting subject anyway, so it's worth taking a look.

PS/2 History

The PS/2 keyboard specification appeared in 1984 with the release of the IBM PC AT. It's only in the last five years that USB keyboards have started to replace PS/2 as the dominant interface; therefore, PS/2 interfaces have been the *defacto* standard *for almost 20 years* – quite an achievement. As you might imagine, having a standard in place for such a long time has helped to drive the costs down considerably (at the expense of quality, no doubt) and also allowed for a market to appear in 'alternative' input devices – such as bar code scanners and magnetic card swipe readers.

So, although this article is predominately about keyboards, exactly the same code and hardware can be used to interface to a number of other exotic devices based on the PS/2 interface. While the PS/2 keyboard is beginning to go out of fashion now, it is still possible to purchase them new in retail stores, at very low cost. And, of course, there is always eBay. Interfacing to a USB keyboard is significantly more complicated, so let's hope those older standard devices stay around for a while.

The physical interface has now settled on a small, six-pin connector, only four pins of which are used (Fig.1). Two for communication and two for power. Keyboards operate at 5V and would not be expected to draw more than 275mA, so you have to account for this potential current consumption in your hardware design, making sure you have the headroom in your 5V power supply. In some cases your keyboard may draw more power than your own circuit!

As the keyboard runs at 5V, it therefore outputs a data signal to your processor with a 5V 'swing'. This should not cause any problems when interfacing to a 3V processor – so long as the processor can tolerate 5V on its inputs. Many do, such as the PIC24 device that we will be using in this article. You are free of course to use a 5V processor, which will save you the cost of a regulator (although as you will soon see, we have a trick up our sleave to avoid using two regulators).

While the physical interface is a standard, not all keyboards implement identical data protocol features. If your requirements are for a simple keyboard input device, then that is not a problem. If you would like to configure the keyboard or perhaps access special keys, then each keyboard type will require different codes to be sent or received.

It's easy enough to work out (you can use the source code provided with this article to examine the codes sent when keys are pressed and released) but it does mean that one solution does not fit all. For the basic keys, however, a common standard exists, and is supported by the code which accompanies this article.

Physical Interface

The physical interface is shown in Fig.1, with the associated signal names. Note that this is the socket end, as found on PCs. The clock and data signals are bi-directional, and to achieve this they are both implemented within the keyboard (or whatever device you are connecting) as an open-collector.

That means that the logic levels on these pins can be either 0V or high impedance; pull-up resistors fitted between your processor and the connector ensure that when the lines are in a high impedance state the voltage rises to 5V. When you are reading the keyboard this means that your processor pins must be inputs. When writing to the keyboard, care must be taken to not set a pin to output-high; do it at the wrong time and your keyboard may try to drive the line low.

We don't address writing to the keyboard in this article, relying instead on the default configuration of the keyboard on power up. The circuit fully supports bi-directional communications, however, should you wish to write the software yourself.

The data signal is a synchronous bit stream with the timing aligned to a clock signal generated at the same time, as shown in Fig.2. A device will typically operate with a clock rate of about 10kHz, but you cannot rely on this for performing your own timing – your software must read the level of a data bit as the clock signal is moving from high to low. This can be achieved by implementing a 'tight loop' polling the level of the clock bit, or through an interrupt. Both are perfectly acceptable, but as we intend to use the code developed in this article in a video project, interrupts will give us better flexibility and so we are taking the interrupt route.

Data Bits

The keyboard protocol consists of between one and three bytes of data

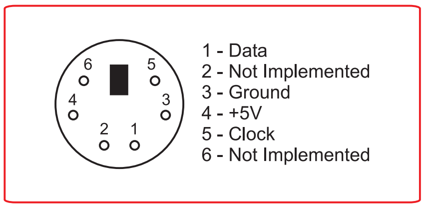

Fig.1. PS/2 socket

transmitted in quick succession. Each byte is sent as 11 bits – one start bit, eight data bits, a parity bit and a stop bit. The parity bit is present to allow you to perform some basic error detection; we ignore this and simply decode each byte within the 11-bit sequence.

It's possible for the processor to 'pause' the keyboard from sending data by driving the clock line low. When the keyboard detects this, it will buffer any data until the clock line is released.

How many keyboard events actually get buffered is keyboard specific, so you should take care if you choose to use this feature. In this article, we don't try, and instead buffer the received data within our keyboard interrupt routine.

Because the number of data bits used in each transfer is not a convenient multiple of eight we cannot rely on the SPI or USART hardware module within the PIC processor to handle the incoming data – we will have to use a simple interrupt on the clock pin. We read a data bit on the falling edge of each clock pulse, a technique which is quite simple to implement with an interrupt, but a certain amount of care will be needed when integrating the software with your own application later on. We do of course have in mind the video generating application, which has some very tight timing requirements. Integrating a keyboard interrupt while time-critical video interrupts are occurring will present a particularly interesting challenge!

Keyboard Interface

Our circuit for this month is shown in Fig.3. It's based largely on the processor setup from last few month's video article, primarily because, in a later article we wil be integrating the two together. The

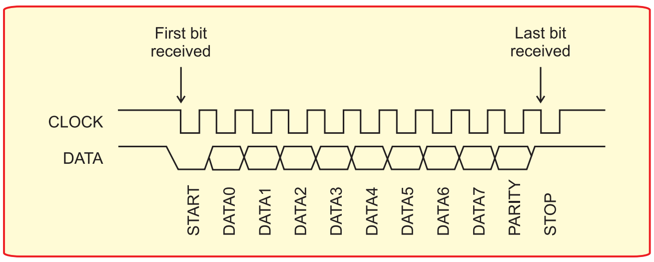

Fig.2. Data format

keyboard interface is actually nothing more than a connector and two pullup resistors.

You may have noticed that we have changed our power source from the typical 9V DC unregulated input to a 5V regulated one. This is because 5V power supplies have become very cheap recently with the proliferation of PDAs and large mobile phones. It's also because our microcontroller designs are now moving towards 3.3V or mixed 3.3V and 5V circuits.

Converting from 9V to 12V down to 3.3V with a standard linear regulator such as the LM7805 or LM317 is going to waste a lot of energy, all as heat, requiring unattractive heatsinking. By using a 5V to 3.3V linear regulator the energy loss is significantly less and a typical circuit can be powered without the need for a bulky heatsink. It will save money too!

The LD1086V33 3.3V linear regulator used in this month's circuit is just one example of such devices suitable for use in this configuration (converting 5V to 3.3V). It's a simple device to use and requires fewer components than the LM317. We were so impressed with this device that we have decided to standardise on it for use in future *PIC n' Mix* projects. You may, of course, continue to use whatever 3.3V power generation circuit you choose, but keep in mind that the LM317 would not be able to convert 5V down to 3.3V – it requires a higher input voltage.

In Fig.4 is shown the pin layout of the LD1086V33 regulator. It comes in a standard package similar to the LM7805, which will be familiar to many, can supply up to 1.5A, requires just two capacitors and is relatively inexpensive. It's not the only 3.3V regulator and possibly not the best, but it is a good work-horse regulator. We now have a stock of them in the *PIC n' Mix* lab.

The other new component this month is the PS/2 keyboard socket. Ours was salvaged from an old PC motherboard (using a large soldering iron and a big blob of solder. A heat gun would have been better.) The sockets are described as '6-pin mini DIN female sockets' and are available through the usual electronic component suppliers.

Software

The full software for the interface is contained within **pic24ps2key.c, pic24ps2key-keymap.h** and **pic24ps2key.h**. The latter header file provides the list of functions that may be used by your own software to access the keyboard interface. Using the software is very straightforward; a typical initialisation routine called

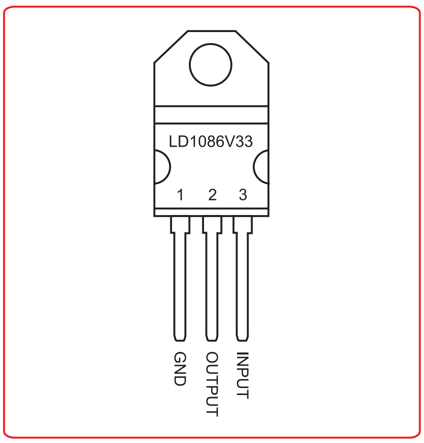

Fig.4. Low drop-out (LDO) regulator

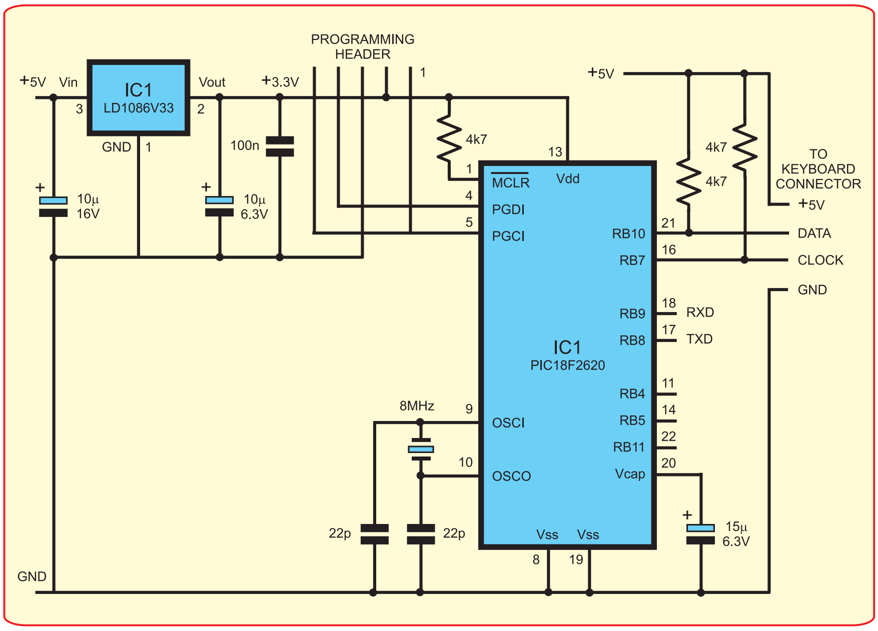

Fig.3. Circuit diagram

PIC24ps2keyInit() should be called at the beginning of your application to set-up the two I/O pins and the interrupt. After that, just make a call to **PIC24ps2keyGetKey(),** which will return the value of any key pressed, in ASCII.

The function **PIC24ps2keyGetByte()** can also be used if you want to see the raw bytes coming back from your keyboard, or whatever device you plug in. This can be used to help you develop special interface software for other more exotic devices.

At the beginning of the header file is a statement that you may not be familiar with – *enum*. This is a C language feature that allows you to define a set of named constants, a little like a short cut to creating a list of *#define* values. Each named constant takes a value one higher than the constant to its left in the list. *Enums* can be used in more complicated ways than simply as a short cut to creating constants, but that's a more complicated topic for a later date.

The *reason* for creating these values is to enable the **PIC24ps2keyGetKey()** routine to return values for keys other than the normal alphanumerics, such as function or arrow keys. The *enum* lists, in hopefully an obvious manner, names for keys that you may well want to use. A typical use would be like this:

```
key = PIC24ps2keyGetKey();

if ( key >=  F1 ) {
   /* handle function keys */
   switch (key) {
      case F1:
      break;
      case F2:
      break;
   }
} else {
   /* display key pressed */
   putch(key);
}
```

Unfortunately, there isn't a simple relationship between keys on a keyboard and the values that are transmitted over the interface. In fact, it's quite a confusing jumble. To simplify the translation between the two, a lookup table is implemented within the software. This is held in a separate header file, **pic24ps2key-keymap.h**.

The bulk of the interface software is within a very short interrupt routine at the end of the main source file. Its job is straightforward, shifting in data bits from the interface, stripping out a byte after every 11 bits and storing the byte in a small buffer. The buffer, held in the variable **keyBuffer**, reduces the burden on your main software to respond to incoming data quickly.

If your application is busy doing something, such as a lengthy calculation, the interrupt routine will buffer up to 16 data bytes for you. It's not a requirement that the keyboard library provides a buffer, but it does make sense in many applications and 16 bytes of data is tiny in comparison with the amount of RAM available to us.

Adding this code to your own project is simple. Include the names of the three files in your project workspace, and then include the line **include "pic24ps2key.h"** within your C source files that need to use the functions. An example project and test program are included with the main files, available for download from the *EPE* website. The program outputs keypresses from a keyboard over the serial pin TXD at 9600 baud.

Next month, we look at integrating this keyboard code into the video library to create an RS232 terminal, reminiscent of the classic VT100 mainframe computer interfaces. A potentially useful device in its own right, but once more just a step in the direction of a more interesting device – but more on *that* next month!

Competition

It would be interesting to see what applications people can dream up for the video hardware and software we have developed over the last few months, and we would love to see them. To provide a bit of encouragement we are offering a Nurve Networks XGS PIC 16 development system (reviewed elsewhere in this issue) for the most interesting design submitted by the end of October.

We'll announce the winner, and publish the design in *PIC n' Mix* later in the year. Send your submissions (or indeed any other comments) to **mike.hibbett@gmail.com**.

Our thanks to Nurve Networks for making an XGS available.

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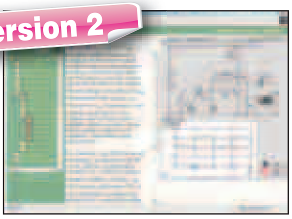

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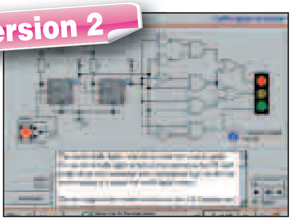

Virtual laboratory - Traffic Lights

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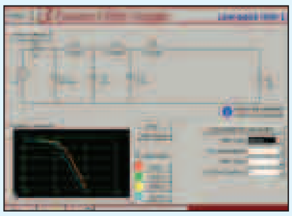

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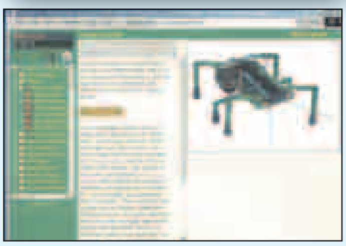

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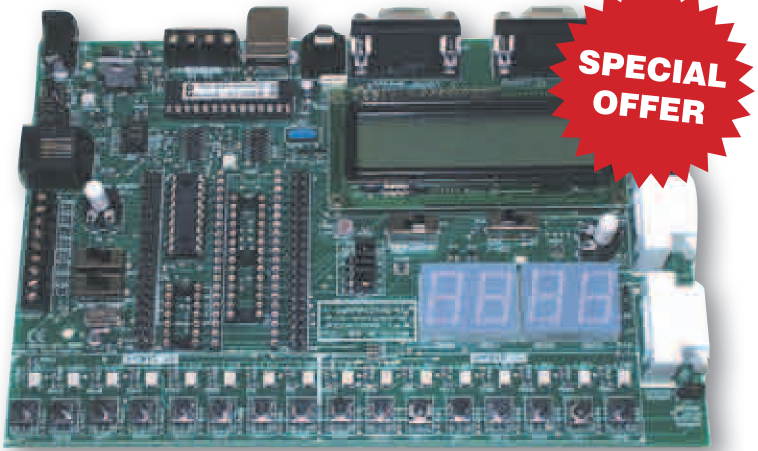

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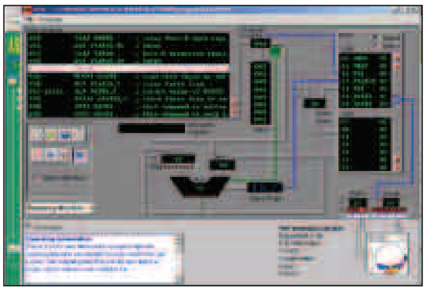
(Formerly PICtutor)

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

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

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

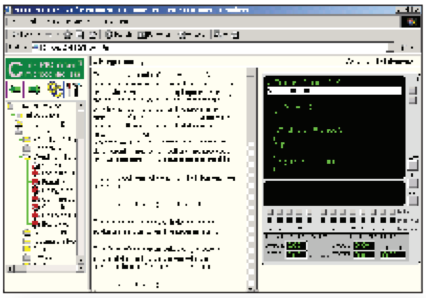


'C' FOR 16 Series PICmicro Version 4

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

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

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



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

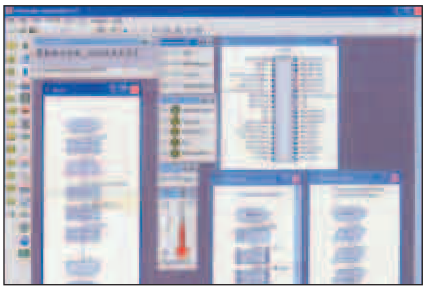
FLOWCODE FOR PICmicro V3

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

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

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

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



PRICES

Prices for each of the CD-ROMs above are:

(Order form on next page)

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Site licence	£599	plus VAT
Flowcode 10 user (Network Licence)	£350	plus VAT
Flowcode 50 user (Network Licence)	£699	plus VAT

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

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

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

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Runs in Microsoft Internet Explorer

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

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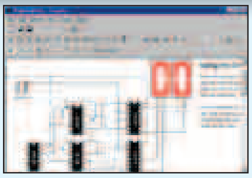
Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 95/98/NT/2000/ME/XP, mouse, sound card, web browser.

DIGITAL WORKS 3.0



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- ☐ PICmicro Development Board V3 (hardware)

- ☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
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READOUT

Email: editorial@wimborne.co.uk

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

All letters quoted here have previously been replied to directly

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

★ LETTER OF THE MONTH ★

Stripboard CAD

Dear EPE

You asked for comments on stripboard layout programs following Peter Barrett's letter in the April issue.

I have been using VeeCad for over a year and produced a number of boards with it in combination with, initially, Circuit Maker (a program which I purchased some years ago, but which is unfortunately now no longer supported) and more recently, the free TinyCad, which is currently being invigorated by a new group of developers.

My experience with VeeCad has been very good. It does exactly 'what it says on the box', and first-time working layouts are the norm, provided a schematic is drawn first and its netlist imported. This, of course, also improves project documentation, as the schematic and layout are tied together in a similar manner to a schematic/PCB layout combination. Another advantage is that a one-to-one printout of the layout can be stuck to the stripboard and there you have a pseudo silk screen to work to, again reducing the likelihood of errors.

Like all CAD programs, there is a degree of learning to do before things become second nature, but if the guidelines and tutorials on the 'Help' pages are followed, then VeeCad is soon mastered. Again, as with just about every PCB layout program I have used, the interface with the Schematic Editor has to be understood and configured so that they work together. I think the rules that VeeCad requires are simple to implement and quite logical. The reasoning behind them is discussed at: http://veecad.com/resource/parts/cadsanity.html

I think that Peter's comment, 'Also, in general, the software prefers all through-hole components to surface mount ones, and if your project has a lot of ICs, then you are going to be placing a lot of 'X's, which is the software mark for cutting a track' is unfair to VeeCad. It is the stripboard that imposes these limitations – not the program!

One final point, I have found that Roger Lascelles, the VeeCad developer, is always open to suggestions for improvements and offers help on the VeeCad forum. I must point out that other than being a very satisfied user, I have no connections with VeeCad or Roger Lascelles.

Dave Sims, by email

Thank you David, there's no recommendation like a satisfied customer.

Mac OSX and Linux interfacing

Dear EPE

Thank you for your interest in Mac and Linux platforms. Our products are entirely designed and manufactured in the UK. Although we are a small company, we are expanding and currently export to customers in 39 countries.

Please see the following two links, the first for Mac customers and the second for Linux customers. The Linux datasheet is useful because it describes the low level access to the port and the simple command structure to command the relay/DIO cards. Note that with both Linux and Mac platform the FTDI (virtual COM port) drivers are already installed as part of the OS build – you don't need to download any drivers (unlike Windows – there are both 32- and 64-bit drivers, depending on which processor type the PC has).

The Mac application was developed by a customer in Australia as a home automation project. It is an open source app, so customers can download the code and use it as a basic building block for their own requirements. Also, Indigo customers have used our products in conjunction with their home automation systems: www.easydaq.biz/Downloads/Downloads(Mac).htm

The following link will jump you to the Linux datasheet: www.easydaq.biz/Datasheet%20Contact%20Details/indexEeePCInfoRequest.htm

Chris Harden
Product Design & Tech Support
www.easydaq.biz

Thank you Chris – readers will note that this letter is a response to last month's Editorial, where I asked for advice on interfacing non-Windows computers. It is no slight to Easydaq (or Chris) to note that EPE is not offering official endorsement of their products. Views expressed in Readout *are always solely those of the author, and are printed because of their topical or general interest value – or, as in this case, in response to specific requests for information.*

Oscar LEDs

Dear EPE

I was delighted with the simplicity of Brian Healy's *Oscar* project in the April issue. However, on closer inspection, I notice that there are no current-limiting resistors for the LEDs. Was this deliberate, or an oversight? With a supply voltage of approximately 5.5V the LEDs will pass a lot more current than the recommended 20mA or so that the ports of the PIC can safely supply. Even when the ports are multiplexed in the manner described, ports RA1 and RA2 will be driving most of the time. I suggest that a couple of 150Ω resistor be placed in the leads from ports RA1 and RA2 to limit the current. This results in only two more resistors, and it will save blowing the output drivers of the PIC.

Colin Wilson, by email

You are correct – the maximum current sourced by an output pin should be 20mA and the LEDs are not current limited by a resistor.

Looking at the specifications of current versus output, at 20mA a high output is typically 3.25V and low output is 0.7V when running from a 5V supply. So the available voltage for the LED, when driven by a high output for the anode and a low output for the cathode, is 3.25V – 0.7V, or 2.55V.

We measured a red/green LED at 20mA and found that the forward voltage for the green LED was 2.25V and 2.2V for the red. So the current is therefore more likely to be about 22mA instead of 20mA.

The PIC will probably survive this extra current. However, as you say, 150Ω limiting resistors at pin 1 and pin 18 would be better.

Net Work

Alan Winstanley

It's the Wolf man

Google is among the world's most prominent brands, and it must be serious if the verb to *google* can be conjugated from the eponymous search engine's name. A number of challenges to Google's dominance have appeared in recent years. At one time a direct rival – Yahoo! – could actually charge businesses for the privilege of appearing in the Yahoo Directory.

Runners-up in the race are MSN, with Ask coming a distant fourth. Microsoft now offers 'Live Search' at **www.live.com** and Ask recently resurrected its English butler, Jeeves, in its commercials, at **ask.com**. Other search engines or directories for you to try include Dogpile (**www.dogpile.com**), the Open Directory Project (**www.dmoz.org**) and the venerable AltaVista (**www.altavista.com**) which is now owned by Yahoo. Ask.com absorbed the interesting Teoma search engine technology first mentioned in *Net Work* in July 2004. AltaVista is notable for its easily accessible Babelfish language translator tool.

Apart from some relatively unobtrusive advertisements, Google's 'natural' results are the battleground where online businesses fight for first prize. In their quest for more clicks and greater profits, owners of websites can pay good money to ensure their website can leapfrog over their competitors' to be No. 1.

Google has an immense built-in artificial intelligence that strives to deliver accurate results. It knows that if it responded with inaccurate recommendations then its usefulness would be devalued (along with its advertising revenue). Therefore, Google dislikes being 'fooled' by search engine optimisers and it penalises an 'inaccurate' website by dropping them altogether.

One trend is emerging as the Internet becomes choked with ever more online resources: poking a search phrase into Google and ploughing through an onerous list of recommendations starts to leave users feeling rather short-changed if not exasperated. It's like asking a librarian to locate the best book on a topic and he or she throws a pile of index cards at us, so we have to start searching for ourselves. If we don't like what we read, the librarian suggests we read the next card in the pile.

With the road to search heaven littered with the remains of Teoma, AltaVista, Yahoo, The Open Directory and more, periodically a search engine comes along that promises to change everything for the better. Instead of typing keywords or phrases into Google and being hit with a blizzard of web links, what if a search device actually answers your question for you?

This has partially been the approach of Ask.com – type in a question in plain English and you get… a list of web links. Plenty of data, but no information. In an attempt to offer a straight answer to our search queries, the latest 'Google-beating' search engine to launch is WolframAlpha (**www.wolframalpha.com**). This new arrival has at least one thing in common with Google: its founder is a mathematical genius. It describes itself as a 'computational search engine' and its declared aim is to provide 'definitive answers to factual queries'.

Founded by London-born Stephen Wolfram (**www.stephenwolfram.com**), WolframAlpha utilises Wolfram's Mathematica modelling and visualisation software (**www.wolfram.com**) behind the scenes. Mathematica lets you manipulate molecules or visualise a virtual volcano, compute and document any technical concept or distil virtually any type of technical data into a human-digestible form. Mathematica Home Edition is £230.00 inc VAT ($300) and in essence it combines the powers of a super-spreadsheet, a 3D modelling package, a documenting, mapping, programming and algebraic engine with almost any other technically-based algorithm function you could need.

Need more input...

WolframAlpha is a brave attempt to compute answers in response to calculations or queries. It is as if Google Calculator meets Robot No. 5 from the movie *Short Circuit*. It has passed its first test already – after widespread media coverage in the UK, the site stood up on 'day one' with no particular sign of falling over, which is more than other ambitious projects (eg, the British Census website) can boast.

Much is promised by WolframAlpha, but the computational engine is careful not to raise our hopes too high at this embryonic stage of its development. Perhaps expectations are presently unrealistically high, as it probably signals the way ahead rather than being a milestone in itself. So far, I have yet to witness any real everyday benefit from the new engine: after bashing in a variety of 'factual questions' including enquiries on swine flu statistics, the number of transistors in a Pentium processor, railway passenger totals for 2008 and many more, I was constantly greeted with the Short Circuit No. 5 response 'WolframAlpha isn't sure what to do with your input'.

WolframAlpha could signal a new way of finding answers on the web.

We have heard of Google-beating search engines before, the last one being Cuil (**www.cuil.com**) which has disappeared off the radar of regular web users. Cuil launches a small thumbnail image alongside search results, attempting to guess what the most appropriate image will be. (The meaningless one alongside ***EPE*** mag's entry resembles an explosion in a psychedelic knitting yarn factory.)

WolframAlpha promises much, but for everyday users, that multi-coloured Google logo will remain a feature of our Internet 'search experience' for some time into the future.

Don't forget to check over the *EPE* website at **www.epemag.com.** You can email me at **alan@epemag.demon.co.uk**

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Mike Tooley
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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.

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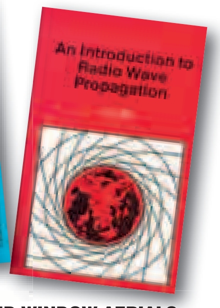

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Many people live in flats and apartments or other types of accommodation where outdoor aerials are prohibited, or a lack of garden space etc. prevents aerials from being erected. This does not mean you have to forgo shortwave-listening, for even a 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.

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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.

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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.

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THEORY AND REFERENCE

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

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

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

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

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

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R. A. Penfold
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Ian R. Sinclair
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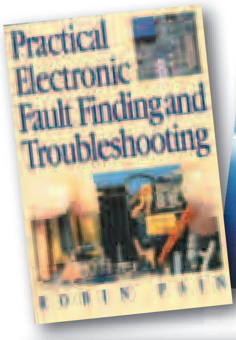

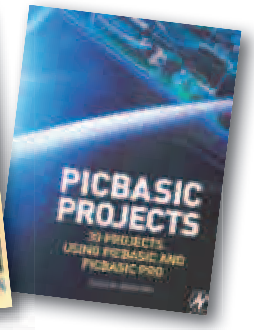

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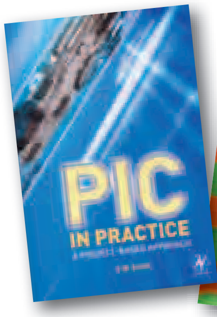

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1·0, 2·5 + 30·0 RPM MAINS MOTORS 240V 4W. Body 50mm diameter × 25mm with lugs. Shaft 7mm diameter. £9.85 including postage. C. Brittain, 12 Marina Drive, Wolverton, MK12 5DW. 07986 824998

KITS, TOOLS, COMPONENTS. S.A.E. Catalogue. SIR-KIT ELECTRONICS, 52 Severn Road, Clacton, CO15 3RB, www.geocities.com/sirkituk

EPE EVERYDAY PRACTICAL ELECTRONICS

NEXT MONTH

KEYLESS ENTRY SYSTEM

Ideal for doors in cars, homes and industry, this is a keyless entry system with a difference. It's super secure because it features a rolling code – forget about someone reading and using your infra-red signal to break in. With this system, every time you use it the code changes, making 'hi-tec' intruders' lives a well-deserved misery.

FAST NiMH BATTERY CHARGER

This is a truly versatile charger – it can charge up to 15 identical NiMH or NiCad cells, and you can build it to suit any size cells or cell capacity. Users set the charge rate to fast or trickle, and, of course, it has built-in safeguards, including temperature sensing.

PROGRAMMABLE IGNITION – PART 1

Want to program the ignition timing on your car? Now you can, with this completely new design. It can even be used in older cars that don't have electronic ignition or used as an 'interceptor' for cars with engine management systems. Your spark plugs will thank you.

RECYCLE IT! – ANEMOMETER

Next month, we have a real treat for recycling fans – especially those who kept an old video player on the off chance that surely it's too good to bin. The connection between measuring wind speed and the technology to play Gone with the Wind? – you'll have to wait for the next issue…!

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