elektor

electronics worldwide

SCRATCH AND WIN

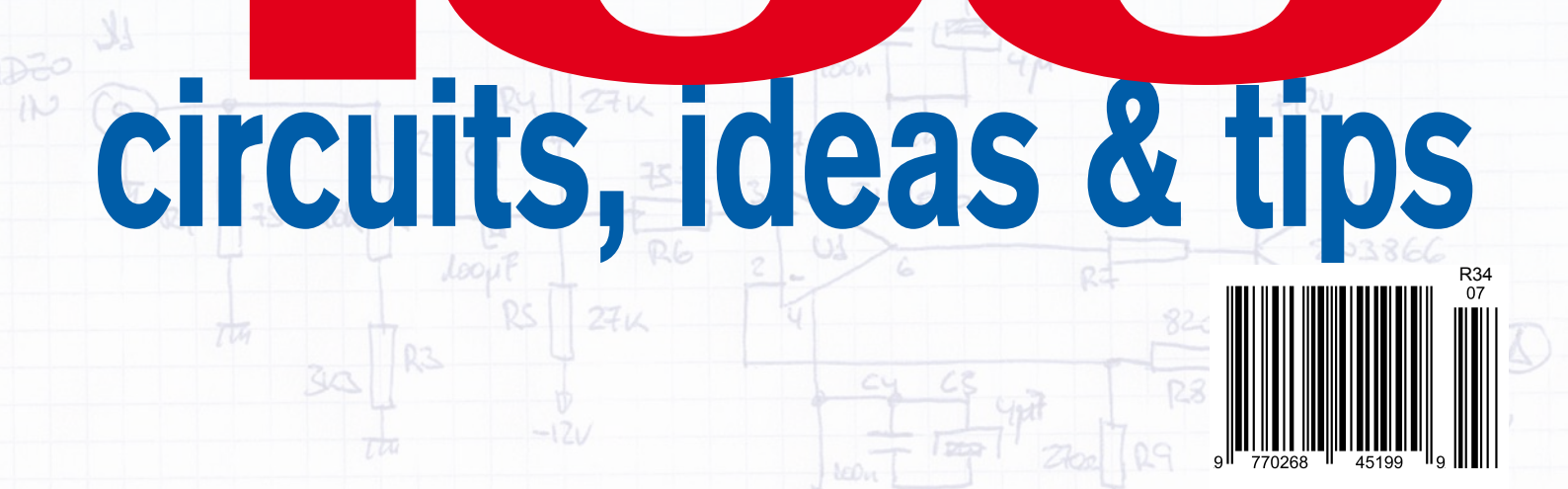## a trip to China!

or one of the marvellous prizes from our scratch lottery!

SUPERSIZE SUMMER ISSUE

with more than

100

circuits, ideas & tips

EasyPIC5 is a world-class tool that enables immediate prototype design...
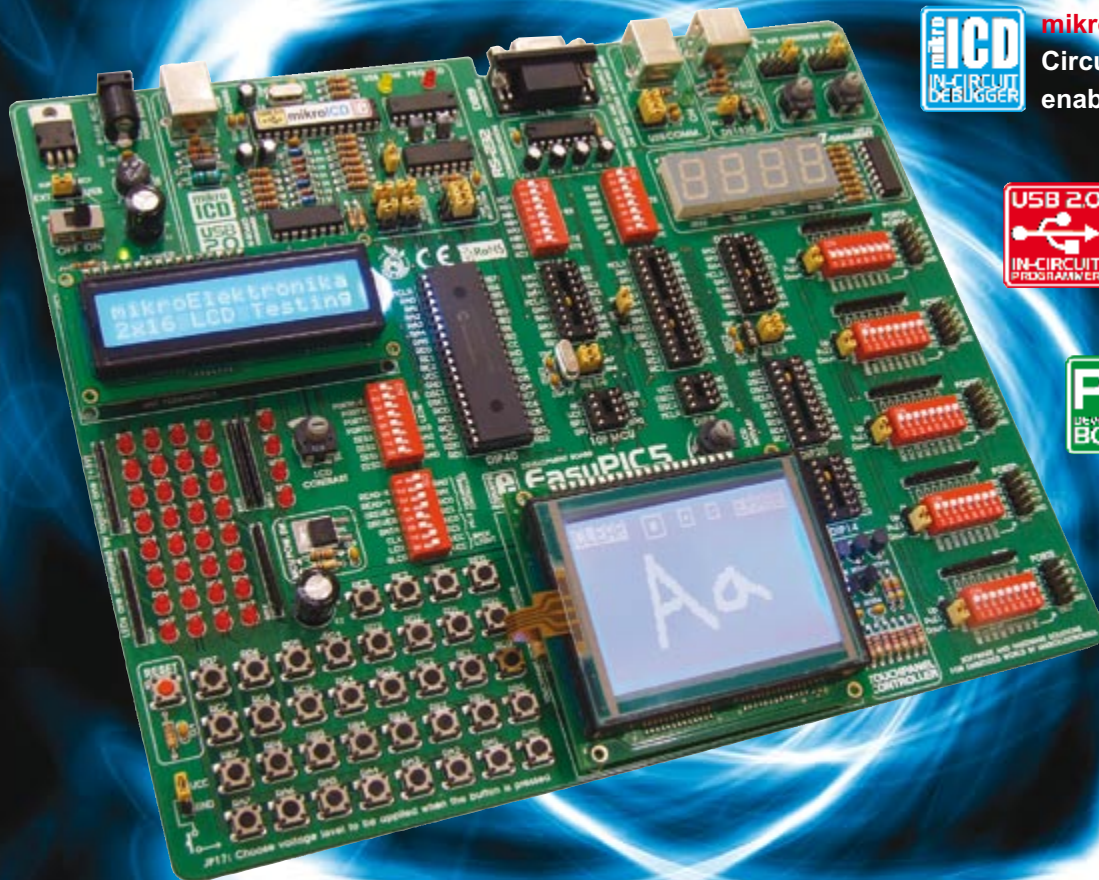
mikroICD - Hardware In-Circuit Debugger on-board enables easy debugging

High-Performance **USB 2.0** On-Board Programmer

User-Friendly PIC development system

Thanks to many new features, you can start creating your great devices immediately. **EasyPIC5** supports 8-, 14-, 18-, 20-, 28- and 40- pin PIC microcontrollers (it comes with the PIC16F887). The **mikroICD** (Hardware In-circuit Debugger) enables very efficient step by step debugging. Examples in **C**, **BASIC**, **Pascal** and **Assembly** language are provided with the board. EasyPIC5 comes with the following printed documentation: EasyPIC5 Manual, PICFlash2 Manual and mikroICD Manual. Also EasyPIC5 is delivered with USB and Serial cables needed for connecting with your PC.

Evolving product features and modern input design require the use of touch screens. The **Touch screen controller** with connector available on EasyPIC5 is a **display overlay** with the ability to display and receive information on the same display. It allows a display to be used as an input device. Simple installation onto the face of a GLCD for easy connection to EasyPIC5 board with built-in Touchscreen Controller and Connector.

SOFTWARE AND HARDWARE SOLUTIONS FOR EMBEDDED WORLD

Scratch-and-win

Join the lottery and qu to China worth £3,000

This year's edition of Summer Circuits is quite special. Apart from a vast number of circuits and ideas we present a scratchcard lottery unique to electronics magazine publishing. The hidden number on the scratchcard on the opposite page may win you a trip to China! Or an oscilloscope, a development kit, a voucher, Elektor Credits and lots more.

Elektor editors have phoned their contacts in the trade and industry to request sponsorship for this special event. The response was overwhelming. For example, National Instruments have sponsored 8 LabVIEW packages complete with USB data acquisition modules, representing a total value of £18,500! Agilent kindly added a fantastic portable oscilloscope worth £1,300 to our stock of prizes. Fluke obliged by allowing us to give away one of their digital multimeters worth £460. Elektor themselves added a little something to the stock of prizes: an ElekTrack unit that allows you to find back your caravan at all times, or indeed any other vehicle or valuable object. Also from Elektor are sets of E-credits and a number of vouchers that allow you pick your own prize from the Elektor Shop.

Main prizes worth in excess of £40,000

The main prize

Join the scratchcard lottery and win a unique trip to China. Visit the Great Wall — discover the culture of this extraordinary country. Besides, the trip allows a peek into China's electronics industry. As part of the trip you will visit a trade fair, a number of product manufacturers as well as some of the largest electronics shops in the world. After the visit, we're sure a wondrous world has opened up for you.

Agilent U1604A handheld oscilloscope type, worth £1,300 (€ 1,700)

Fluke 87V/E2 multimeter kit, worth £460 (€ 600)

8 pcs NI LabVIEW with NI USB-6009 data acquisition card, worth £2,300 (€ 3,000) each

with Elektor!
alify for a 10-day trip

Scratch and enter a draw for prizes worth £40k+ !

Winning was never easier.
Before 31 August 2008, scratch to reveal your
personal code and go to the Elektor website.

On the website, answer the (very) simple
question and then enter your code.

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1. Scratch to reveal your personal code

2. Go to www.elektor.com/scratch

3. Answer a simple question

4. Enter your code and win

elektor
Scratch and Win!

Your personal code:

Now go to: www.elektor.com/scratch

everyone's a winner!

Elektor ElekTrack module
worth £300 (€ 400)

Velleman Personal Pocket Scope
PPS10, worth £170 (€ 220)

Texas Instruments F28335 eZdsp
Starter Kit, worth £295 (€ 380)

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You should get out more...

Those first days of spring are so hard on our lab workers — birds are singing and you can smell the grass but the only thing these poor souls smell is solder fume. More than one hundred circuits pass their hands — requiring boards to be designed and parts to be ordered. Once the boards arrive, they have to be tested and one mistake means 'all over again'. Then the material is passed to the Dutch, English, French, German and Spanish editors who provide the matching texts and illustrations. Manuscripts are returned to the lab for a check on technical aspects. Meanwhile drawings are produced in Elektor style (well done Marty) and with these finished, DTP assembles the text and illustrations into an 'SC item', which is handed to the editors for final corrections.

I will not diverge into more technicalities of Elektor magazine production. Our aim is for you to trawl the magazine contents for nice projects and ideas as you can hear birdsong and smell the new grass.

This year our source of inspiration was 'all things outdoors': do-it-yourself, sporting, biking, on the road by car or camper, with or without caravan, you name it — everything that keeps us out of doors long enough to take our minds off electronics.

Scratch-and-Win!

This years' Summer Circuits edition contains a Scratch Number lottery. We called half a dozen selected suppliers and advertisers and they all agreed to make prizes available for this unique event. If the Summer Circuits issue is a cake made from many ingredients then scratch-and-win is the icing!

Wisse Hettinga
International Coordinating Editor

SUMMER CIRCUITS 2008

(bold type = PCB design included)

CONTENTS

elektor international media

Elektor International Media provides a multimedia and interactive platform for everyone interested in electronics.
From professionals passionate about their work to enthusiasts with professional ambitions.
From beginner to diehard, from student to lecturer. Information, education, inspiration and entertainment.
Analogue and digital; practical and theoretical; software and hardware.

English
German
Dutch
French
Chinese

Greek
Spanish
Swedish
Finnish

SAPS-400

Live EDGE 2008 US$ 100,000 challenge in support of green design

Premier Farnell plc and its subsidiary companies Newark, Farnell, Premier Electronics, CPC, Farnell-Newark and MCM launched its international competition Live EDGE – Electronic Design for the Global Environment, now in its second year. Trees were planted worldwide to celebrate the launch of this year's challenge which includes a second category for students.

The competition is designed to provide a forum where electronic design engineers and students can design products that are environmentally friendly through the use of electronic components.
Registration for news, updates and activities started on 6 May 2008 via the Live EDGE website and on the Live EDGE Design Challenge group on Facebook. The Live EDGE website will soon feature social networking tools, and a leading edge community forum in the near future for engineers to share and develop ideas.
Entries can be submitted between 1 October 2008 and 31 January 2009. Judging will start on the

1 February 2009 and winners will be announced on the 2 April 2009. The competition is open to anyone aged 18 or over.

Electronics engineers, students and inventors around the world are invited to submit designs for an innovative product that utilises electronic components and has a positive impact on the environment, for example by increasing

energy efficiency or reducing carbon emissions.
The winning entrant for both the full-time student and the general/open category will receive a cash prize of US$ 25,000 as well as a design support package valued at an additional US$ 25,000 to move the design towards production. The support package will include the services of an electronic design consultancy to help develop

the design to prototype stage, assistance with legal matters and IP registration, some marketing and publicity, as well as Premier Farnell's help in securing investment funding. The group will actively market the end product to millions of customers globally through their leading edge website, catalogue and direct marketing.

In addition, up to three entrants for the full-time student category and three entrants for the general/open category will be eligible for 'honourable mentions', each receiving a cash prize of US$ 5,000. Reflecting the environmentally friendly theme of the competition, Live EDGE will be largely web-based to avoid international travel and transportation. For example, the judges will confer online and it will be possible to view the award ceremony from the competition website.

www.live-edge.com
www.premierfarnell.com

(080485-III)

12 GHz USB sampling oscilloscope

Pico Technology's new PicoScope 9201, a dual-channel PC Sampling Oscilloscope has a bandwidth of 12 GHz. The instrument uses sequential equivalent-time sampling to achieve a sampling rate of 5 TS/s. The wide bandwidth allows acquisition and measurement of fast signals with a transient response of 50 ps or faster. Timebase stability, accuracy, and a sampling interval of 200 fs allow timing characterization of jitter in the most demanding applications. The ability to trigger on high frequencies up to 10 GHz allows measurements on microwave components with extremely fast date rates.
Data acquisition and measurement analysis are performed in parallel, enabling the instrument to achieve outstanding measurement throughput. The instruments provide fast acquisition speed up to 200 kS/s and waveform performance analysis with automated direct or statistical measurements on both single-valued signals (sine-wave, pulse, impulse) and multi-valued
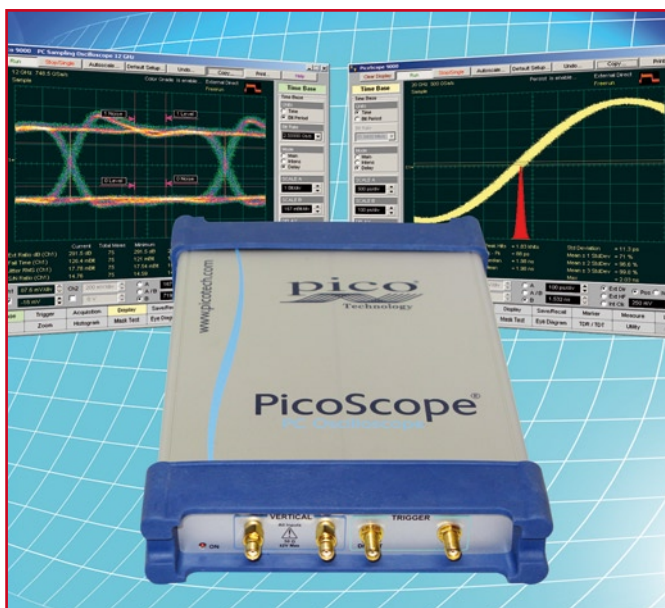
signals (NRZ, RZ). Markers and histograms, math and FFT analysis, colour-graded display, parametric limit testing, eye diagrams and mask template testing can be used independently or in concert. Accurate eye-diagram analysis for

NRZ and RZ signal types is essential for characterizing the quality of electrical and optical transmitters to beyond 7 Gb/s. The PicoScope 9201 was designed specifically for the complex task of analyzing digital communications wave-

forms. Compliance mask and parametric testing no longer require a complicated sequence of setups and configurations. The important measurements you need are right at your fingertips, including industry-standard mask testing with built-in margin analysis, extinction ratio measurements with improved accuracy and repeatability, automatic eye measurements — crossing %, eye height and width, one and zero levels, jitter, rise and fall times — and more. In addition, mask testing of SDH/SONET, Fibre Channel, Ethernet and other standards simplifies compliance testing. A full colour display helps you to discriminate waveform details. A colour-graded display mode adds a third dimension — sample density — to your signal acquisitions and analysis.
The PicoScope 9201 is available from local distributors, or direct from Pico Technology.

www.picotech.com

(080452-V)

Design your own chips with MACH64

The MACH64 Programmable Logic Starter Kit from Nurve Networks takes you from mystery to mastery in the black art of Complex Programmable Logic Devices (CPLDs).
CPLDs are chips that are internally constructed of an array or matrix of programmable logic units or blocks. Each cell can perform various logic functions. The power of CPLDs is that with a software based tool you can write 'code' that is compiled into a hardware description that is then downloaded and flashed into the CPLD changing its behaviour to your exact specifications. By mastering this technology, you can develop your own chips that run at blazing speeds as well design very complex systems that would be impossible with discrete TTL chips.
CPLDs are a great starting point for those interested in programmable logic technology and allow you to seamlessly move into their bigger brothers — Field Programmable Gate Arrays (FPGAs) when you're ready.
The MACH64 kit is actually two kits in one:
- A complete Lattice ispMACH 4064 series development kit with a built-in programmer which supports external targets as well.

- The MACH64 is a powerful educational kit that teaches CPLD technology and programming from the ground up — applicable to any CPLD.

The MACH64 kit comes complete with everything you need to learn, experiment, design and program with CPLDs. The included 250+ page manual starts off with the technology of CPLDs and then eases you into the ABEL language used to program CPLDs. The numerous challenging hands-on projects include: basic logic gates, counters, state machines, ALU design, audio generation, NTSC and VGA video generation and much more. Everything you need to build all the labs is included in the kit along with extra parts for your own creations. Resistors, capacitors, LEDs, transistors, diodes, and more!

Package includes
- MACH64 development board
- Built-in programmer
- 250+ page hard copy user manual
- 9 V @ 300 mA, 2.1 mm, DC wall adapter
- DB25 parallel port programming cable
- External CPLD programming cable
- A/V cable
- Solderless breadboard
- 40 hookup wires (20 long, 20 short)

- Over 75 passive components
- 1.0 MHz, 3.58 MHz, 25.175 MHz oscillators
- Windows CD-ROM with software & tools
- Over 20 step by step tutorials

System requirements: Windows PC

with parallel port. NTSC TV monitor for NTSC labs. VGA monitor for VGA labs.

Nurve Networks LLC,
www.xgamestation.com

(080485-I)
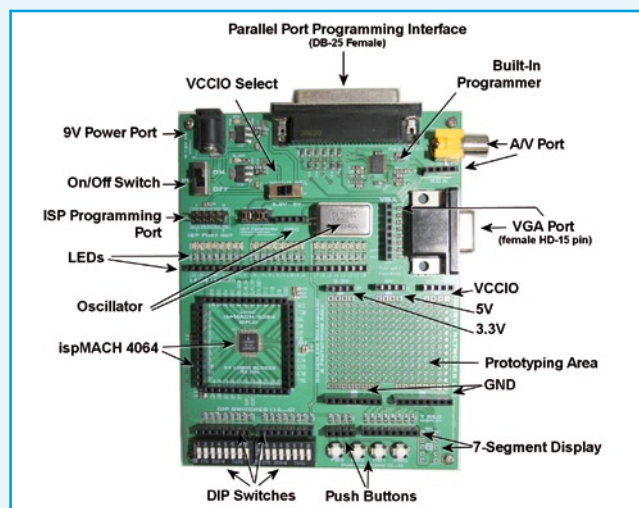
More analogue 3-axis accelerometers from Freescale

Accelerometers are becoming mainstream technology for consumer applications that require low power consumption and advanced motion sensing within a small form factor. Freescale Semiconductor has expanded its low-g triple-axis analogue accelerometer product family to address this rapidly emerging trend in consumer electronics.

The MMA7361L, MMA7368L, MMA7341L and MMA7331L triple-axis analogue accelerometers have tailored features designed to enable motion sensing in mobile phones, hard disk drives, media players, games and toys.

The MMA73xxL XYZ-axis analogue accelerometers provide a self-test diagnostic feature that verifies the accelerometer is in working order at any time before or after it is implemented in design. All four de-

vices are extremely flexible with a selectable 1.5 – 12 g range to tackle various sensing functions, such as fall, tilt, motion, positioning, shock and vibration for multifunctional applications.

Consumer designers will find the MMA73xxL accelerometers ideal for use in cell phones and portable media devices to provide functions such as tilt scrolling, gaming control, tap to mute and freefall hard disk drive protection.

In addition to enabling mobile platforms, the MMA73xxL devices also can be used in consumer applications that require wireless sensing, such as enabling remote control LED lighting for home and industrial automation.

www.freescale.com

(080452-VIII)

Open-air metal alloy resistors are flameproof

Providing design engineers with a robust current sense device for thermal conditions, IRC's OAR-TP series open-air sense resistors are ideal for use in high reliability servers, lithium ion battery packs and open-frame power supplies.

The resistors are constructed with a flameproof heavy gauge metal alloy, welded nodes and copper leads, and the long form factor dissipates heat at the solder joints.

The OAR-TP Series resistors are also suitable for surge and pulse, feedback and low inductance applications.

The OAR-TP Series open air sense resistors feature power ratings of 1 W, 3 W and 5 W, with TCRs to ±20 ppm/°C and tolerance to ±1% and ±5%. Inductance values are typically less than 10 nH.

http://www.irctt.com/

(080452-VI)
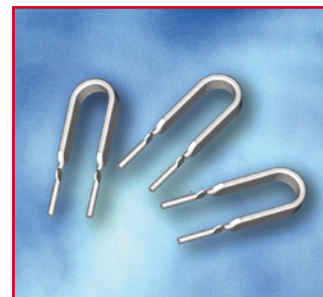
New Cypress PSoC(r) enables motor control and other applications

Cypress Semiconductor Corp. supplies a new PSoC(r) mixed-signal array with an enhanced analogue-to-digital converter (ADC) for fast analogue sampling and expanded 8 k Flash memory capacity for complex algorithm processing. The CY8C23x33, the newest member of Cypress's flagship PSoC family, targets applications with rich feature and software content, ranging from motor control, to camera image engines, to powerline communications (PLC) and more.

The new CY8C23x33 device features an 8-bit successive-approximation (SAR) ADC to allow a high sampling rate of 375 Ksps. It offers 26 GPIOs to deliver a premium level of configurability to quickly adapt to changes in feature requirements. The device is available in a 5x5 mm QFN package to minimize board space.
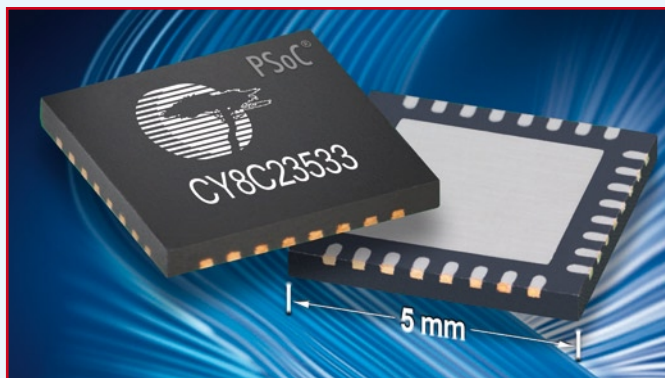
The CY8C23x33 PSoC devices feature four digital blocks, including two basic and two communication blocks, and four analogue blocks, including two continuous time and two switched capacitor blocks. One of the device's digital blocks is a dedicated hardware I^{2}C block that enables fast and easy programmability to reduce design time.

www.cypress.com/psoc
www.cypress.com/psoctraining

(080485-II)

Summer Circuits 2008 contributors rewarded!

For the second year round, all free-lance contributors that made it into Elektor's Summer Circuits edition receive a present alongside payment, some paperwork (sorry for that!) and eternal fame in electronics land.

This year we've Freescale Flexis™ JM USB Microcontroller Family development kits to send to those who responded successfully to our call for contributions published over the period February through April 2008, on our websites and in the magazine. We're grateful to Freescale Semiconductor for supplying the kits.

Congratulations everyone and keep sending us Summer Circuits items — the 2009 edition is waiting to be filled!
Jan Buiting, Editor

(080452-VII)

Flowcode for ARM is here

Matrix Multimedia have recently launched a new version of their popular graphical programming language for microcontrollers – Flowcode for ARM microcontrollers. 32 bit ARM microcontrollers are now available for the same price as 8-bit micros but offer massive advantages to developers: low power, more I/O lines, several times more ROM and RAM than a typical 8 bit micro, full floating point and maths libraries and a massive increase in processing speed and power. This new version of Flowcode provides engineers and developers access to all of these features of the ARM based on Atmel's popular range of AT91 microcontroller range. Flowcode for ARM is also backwards compatible with Flowcode for PICmicro® microcontrollers and Flowcode for AVR® microcontrollers which provides an easy migration route to 32 bit power. ARM hardware development tools, based on the Matrix's E-blocks range, are also available. A fully functional demonstration version is available on the Matrix web site.

www.matrixmultimedia.com

(080452-IV)

In all mains-operated equipment certain important safety requirements must be met. The relevant standard for most sound equipment is Safety of Information Technology Equipment, including Electrical Business Equipment (European Harmonized British Standard BS EN 60950:1992). Electrical safety under this standard relates to protection from

• a hazardous voltage, that is, a voltage greater than 42.4 V peak or 60 V d.c.;
• a hazardous energy level, which is defined as a stored energy level of 20 Joules or more or an available continuous power level of 240 VA or more at a potential of 2 V or more;
• a single insulation fault which would cause a conductive part to become hazardous;
• the source of a hazardous voltage or energy level from primary power;
• secondary power (derived from internal circuitry which is supplied and isolated from any power source, including d.c.)

Protection against electric shock is achieved by two classes of equipment.

Class I equipment uses basic insulation ; its conductive parts, which may become hazardous if this insulation fails, must be connected to the supply protective earth.

Class II equipment uses double or reinforced insulation for use where there is no provision for supply protective earth (rare in electronics – mainly applicable to power tools).

The use of a a Class II insulated transformer is preferred, but note that when this is fitted in a Class I equipment, this does not, by itself, confer Class II status on the equipment.

Electrically conductive enclosures that are used to isolate and protect a hazardous supply voltage or energy level from user access must be protectively earthed regardless of whether the mains transformer is Class I or Class II.

Always keep the distance between mains-carrying parts and other parts as large as possible, but never less than required.

If at all possible, use an approved mains entry with integrated fuse holder and on/off switch. If this is not available, use a strain relief (Figure, note 2) on the mains cable at the point of entry. In this case, the mains fuse should be placed after the double-pole on/off switch unless it is a Touchproof® type or similar. Close to each and every fuse must be affixed a label stating the fuse rating and type.

The separate on/off switch (Figure, note 4), which is really a 'disconnect device', should be an approved double-pole type (to switch the phase and neutral conductors of a single-phase mains supply). In case of a three-phase supply, all phases and neutral (where used) must be switched simultaneously. A pluggable mains cable may be considered as a disconnect device. In an approved switch, the contact gap in the off position is not smaller than 3 mm.

The on/off switch must be fitted by as short a cable as possible to the mains entry point. All components in the primary transformer circuit, including a separate mains fuse and separate mains filtering components, must be placed in the switched section of the primary circuit. Placing them before the on/off switch will leave them at a hazardous voltage level when the equipment is switched off.

If the equipment uses an open-construction power supply which is not separately protected by an earthed metal screen or insulated enclosure or otherwise guarded, all the conductive parts of the enclosure must be protectively earthed using green/yellow wire (green with a narrow yellow stripe – do not use yellow wire with a green stripe). The earth wire must not be daisy-chained from one part of the enclosure to another. Each conductive part must be protectively earthed by direct and separate wiring to the primary earth point which should be as close as possible to the mains connector or mains cable entry. This ensures that removal of the protective earth from a conductive part does not also remove the protective earth from other conductive parts.

Pay particular attention to the metal spindles of switches and potentiometers: if touchable, these must be protectively earthed. Note, however, that such components fitted with metal spindles and/or levers constructed to the relevant British Standard fully meet all insulation requirements.

The temperature of touchable parts must not be so high as to cause injury or to create a fire risk.

Most risks can be eliminated by the use of correct fuses, a sufficiently firm construction, correct choice and use of insulating materials and adequate cooling through heat sinks and by extractor fans.

The equipment must be sturdy: repeatedly dropping it on to a hard surface from a height of 50 mm must not cause damage. Greater impacts must not loosen the mains transformer, electrolytic capacitors and other important components.

Do not use dubious or flammable materials that emit poisonous gases.

Shorten screws that come too close to other components.

Keep mains-carrying parts and wires well away from ventilation holes, so that an intruding screwdriver or inward falling metal object cannot touch such parts.

As soon as you open an equipment, there are many potential dangers. Most of these can be eliminated by disconnecting the equipment from the mains before the unit is opened. But, since testing requires that it is plugged in again, it is good practice (and safe) to fit a residual current device (RCD)*, rated at not more than 30 mA to the mains system (sometimes it is possible
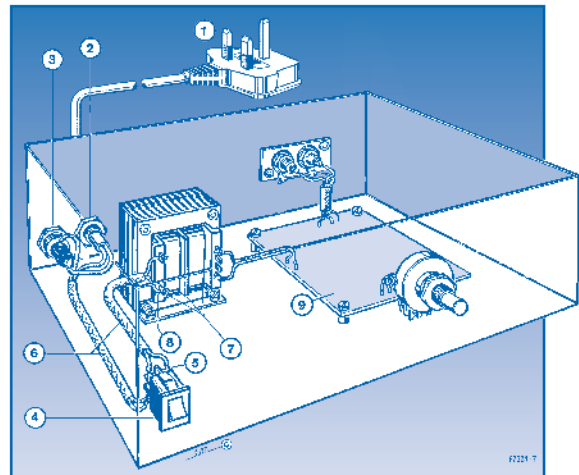
1. *Use a mains cable with moulded-on plug.*
2. *Use a strain relief on the mains cable.*
3. *Affix a label at the outside of the enclosure near the mains entry stating the equipment type, the mains voltage or voltage range, the frequency or frequency range, and the current drain or curent drain range.*
4. *Use an approved double-pole on/off switch, which is effectively the 'disconnect device'.*
5. *Push wires through eyelets before soldering them in place.*
6. *Use insulating sleeves for extra protection.*
7. *The distance between transformer terminals and core and other parts must be ≥6 mm.*
8. *Use the correct type, size and current-carrying capacity of cables and wires – see shaded table below.*
9. *A printed-circuit board like all other parts should be well secured. All joints and connections should be well made and soldered neatly so that they are mechanically and electrically sound. Never solder mains-carrying wires directly to the board: use solder tags. The use of crimp-on tags is also good practice.*
10. *Even when a Class II transformer is used, it remains the on/off switch whose function it is to isolate a hazardous voltage (i.e., mains input) from the primary circuit in the equipment. The primary-to-secondary isolation of the transformer does not and can not perform this function.*

to fit this inside the mains outlet box or multiple socket).

* Sometimes called residual current breaker – RCB – or residual circuit current breaker –RCCB.

These guidelines have been drawn up with great care by the editorial staff of this magazine. However, the publishers do not assume, and hereby disclaim, any liability for any loss or damage, direct or consequential, caused by errors or omissions in these guidelines, whether such errors or omissions result from negligence, accident or any other cause.

3-core mains cable to BS6500 1990 with three stranded conductors in thick PVC sheath

Max current	3 A	6 A	13 A
conductor size	16/0.2 mm	24/0.2 mm	40/0.2 mm
Nom cond area	0.5 mm^2	0.75 mm^2	1.25 mm^2
overall cable dia.	5.6 mm	6.9 mm	7.5 mm

Insulated hook-up wire to DEF61-12

Max current	1.4 A	3 A	6 A
Max working voltage	1000 V rms	1000 V rms	1000 V rms
PVC sheath thickness	0.3 mm	0.3 mm	0.45 mm
conductor size	7/0.2 mm	16/0.2 mm	24/0.2 mm
Nom cond area	0.22 mm^2	0.5 mm^2	0.95 mm^2
overall wire dia	1.2 mm	1.6 mm	2.05 mm

3-flat-pin mains plug to BS 1363A

Tracking Solar Panel

Manfred Schmidt-Labetzke

This small 12 V solar power source maintains its orientation towards the sun under control of a timer rather than the more usual light-sensitive arrangement. All the parts needed to build the project can be found in a well-stocked hardware shop or DIY store.

The axle is made from the core of a roller blind with two bearings. Suitable angle brackets are readily available to hold these bearings. The axis of rotation is set vertically, and the whole thing is directly driven by a battery-powered rotisserie motor. This motor already includes a gearbox to give a slow rotation and is capable of turning in either direction, and so one could hardly ask for a more perfect device for the job.

The upper end of the roller blind axle must be filed down to a suitable (generally square) cross section to allow it to be driven by the rotisserie motor.
Now to the electrical department to find a cheap electronic mains timeswitch. The

switch must be programmable for at least four on-off cycles per day. For the solar panel itself any 12 V solar charger designed for car, camping or boat use is ideal. It should be at most 0.25 m^2 in area as otherwise the force of the wind may be too great for the gears in the rotisserie motor's gearbox to withstand. The angle of inclination of the module is fixed, and depends on the latitude at which it is installed.

The mains portion of the timeswitch and the switching relay are not required and are removed. The remainder of the timeswitch will act as a clock which causes the axle to be rotated eight times during the course of each day: each on-to-off or off-to-on transition of the clock will advance the axle by 22.5 degrees from east to west via south. The angle through which the roller

080119 - 11
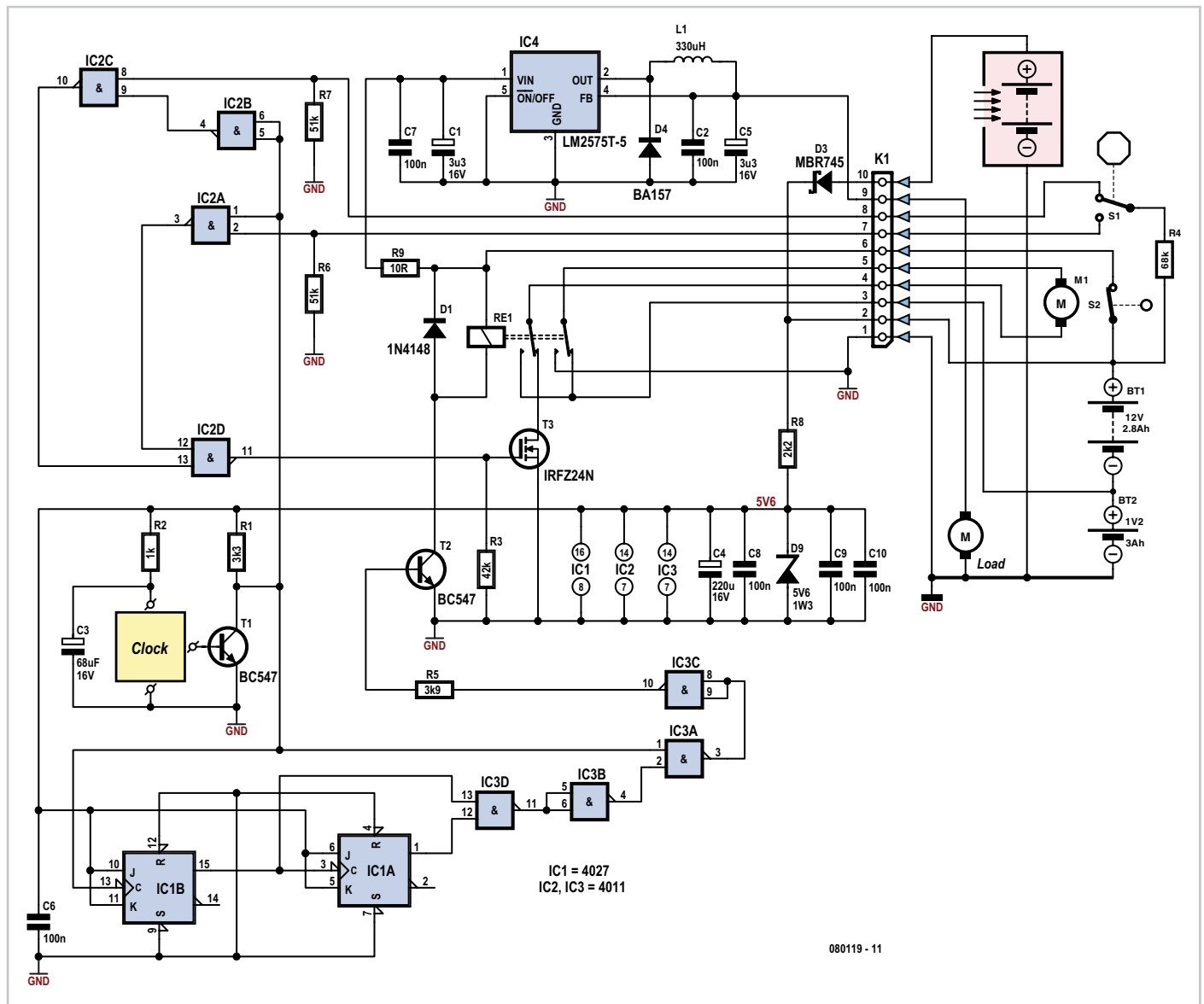
blind axle turns is defined by its octagonal shape: the corners operate a microswitch S1, which is fitted with an actuation lever. The position of the microswitch must be set carefully so that the switch is closed when the lever is pushed aside by a corner and open when between corners. Each time the timeswitch changes state IC2, a CMOS 4011 which contains four NAND gates, switches the drive motor on via p-channel MOSFET T3 for as long as necessary until the microswitch also changes state. Reasonable settings for the timeswitch have been found to be as follows: 7.30 am on; 9.00 am off; 10.30 am on; 12 noon off; 2.00 pm on; 4.00 pm off; 6.00 pm on; and 9.00 pm off.

After eight moves the solar panel has rotated through a total of 180 degrees and points directly west. Counter IC1, constructed from the two CMOS JK flip-flops in a 4027, detects the eighth clock pulse and turns on relay Re1 via IC3. This

in turn reverses the polarity of the power to the motor and the panel starts to turn back from west to east. When it reaches its original position facing due east limit microswitch S2, actuated directly by the solar panel, opens. The connected load is also switched on and off by S2, which is open during the night and closed during the day.

The author uses his solar panel to operate a small water pump. For this purpose the output of the panel is regulated to 5 V using a highly efficient switching regulator. Alternatively, 12 V lighting could be powered from the panel, with no need for the regulator.

Of course, both the control electronics and the timeswitch need to be housed in a waterproof enclosure. Energy storage to cover for the inevitable cloudy days can be provided by a 12 V battery comprising ten 2800 mAh AA-size NiMH cells in a suitable battery holder, which can be fit-

ted inside an ordinary electrical junction box. A 3000 mAh D cell is fitted in the battery compartment of the rotisserie motor, wired in series with the 12 V battery and also charged from the solar panel.

The motor and battery connections from the rotisserie motor are taken to the control circuit using a four-core cable. The rotisserie motor's switch is removed. Resistor and capacitor values shown in the circuit are not particularly critical, and other similar types can be substituted for T1, T2 and T3. A Schottky diode should be used for D3, which prevents current flow back into the solar panel, in order to minimise power losses. The 5 V regulator operates at around 250 kHz and so a high-speed switching diode is needed for D4. Using an ordinary 1N4007 considerably reduces the efficiency of the regulator and is therefore not a good idea. A small toroidal-core inductor is used for L1.

(080119-I)

Portable Thermometer

Joseph A. Zamnit

It's usually is a good idea to check the temperature before setting off for an outdoor activity. Equally important is a temperature check while at the actual place. The former is easy to do using the local TV or the Internet but once you are in the bush or the countryside such a task becomes more difficult. The small circuit described here solves the problem. It is very easy to use and consumes so little current that it will work for the battery's shelf life.

The circuit uses a standard LM35DZ sensor (IC3) whose analogue output voltage is buffered by an LM358 (IC2A). The voltage is read by the microcontroller and converted into a BCD value so it can appear on the multiplexed 7-segment displays. The display will switch off after approximately 30 s unless button S1 is pressed. In this way battery power is conserved. Pressing the button again will show the temperature. In the prototype two 0.56" (14.2 mm) common-cathode (CC) green displays were used to show the current value of the temperature. The meter can show temperatures between 0 and 100 ºC.

The first time it is used the meter has to be calibrated against a known reading. Preset P1 can be varied to change the value of the
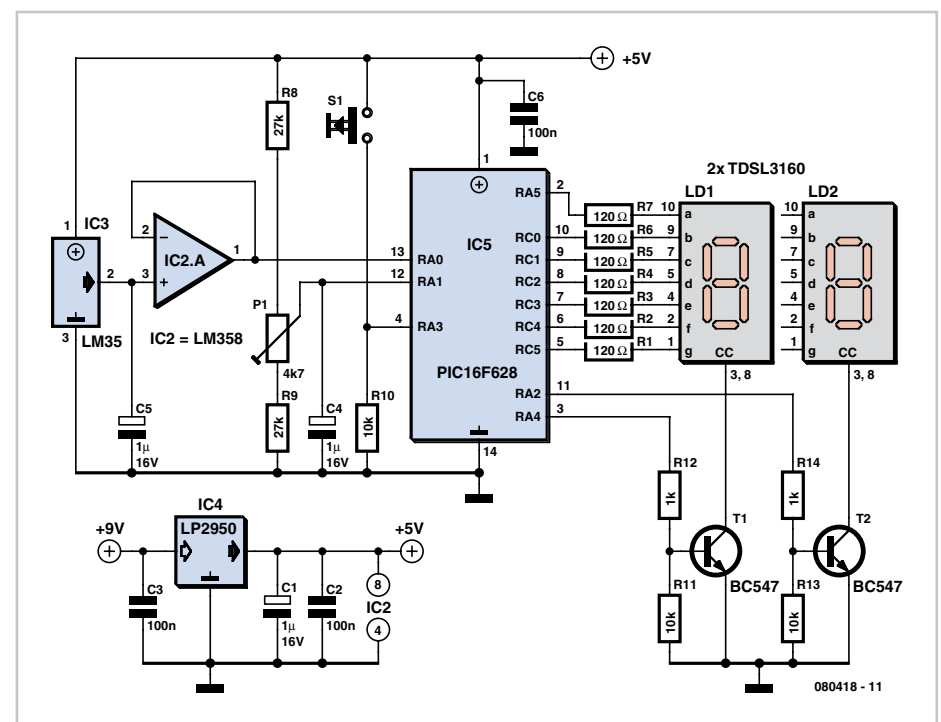
temperature by about 4 ºC. Press the button and then turn the preset until the correct value of the temperature is shown.

The microcontroller used is a PIC16F684. This has been chosen because it has a number of inbuilt functions and most

importantly an internal oscillator which obviates the need for an external crystal, freeing up pins for I/O activities.

Two 7-segment displays are connected in a multiplexed fashion. The displays are alternately switched on and off by the BC547

transistors. Each display is blanked before displaying the value to prevent ghosting. A temperature sample is read every 30 s to prevent the value displayed from changing due to fluctuations in the temperature. An LP2950 is used to regulate the supply volt-age to 5 V. This is a low dropout regulator which can work down to 6 V hence juicing the battery for the last drop of energy. The thermometer may also be run from three AA dry batteries in series with no series regulator.

The PIC software can be downloaded free of charge from the Elektor website. The archive file number is 080418-11.zip. The software was developed using CCS C.

(080418-I)

Multitasking Pins

Roland Plisch

It's entirely logical that low-cost miniature microcontrollers have fewer 'legs' than their bigger brothers and sisters – sometimes too few. The author has given some consideration to how to economise on pins, making them do the work of several. It occurred that one could exploit the high-impedance feature of a tri-state output. In this way the signal produced by the high-impedance state could be used for example as a CS signal of two ICs or else as a RD/WR signal.

All we need are two op-amps or comparators sharing a single operating voltage of 5 V and outputs capable of reaching full Low and High levels in 5-V operation (prefera-

080095 - 11
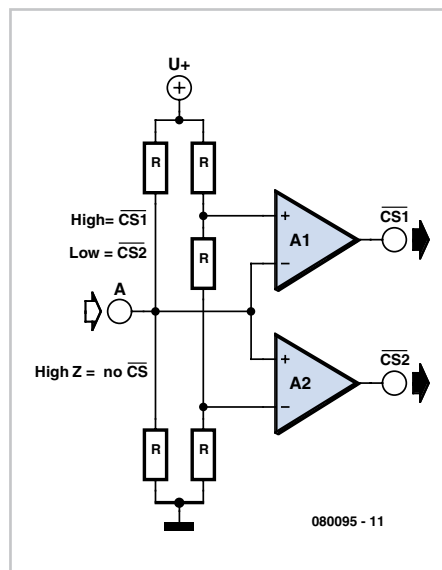
bly types with rail-to-rail outputs). Suitable examples to use are the LM393 or LM311. The resistances in the voltage dividers in this circuit are uniformly 10 kilohms.

Consequently input A lies at half the operating voltage (2.5 V), assuming nothing is connected to the input – or the microcontroller pin connected is at high impedance. The non-inverting input of IC1A lies at two-thirds and the inverting input of IC1B at one third of the operating voltage, so that in both cases the outputs are set at High state. If the microcontroller pin at input A becomes Low, the output of IC1B becomes Low and that of IC1A goes High. If A is High, everything is reversed.

(080095-I)

Environmentally-friendly Mosquito Repeller

B. Broussas

With the return of the fine weather, you'll doubtless be enjoying lazing around of an evening on your patio or in your garden, but even if you're not surrounded by marshes or other shallow water it's very likely some intruding mosquitoes will come along to spoil this idyllic scene.

Although indoors it's easy to get rid of them these days, indeed even to prevent them coming into the house, the same can't be said for the great outdoors. We might mention the well-known Chinese coils – the only thing Chinese about them is undoubtedly their name – which very often drive people away as much as mosquitoes, if not more! Moreover they are nasty things to handle. There are also UV (ultra-violet) 'electrocutors' consisting of a blue lamp surrounded

080230 - 11
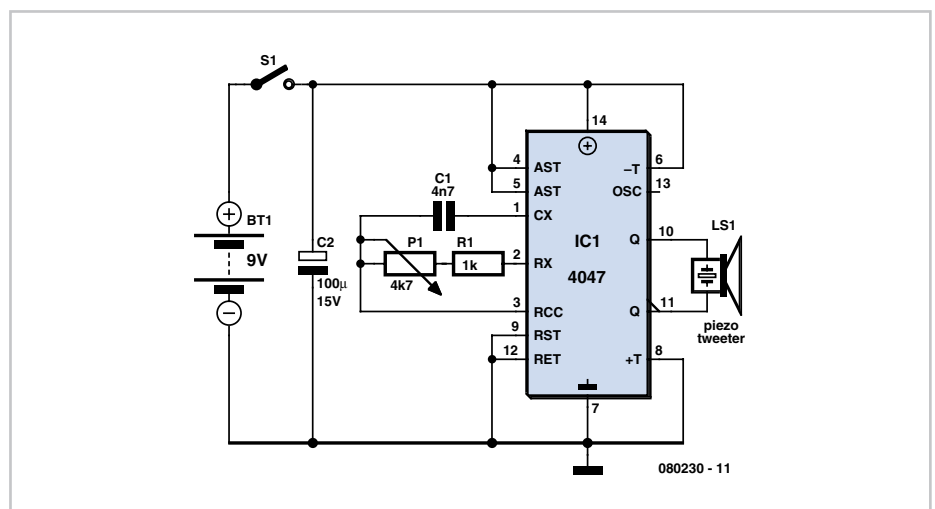
by two closely-spaced grilles between which a high voltage is applied. The mosquitoes (and flies and other flying insects) are supposedly attracted by the colour of the lamp and as they approach, get electrocuted in contact with the two grilles.

The only thing you have to do is pull out the drawer from time to time and get rid of the mass of dead insects.

Even though the effectiveness of these first two products remains questionable, it is less so than the one we're nonetheless going to describe here. We're talking about an ultrasonic mosquito repellent.

The principle, as described by its numerous promoters, is as follows. Only the female mosquitoes bite (that at least is an undisputed scientific fact) and they bite when they need to feed, and above all, to feed their eggs. In this situation, they seek to avoid the males whose 'job' has already been done, and so they fly away from the frequencies emitted by the males when they are on heat. This is where opinions now diverge. According to certain publications, the frequency emitted by the male mosquitoes is said to be around 20–25 kHz, and so within the realm of ultrasound. But according to others, it is in the region of 5–7 kHz instead; frequencies that a human ear, even

an elderly one, can still hear very well. Rather than spending lots of money (of the order of tens of pounds) buying such a device, which moreover generally have a fixed frequency, we're suggesting building one yourself so that you can carry out your own research this summer, especially since the circuit proposed is very simple and cheap to build.

As the figure shows, it uses just a single IC, a CMOS type 4047. This very multi-purpose IC can be wired in very many operating modes, including that of the multivibrator or astable used here. The operating frequency is set by the external components C1, R1, and P1; the latter makes it possible to slightly adjust the frequency, given the uncertainty that exists over the most effective value…

To best reproduce the high frequencies produced by the generator, the output transducer used is a simple tweeter, but it must be a piezo one. Such a tweeter behaves in fact much like a capacitor, and

so doesn't overload the CMOS IC outputs that are incapable of supplying a substantial current, as everyone knows who's ever worked with 400 series CMOS logic.

To obtain an output signal of sufficient amplitude while being powered from a single 9 V battery, this tweeter is connected between the 4047's Q and Q̄ outputs, making it possible to apply complementary (antiphase) signals to the tweeter so it 'sees' an alternating voltage of double the supply voltage. In purely theoretical terms, this quadruples the output power available. In practice, it's better to regard it as tripling it, but the benefit achieved by doing it this way is nonetheless very real. All that remains is for you to place the project in the middle of the patio table or beside your lounger in order to get a taste of the calm of a summer's evening without mosquitoes bothering you acoustically or worse, biting. At any rate, that's what we wish for you…

(080230-I)

Dimmable LED Light

070963 - 11

Jean-Claude Feltes

As we all know, LEDs are dimmed by altering the current flowing through them, not the voltage. We achieve this effect in this circuit by using an AVR microcontroller (the

2313 from Atmel) operating in comparator mode (**Figure 1**).

The nominal value is preset on comparator input AC1 and compared with the voltage (proportional to the LED current) at AC2.

On power-up the microcontroller sets the gate of the MOSFET (connected to output B.4) to 0 so that it conducts; a linearly rising current then flows through the choke and LED. The voltage drop across the 0.1-Ω shunt resistor is proportional to

Listing

```
'SMPSU for Luxeon LED using PMOS
$regfile = "2313def.dat"
$crystal = 4000000

config pind.0 = output
DDRB = &B00010000        'B.4 =
   Output
ACSR = &B00000000        'Set up
   as a comparator
dim i as byte
Portb.4 = 1     'off

do
Portb.4 = 0     'Switch on
   inductance
do
loop until acsr.aco = 1
   ,When Imax reached -> Switch
   off
Portb.4 = 1
waitus 5
loop
```

this current. Once the nominal voltage is reached, the microcontroller switches off the MOSFET and waits a few milliseconds. During this time a linearly decaying current flows through the choke, LED, shunt and recovery diode. Then everything restarts and it happens all over again. The result is a direct current voltage with a triangular waveform overlaid. The Bascom program for the microcontroller (see Listing) is short and simple to understand. Source code and hexfile for the program can be downloaded free of charge at www.elektor.com.

In this circuit we use a 6-V lead-acid gel-cell battery for the power supply; although these are heavy, they are dependable and simple to charge. The 56-Ω resistor and zener diode act to limit and stabilise the microcontroller supply voltage, which is used also as a reference voltage for the voltage divider set with P1.

The LED chosen is a Luxeon LXHL-LW3C (nominal values: 3 watts, U_{LED} = 3.7 V, I_{LED} = 0.7 A). A 100-nF capacitor connected in parallel with the LED and shunt is wired direct to the PCB; this is to eliminate possible interference effects from cable capacity. The 100-µF electrolytic capacitor is vital to smooth the 6 V operating voltage, which would otherwise 'droop' or 'sag'. The choke should not saturate at maximum current but match the load of the current being carried. To avoid generating square-wave effects that could produce false current values, the shunt resistor used should be a carbon film type, not wirewound.

The lamp, used for speleology (cave exploration), has operated very reliably over a lengthy period and is more economical in battery use than a halogen lamp. One problem arose in use when the LED got (far) too hot. It appeared that the current cut-off value was not being observed, due possibly to microcontroller failure or a dirty (or faulty) trimpot. If the latter's wiper loses contact with the carbon track the comparator input becomes open-circuit and can become any old value (as then does the LED current). Installing a watchdog timer could help (to restart the microcontroller promptly), also a pulldown resistor from the comparator input to ground.

(070963-I)

Solar-powered Automatic Lighting

C. Tavernier

You're doubtless familiar with the little solar-powered automatic lighting units found in DIY stores each year as summer approaches, sold in packs at ridiculously cheap prices. They certainly work, but their electronics and most of all their housings, manufactured for extreme cheapness, have a life expectancy that's proportional to the purchase price…

Our project here adopts a slightly different approach. It's intended for use in conjunction with existing or still-to-be-built garden lighting systems, which in particular may be more powerful than the cheapo stuff mentioned above. The project described here cannot operate alone, but must be used in conjunction with the 'Solar-powered Battery Charger' project described elsewhere in this issue. This charger has a connector already provided to interface directly with the garden lighting systems described here.

So the charger handles the 'intelligent' charging of the battery by the solar panels, while the circuit shown here takes care of the control of the lighting part. Naturally, it includes a photocell, in the form of an LDR (light dependent resistor), to measure the ambient light and, to avoid wasting the precious energy stored in the batteries, a presence detector so as to only light up when there is a need. Furthermore, the detector

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has a time delay, which makes the lighting unit very convenient in practice.

Given that it has to be used in conjunction with the solar-powered battery charger, the circuit is obviously very simple, as you can see from the schematic diagram. It uses just a single IC, a Microchip type 12C671 PIC microcontroller – i.e. the same type used in the charger, to make your buying easier.

Let's remember that this IC includes an analogue-digital convertor with several inputs, which is obviously going to be put to good use here. It's powered from the stabilized 5 V supplied by the charger, via pins 3 and 4 of

the connector provided for this purpose. Take a look for a moment at the charger circuit and note that, when it is used in conjunction with the automatic lighting system, the jumper between pins 1 and 2 of its connector has to be removed. This allows relay Re2 in the charger to be driven by our automatic lighting system, instead of directly by the charger itself. So, the load fed by the automatic charger here comprises the lamps or other lighting devices to be controlled. However, the excessive battery discharge protection is retained, as this information, from output GP4 of the charger's 12C671, is fed to input GP4 of IC1 via pin 2 of the connector.

This same input also receives override (optional) switch S1, which makes it possible to force the lighting off. Input GP3 also receives a switch making it possible to force the lighting on all the time, for example, when you want to admire or show off your garden at night, by overriding the presence detector circuit.

The latter employs a ready-to-use off-the shelf module, since these days it's no longer worthwhile nor sensible to build such a unit from scratch. It's powered at 5 V and provides a logic high output when a presence is detected, which is connected to input GP3. Watch out! Different modules of this type currently on the market exist with various supply voltages and generating high or low levels during detection. One module suitable for this application is available for example under reference PI8377 from Lextronic (www.lextronic.fr) where the author got it from. Some judicious online shopping may be in order to find a local equivalent

The ambient light level is measured using an LDR connected to analogue input AN2, while adjustable potentiometers are connected to both inputs AN1 and AN0. Preset P2 allows adjustment of the day/night threshold according to the characteristics and positioning of the LDR used, while P1 allows adjustment of the duration of the lighting following presence detection, from a few seconds to around ten minutes or so.
The program for the 12C671 PIC is of course available for free download from the Elektor website or from the author's own website: www.tavernier-c.com. The project

works immediately and only requires correct setting of P1 and P2 as indicated above.

Finally, it should be noted that that before it can be used with the automatic charger described elsewhere in this Summer Circuits issue, the charger must first be adjusted on its own, as described in the relevant article. In other words, do not connect up the two projects as you will be struggling with an equation with at least two variables that may interact in unexpected ways.

(www.tavernier-c.com) (080228-I)

Fog Lamp Sensor

Harrie Dogge

For several years now, a rear fog lamp has been mandatory for trailers and caravans in order to improve visibility under foggy conditions.

When this fog lamp is switched on, the fog lamp of the pulling vehicle must be switched off to avoid irritating reflections. For this purpose, a mechanical switch is now built into the 13-way female connector in order to switch off the fog lamp of the pulling vehicle and switch on the fog lamp of the trailer or caravan.

For anyone who uses a 7-way connector, this switching can also be implemented electronically with the aid of the circuit illustrated here.

Here a type P521 optocoupler detects whether the fog lamp of the caravan or trailer is connected. If the fog lamp is switched on in the car, a current
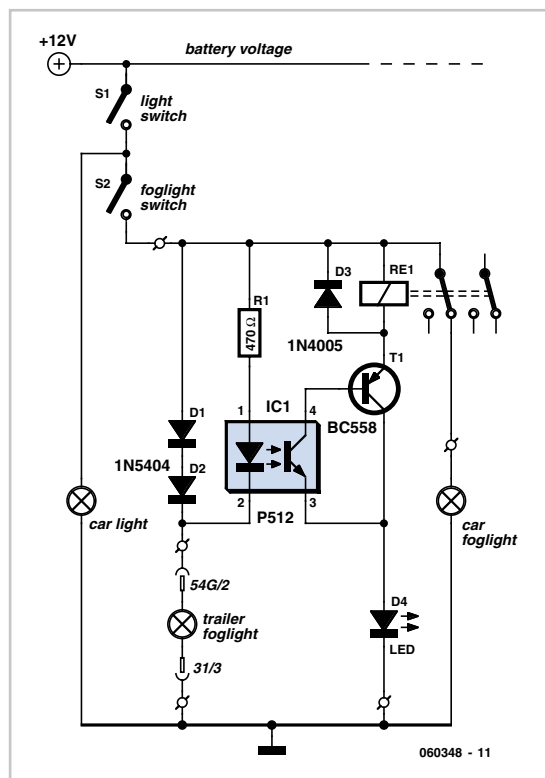
flows through the caravan fog lamp via diodes D1 and D2. This causes the LED in the optocoupler to light up, with the result that the phototransistor conducts and energises the relay via transistor T1. The relay switches off the fog lamp of the car.

For anyone who's not all thumbs, this small circuit can easily be built on a small piece of perforated circuit board and then fitted somewhere close to the rear lamp fitting of the pulling vehicle.

(060384-1)

Battery Discharge Meter

Christian Wendt

Men like their hobbies. The author is a particular fan of fishing, and like many anglers is the proud owner of not only a fishing rod, but also a boat: and this is where the electronics comes in. The author's boat has an electric outboard motor, and with his mind wrapped up in his sport it can easily happen that the battery is allowed to run down, leaving the not very enticing prospect of a long paddle home. Simple approaches, such as computing the optimal point to stop and turn round, are not really satisfactory, as angling involves the boat making a relatively large number of short hops. The author therefore decided to go back to first principles and find an electronic solution.

Energy measurement

In order to estimate and show the energy stored in the battery we need an LCD panel, a microcontroller and suitable sensors. In theory we need to measure time (easy enough) and voltage (also easy) as well as current. Energy dissipated in measurement should be minimised (trickier). The product of the three measured values gives electrical energy.
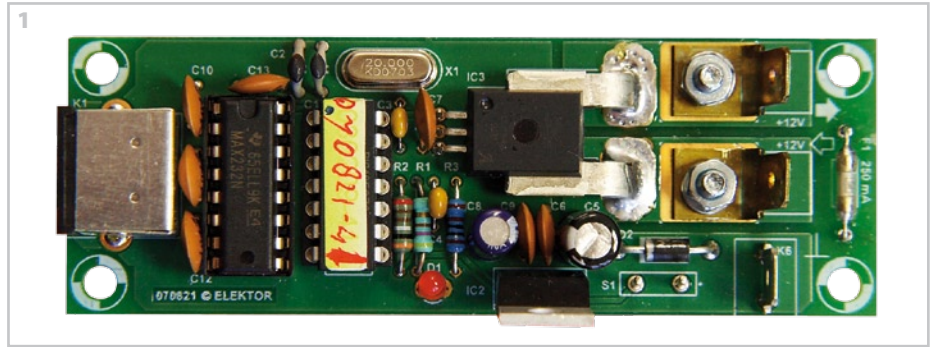
Time measurement is straightforward on a microcontroller. Modern devices have an integrated analogue-to-digital converter which is accurate enough for measuring the battery voltage. It is harder to measure current as the current drawn by the outboard motor is large and it is difficult to avoid dissipating a few percent of the
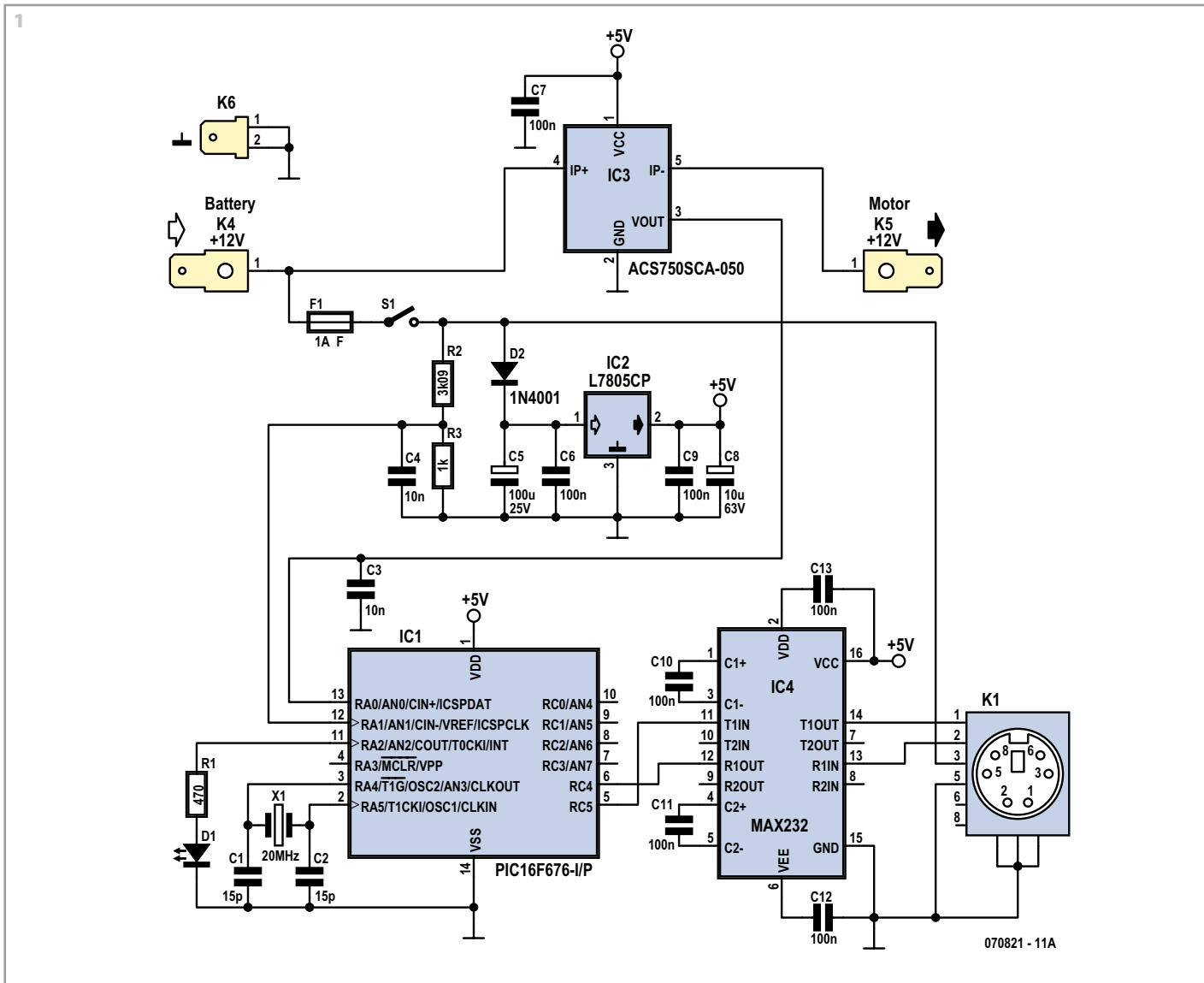
power delivered by the battery in heating up the shunt resistor.

Fortunately there are current sensors available for just this kind of application. The ACS750 [1] is essentially a thick piece of wire with accompanying Hall-effect sensor and conditioning circuitry. The series resistance is 130 µΩ and so the voltage dropped across the sensor is very small. The IC requires a 5 V supply and in the quiescent state (no current flow) has an output voltage of 2.5 V. When a current flows this voltage will rise or fall, depending on the direction of flow. The version used here, the ACS750SCA-050, is linear from –50 A to +50 A with a transfer characteristic of 1 V per 25 A, ideal for feeding into the analogue-to-digital converter in the microcontroller.

In this application voltage measurement is not so critical. The voltage should be monitored in case a fault (such as a bad connection) causes it to drop rapidly. Typically, however, the voltage remains fairly constant and it is adequate to dis-

play the charge used in amp-hours (Ah), the unit normally used to express battery capacity.

The capacity of the battery is best determined experimentally: charge the battery, do a few laps of a lake until the battery is completely flat, and let the circuit tell you the capacity in Ah. Make a note of this value. It would be possible to extend the meter to allow the battery capacity to be entered, in order to provide a 'petrol gauge' display calibrated in percent.

The circuit's 'user interface' consists of a single button which is used (among other things) to reset the Ah counter. If the button is held down when the meter is turned on the counter will be reset to zero; if the button is not held down when the meter is turned on, it will start from the most recent stored value.

Circuit(s)
In the interests of reliable operation the circuit of the battery meter is divided into two parts. The normal arrangement is that

the battery and motor are at the stern of the boat, while the captain is looking forward. A couple of meters of cable are therefore required between the two parts. Data transfer between the two parts of the circuit must be resilient to noise (even that generated by electric eels!).

The author decided to use a microcontroller both in the measurement part of the circuit and in the display part, with an RS-232 serial link between the two. Conversion to standard voltage levels is done using a MAX232 at each end, as shown in the combined circuit diagram (**Figure 1**).

On the sensor side of the system a PIC16F676 is used. It has analogue inputs with a resolution of 10 bits, which, taking into account the effect of the voltage divider formed by R2 and R3, gives a resolution of 20 mV for the battery voltage measurement. LED D1 is an under-voltage alarm, lighting when the battery voltage falls below 10.6 V. RA0 of IC1 is connected directly to the output of current
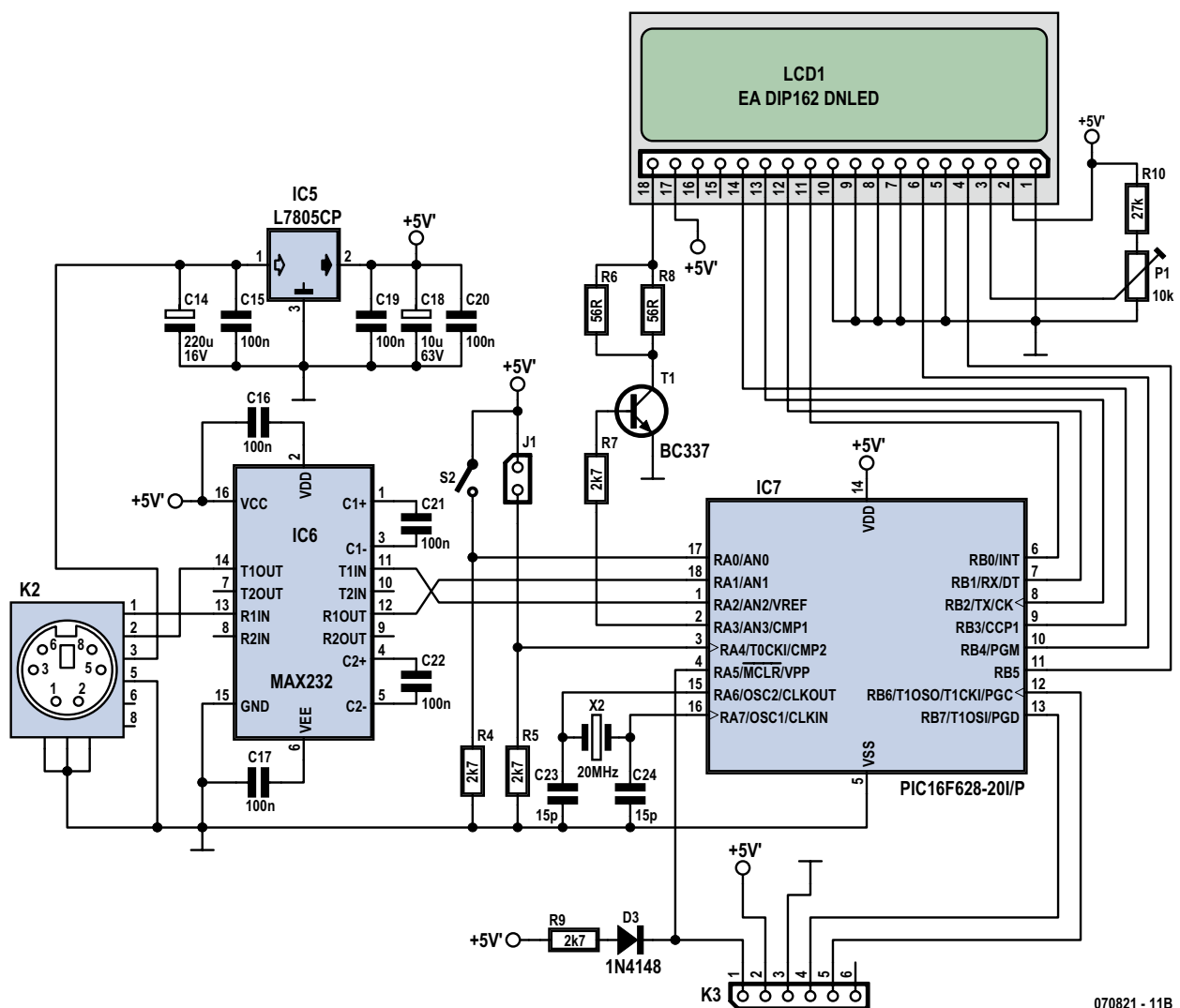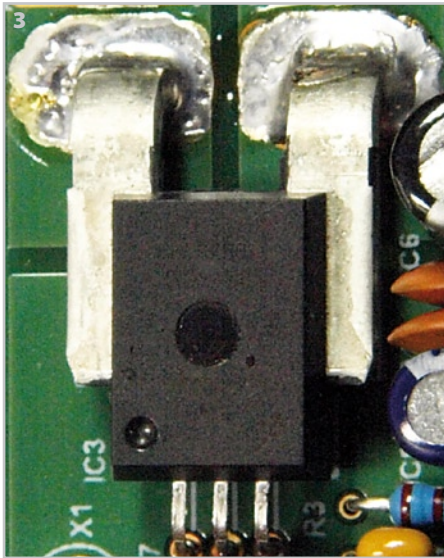
sensor IC2, giving a current resolution of approximately 125 mA. The measurement results then flow out of the serial port and via the MAX232 over the RS-232 link to the display.

A PIC16F628 drives the display, polls push-button S2 and jumper J1, and receives serial data from the measurement unit. Contrast is adjusted using P1, and T1 switches the backlight on and off. With the suggested values for R6 and R8 the backlight current in the prototype was 38 mA. If more bright-ness is required, lower resistor values can be used as long as the maximum rating for the display (150 mA) is not exceeded.

Each part of the circuit has its own regu-lated 5 V supply to improve overall reliabil-ity. The current consumption of the sensor part is approximately 20 mA, and the dis-play part draws approximately 17 mA with the backlight off.

Circuit board

A printed circuit board has been designed for each half of the circuit, making two small modules that can be connected together using a cable. The only unusual component on the sensor module (**Fig-ure 3**) is the current sensor. The copper tracks that run to it are wide and the tags are fixed to the board with assistance from plenty of solder tinning. Other slightly unu-sual sights are the miniature fuse with sol-der connections to the right and the six-pin PCB-mount mini-DIN socket to the left. This socket allows ready-made six-way cables to be used, and the miniature plugs also are conveniently able to pass through small holes. Cables with four-way plugs will of course not fit in six-way sockets.

If you wish to use a different sort of con-nector, then you should of course dispense with the mini-DIN sockets. The important thing is to ensure that the 12 V supply is

provided on the cable along with ground and the RxD and TxD signals.

The LCD panel is fitted directly to the sol-der side of the display module circuit board (see **Figure 4**). It is therefore best to leave soldering the display until last.

Pin 1 of the display is marked 'LCD1' on the component side of the circuit board. As long as care is taken to observe this, noth-ing should go wrong with mounting the display.

It is well worth fitting the two microcon-

trollers in sockets in case you should want to alter the program at a later date. The dis-play board is equipped with a six-way con-nector K3 to allow in-circuit programming of the microcontroller.

The software for each processor is as always available as source code (for Microchip's MPLAB) and as object code for free down-load from the Elektor website [2].

Operation

When the unit is switched on using S1 the

COMPONENTS LIST

Sensor module

Resistors
R1 = 470Ω
R2 = 3kΩ09
R43 = 1kΩ

Capacitors
C1,C2 = 15pF ceramic, lead pitch 5mm
C3,C4 = 10nF ceramic, lead pitch 5mm
C5 = 100µF 25V radial, diameter 6.3mm
C6,C7, C10-C13 = 100nF ceramic, lead pitch 5mm
C8 = 10µF 25V, radial, lead pitch 2.5mm
C9 = 100nF ceramic, lead pitch 5mm

Semiconductors
D1 = LED, red
D2 = 1N4001
IC1 = PIC16F676-20I/P, programmed, Elektor SHOP # 070821-41
IC2 = 7805
IC3 = ACS750SCA-050
IC4 = MAX232 (DIP16)

Miscellaneous
K1 = 6-way mini-DIN socket, PCB mount
K4,K5,K6 = spade terminal
2 M3 screws and nuts
F1 = miniature fuse, 1A, fast, for solder mounting
S1 = on/off switch
Mini DIN cable with moulded 6-way plugs for connection of module
X1 = 20MHz quartz crystal, parallel resonance
PCB, ref. 070821-1, from www.thepcbshop.com

Display module

Resistors
R4,R5,R7,R9 = 2kΩ7
R6,R8 = 56Ω
R10 = 27kΩ
P1 = 10kΩ preset

Capacitors
C14 = 220µF 16V radial, lead pitch 2.5mm, diameter 6.3mm
C15,C16,C17,C19-C22 = 100nF ceramic, lead pitch 5mm
C18 = 10µF 25V radial, lead pitch 2.5mm
C23,C24 = 15pF ceramic, lead pitch 5mm

Semiconductors
D3 = 1N4148
T1 = BC337
IC5 = 7805
IC6 = MAX232 (DIP16)
IC7 = PIC16F628-20/P, programmed, Elektor SHOP # 070821-42

Miscellaneous
J1 = 2-way pinheader and jumper
S2 = pushbutton
K2 = 6-way mini-DIN socket, PCB mount
K3 = 6-way pinheader, lead pitch 2.54mm
LCD1 = LCD, 2x16 characters, e.g. EA DIP162 DNLED
X2 = 20MHz quartz crystal, parallel resonance
PCB, ref. 070821-2, from www.thepcbshop.com

display will briefly show:

Accu Control
WEN May 07

and then subsequently:

for reset press
switch... 7

whereupon a seven-second countdown will start.
The current state of the battery will then be displayed: its terminal voltage, instantaneous current, and the remaining battery charge.

If jumper J1 is fitted the zero point of the current sensor can be calibrated by up to ±10 units in the least significant digit. Every ten seconds the remaining charge value is stored in the EEPROM of the display microcontroller. The display backlight is only enabled while the motor is running or by a brief press of the button. In his prototype the author used a waterproof 'vandal resistant' pushbutton.

Something fishy
No angler is properly equipped to go about his hobby without special glasses that include a polarisation filter to reduce the effect of light reflections from the water. As a result it is possible that the display can appear to be unstable and flickery: sometime legible, sometimes not. When he first saw this effect the author suspected a fault in the electronics or software and it was some time before he realised that the operation of LCDs depends on polarised light, and that the problem was right under (or rather over) his nose.

(070821-I)

Web Links
[1] http://www.allegromicro.co
m/en/Products/Part_Numbers/0750/

[2] http://www.elektor.com

Mysterious Self Charging

Peter Lay

Here we take a light-hearted, exploring yet purposely unscientific look at one of the fundamental effects of physics, namely contact voltage. When two dissimilar materials come into contact an exchange of (negatively charged) electrons occurs so that the donor material losing electrons takes on a net positive charge while the material receiving electrons takes on a negative charge, the overall effect giving rise to a contact potential. This effect occurs to a greater of lesser extent in all materials, the most common examples are the production of static electricity produced by rubbing two different materials together and also the thermo-voltaic effect. So much for the theory, now to practice...

To take what at first sight may seem like a mistaken example of this phenomenon we will need a discharged capacitor and a DVM (digital voltmeter) with a high input impedance. Connect the capacitor terminals to the DVM and short together the capacitor terminals using a length of wire and two crocodile clips. If all is in order the DVM display will read 0 (zero) volts. Now remove the short circuit and closely watch the DVM display as the voltage, microvolt by microvolt slowly rises. The capacitor is gaining charge from somewhere…

This effect is the result of the contact voltage (see diagram). In the capacitor there are two boundaries: (1) the metal electrode and the dielectric and (2) the dielectric and second electrode. At both boundaries free
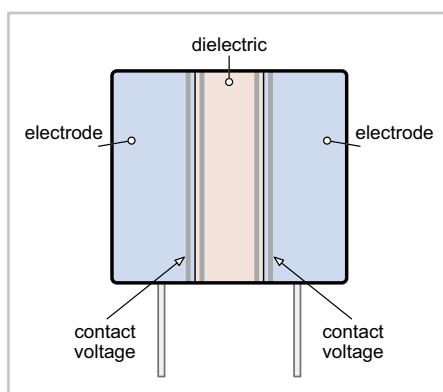
electrons pass from one material to the other. The two contact voltage sources are connected back to back in series which should cancel out the contact potential. So much for theory, in practice the boundary structure is not entirely homogeneous so that tiny potential differences are present. This produces the small potential difference that we can measure at the terminals.

Aluminium electrolytic capacitors are a little more complex; one terminal is connected to aluminium foil which has an insulating oxide layer; next comes a layer of liquid electrolyte and finally another aluminium foil connected to the other terminal. This structure gives rise to three potential boundaries. In addition, when the capacitor is charged, free electrons from the terminal electrode store energy by producing electrochemical reactions within the electrolyte (a process known as dielectric absorption or 'soakage'). These effects are more pronounced in electrolytics compared to other types of capacitor.

Experimental results indicate that the measured voltage is higher with larger value capacitors. It has also been shown that the voltage exhibits a temperature coefficient; the higher the temperature, the greater the measured voltage.

To explore this characteristic further, a capacitor was carefully heated in a controlled manner. It is important not to use a naked flame or microwave oven; not just to prevent the possible melting or combustion of the external plastic casing, but more importantly to guard against the possible production and release of poisonous fumes. Once an electrolytic capacitor has been heated up in this way it will be irreversibly damaged so that it will no longer be suitable for use in a circuit. Having said that, sometimes it's necessary to sacrifice a few capacitors for the sake of experimentation.

Measurement with a DVM (R_i = 1 MΩ) of a radially leaded electrolytic capacitor with a rated capacitance of 100 μF gave a terminal voltage of 5 mV at 20 °C. At a temperature of 120 °C the potential had risen to 230 mV and the short circuit current was 0.5 μA. More precise measurements of the capacitor indicated that the voltage source had a source impedance of 852 kΩ and a source voltage of 426 mV. As a first approximation we can say that the correspondence between the terminal voltage and temperature is approximately linear. Using the measurements from the example above we therefore get a temperature coefficient of 2.25 mV/K.

Tests with other capacitors have produced a no-load terminal voltage of over 0.9 V. Several capacitors could be connected in series, not as a potential power source but as a sensor.

Two final notes:
1. The term 'no-load voltage' ignores the 1 MΩ input impedance of the voltmeter, which in series with the 852 kΩ source impedance loads the measured potential.

2. All of the measurements were made using discharged capacitors with no external voltage source.

(071153-I)

LED Tester

Henry Schouwstra

This simple LED tester consists of a current source with a potentiometer that can be used to adjust the current. The current source is implemented using a type TL081 opamp.

The output current of the opamp flows through the diode and R2. The voltage drop across R2 is fed back to the inverting input and compared with the reference voltage, which is set with R1 and applied to the non-inverting input. The adjustment range is approximately 0–30 mA, which is suitable for testing all normal
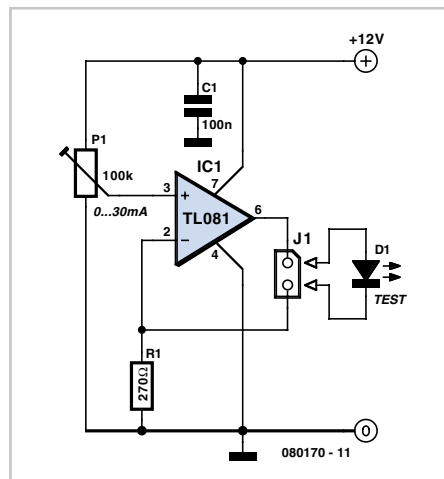
LEDs. If you wish, you can connect a multimeter across the LED to measure the voltage on the LED.

For the power source, a good option is to use a small laboratory power supply with the output voltage set to 5 V.

It is convenient to fit the potentiometer with a scale so you can see directly how much current is flowing through the LED. In order to calibrate the scale, you can temporarily connect an ammeter in place of the LED.

(080170-1)

Wireless Audio Transmitter

C. Tavernier

Sitting peacefully under a tree at the bottom of your garden, or stretched out beside your swimming pool, you may feel like listening to your favourite music from your hifi. Rather than turning the volume up beyond reasonable limits and risking upsetting all your neighbours or attracting the wrong audience, we suggest building this little wireless audio transmitter/receiver combination. Using the UHF ISM (industrial, scientific, medical) band and quality FM (frequency modulation), it won't impair the sound quality and will let you listen nice and discreetly.

The transmitter uses a well-known module manufactured for some years now by Aurel as their 'FM audio transmitter'. It works in the licence-free 433.92 MHz band and so allows our project to operate completely legally as the transmitter is type-approved to quite strict technical specifications. Note however the frequency you're using is not
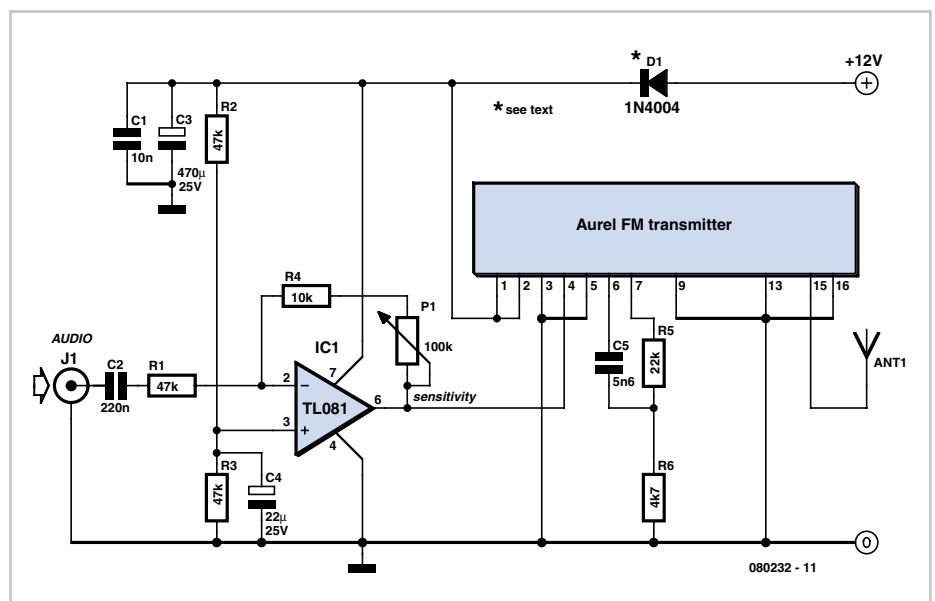
exclusive as it is shared by many other wireless devices such as headphones and key fobs for garage doors and so on. The equipment is low-power however and should

have a short range.

The Aurel module is a complete FM audio transmitter designed for powering from

12 V. The only external components required, R5, R6, and C5, form the pre-emphasis (high-boost) network specific to frequency modulation.

Used alone, this module offers a typical audio input sensitivity of 100 mV rms. So we are driving it from an opamp with gain adjustable between 0.5 and 5, extending the voltage range from 50 to 500 mV, to make it compatible with any audio device line output. Note in passing that, if you reduce resistor R1 to 2.2 kΩ, you can increase the sensitivity to 2.5 mV so that the transmitter could then be used as a UHF radio mic for use in shows and events, for example.

The power supply can be obtained from a 12 V battery or a 'plug-top' power supply; diode D1 protects the circuit from reversed polarity by.

The receiver is just as simple, since it uses the complementary module to the previous one, again from Aurel, and naturally called their 'FM audio receiver'.

This receiver has a squelch (FM noise silencing) adjustment, set by the voltage applied to pin 15. Potentiometer P1 connected to this makes it possible to adjust the squelch threshold so as to have a receiver that won't output noise in the absence of a signal, using the information provided on pin 18. This is High when a signal is present and Low when absent. Here it drives an 8-into-1 CMOS analogue multiplexer, of which only input 8 is used. This solution employs a very cheap, good-quality analogue switch that is easy to use.

Its output passing via the volume control P2 and is applied to the well-known small integrated power amplifier LM386. The transmitter's RF output power of a few hundred milliwatts is more than adequate for such an application, and its quality likewise, especially if you combine it with a loudspeaker worthy of the name, with
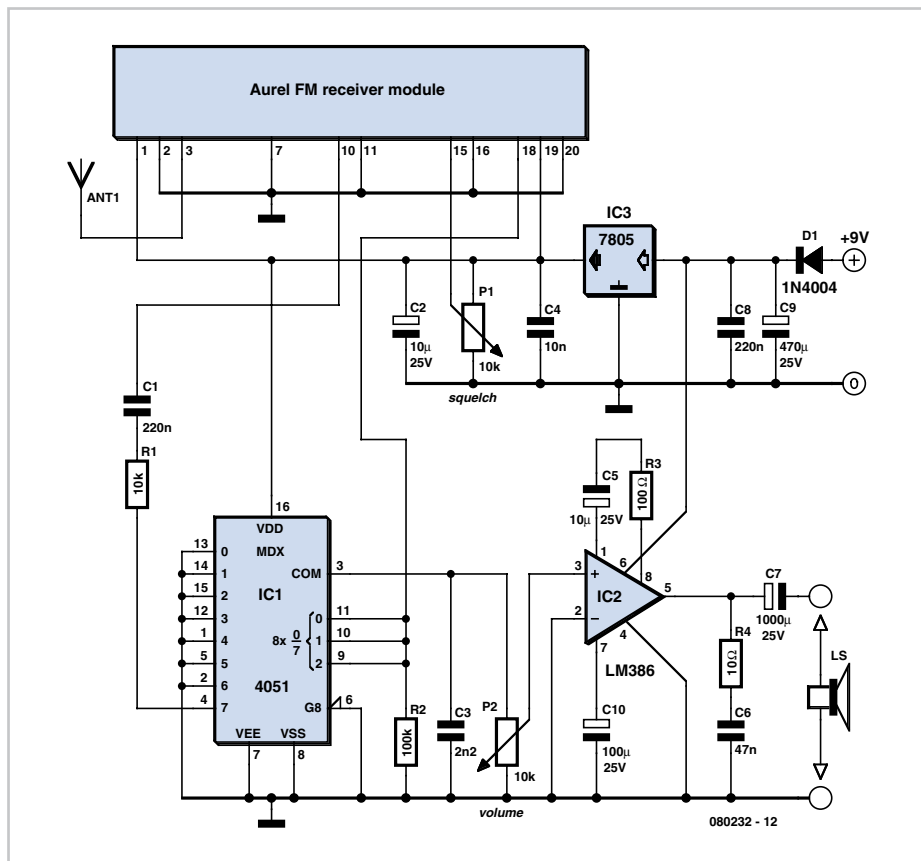
a pair of headphones as the next best alternative.

The Aurel receiver module and CMOS multiplexer both require a 5 V supply; this is stabilized by a standard 3-terminal regulator. The circuit as a whole is powered from 9 V, and is also protected against possible reverse polarity by diode D1.

Given the relatively high current consumption of the amplifier, especially if you use it for longer periods, rechargeable NiMH batteries will obviously be preferable to primary cells, which wouldn't last very long and will turn out rather expensive in the long term, as well as bad for the environment.

As far as the antennas are concerned, for both transmission and reception, simple quarter-wave whips ensure a range of a hundred metres or so – even more if line-of-sight. You can of course buy such antennas ready-made, but a simple piece of stiff wire around 17 cm long (i.e. a quarter wavelength at 433.92 MHz) will do the job just as well, and cost a lot less.

Equipped with these two modules you can make the most of your music wherever you like. Don't forget, though, that outdoors, the best music of all is that of birds, that is, the feathered variety.

(www.tavernier-c.com) (080232-I)

Gas Flow Meter

R. Pretzenbacher

The most surprising thing about this circuit is the sensor that it uses: a 4.5 V miniature torch bulb. The glass envelope is (carefully!) broken and then the pieces of glass removed, leaving just the filament intact. The filament forms the actual sensor element (see **Figure 1**).
As you can see from the circuit diagram in **Figure 2**, the bulb filament is supplied with

1
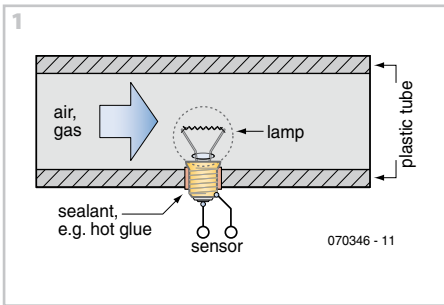
20 mA from a constant current source, with the result that the filament warms up. The current, which can be adjusted using P1, is a compromise between the sensitivity of the unit and its operating life. If the current is too high the filament will reach too high a temperature and sooner or later will burn out. The filament has a positive, although relatively small, temperature coefficient of resistance: the hotter the filament the greater its resistance and so the greater will be the voltage dropped across it at a given constant current.

If air (or another **non-flammable** gas) flows through the pipe in which the filament is mounted, the filament will be cooled and the voltage across it will fall. The greater the air flow the cooler the filament and so the lower the voltage. The relationship between flow rate and voltage is reasonably linear. An important use of this measurement technique is in the air intake of car engines, where an ordinary thin heated wire is used as the sensing element in place of the lamp filament.

Operational amplifier IC1.A is used to subtract the voltage drop across the coil from a voltage produced by the PICAXE microcontroller (IC3) via its PWM output on pin 5, filtered by the RC-network comprising R9 and C5. The second operational amplifier amplifies the residual signal as needed. The gain can be adjusted using P2.
The PICAXE08M from Revolution Education Ltd is a PIC microcontroller that can be pro-

grammed in BASIC (see www.picaxe.com). When power is applied the PICAXE automatically goes through the offset calibration procedure, which helps the unit achieve excellent sensitivity. Simultaneously the measured voltage is digitised within the PICAXE. The result of the flow rate measurement is made available both as an analogue voltage (pin 7 of IC1.B) and in digital form on the TTL-level RS-232 output K1. The BASIC program that runs in the PICAXE is available for free download from the Elektor website at http://www.elektor. com, look for file # 070346-11.zip.

The NE555 is present only to provide a small negative voltage of around –2 V for the LM358. This lets us use this low-cost operational amplifier in such a way that its output can swing down to 0 V. The NE555 inverter circuit allows the unit as a whole to be powered from a single 5 V supply.

Using this circuit the author has obtained a usable output signal from 0 V to 3.5 V when

measuring very gentle flows from 0 nl/h to only 120 nl/h. He used the circuit to check the operation of an industrial nitrogen (N_2) flow rate meter.

It must be admitted that a circuit as simple as the one described here has a few infelicities. The sensitivity of the unit is highly dependent on the filament used and on the current through the filament (although this is compensated for by the calibration that the PICAXE carries out). Also inconvenient is the strong dependency on the temperature of the gas whose flow rate is being measured. To compensate for this the gas flowing through the pipe must be heated to a defined temperature before being passed over the filament.

And we cannot emphasise strongly enough:

do not under any circumstances use this circuit with flammable gases!

(070346-I)

2

RFID Door Opener

Ralf Künstler

The RFID-based project described here employs a specially-programmed IC from the 'SFChip' (the 'SF' stands for 'Special Function') product family. The SF6107 [1] is an IC designed to work as an RFID receiver for tags that operate on a nominal frequency of 125 kHz. Tags (or, more properly, 'transponder cards') compatible with the EM4102 contain forty bits of data and are available for a pound or two each.

The support circuitry required for the SF6107 consists of just a couple of passive components, two transistors, a hand-wound coil and, if desired, a DC buzzer. As the circuit diagram shows, a complete door opener, capable of recognising a master RFID tag and learning the codes of up to twenty further tags, is not very complicated at all.

The IC drives the coil via pin 3 and T1. Together with C1, the coil forms a parallel resonant circuit. The cable linking the main electronics and the coil can be up to 80 cm long. If the coil is reasonably well adjusted, tags can be read at distances of up to about 3 cm.

The voltage across the coil is demodulated by D2 and then passes via C3 to pin 6 on the IC. An RFID tag in the vicinity of the coil absorbs energy from the field produced by the coil and uses it to subsequently transmit its stored ID code. The IC compares this code against the values it has registered in its memory. If there is a match, T2 is driven on, which in turn activates the relay and then the door lock electromagnet.

Simultaneously the IC emits the ID code of the recognised tag in serial format on pin 2. Alternatively, for audio feedback a piezo buzzer can be connected to this pin. The buzzer will sound whenever the card that is being held next to the coil is recognised. After the IC is reset (either when power is applied or by taking pin 1 briefly down to ground) the IC emits status information on pin 2. This consists of a list of the stored transponder ID codes preceded by their count. In the case of one master tag and two additional tags, the following might be output:

```
#T3
#R00:CC00154423
#R01:CC00154427
#R02:CC00154434
```

Each line is terminated by a 'CR' and an 'LF'. The first line gives the count of stored tag ID codes. There follow the individual ID codes, starting with the master tag. Each ID code consists of ten hexadecimal digits, making a total of 40 bits. The data transfer format is 9600 baud, 8 data bits, no parity and one stop bit. If a piezo buzzer has been connected to pin 2 it will emit a strange sound during any serial activity.

If, instead of the piezo buzzer, a 10 kΩ pull-down resistor is connected to pin 2, the signal output will be suitable for connecting directly to pin 2 of a 9-way sub-D socket, which can then be taken to a PC using an ordinary serial cable. If, on the other hand, the serial output is to be taken directly to a microcontroller without level-shifting, a 10 kΩ pull-up resistor should be connected A to pin 2. The IC checks which resistor is present at start-up and inverts its serial output if necessary.

Use the following procedure to erase all the stored ID codes prior to reprogramming:

1. Switch the unit off
2. Fit JP1 (this pulls pin 5 to ground)
3. Switch the unit on
4. Wait ten seconds
5. Switch the unit off
6. Remove JP1

Now a master tag (any RFID card) can be read and its ID stored. Hold the tag up to the coil. Then take it away and bring it up

a second time: if the relay is activated then this means that the card has been successfully programmed as the master and its ID code has been stored.

To program further tags into the unit it is necessary to switch it into programming mode. This is done by holding the master tag up to the coil for around one minute. There then follows a twenty-second time window during which further tags can be programmed. Programming mode can be reentered as above to store further tag IDs, up to a maximum of twenty (plus the master tag).

The circuit can be constructed using the printed circuit board shown, whose layout is available for download from the Elektor website. Current consumption with the relay off is around 16 mA.

If a more powerful relay is to be used, drawing more than 100 mA of coil current from the 5 V supply, a BC337 should be used for T1.

For optimum tag reading reliability and range the parallel resonant circuit consisting of the coil and capacitor should have as high a *Q* (quality) factor as possible. Coils made from 0.5 mm enamelled copper wire on a diameter of between 50 mm and 60 mm have given good results. These dimensions are not particularly critical, but it is important that the resonant frequency of the circuit is as close to the operating frequency of 125 kHz as possible.

In our prototype we measured the inductance of a 30-turn coil with a diameter of 55 mm at about 100 µH. It was possible to read RFID tags with values of C1 between about 47 nF and 14 nF, corresponding to resonant frequencies of 71 kHz to 133 kHz.

It is not necessary to have an oscilloscope to adjust the resonant frequency and *Q* factor. An ordinary digital voltmeter measuring the voltage across capacitor C4 (or at the cathode of D2) will do. Different values for C1 can be tried: the higher the measured voltage, the better. With the correct capacitance voltages of more than 8 V are possible.

After these measurements have been carried out and the tag IDs have been programmed into the unit, further tests can be carried out making small adjustments to C1 to obtain maximum reading range.

(071154-I)

Web Link

[1] SF6107 information (in German): http://www.sma-tronic.mine.nu/SF6107.htm

Bell Alarm

Patric 't Kindt

If you use a lamp with a motion sensor for outdoor lighting, the original electrical switch is actually no longer necessary. If you replace the switch with the circuit described here, an acoustical signal will be generated each time the outdoor lamp is switched on. It's thus somewhere between an alarm and a doorbell.

The operating principle is simple. A circuit that causes a voltage drop of only a couple of volts is connected in series with the lamp. As the circuit needs a DC voltage, the current for the lamp is passed through a bridge rectifier. The voltage drop across the circuit is determined by R1. The function of C1 is to smooth the raw DC voltage. Note that this is not an example of peak rectification, but instead of averaging. For this reason, the voltage on C1 is lower than you might expect. Ultimately, the DC voltage on C1 reaches the same value as the average voltage across R1.

For example, consider what happens with a 100-W lamp. For convenience, we can assume that the lamp has a resistance of 529 Ω. If we ignore the voltage across the diodes and the voltage across R1, the current is approximately 0.39 A on average (not 0.43 A). This is because the average mains voltage is only 207 V = (230 × √2) ÷ (π/2). This yields a voltage of approximately 8.5 V on C1. As the buzzer and T1 only draw a few milliampères from C1, in practice the voltage will differ from this value by at most a few tenths of a volt. Here you should use a DC buzzer with a large operating voltage range. A good example is the CEP-2260A, which has a volt-

age range of 3–20 V (available from Digi-Key and other online sources).

The charging time of C2 determines how long the buzzer remains energised, and here it will be a few tenths of a second. Depending on how much current the buzzer draws, you can increase the value of R2 in order to extend the time (this is certainly necessary with the above-mentioned buzzer type).

Depending on the lamp power, you can consider adjusting the value of R1. This will certainly be necessary if you use a 150-W lamp or larger. In this case, cut the value of R1 in half, primarily because the power dissipation will otherwise be too large. In the example described here, it is around 3 watts.

080169 - 11
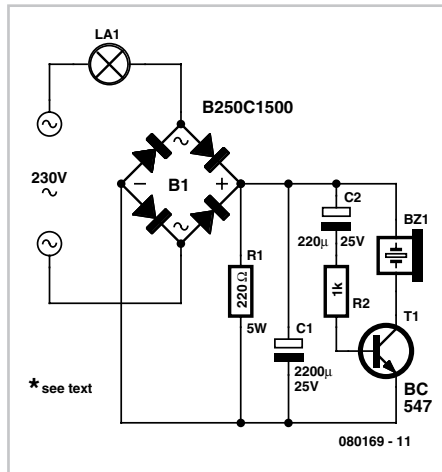
The bridge rectifier also deserves special attention. A large current can flow briefly

when the lamp is switched on 'cold'. A 250-V, 1.5-A bridge rectifier is adequate for a 100-W lamp, but heavier-duty diodes are necessary with higher lamp power – such as the 1N5408 (1000 V / 3 A).

Due to the heat generated by R1, make sure that R1 is located a certain distance away from the other components in the assembled circuit. Also bear in mind that the entire circuit is connected to mains potential. Never make any adjustments while the circuit is connected to the mains! It's thus a good idea to test the circuit before fitting it into the switch box.

(080169-1)

Smart Chocolate Block

Edmund Martin

What can be done, when two light bulbs in one light fitting are to be switched separately, but only one switch circuit is available? Simple: build a 'smart chocolate block' into the ceiling rose! The circuit is built from discrete components and with a bit of ingenuity can be fitted onto a printed circuit board measuring just a centimetre or two square.

When light switch S1 is operated for the first time lamp La1, which is connected in the usual way, lights; La2 remains dark. Electrolytic capacitor C1 starts to charge via rectifier diode D1 and resistors R1 and R2 until zener diode D3 conducts, limiting the voltage to about 6.8 V. This voltage is used as a supply for the rest of the circuit. The second lamp is connected via a triac and a fuse (1.5 A, medium speed recommended). The triac is triggered by T4, which can only happen when T3 does not pull its base down to ground. The first time the circuit is switched on this is the case, as we shall see below.

070466 - 11
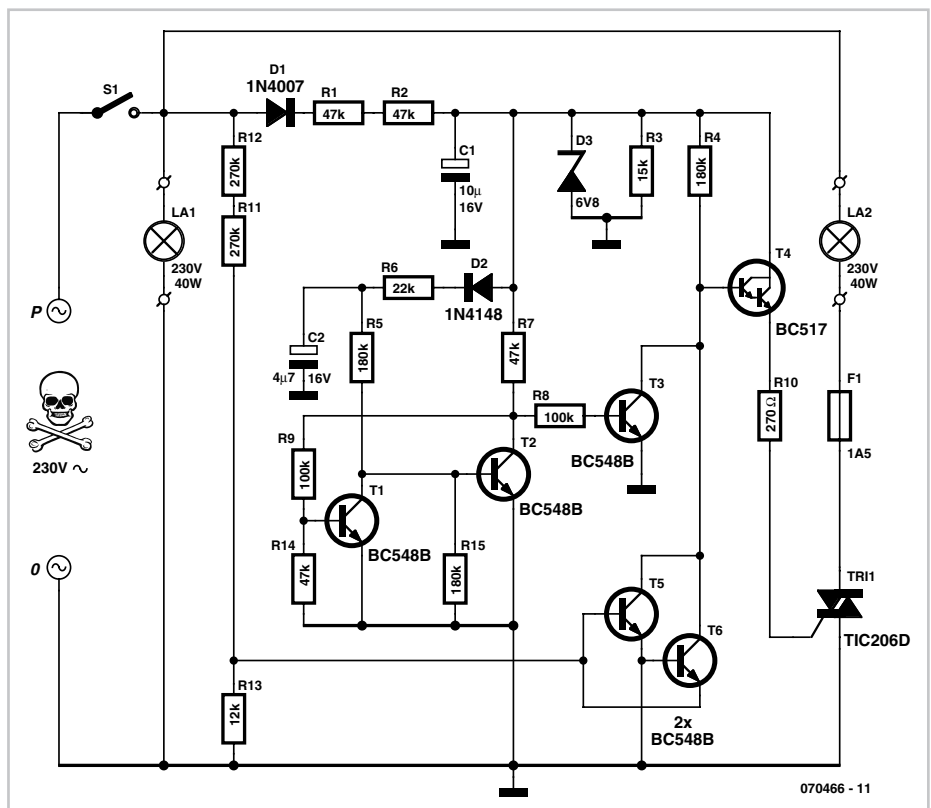
Transistors T1 and T2 form a bistable flip-flop with a well-defined power-up state. R14 and R15 cause both transistors to be initially turned off. As the voltage across C1 rises, transistor T1, driven via resistors R7 and R9, turns on. The base drive for transistor T2, which is provided via D2, the low-pass filter formed by R6 and C2, and R5, would arrive

a little later, but when T1 turns on it diverts the base current away from T2, which therefore remains turned off. This situation is stable: the base of T3 is not pulled down and so this transistor conducts.

To turn the second lamp on, switch S1 is opened and then, within a second or so,

closed again. The effect of this action on the flip-flop is as follows.
When the switch is opened the voltage across C1 falls more rapidly than the voltage across C2. The main reason for this is resistor R3, which is directly responsible for the discharge of C1; C2 can only discharge through the relatively high resistance of R5,

since the other path is blocked by diode D2. This means that T2 is driven via R5 for one or two seconds longer than T1 is driven via R7 and R9. If during this time the supply voltage reappears, it can no longer drive the base of T1 via R7 as T2 is conducting all the current to ground. This situation is also stable, as C2 is recharged via D2 and R6. When T2 conducts it pulls the base of T3 to ground, so that this latter transistor turns off. Darlington transistor T4 now conducts as its base is pulled high via R4. T4 now provides the trigger current for the triac via current limiting resistor R10, and the second lamp lights.

T5 and T6 together form a zero-crossing detector. It ensures that the triac is never triggered at a moment when the AC mains supply is at a high voltage point in its cycle. This avoids a rapid inrush current into La2, which would give rise to considerable radio interference. Also, trigger current is only required for the triac for a small fraction of the period of one cycle of the mains supply. If this current were drawn continuously from the low voltage supply, C1 would rapidly discharge; R1 and R2 would have to be considerably reduced in resistance, which would increase the heat dissipation of the module, perhaps making it infeasible to build the circuit into a plastic ceiling rose.

Using the component values shown the triac is only driven when the instantaneous mains voltage is less than about 15 V in magnitude. The voltage divider formed by R11, R12 and R13 switches on the transistors T5 and T6 when the voltage is greater than +15V or less than –15 V respectively. The collectors of these transistors, which are connected together, pull the base of T4 down to ground or to a slightly negative voltage when the mains cycle is outside the desired phase window.

Any resistors across which mains voltages will be dropped are formed from two individual resistors wired in series to ensure that the maximum voltage specifications of ordinary 0.25 W components are not exceeded. This applies to R1 and R2, as well as R11 and R12. The whole circuit is at mains potentials and great care must be taken to observe all relevant safety precautions in construction and installation.

(070466-I)

Slave Flash Trigger

Hermann Sprenger

The flash that is built into digital cameras is designed for indoor photography. At subject distances of greater than five metres or so, the light is usually not powerful enough to take a satisfactory picture. Unfortunately most such cameras do not include a shoe for an external flashgun, and so a light-triggered slave flash is called for.

The flash built into the camera produces a very rapid change in light intensity which is picked up by a phototransistor in the slave.

080319 - 11
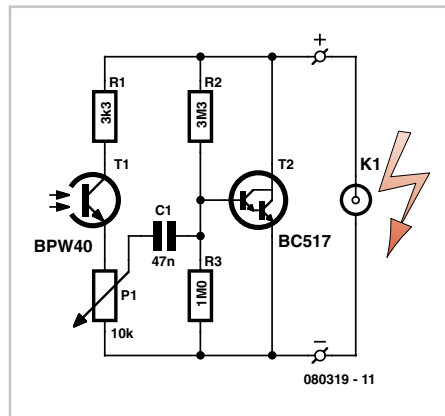
The pulse is transmitted via C1 to the transistor, which then briefly shorts the contacts on the slave gun together. The sensitivity of the device can be adjusted using P1. The circuit can be connected to the shoe contacts of the slave flashgun using a coaxial cable, or, with space permitting and a nimble bit of DIY, can be built inside it.
The circuit is not suitable for use with flashguns which have a voltage of more than 20 V across the trigger contacts, or with cameras that emit a number of 'preflashes' before taking the picture proper.

(080319-I)

Operating Hour Counter

Thomas Rudolphi

These days there are all kinds of power/energy meters available which can measure the power consumption and the operating costs of mains powered appliances. A prerequisite is that the appliance has a mains plug. However, if the power consumption is known then the energy use of the appliance can also be determined in a much easier way.
The operating hour counter for mains (230 VAC) appliances described here can measure the following, even in difficult to access places:
1. Number of times that it is switched on and off (up to 99999)
2. How long the load (lamp, fan, etc.) has been switched on (up to 99999:59:59 hours, resolution 1 s).

Because the power consumption of the load is known and using the information from the PIC, the energy consumption can then easily be determined using a Microsoft Excel file.

The whole circuit is built around an 8-pin PIC12F682 processor. The circuit draws very little current, so that it can be powered directly from the mains via two series resistors of 68k each (R1, R2). Zener diode D1 limits the positive voltage to 5.6 V and the negative voltage to –0.6V. At the node R2/D1 there is therefore a, more or less, square wave voltage. D3 and C1 provide a filtered voltage for the PIC processor. D2 ensures that at input GP2 with internal weak pullup there is a square wave voltage of 5 V with a frequency of 50 Hz.

The data is sent every second via IrDA using an IR LED and at a baud rate of 38k4. With R3 the current during the short pulse is limited to about 35 mA.

With J2 the accumulated data can be reset (counter and time back to 0). To do this, the jumper has to be installed before the circuit is turned on, and it's removed again after the circuit is switched off.

The software has been written with the freeware 'SourceBoost' C compiler (see web links). It has the following functions:

- initialisation of the processor (init())
- writing the data to the internal EEPROM
- deriving time information from the 50 Hz zero-crossings (Realtime())
- sending of the IrDA data via an IR-LED (HandleIrDaCommunication())
- power-down detection after which the time information is written to the internal EEPROM.

In the Init() routine the processor is initialised and the ON/OFF counter is incremented by one and the value is saved in EEPROM. It also clears the data in the EEPROM if the jumper is in place.

The main loop (for(;;)) waits for the zero-crossing detection in the CheckZero-Cross() routine. As soon as this arrives the time information is updated in Realtime(), which also sends part of the IrDA data every 100 ms. Only a small part of the data is sent to the IR-diode each time to prevent C1 from being discharged too much (relatively large current through the LED).
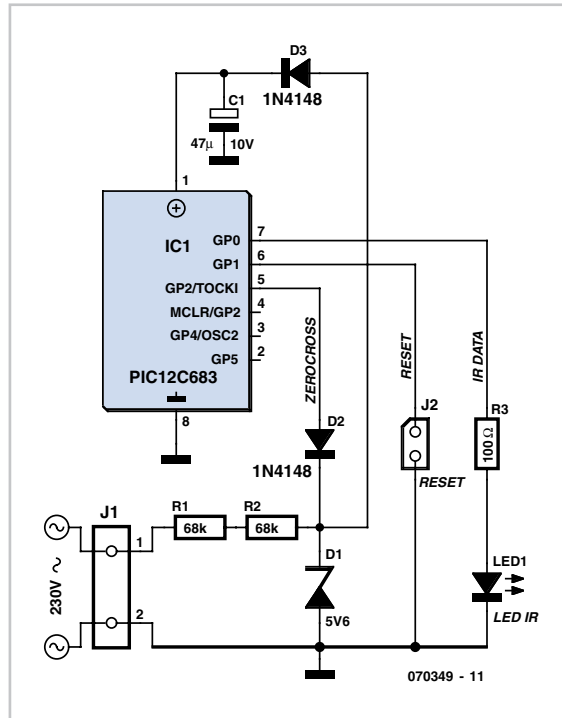
The CheckZeroCross() routine also checks whether the zero-crossing arrives every 20 ms. If not, then is the power has been switched off and the data has to be saved to the internal EEPROM as quickly as possible (before C1 discharges too deeply).

With a Pocket PC (PDA) (always fitted with an IrDA port as standard) and a terminal program (for example Zterm/PPC, see web links) the data can be very easily read out. The (ASCII-) output is in the form:

C=00000
H=00000:00:00

The circuit can easily (temporarily) be mounted inside, for example, a lamp fitting and must be connected in parallel with the load.

(070349-I)

Downloads

The source and hex code files for this project are available as a free download from www.elektor.com; file # 070349-11.zip.

Web Links

Freeware C-compiler:
www.sourceboost.com/CommonDownload/Binaries/SourceBoostV6.85/sourceboostv685.zip

Terminal program for PDA:
www.coolstf.com/ztermppc

Put that Light Out!

Stefan Hoffmann

If you forget to switch off the light after leaving a seldom used room (such as the loft), there's a strong likelihood that it could remain lit for months, running up an expensive power bill in the process. How can we prevent this waste?

It's not hard for electronics enthusiasts to design a little circuit to mitigate the effects of absentmindedness. The notion is simple; if the light is left on when the hatch or door is closed, a rhythmic sounder/buzzer signal produces an alarm that hopefully will not be masked by other noise.

The circuit is powered as long as the lamp bulb is switched on by light switch S1. If the reed switch S2 then signals that the hatch has been closed, the sounder operates. The red LED, mounted outside the loft next to the entry hatch, also indicates that the lamp up there needs to be switched off. The circuit does not use a transformer, meaning that the whole circuit is at mains potential. For this reason the components must be placed inside an insulated plastic case for protection, with no way that people can touch any part of the circuit (this includes the sounder).
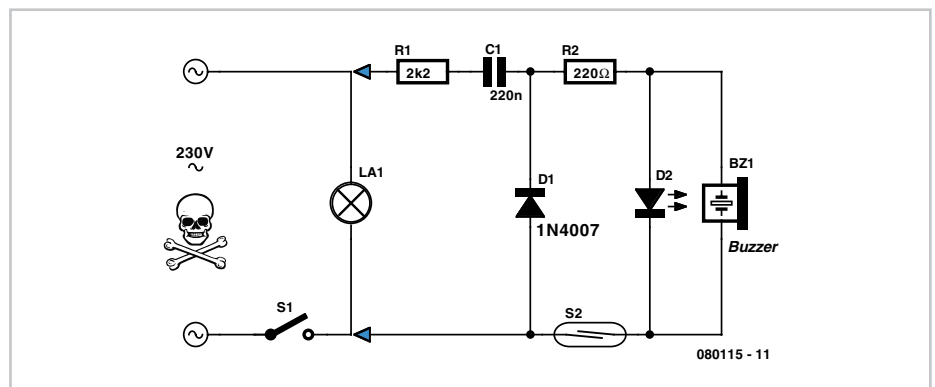
The connecting wires to the LED and the reed switch contact must be fully protected to the same touch-proof degree too. For the sounder you can use any type that operates on direct current in the region between 1 V and 3 V. In this circuit the operating voltage is limited by the LED connected in parallel to the buzzer. Using a red LED will provide around 1.7 V to the sounder. The current requirement of this kind of miniature sounder is about 5 mA.

Post-box Monitor

Mathieu Coustans

Or "Has the postman been yet?" This project was born out of the idea of avoiding having to go out to the post-box on a rainy day to see if the postman has been. Whereas in the UK the letterbox is often a slot in the front door, very remote road-side post-boxes are common in other countries.

Of course, it rains a lot less in Summer, but it does still happen — and always just when you're expecting an important letter; what's more, not everyone is on holiday, and loads of people go straight indoors without checking their post-box.

It would be nice to have some way of displaying the status of the post-box.

Until very recently, this type of (luxury) accessory was the privilege of private villas fitted with CCTV systems, the rest of us mere mortals not really feeling the need to spy on the postman using a CCTV camera. So the author decided to build a little circuit which is ridiculously cheap to build — in its most basic version, it ought not to cost more than about £ 3.

The author's project was built on prototyping board (perfboard) and uses only very standard components, the object of the exercise being to produce a simple but effective circuit. In its basic version, the circuit in question remembers if the postman has been (it doesn't actually detect the postman, but any kind of post slipped into the post-box by lifting the flap protecting the opening) and can indicate this 'event' visually (an LED) or audibly (buzzer or vocal alarm based on the ISD25xx). However, that the author soon ruled out the latter option because of the noise pollution it generates and the noticeably higher current consumption compared with just an LED.

Those readers who are keen to provide their system with a vocal-type alarm at any cost can take a look at the author's website, where he describes the system he used

080243 - 11

from the following supplier, before abandoning it. Conrad Electronics sell a module the size of a chewing-gum leaf for around £ 6 [1].

A glance at the circuit shows how staggeringly simple it is. The central component is a CD4013 logic IC (sequential logic), a D-type flip-flop with reset and priority set to '1', active high. You can find the truth table for the flip-flop in the inset. It's more complicated than it seems at first sight (CL = Clock, D = Data, R = Reset, S = Set, Q = Q output and $\overline{Q}$ = $\overline{Q}$ output).

CD4013 truth table					
CL	D	R	S	Q	$\overline{Q}$
Low>High transition	0	0	0	0	1
Low>High transition	1	0	0	1	0
High>Low transition	x	0	0	Q	Q
Immaterial	x	1	0	0	1
Immaterial	x	0	1	1	0
Immaterial	x	1	1	1	1

You can see that this is only triggered once on a rising edge.

This edge is generated by the magnetic leaf switch, since the latter is sensitive to any significant variation in the magnetic field: the simple fact of opening the hinged flap of the post-box to put the post in can be used to produce a change of state in the reed switch. The diagram illustrates the respective positions of the reed switch and magnet.

The author has all sorts of potential developments in mind for his circuit. If the subject intrigues you, why not drop by his blog [2] from time to time, to see how things are developing? — a basic knowledge of French is required, though.

(080243-I)

Web Links

[1] Author's website:
http://ludvol.free.fr/articles.php?lng=fr&pg=211

[2] Author's blog:
http://lespace-electronique.blogspot.com

Lamp in a Wine Bottle

Sebastian Westerhold

Electronics need not always be a matter of dry theory or be taken with great seriousness. We were reminded of this by the author, who wrote to us to describe a very peculiar 'circuit':

'My other half Jessica is the kind of woman, rather rare on this planet, who takes a keen interest in the wonderful world of electronics and who shows great forbearance towards the hours I spend immersed in my hobby.

For Christmas 2006 I gave her a soldering iron, a small set of tools and a bundle of components. They went down rather well, and it was not long before LEDs were flashing away under the control of an NE555, 4017 and other bits and pieces.

At some point in the following autumn Jessica asked me to come and look at her latest 'circuit'. On the way down to the cellar I imagined the possibilities for what might await me in my workshop. What I saw, however, I never would have expected: each made from a resistor and a capacitor, artfully soldered together, a pair of earrings! And all RoHS compliant, of course.'

The inventive project described here is also a product of Jessica's creative flair. The couple were experimenting with filling wine bottles with water, and adding various chemical colourants. Then LEDs of various colours were submerged in the liquid, giving strange and beautiful lighting effects. The ultraviolet-active dye 'fluorescein sodium' gives off an intense green light when stimulated using blue, or even better, ultraviolet, LEDs. Rhodamine B is another ultraviolet-active dye: in this case the emitted light is bright red. Both fluorescein sodium and Rhodamine B can be ordered via chemist's shops, or, more economically, over the Internet. Although the prices of these dyes may appear high, only very tiny quantities are needed: one gram of dye is enough for at least ten wine bottles full of water.

Even more spectacular effects can be achieved using a full-colour RGB LED in conjunction with these dyes. The driver circuit, which is an ideal project for beginners, can be built on a small piece of perforated board in half an hour or so. Being microcontroller based, the circuit is very compact. As always, the software is available for download from the Elektor website at http://www.elektor.com. Ready-programmed microcontrollers are also available: the order code is 080076-41.

(080076-I)

080076 - 11

Pitch Meter for Model Helicopters

Hanspeter Povel

'Pitch' is the name given to the angle of inclination of the rotor blades of a helicopter. In model helicopters the pitch angle is critically important to flight performance. Typical pitch values lie in the range from –3 degrees to +10 degrees.

There are various ways to check and set the rotor blade angle. One method uses a flybar rod (which resembles the small auxiliary rotor blade under the main rotor) set horizontal with the help of a spirit level, a protractor fixed to the rotor blade, and a plumb line. The method does work, but the rotor axis must be kept as vertical as possible and the blades as horizontal as possible to obtain an accurate measurement. As so often, a little electronics can make life a lot simpler.

Searching for a suitable IC, the author came upon the SCA100T inclinometer from VTI Technologies [1]. The device is a micromechanical sensor which measures angle on two axes using a capacitive method. The SCA100T-D01 has a range of –30 degrees to +30 degrees and a resolution of 0.0025 degrees. The measured angle can be read out in digital form over an SPI port.

If we want to connect the device to a laptop or desktop PC, we need a suitable interface. A simple approach is to use a ready-made USB-to-SPI converter such as the IO-Warrior 24 from Code Mercenaries [2]. As the circuit in Figure 1 shows, this unit can drive two SPI ports simultaneously, and also sports an LED to indicate operation. The circuit diagram shown in Figure 2 therefore shows how two identical inclinometers are connected to the two SPI ports.

The completed module is shown in Figure 3. One inclinometer is screwed to a black guide plate in order to simplify attaching it to the rotor blade. The other inclinometer, which is mounted on a grey block, is attached to the flybar. The whole assembly is shown in Figure 4, attached to a model helicopter and ready to make some adjustments.

The last piece in the jigsaw is some suitable software running on the host PC. Using the IO-Warrior hardware simplifies matters considerably in talking to the hardware, as libraries are available for download from the Code Mercenaries website to allow access

080101 - 11

080101 - 12
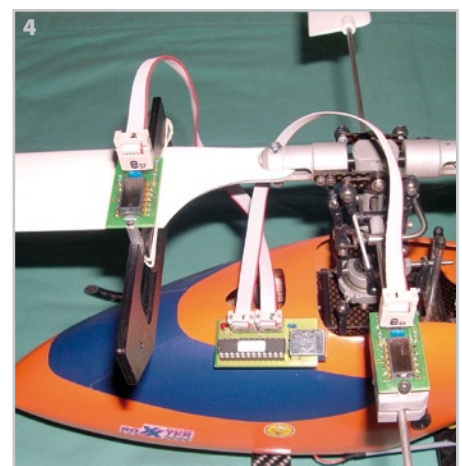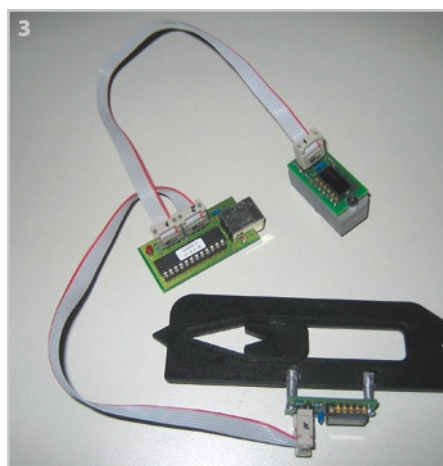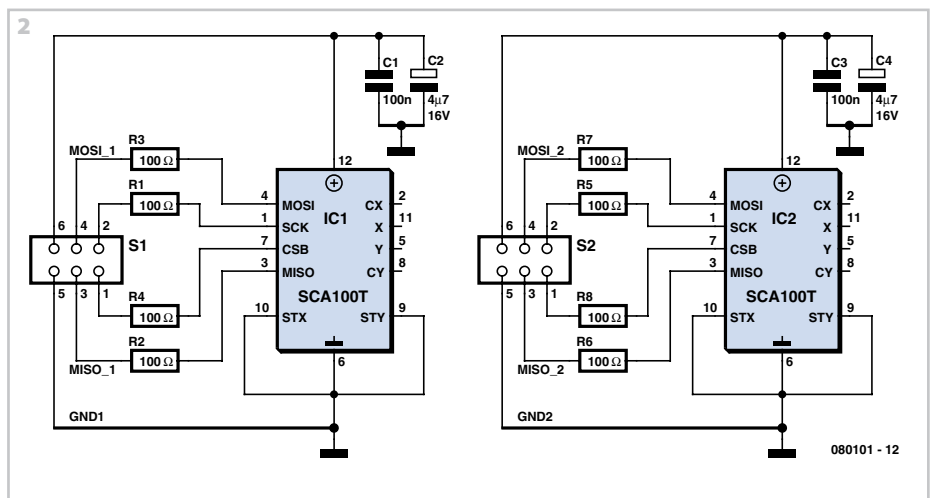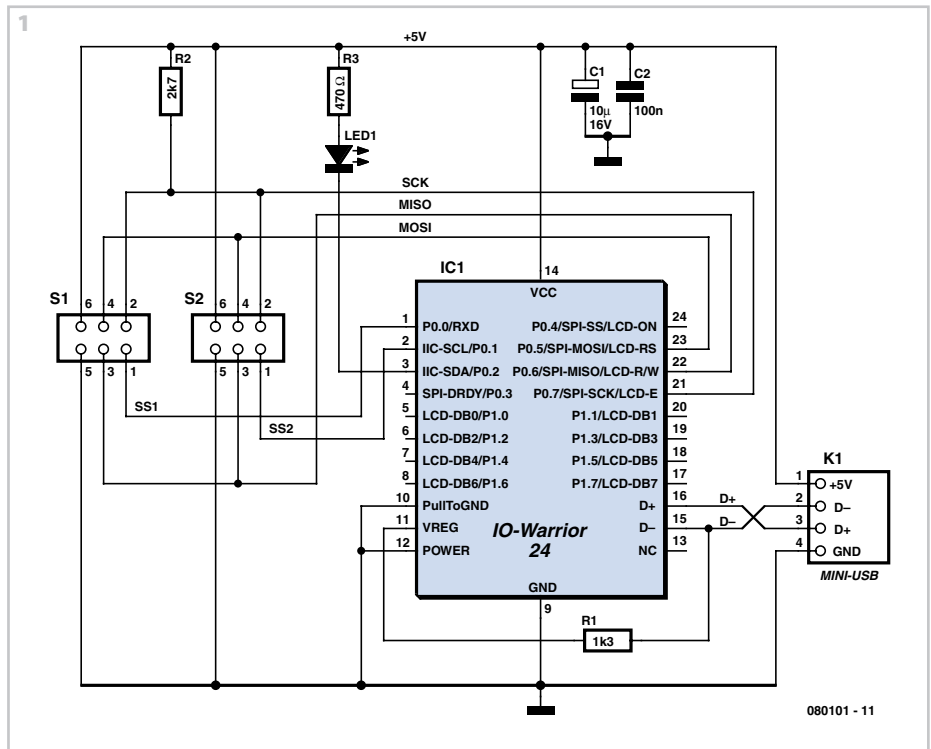
to the SPI data from programs written in C++ or in Visual Basic. The author plumped for the latter language, as a free development environment for it is available from Microsoft. He then wrote a short Visual Basic program to display the measured angles, rounded off to the nearest tenth of a degree.

The two values measured are the inclinations of the flybar and of the rotor blade.

The difference between these two values can be calculated to yield the pitch angle. Since the sensors measure angles on two axes, the less relevant values are shown in smaller text on the display. These values depend on the horizontal alignment of the model and should be less than ten degrees. The sign (positive or negative) of the displayed results can be changed to suit the mounting arrangement with a click on the

button marked '+/–'. The Visual Basic software is available as a free download from the Elektor web page for this project.

(080101-I)

Web Links

[1] http://www.vti.fi/en/products-solutions/product-finder/search/motion.html

[2] http://www.codemercs.com

Smooth Flasher

Burkhard Kainka

Ordinary LED flashers turn the LED on and off abruptly, which can get a little irritating after a while. The circuit shown here is more gentle on the eyes: the light intensity changes very slowly and sinusoidally, helping to generate a relaxed mood.

The circuit shows a phase-shift oscillator with an adjustable current source at its output. The circuit is capable of driving two LEDs in series without affecting the current. The frequency is set by three RC networks, each of which consists of a 100 µF capacitor and a 22 kΩ resistor.
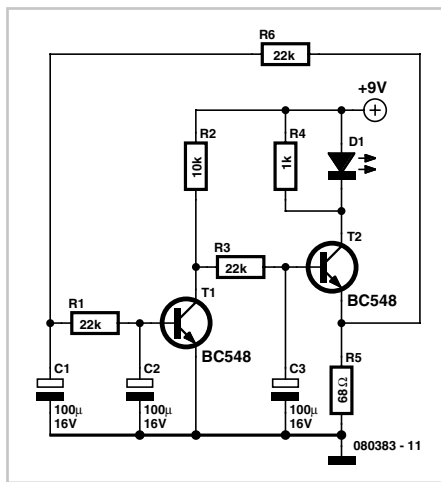
Operation is largely independent of supply voltage, and the average LED current is set at about 10 mA. The circuit adjusts the voltage across the emitter resistor so that it matches the base voltage of the first transistor (around 0.6 V). The phase shifting network gives rise to the oscillation around this average value.

In the prototype of this circuit we used an ultra-bright red LED.

(080383-I)

Deluxe '123' Game

Stefan Hoffmann

The rules of the '123' Game are described in the '*123 Game – all MCU-free*' article. Naturally, a more luxurious version can be built with a microcontroller. Here you don't have to manipulate a probe tip to play the game, and the playing field is formed by LEDs instead of mini-sockets. A microcontroller drives the LED array, and three input buttons take over the role of the probe tip. In contrast to the simple version, the built-in 'intelligence' of the microcontroller also allows two humans to play against each other.

A 'welcome screen' with various LED patterns is displayed after the circuit is switched on. A bicolour LED then cycles through all three colours (red, green and

orange) while waiting for the player to select a game mode:

- Button 1: Human *vs*. MCU; human starts;
- Button 2: MCU *vs*. human; MCU starts;
- Button 3: Human *vs*. human.

The course of play is essentially the same as before. The human player and the computer take turns moving by one, two or three steps. When it's the human's turn to move, he or she presses a button for the desired number of steps ('1', '2' or '3'). The selection steps is confirmed by the '123' LEDs and then performed on the playing field LEDs. The bicolour LED is green when it's the human's turn and red when it's the computer's turn. Purely for effect, the computer does not move right away, but instead 'ponders' a while before mov-

ing, and the moves are made slowly, step by step, instead of all at once.

The number of steps the computer wants to move is also shown by the '123' LEDs. The move is then performed on the playing field LEDs. If the human player tries to move past the goal, this is corrected automatically. In the human vs. human mode, the bicolour LED turns orange to indicate that it's the opponent's turn.

The winner is determined by the microcontroller. If the human player wins, the bicolour LED blinks green, and if the computer wins it blinks red. If the opponent wins, the LED blinks orange/red. A beeper gives extra lustre to the 'victory ceremony'. It gives a low beep if the human loses and celebrates a human victory with two high beeps.
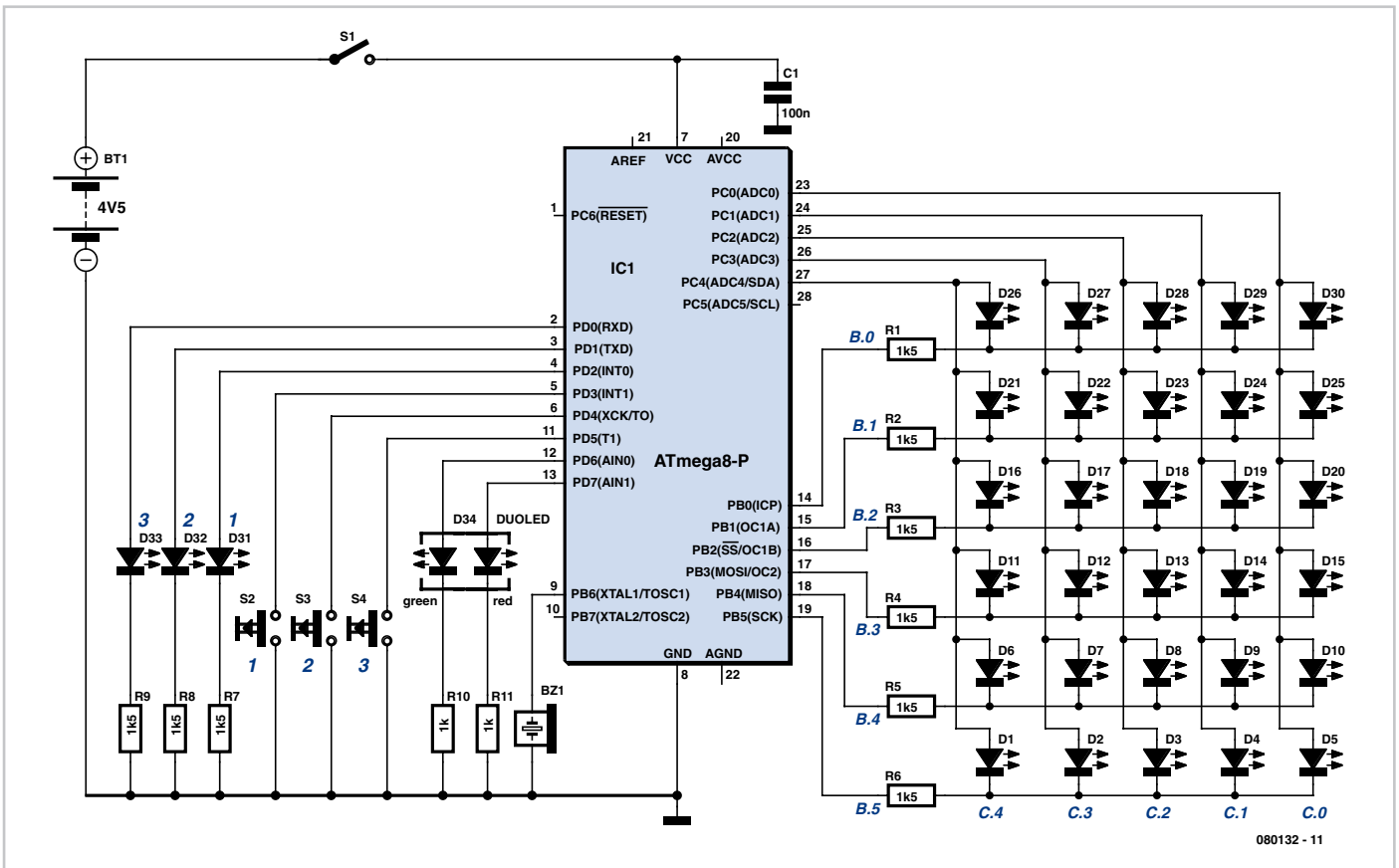
080132 - 11

The software for the ATmega8 was generated using BASCOM, and it can be compiled with the demo version. The BASCOM source code and a hex file can be downloaded from the www.elektor.com — the archive file number is 080132-11.zip. A pre-programmed microcontroller is also available (order no. **080132-41**).

(080132-1)

Temperature Sensor with 2-Wire Interface

Stefan Dickel

When designing a precision outdoor temperature sensor it is a good idea to electrically isolate the sensor from the signal conditioning circuitry to protect it from voltage spikes such as might be induced by lightning. Digital signal transmission is preferred over analogue as the circuitry is more straightforward, communication is more reliable and subsequent processing of the temperature readings is easier. In the design shown here the signal and the power for the converter circuit are both carried on just two wires.

A type PT1000 temperature sensor is used. This is capable of withstanding temperatures of well over 130 °C (such as might be found in solar heating systems). The voltage dropped across the sensor is taken as input to an Analog Devices AD654 vol-

tage-to-frequency converter. The power rail is then modulated with a square wave signal whose frequency is dependent on the measured temperature. The signal can be carried on a cable over a great distance. At the receiver end an optocoupler provides for electrical isolation.

T1 forms a current source that delivers a constant current of 1 mA into the temperature sensor R2. The current can be adjusted for calibration using trimmer potentiometer P1. The voltage across the sensor is taken to the VIN input (pin 4) of the voltage-to-frequency converter IC1. R4 and C1 are chosen so that the conversion factor is 10 kHz per volt.
The temperature is given by the formula

$$T = (f - 10000) / 38$$

where T is the temperature in °C and f the frequency in Hz. The frequency therefore

ranges from 8.8 kHz (at −30 °C) to 15.7 kHz (at +150 °C).
The output transistor of IC1 has its collector at pin 1 and its emitter at pin 2. Pin 1 is connected to the positive signal line via resistor R5, and pin 2 is taken directly to the negative signal line.

The demodulation function is carried out by the circuit around T2. The value of the current sense resistor R6 is chosen so that when converter IC1 is in its quiescent (off) state T2 is not switched on. When the output transistor of the converter turns on, extra current is drawn from the supply via R5, making the total current drawn considerably higher. In turn, the voltage drop across R6 increases significantly and T2 is turned on. A large collector current now flows through R7, R8 and the LED inside optocoupler IC3. The phototransistor inside the optocoupler is now also turned on.
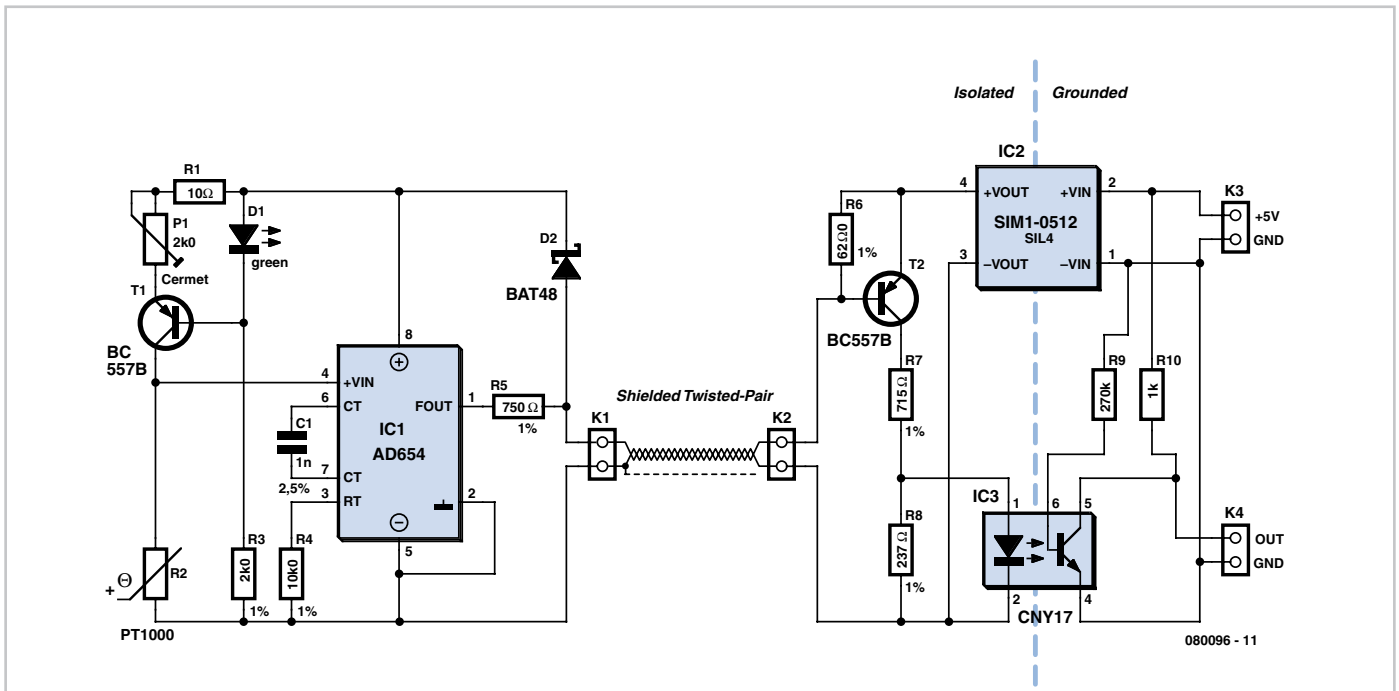
Finally, at connector K4 the signal is available with a low impedance, suitable for further processing.

So that we can arrange for the circuit to operate from a single supply we use an isolating DC-DC converter. This not only provides the 12 V needed by the sensor circuit, but also offers up to 1000 V of electrical isolation.

(080096-I)

Video Isolator

Harry Baggen

These days many more audio-visual devices in the home are connected together. This is especially the case with the TV, which may be connected to a DVD player, a hard disk recorder, a surround-sound receiver and often a PC as well.

it's highly likely that the PC has a TV-card, which again is connected to the same system. On top of this, there are many analogue connections between these devices, such as audio cables. The usual result of this is that there will be a hum in the audio installation, but in some cases you may also see interference on the TV screen.

loop isolators.

Good news: such a filter can also be easily made at home by yourself. There are two ways in which you can create galvanic isolation in a TV cable. The first is to use an isolating transformer with two separate windings. The other is to use two coupling
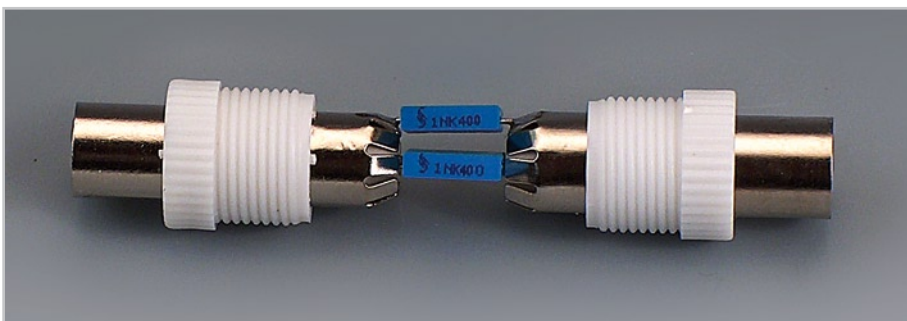
This often creates a problem when earth loops are created in the shielding of the video cables, which may cause hum and other interference. The surround-sound receiver contains a tuner that takes its signal from a central aerial distribution system. The TV is also connected to this and

The ground loop problem can be overcome by galvanically isolating the video connections, for example at the aerial inputs of the surround-sound receiver and the TV. Special adaptors or filters are sold for this purpose, known as video ground
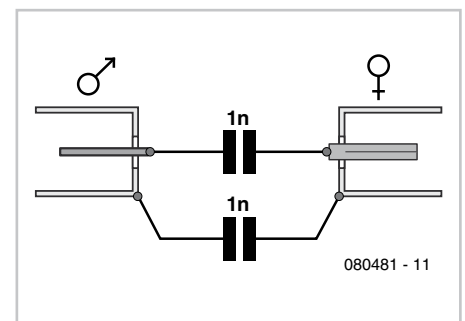
capacitors in series with the cable. The latter method is easily the simplest to implement and generally works well enough in practice.

The simplest way to produce such a 'filter' is as an in-line adapter, so you can just plug

it onto either end of a TV aerial cable. The only requirements are a male and female coax plug and two capacitors. The latter have to be suitable for high-frequency applications, such as ceramic or MKT types. It is furthermore advisable to choose types rated for high voltages (400 V), since the voltages across these capacitors can be higher than you might expect (A PC that isn't connected to the mains Earth can have a voltage as high as 115 V (but at a very low, safe current), caused by the filter capacitors in its power supply.

These capacitors don't need to be high value ones, since they only have to pass through frequencies above about 50 MHz. Values of 1 nF or 2.2 nF are therefore sufficient.

To make the isolator you should connect one capacitor between the two earth connections of the coax plugs and the other between the two signal connections. The mechanical construction has to be sturdy enough such that the connections to the capacitors won't break whenever the in-line adapter is removed forcibly. A good way to do this is to make a cover from a piece of PVC piping for the central part. Wrap aluminium foil round the outside and connect it to one of the plugs, so that the internal parts are properly shielded from external interference. Make sure that the aluminium foil doesn't make contact with the other plug, otherwise you lose the isolation.

The majority of earth loops will disappear when you connect these filters to all used outputs of the central aerial distribution system where the signal enters the house.

(080481-I)

Reaction Race using ATtiny13

Stefan Hoffmann

This is a reaction timer game between two players, red and green. Each player has a pushbutton in front of him that he must press at just the right moment: not too early and not too late. The aim is to be the first to press the button. The 'right time' is indicated by a multi-colour LED.

Each round of the game runs as follows: after a welcome pattern (flashing red and green, playing two tones), the LED starts to blink red slowly. A player who presses during this phase (too early) is 'punished' by a low-pitched tone and the lighting of the LED in his colour.

080118 - 11
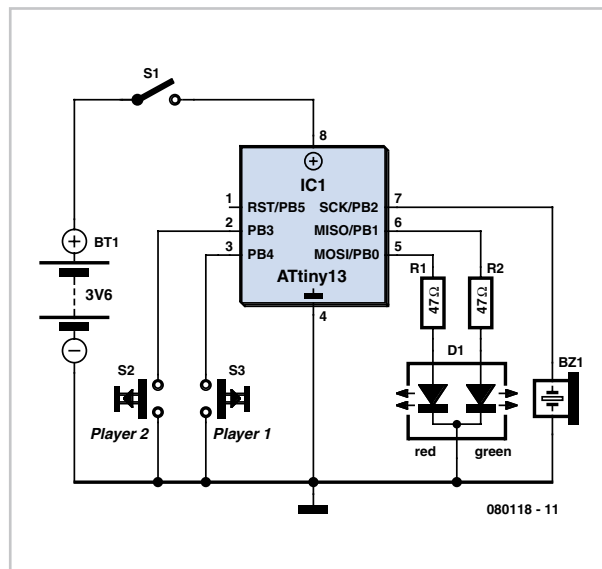
After a random time period the LED turns yellow. The first to press during this period is the winner and is rewarded by a rapid flashing of the LED. If the LED goes out again before either player has pressed his button, it is too late and another round of the game starts.

As a glance at the well-commented source code for the microcontroller software shows, the sequence of events and their timing can easily be adjusted as required. Source and object code files are as usual available for free download from the Elektor website (http://www. elektor.com). Ready-programmed microcontrollers are also available.

(080118)

48-V Microphone Supply

Joseph Kreutz

48 V 'phantom' powering has become the standard for professional condenser microphones. The supply (or rather bias) voltage is applied over both wires of the balanced screened cable via two 6kΩ8 resistors (see reference [1]) – the absolute value is not critical, since a variation of ±20% is permitted, but they must be matched to an accuracy of 0.4% or better [2]. Many microphones are fitted with an output transformer, and derive their power from a centre tap on the secondary. If the currents supplied by the two wires of the balanced line, which flow in opposite directions through the two halves of the secondary winding, are not identical, the magnetic fluxes they induce in the core of the transformer do not cancel out properly, and spurious magnetization occurs, causing distortion and a reduction in the microphone's dynamic range.

With an output current of 0.4 A, the PSU described in this article can 'supply' at least 40 microphones. The mains voltage is applied to a 30 VA transformer which supplies 24 V_{rms}. Its secondary feeds a voltage doubling rectifier formed by diodes D1 and D2 and capacitors C3 and C4. Capacitors C1 and C2 suppress the switching noise produced by the rectifier diodes. This voltage-doubling rectifier provides around 72 VDC, and so offers an adequate margin to allow for ±10% fluctuations in the mains voltage.

Voltage regulation is taken care of by

TL783KC regulator IC1 on which an abundant amount of information may be found at [3]. Basically, this is an adjustable regulator in a TO220 package that offers excellent residual ripple and low noise on its output voltage. The TL783KC regulator includes a MOS series pass transistor and accepts an input voltage of up to 125 V, making it an ideal candidate for this application. Diodes D3 and D5 respectively protect the PSU against transients at switch-off and reversed polarity.

The output voltage is set by resistors R1 and R2 according to the formula:

$$V_{out} = V_{ref} \times (1 + R2 / R1)$$

where reference voltage $V_{ref} = 1.27$ V.

These resistors should preferably have a tolerance of 1%, and R2 is likely to dissipate 0.5 W. Resistor R3 provides a minimum load that is vital for maintaining the PSU's off-load voltage at 48 V, and is also used to supply LED D4. If the LED is not used, R3 must without fail be connected to ground.
Last but not least, regulator IC1 must be
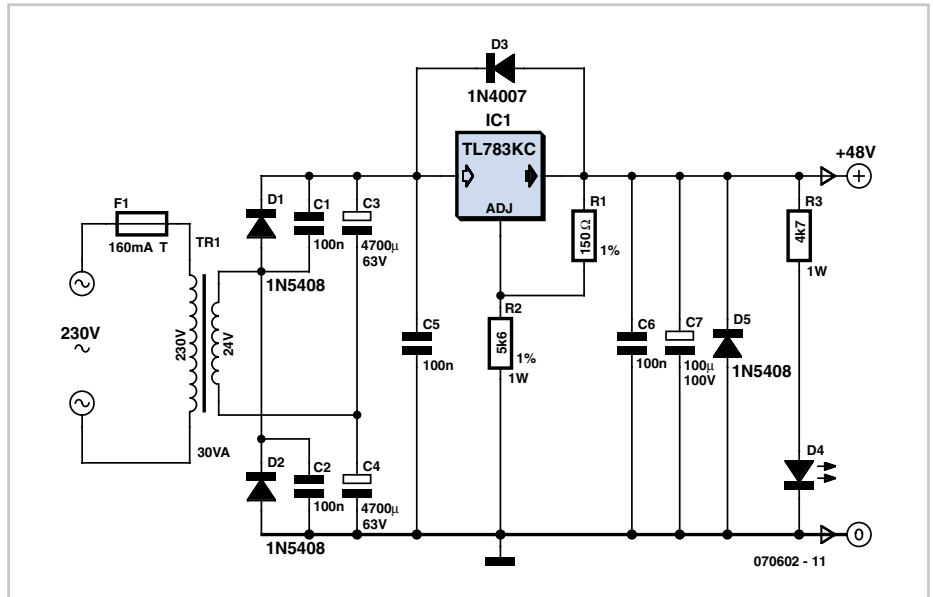
mounted on a heatsink with a thermal resistance of less than 1.5 °C/W using the standard insulating kit: top-hat insulating washer, mica washer, and heat sink compound... make sure you use enough, but not too much!

(070602-I)

Bibliography and Web Links

[1] Microphone Essays, p. 83. Jörg Wuttke, www.schoeps.de/E-2004/miscellaneous.html
(11 MB document in German, downloads via links at bottom of page)

[2] DIN EN 61938 standard

[3] http://focus.ti.com/docs/prod/folders/print/tl783.html

[4] http://en.wikipedia.org/wiki/Phantom_power

Discrete PWM Generator

Alexander Wiedekind-Klein

PWM waveforms are commonly used to control the speed of DC motors. The mark/space ratio of the digital waveform can be defined either by using an adjustable analogue voltage level (in the case of a NE555 based PWM generator) or digitally using binary values. Digitally derived PWM waveforms are most often produced by the timer/counter modules in microcontrollers but if you do not want to include a microcontroller in your circuit it's also quite simple to generate the signals using discrete logic components. An extension of the circuit shown can produce two PWM waveforms from an 8-bit digital input word. Each signal has 15 values. The 8-bit word can be produced for example from an expansion board fitted in a PC or from an 8-bit port of a processor which does not have built-in PWM capability or from a laptop's printer port.
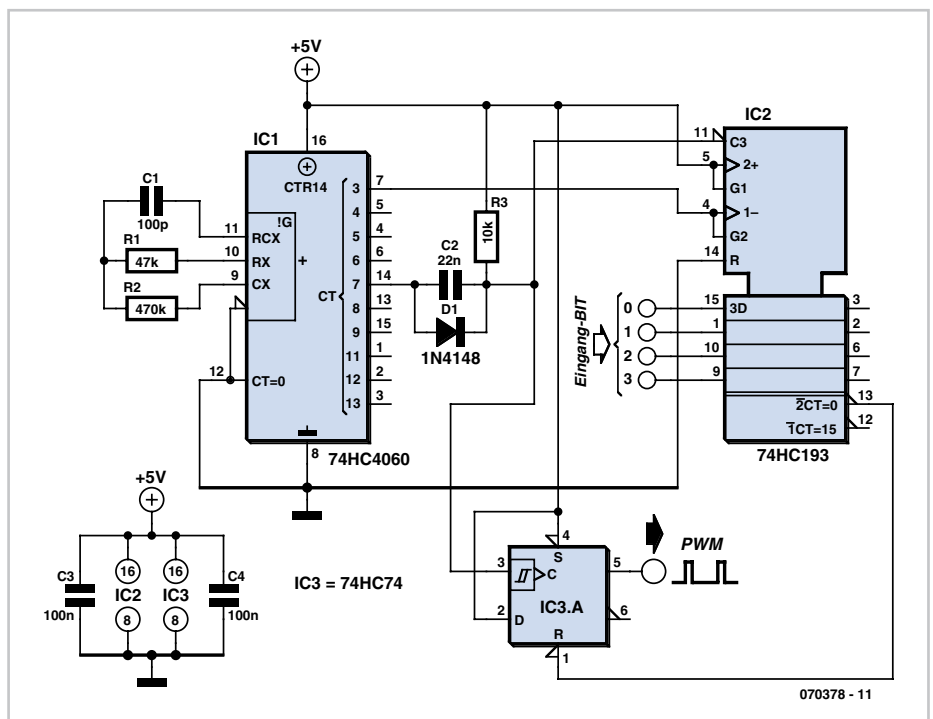
The mark/space ratio is only programmable up to 15/16 rather than 16/16; a binary input of 0000 produces a continuous low

on both outputs turning both motors off. Similar circuits often employ a dedicated 'enable' input to turn the motors off but it is not necessary in this design.

The diagram shows the circuitry required to produce just one waveform. For the full two channel circuit it is necessary to use an additional 74HC193. The clock signal produced by the HCF4060 generator can be used to drive both channels and the free flip flop in the 74HC74 package can be used for the second channel (the corresponding pin numbers are shown in brackets). Altogether the entire two channel circuit can be built using just four ICs.

(070378-I)

Simple One-wire Touch Detector

Lars Näs

This simple circuit can be used to activate whatever you like, for example, by connecting it to microcontroller, relays, secret alarms, robot applications or just turn on LED1 which lights up as long as you touch the metal plate.

The circuit consists of voltage divider R1 and R2, one Schmitt trigger/inverter gate from a 40106 IC, a small capacitor to keep strong RF at bay and LED1 with current limiting resistor R3.

The metal plate is connected via a wire to R1. R1 and R2 together form a voltage divider. Since the current from your body is very small it's understood that R2 has a high value like 10 Megohm to maximise the voltage over R2 so it can be detected by input pin 1 of gate IC1.A. R1 has been added to prevent electrostatic discharge (ESD) energy from damaging the inverter gate input. ESD may occur when you have been charged with an amount of electro static energy by walking on a carpet with rubber soles. You can increase the sensitivity of the detector by experimenting with lower values fore R1 e.g. 1 kΩ and a smaller metal plate.
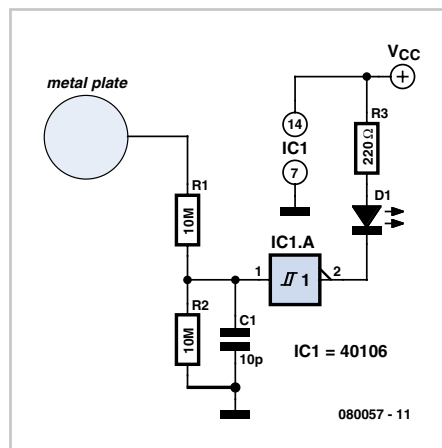
The value of pull-up resistor R3 is calculated such that the current through LED1 is below its maximum continuous rated value. Most regular LEDs are 20 mA types. The circuit still works if you remove LED1 and just have the pull-up resistor R3 connected to output pin 2 and then connect a microcontroller input pin directly to pin 2. Do check however that the microcontroller has a weak pull-up (i.e. to +V_DD) at its port line.

(080057-I)

Solar Cell Voltage Regulator

Reuben Posthuma

This device is designed to be a simple, inexpensive 'comparator', intended for use in a solar cell power supply setup where a quick 'too low' or 'just right' voltage indicator is needed. The circuit consists only of one 5-V regulator, two transistors, two LEDs, five resistors, two capacitors, and one small battery. Although a 4-V battery is indicated, 4.5 V (3 alkalines in series) or 3.6 V (3 NiCd cells in series) will also work.

The specifications of voltage regulator IC1 are mainly determined by the size and number of the solar cells and the current pull of the equipment connected to the output. Here the low-drop 4805 is suggested but other regulators may work equally well as long as you observe the output voltage of the solar cells.
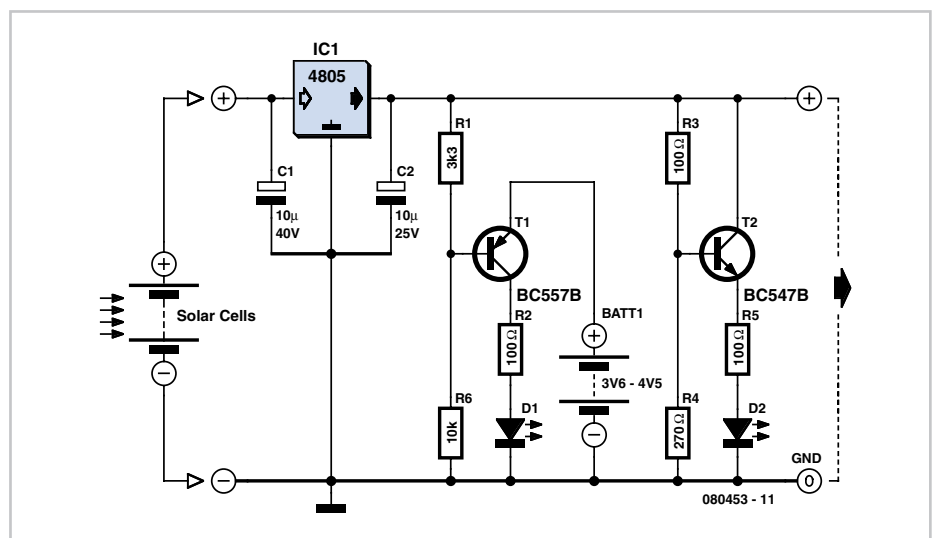
Transistors T1 and T2 are complementary types i.e. one each of the pnp and npn vari-

ety. Although the ubiquitous BC557B (pnp) and BC547B (npn) are indicated, any small-signal equivalents out of the junk box will probably do. The values of voltage dividers R1/R6 and R3/R4 may need to be adjusted according to the type of transistor and its gain, or according to the desired voltage thresholds. Using the resistor values shown in the schematic, LED D2 turns on fully when the voltage is just above 5 volts. LED D1 turns on when the voltage drops below 4.2 volts or so. Between those two thresholds, there is a sort of no man's land where both LEDs are on dimly.

A buzzer or other warning device could be connected across the terminals of LED D1 to give a more substantial warning if the voltage drops below operating limits.

The current consumption of the circuit is about 20 mA at 5 V, and it decreases with the voltage supplied by the solar cells.

(080453-I)

Minimalist Oscilloscope

Burkhard Kainka

If you are the proud owner of an old oscilloscope tube, you may be interested in using it once more for its original purpose. All you need are the right voltages on the right pins: in practice you may need to peer closely inside to find out which pins on the base correspond to the acceleration and deflection electrodes, in particular if there is no part number to be seen on the tube. The tube we had for experimental purposes was a 7 cm model of unknown provenance.

So the first step is to establish which pins correspond to the heater, cathode, grids, deflection plates, and anode. With this done we can make our simple oscilloscope as follows: connect the Y input via a suitable capacitor to one of the Y deflection plates; for X deflection we use a neon lamp oscillator to generate a timebase; and with a focus regulator circuit we have a complete oscilloscope.
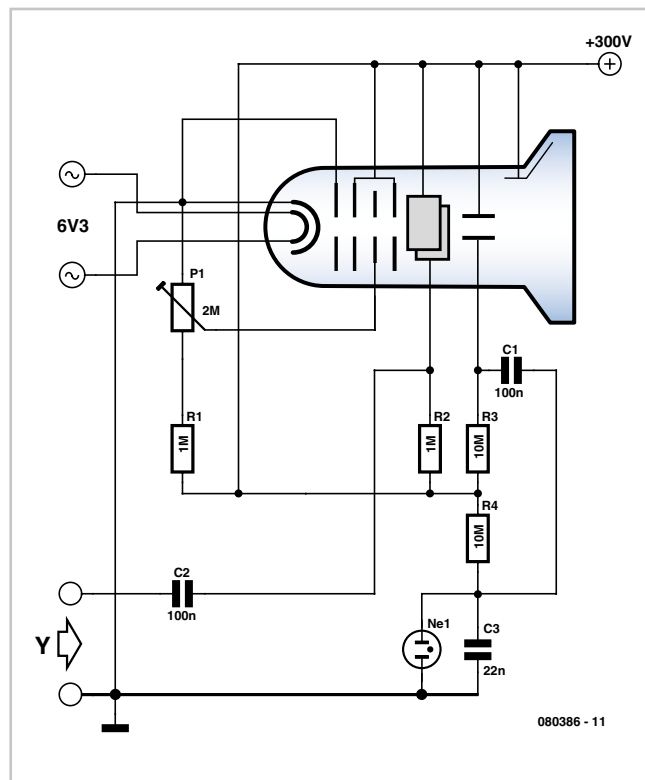
080386 - 11

Operation of the horizontal deflection oscillator is visible as the gentle flickering of the neon lamp. Whenever the voltage across the parallel-connected capacitor reaches the strike voltage of the lamp, it is discharged with a brief pulse of current. It is hard to imagine a simpler way to generate a sawtooth waveform. The supply voltage of 300 V is adequate for simple experiments, even if the tube is rated for operation at 1000 V or even more.

Now, if a signal is applied to the Y input, we should be able to see the waveform on the screen.

It must be admitted that the design's sensitivity, linearity, trace size, bandwidth and triggering facilities leave a little to be desired. Nevertheless we have shown how little circuitry is required to make a real working oscilloscope.

(080386-I)

Underwater Magic
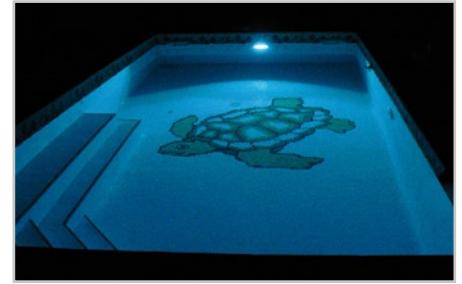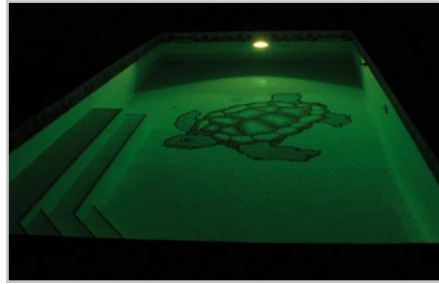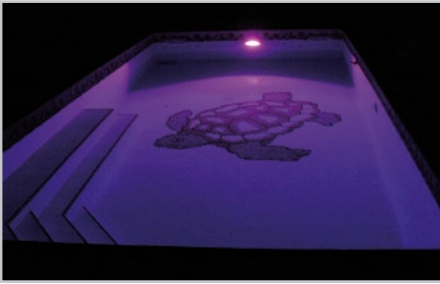
Ludovic Mézière

If we were looking for a slogan to sell this project in some mail-order catalogue, we might

well have chosen the slogan "16 Million Colours in the Water in Your Swimming Pool" as its subtitle. In just a few months, we've seen increasingly 'visible' applications for (high) power LEDs. After all, was it not Philips that paid for the illuminations on some of the most famous avenues in the world?

The author of this project took it into his head to give a festive look to his swimming pool as cheaply as possible. The use of a ready-made PC PSU module to supply the power makes it possible to reduce the overall cost of this project very significantly.

Principle

Three PWM (pulse width modulation) generators drive three groups of high-brightness red, green, and blue LEDs using an 8-bit word per colour – which theoretically gives the possibility of lighting the water in 16 million different shades.

Circuit

A quick glance at the circuit might make us wonder if the designer hasn't forgotten something, given the excellent 'readability' of the electronics employed. A micro-

controller and no less than three strips of ten or so LEDs, each with its own dropper resistor. Each strip is driven by a transistor, and there you have all the ingredients of this recipe.

The potential of microcontroller IC1, an AT90S8515P from Atmel, is admittedly under-exploited, but the choice of it is justified by the presence of three PWM drivers in the same package, as well as by its very affordable price and excellent availability. The board has an ISP connector (In System Programming), K2, to allow for future software updates.

The three PWM outputs drive type IRFI540NPBF MOSFET transistors T1–T3, which have a power dissipation rating that's easily sufficient for this application. You may like to fit them with a small heatsink, which will be enough to dissipate the small amount of heat produced by the transistor switching. These transistors each drive ten or so LEDs. The spot draws a whopping maximum current of nearly 10 amps at 5 V, meaning that a powerful PSU is needed. Building one yourself would turn out expensive. So the solution to this cost issue is to opt for a PC PSU module, which usually has no problems providing some 30 A at 5 V, for only a mod-

est sum. And there you have it — everything has been said that needs to be about the electronics employed. The aspect we're going to tackle in the next paragraph is very important, given its implications…

Construction
As shown in the introductory photo, the whole of the electronics fits onto a pair of printed circuit boards. The LED board is round so it can be fitted easily into a cylindrical body that will conveniently slide into a masonry orifice provided for it in the wall of the swimming pool. The second, smaller board is rectangular, with truncated corners, and it carries the power electronics. The dropper resistors in the LED supply lines also act as spacers for the two boards. The first step in construction is to fit the thirty LEDs on the track side of the round board. Take care to get the polarity correct. This done, we end up with a

board as shown in the second photo. You can then move on to fitting the resistors, which should be pushed fully home into the holes provided for them on the LED board and then be soldered into place. The 3 remaining adjacent lands close to the microcontroller and marked '+5V' should be fitted with a piece of insulated solid wire the same length as the final spacing of the two boards.

Now it's time to move on to building the controller board. IC1 could be fitted into a socket (with spring contacts) just in case. Start by soldering the smaller components, capacitors, diode (only fitted if the voltage supplied by the PC PSU is being increased, see next paragraph; otherwise replaced by a wire link). Next, fit the transistors (paying attention to their orientation – their heatsinks should face the outside of the board) and socket K2 (fitting it later once the two

boards are piggy-backed is tricky because of the difficulty of access under the controller board).

Once the two boards are built and after having taken the trouble to check your work, you'll be able to mount the controller board piggy-back onto the LED board, taking care to leave a certain distance between them so as to ensure a little air circulation (confined). To do this, all you need do is to slip the leads of the 3 W resistors fitted to the LED board into the corresponding holes all round the edge of the controller board. This operation requires a certain dexterity; you can insert the leads of the first row of resistors, then angle the board slightly so as to insert the leads of the next resistors, cut 2 or 3 mm shorter, and so on. Once all the resistors are in place, you can solder them and trim the leads off.

071037 - 11
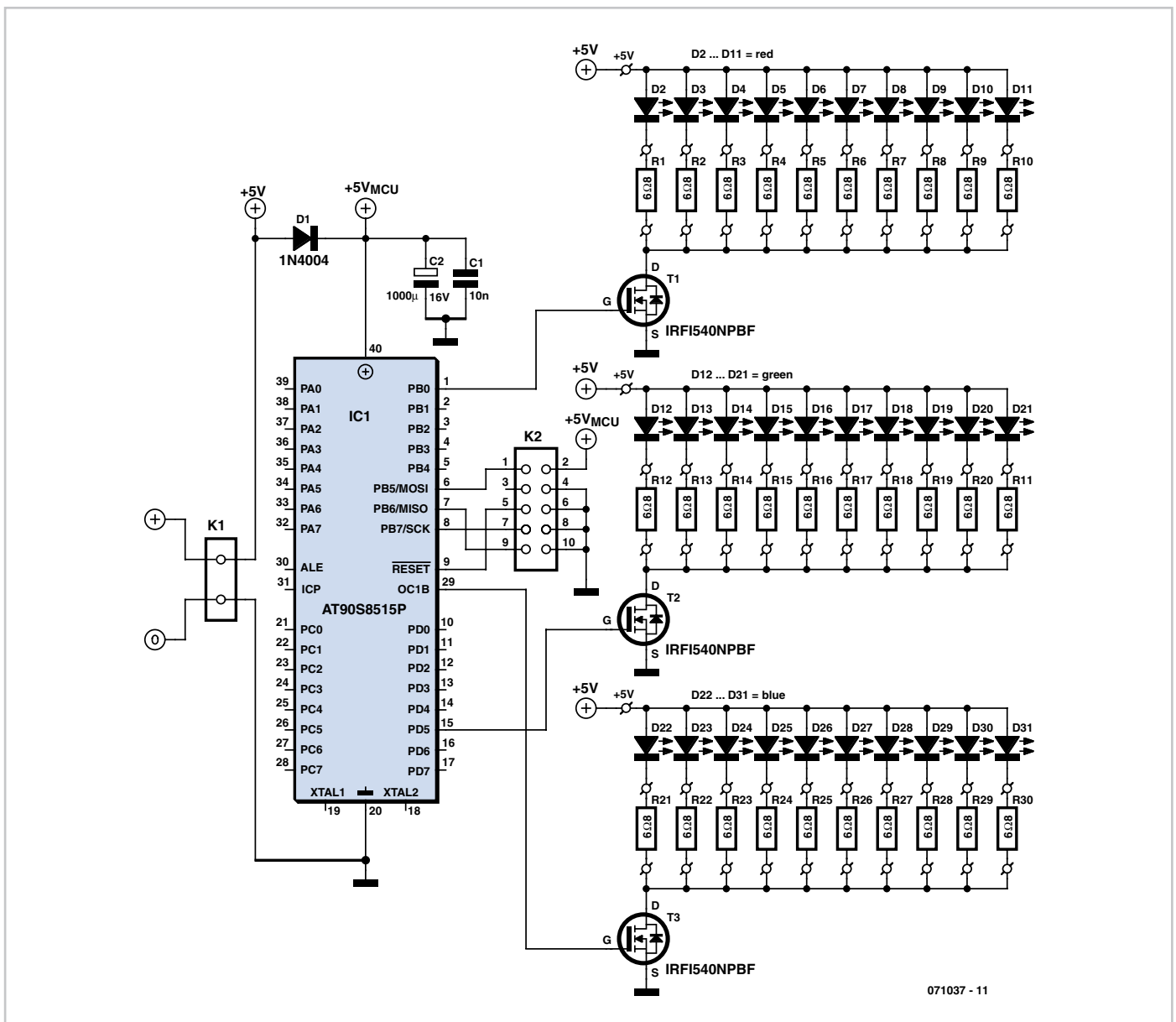
Now let's move on to the PC PSU module, which needs a little 'check-up' – in fact, it needs a slight modification: its green lead (signal: ps_on) must be connected to ground to enable the power supply to start up. Keep only all the black leads (ground) and all the red leads (+5 V) — the other output wires/leads can all be cut off.

The available power supply allowing, it's worth increasing the 5 V level up to 5.6 V by adjusting the potentiometer in the regulator circuit – this will increase the brightness of the LEDs a little bit. If the voltage is increased in this way, the microcontroller supply is brought back down to 5 V by the use of series diode D1 in the microcontroller supply line. Clearly, if the voltage is not adjusted, D1 should be omitted and a wire link fitted in its place.

This done, the 5 V lines from the PC PSU can be connected to the controller board. It is fitted with a connector, K1, for this purpose, in the form of a pair of pins. Take care to correctly identify the positive (+, closest to the silk-screened legend K1 and the microcontroller) and negative poles (–, the other pin). The three points marked '+5V' should have already been connected to the matching points on the LED board when the two boards were connected together.

Now all that remains, after checking the quality of your work one last time, is to try it out for the first time. Whatever you fancy, don't look straight at the front side of the LED board (to see if all the LEDs are working!). It should be obvious if it's working OK, the light will gradually change colour. But don't expect to be able to see all 16 million different shades ;-).

Installation
The spotlight should be fitted into a position provided for it in the swimming pool, either in place of a standard spot, or, as the author did, in place of the return flow of a swim-jet system. A sheet of Perspex® fastened using nylon bolts with a silicone seal will ensure it is nice and watertight. A sheet of 'White Frost' – a type of diffusing filter used in video – is fitted behind the plastic window for better diffusion of the light from the LEDs. The PSU module is fitted well out of harm's way in the pool pump space, connected to the piggy-backed boards via an extension of a few metres. To avoid excessive volts drop, this extension should use the thickest cable practical.

Software
The software written for the microcontroller to execute is very simple. It includes

(artwork reproduced at 90% of actual size)
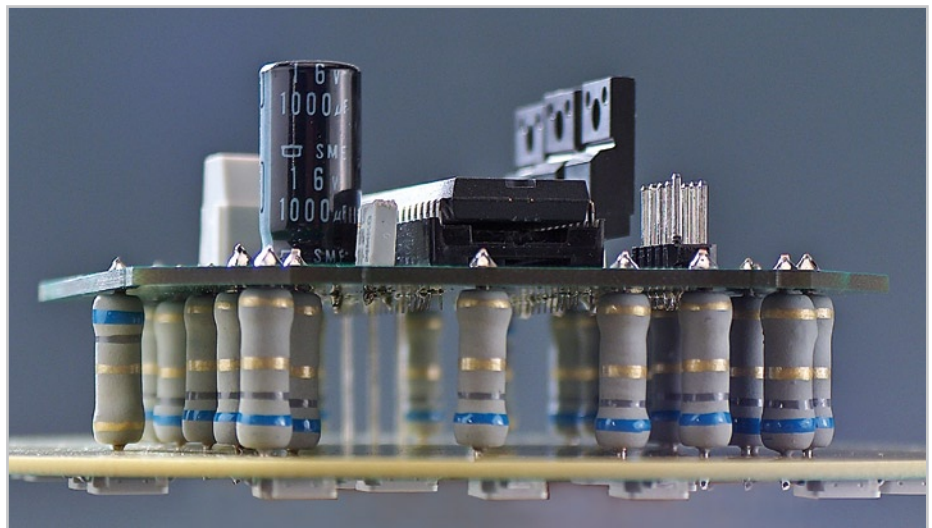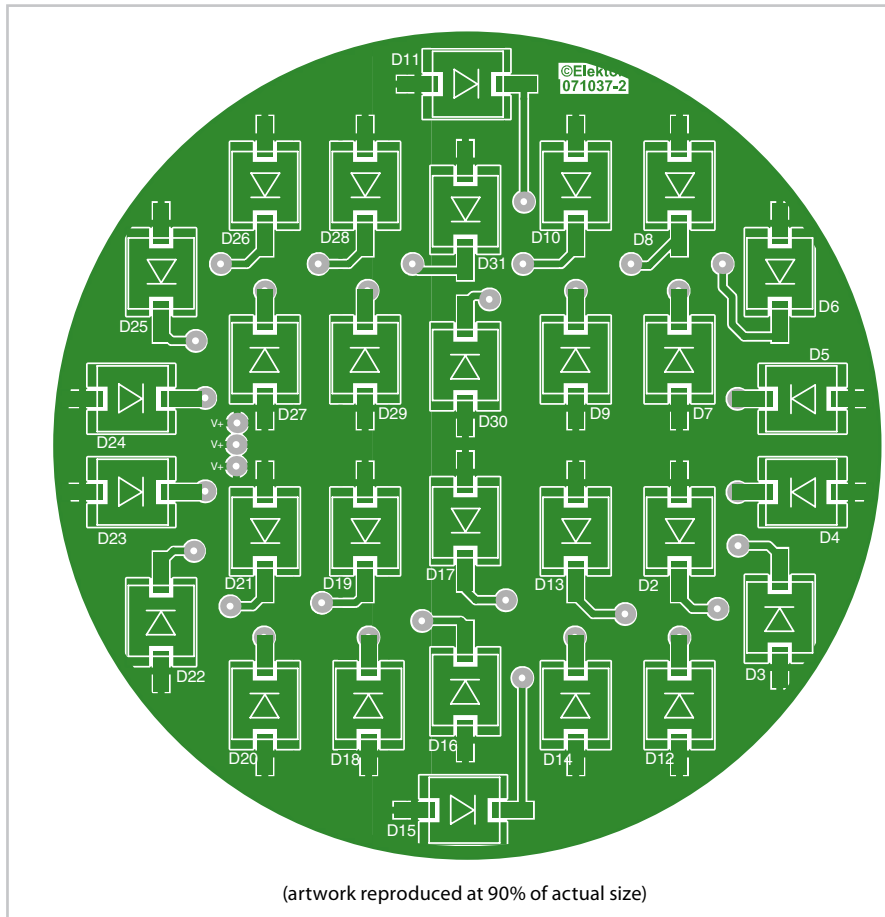
COMPONENTS LIST

Resistors
R1-R30 = 6Ω8/3 W

Capacitors
C1 = 10nF
C2 = 1000 µF 16V radial

Semiconductors
D1 = 1N4004
LED1 - LED10 = Golden Dragon blue LB-W5KM-EZGY-35 from OSRAM
LED11 - LED20 = Golden Dragon green LT-W5KM-HZKX-25 from OSRAM
LED21 - LED30 = Golden Dragon red LR-W5KM-HXJX-1 from OSRAM
T1 à T3 = IRFI540NPBF, isolated
IC1 = AT90S8515P, Atmel, programmed with hex file from archive 071037-11.

Miscellaneous
K1 = 2 solder pins
K2 = 10-way DIL (2x5) pinheader
Heatsink for the 3 transistors (optional)
PC power supply
PCBs, ref 071037-1 (controller) and 071037-2 (LED) available from www.thepcbshop.com
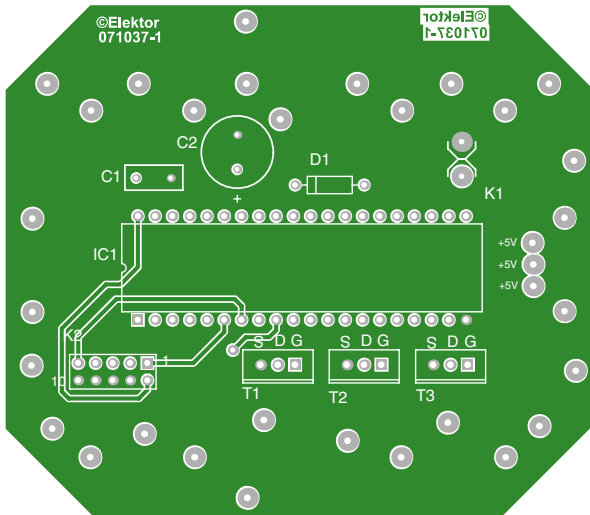
(artwork reproduced at 90% of actual size)

several subroutines whose function is to light or extinguish a colour instantaneously, and light or extinguish a colour in progressive mode. The primary loop calls these subroutines to create the effects. Each PWM (pulsewidth modulation) receives a value between 00 and FF that determines the mark/space ratio of the signal driving the bases of the transistors. The first part of this loop makes the spot change gradually from one colour to another by combining the three primary colours. The second part, much more dynamic, comprises coloured flashes that appear faster and faster until you get a near-stroboscopic effect.

Results

As shown in the photos, at night the result is impressive. The cat seems to likes it a lot, too, though the wavelength of the red light is soon attenuated as it travels through the water.

(071037-I)

Web Links

[1] AT90S8515P datasheet
www.atmel.com/dyn/resources/prod_documents/DOC0841.PDF

Downloads

The artwork for the two PCBs (071037-1 and 071037-2) can be downloaded from the Elektor website at www.elektor.com.

The source code and .hex files for this project (071037-11.zip) are also available from www.elektor.com

Flowcode for Garden Lighting

Jan Middel

Flowcode is well known from the many 'E-blocks' projects that have been published by *Elektor* over the last few years. This year's Summer Circuits also has a project that is programmed using Flowcode. The circuit presented here uses a microcontroller programmed with Flowcode to turn garden lights on and off at user-definable times.

At the hart of the circuit is a PIC16F88 microcontroller. It uses a 2 line by 16 character display to show the settings. These can be adjusted using a set of three push buttons. Potentiometer P1 is used to adjust the contrast of the display. Output RA3 of the PIC is used to drive transistor T1, which in turn drives a relay that turns the lights on and off.

The supply voltage is stabilised using a standard 7805 voltage regulator IC. S1 is the reset switch, which is connected to the MCLR input of the PIC. MCLR should be

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'high' during normal operation (and 'low' for a reset). Hence this input has been connected to the positive supply voltage via pull-up resistor R1.

A program has been written in Flowcode that activates the relay when the following conditions apply:

- when it is later than 16:00;
- when the amount of light reaching the LDR is less than an adjustable threshold;
- during the morning between seven and eight o'clock;
- at night the relay is turned off at 23:00 (except on Friday, Saturday or Sunday, when the lights stay on one hour longer). During the day the display shows at what time the garden lights were last turned on.

The following procedure should be used to set the time: press the Reset switch; the program then shows a welcome message. Next, press the Enter switch. Use the Up and Down switches to set the correct value for the hours. Press the Enter switch
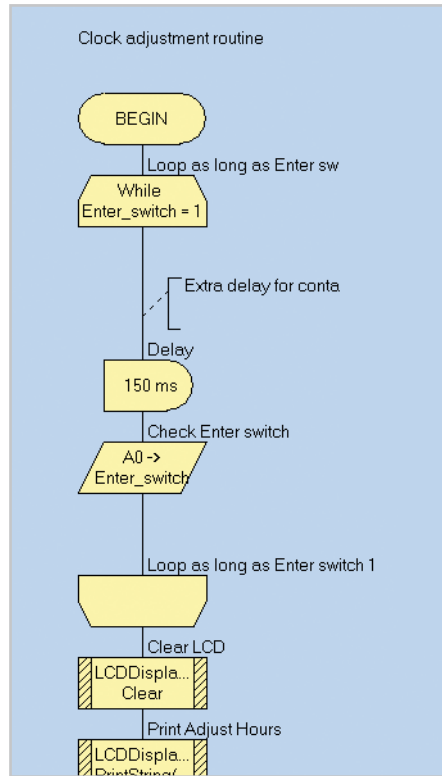
to set the minutes (in the same way as for the hours). After pressing Enter again, you are asked for a value for the light threshold. This value is compared with the amount of light falling on the LDR. When the value of the LDR becomes less than the threshold the lights come on.

Another press of the Enter switch takes you to the day-of-week setting. This determines the days when the light stays on for longer at night. A final press of the Enter switch then starts the clock.

It is of course possible to modify the software in certain places. You could for example change the time at which the lights come on in the morning. This function could even be removed completely if you have no need for it.

(080113-I)

Downloads

The Flowcode (.fcf) file for this project, 080113-11.zip, is available on the Elektor website as a free download, as is the layout for the printed circuit board (080113-1.zip).

The Gentle Touch

Rainer Reusch

Consumer appliances these days hardly ever have a proper mains switch. Instead, appliances are turned on and off at the touch of a button on the remote control, just like any other function. This circuit shows how a device (as long as it does not draw too high a current) can be switched on and off using a pushbutton.

The approach requires that a microcontroller is already available in the circuit, and a spare input port pin and a spare output port pin are required, along with a little software.

When power is applied T1 initially remains turned off. When the button is pressed the gate of T1 is taken to ground and the p-channel power MOSFET conducts. The microcontroller circuit is now supplied with power. Within a short period the microcontroller must take output PB1 high. This turns on n-channel MOSFET T1 which in turn keeps T1 turned on after the pushbutton is released.
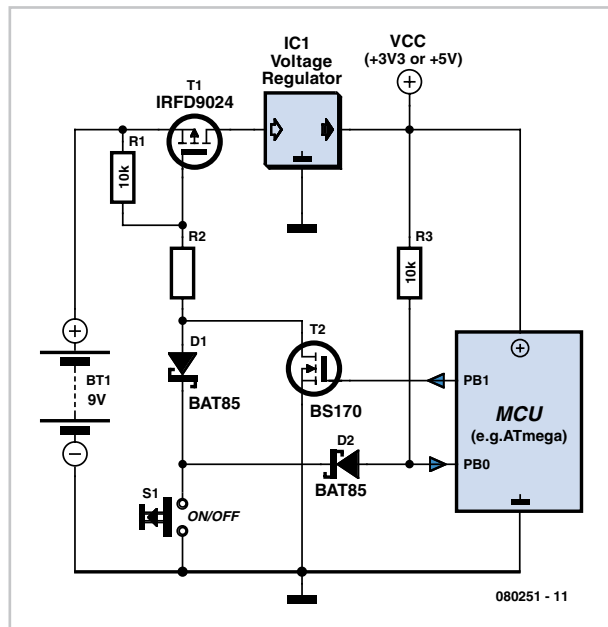
Now the microcontroller must poll the state of the pushbutton on its input port (PB0) at regular intervals. Immediately after switch-on it will detect that the button is pressed (a low level on the input port pin), and it must wait for the button

to be released. When the button is next pressed the device must switch itself off: to do this the firmware running in the microcontroller must set the output port pin to a low level. When the button is subsequently released T1 will now turn off and the supply voltage will be removed from the circuit.

The circuit itself draws no current in the off state, and for (rechargeable) battery-powered appliances it is therefore best to put the switch before the voltage regulator. For mains-powered devices the switch can also be fitted before the voltage regulator (after the rectifier and smoothing capacitor). Since there is no mains switch there will still be a small standby current draw in this case due to the transformer. Be careful not to exceed the maximum gate-source voltage specification for T1: the IRFD9024 device suggested can withstand up to 20 V. At lower voltages R2 can be replaced by a wire link; otherwise suitable values for the voltage divider formed by R1 and R2 must be selected.

The author has set up a small website for this project at http://reweb.fh-weingarten.de/elektor, which gives source code examples (which include dealing with pushbutton contact bounce) for AVR microcontrollers suitable for use with AVR Studio and GNU C. Downloads are also available at http://www.elektor.com.

High-intensity LED Warning Flasher

Jose Luis Basterra

This circuit was designed as a warning flasher to alert road users to dangerous situations in the dark. Alternatively, it can act as a bicycle light (subject to traffic regulations and legislation). White LEDs only are recommended if the circuit is used as a bicycle front light (i.e. for road illumination) and red LEDs only when used as a tail light.

During the day, the two 1.6-V solar cells charge the two AA batteries. In darkness, the solar cell voltage disappears and the batteries automatically power the circuit. The flash frequency is about one per second and the LED on-time is about 330 ms. The duty cycle should enable the batteries to power the circuit over night.

The circuit is composed of three parts. Under normal daylight conditions the batteries are charged through diode D4. In darkness, pnp transistor T1 is switched on, supplying battery current to the second part, a low-frequency oscillator comprising T2 and T3.

The third part is the LED driver around T4. It conducts and switches on the LEDs D1-D2-D3 when the collector voltage of T3 swings high. Two LEDs (D1, D2) are 20,000-30,000 mcd high-brightness yellow types
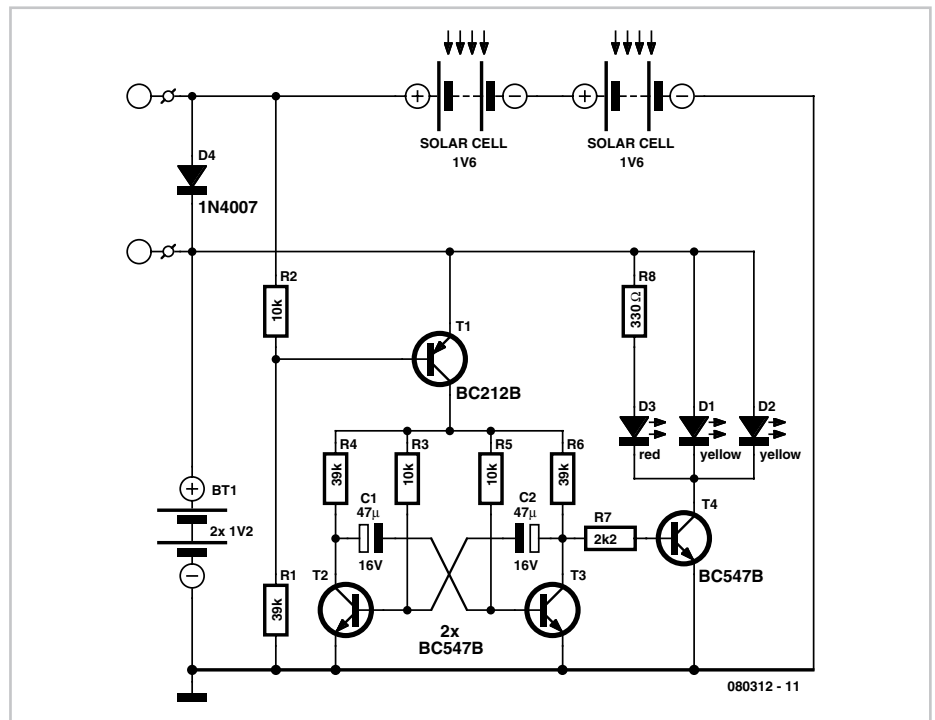
and one (D3) is a normal 3-mm red LED for control purposes. Of course it is possible to increase the number of LEDs to obtain higher brightness. However you will run into limitations regarding the maximum collector current of transistor T4. For really high power applications a MOSFET transistor is suggested instead of the common or garden BC547B.

Stroboscope with Trigger Input

Bernd Oehlerking

The Conrad Electronics company has a light flash stroboscope kit in its product line (number 580406) which can be easily expanded with an electrically isolated trigger input.

Figure 1 shows the original schematic for the stroboscope. The neon lamp shown in the circuit (and which is used to provide a regular triggering of the flash tube) is removed and the additional circuit shown

in Figure 2 is connected to the points labelled 'A', 'B' and 'C'. In this way a flash circuit is created that can be activated with an external trigger signal.

The thyristor on the stroboscope PCB (a C106D from ON Semiconductor) requires only 400 μA to be triggered. Via voltage divider R1-R2-R3, diode D1 and electrolytic capacitor C1, a DC voltage of about 8 V is generated from the incoming mains voltage and, with the values shown, can deliver a current of about 1 mA. This voltage is used to supply the trigger pulse (in practice the duration is about 100 μs) via the transistor in the optocoupler and voltage divider R4/R5.

The trigger signal for the LED in the optocoupler is presented via C2/R6 and R7. Diode D2 is connected in anti-parallel with the LED in the optocoupler to protect this LED from an external trigger signal with the wrong polarity. The differential network at the input (C2/R7) ensures that even if there is a long duration input pulse there

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is nevertheless only a short pulse sent to the gate. R6 is necessary for the periodic discharge of C2. A standard 5 V digital signal is sufficient for driving this trigger input.

With this expansion circuit it is possible to reach a repetition frequency of more than 20 Hz. Above this frequency the flash tube starts to flash erratically.

The optocoupler used is a CNY65, which easily provides class II isolation (generous space between the connections to the LED on the one side and the transistor on the other side).

Please note: this circuit operates at high voltages that can be lethal. Even after the mains voltage is removed there may still be dangerously high voltages present across the electrolytic capacitors in the circuit!

(080367-I)

Remote Control Mains Switch

Jaap van der Graaff

As the only electronics engineer in my family and circle of friends, it is sometimes not possible to evade an appeal for help. This time the request came from a friendly elderly lady in a retirement home. In her room the light switch by the door and the pull cord above the bed operate the light fitting on the ceiling in the middle of the room. However, she would prefer that her standing lamp was operated by these switches instead, since she does not actually have a light fitting mounted on the ceiling. This standing lamp has an on/off switch in the power cord and is plugged into a power point. However, it stands rather far from the bed so that she always has to find her way in the dark. A wireless operated power point is not really a consideration, because it is just a matter of time before the remote is lost. Or maybe not?

080252 - 11

Behold a feasible circuit. Buy a wireless power point and an enclosure that is big enough for the remote control and a small

piece of prototyping board. On the prototyping board build the circuit according to the accompanying schematic and (carefully) open the remote control and solder wires to the push buttons for 'on' and 'off'. Measure if these are polarised and if that is the case connect them to the 4N25 optocouplers as shown in the schematic, where pin 5 has a higher voltage than pin 4.

The operation is as follows. The lady operates the pull cord or light switch to turn the light on. This causes the mains volt-age to be applied to the transformer. The relay is activated which charges C1. While C1 charges, a small current flows through optocoupler 1. The result is that the 'on' button on the remote control is pressed. The remote control switches the corresponding power point on and to which the standing lamp is connected. The standing lamp will therefore now turn on. Capacitor C2 is charged at the same time. If the lady pulls the cord again, or if she operates the switch near the door, the relay will de-ener-gise and C2 discharges across optocoupler #2. This operates the 'off' contact of the remote control and the light goes out.

The remote control continuous to operate from its normal battery and the white enclosure is attached to the ceiling in place of the light fitting. Diode D1 ensures that C1 is discharged when the relay de-energises. D2 ensures that C2 cannot discharge across the relay, but only across optocoupler 2.

(080252-I)

Tent Alarm

Stefan Hoffmann

Although this alarm is designed to protect valuables left in a tent, it can also be used as a baggage alarm (either on or in one's bags) and in similar situations.

The tent alarm can be triggered by many different sensors. One is a current loop, connected to pin PB4 of an ATtiny13 microcontroller: this could be a thin wire which would be broken by a prospective pilferer caught off his guard. Alternatively, it can be a reed switch contact normally held closed by a magnet, arranged so that the budding burglar will accidentally move the magnet and thus open the contact. This could be used to protect a door or a zip fastener securing a tent.

Another sensor connected to PB4 is an LDR (light dependent resistor). If the LDR is left in a dark place (such as under a sleeping bag) the thief will trigger the alarm if he moves the bag to expose the sensor to light. The resistance of the LDR is about 100 kΩ in the dark and just a few ohms in the light. If only the light sensor is to be used, the alarm wire (or reed contact) socket can be shorted using a jumper. If the LDR is not to be used, it can either be (temporarily) taped over to exclude light from it or (more permanently) replaced by a 100 kΩ resistor.

A third sensor which can trigger the alarm is a vibration detector (S6), which is wired in series with a tilt sensor. The tilt sensor allows the vibration sensor to be disabled when the alarm unit is left upside-down. When the tilt sensor contacts are open, PB1 cannot be pulled low and so no alarm can be triggered.

The unit also features a number of push-buttons and switches connected to PB2.

080135 - 11

S5 = vibration sensor
S6 = tilt switch
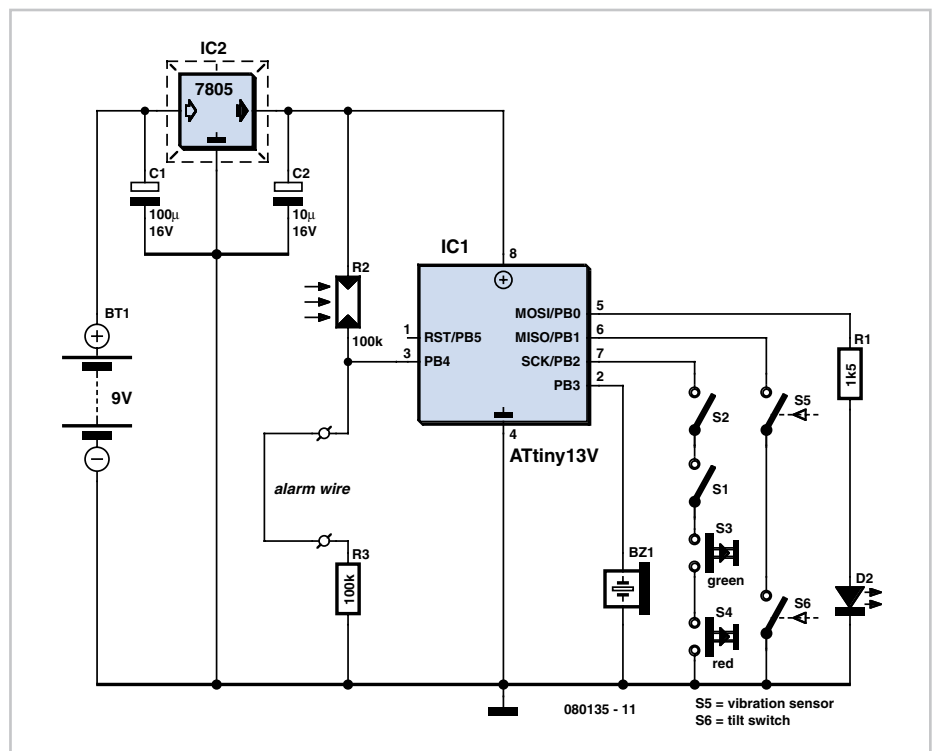
The arrangement and labelling of these buttons and switches is described below. On the left of the device lies switch S1 with the (deliberately misleading) legend 'Power on/off'. Of course, this does not turn the alarm on and off. On the right of the device is switch S2 with the legend 'Speaker on/off', which, naturally, does nothing of the sort. As you have probably already guessed, the red and green buttons also have nothing to do with arming or disarming the alarm.

These decoys should be enough to annoy and delay all but the most resourceful of robbers. Naturally, once the alarm has been triggered by uncovering the LDR, it will not turn off again if the LDR is then covered.

The only way to disable the alarm is to set S1 and S2 in the correct positions (namely, 'Power on' and 'Speaker on') and hold down the two buttons simultaneously for five seconds. More complicated deactivation procedures can be programmed into the software, in case you are worried that some light-fingered *Elektor* reader (not that such a person exists) will be able to steal your valuables after having seen this article.

The circuit requires a supply voltage of between 3.6 V and 5 V. In the circuit diagram we show a power supply made using a 9 V battery and a 5 V voltage regulator. The ATtiny13 microcontroller belongs

to Atmel's AVR family, and can be programmed using BASCOM. Source and object code files, including fuse settings, are available in a ZIP archive that is available for free download from the *Elektor* website. The source code can be modified to suit your own application and then recompiled using the free version of BASCOM. The software arranges matters so that the processor enters sleep or power-down mode when the alarm is correctly deactivated; there is no other way to turn

the device off. To wake the device up the switches must be set correctly (both to 'on') and the unit shaken briefly. The LED blinks twice to confirm that the device has woken up; after a brief delay of approximately three seconds the alarm is armed. This state is indicated by three flashes of the LED. While the alarm remains in the armed state the LED blinks briefly once every few seconds.

When the alarm is triggered the red LED

lights immediately. If it is not disarmed, the alarm sounds after a short pause.

To disarm the unit, both switches again need to be in the 'on' position as described above and both buttons must be pressed. After a double flash, whether the LED is on or off indicates whether the buttons must then be pressed again or not.

(stefankhoffmann@yahoo.de) (080135-I)

Gratis Symmetrical Opamp Supply Voltages

Many ways to obtain a set of symmetrical supply voltages for operational amplifiers and comparators from a single +5-V supply voltage have been described already. The simplest option (including with regard to component availability and price) is to use a MAX232, which is available in the 16-pin DIP package for less than 30 p (50 eurocents).

In nearly all microcontroller circuits with an RS232 port, this IC is already present anyway to provide level conversion between TTl signals (5 V) and RS232 signals (nominally ±12 V), so you can obtain a set of symmetric supply voltages for opamps almost free of charge.

It's not even necessary to add any circuitry around the IC. **Figure 1** shows how a MAX232 is typically wired in a microcontroller circuit**.** The symmetrical voltages (at around ±9 V) generated from the +5-V supply voltage can be taken from pin 2 (V_{DD}; +9 V) and pin 6 (V_{EE}, −9 V) of the IC. As you can see from **Figure** 2, the no-load voltage is nearly 10 V and you can draw up to 5 mA at 9 V, which is enough for most standard opamps and plenty for low-power opamps.

The MAX232 has two charge pumps, each of which has two external capacitors for voltage doubling. These are 10-µF electrolytic capacitors in Figure 1, which yields a somewhat stabler output voltage than the standard circuit with 1 µF as shown in Figure 2. The charge pumps of the MAX232 are operated at an oscillator frequency of around 50 kHz, so the amount of ripple on the output voltage is quite small (typically less than 10 mV with a 2-mA load).
This means that in most cases you can

080498 - 11

OUTPUT VOLTAGE vs. LOAD CURRENT

080498 - 13
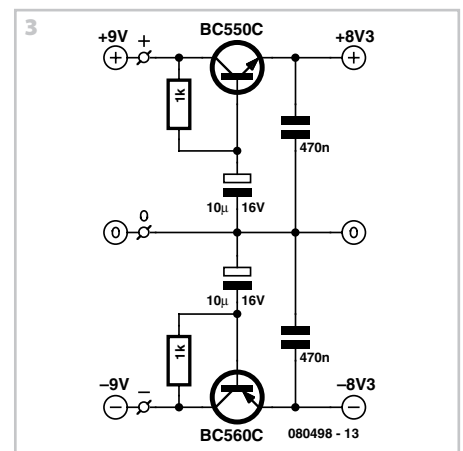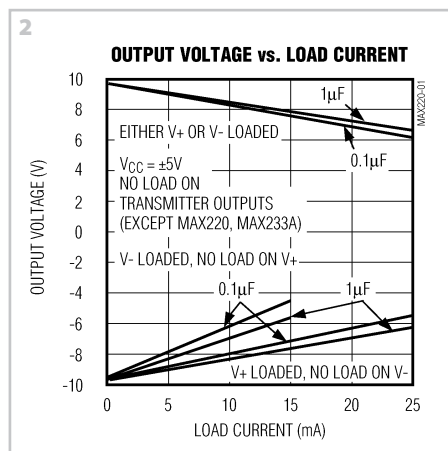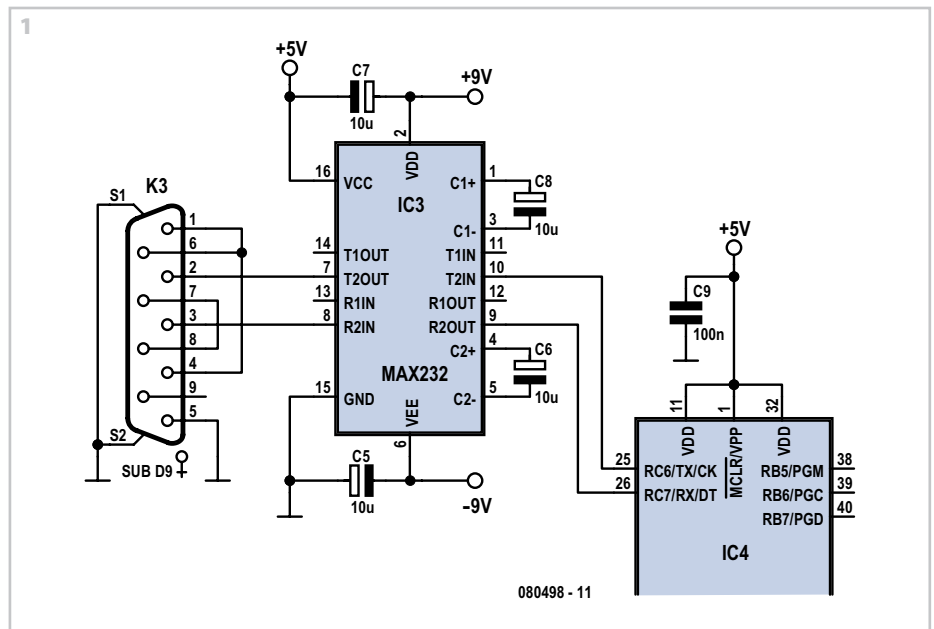
manage without any additional filtering of the output voltage. In sensitive applications, such as amplification of small audio or measurement signals by one or more opamps, it's a good ideal to use a small

gyrator circuit for additional suppression of the residual 50-kHz signal. **Figure 3** is an example of such a circuit that has been proven frequently in practice. Of course, you can use other types of complimentary

small-signal silicon transistors, such as the BC547 (NPN) and BC577 (PNP), in place of the BC550 (NPN) and BC560 (PNP) shown on the schematic. Transistors in the current gain class 'B' (such as the BC547B and BC557B) are also suitable, and the values of the capacitors between the bases of the transistors and ground can also be increased (e.g. 100 µF) or decreased (e.g. 1 µF). The voltage drop across the gyrator circuit is only around 0.7 V.

<div align="right">(080498-1)</div>

Simple Audio Power Meter

Michiel Ter Burg

This simple circuit indicates the amount of power that goes to a loudspeaker. The dual-colour LED shows green at an applied power level of about 1 watt. At 1.5 watts it glows orange and above 3 watts it is bright red.

The circuit is connected in parallel with the loudspeaker connections and is powered from the audio signal. The additional load that this represents is 470 Ohm (R1//R3) will not be a problem for any amplifier.

During the positive half cycle of the output signal the green LED in the dual-colour LED will be turned on, provided the voltage is sufficiently high. At higher output voltages, T1 (depending on the voltage divider R2/R1) will begin to conduct and the green LED will go out.

080506 - 11
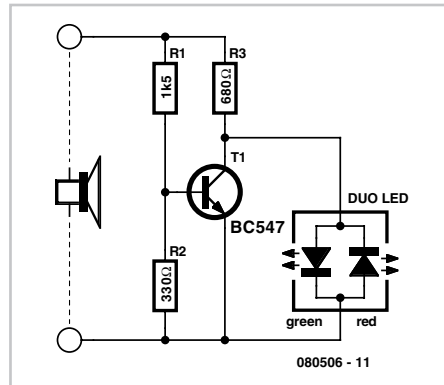
During the negative half cycle the red LED is driven via R3 and will turn on when the voltage is high enough. In the transition region (where T1 conducts more and more and 'throttles' the green LED as a result) the combination of red/green gives the orange colour of the dual-LED.

By choosing appropriate values for the resistors the power levels can be adjusted to suit. The values selected here are for typical living room use. You will be surprised at how loud you have to turn your amplifier up before you get the LEDs to go!

The resistors can be 0.25 W types, provided the amplifier does not deliver more than 40 W continuously. Above this power the transistor will not be that happy either, so watch out for that too. Because T1 is used in saturation, the gain (Hfe) is not at all important and any similar type can be used. The power levels mentioned are valid for 4-Ohm speakers. For 8-Ohm speakers all the resistor values have to be divided by two.

<div align="right">(080506-I)</div>

Mini High-voltage Generator

B. Broussas

Here's a project that could be useful this summer on the beach, to stop anyone touching your things left on your beach towel while you've gone swimming; you might equally well use it at the office or workshop when you go back to work.

In a very small space, and powered by simple primary cells or rechargeable batteries, the proposed circuit generates a low-energy, high voltage of the order of around 200 to 400 V, harmless to humans, of course, but still able to give a quite nasty 'poke' to anyone who touches it.

Quite apart from this practical aspect, this project will also prove instructional for younger hobbyists, enabling them to discover a circuit that all the 'oldies' who've worked in radio, and having enjoyed valve technology in particular, are bound to be familiar with.

080229 - 11
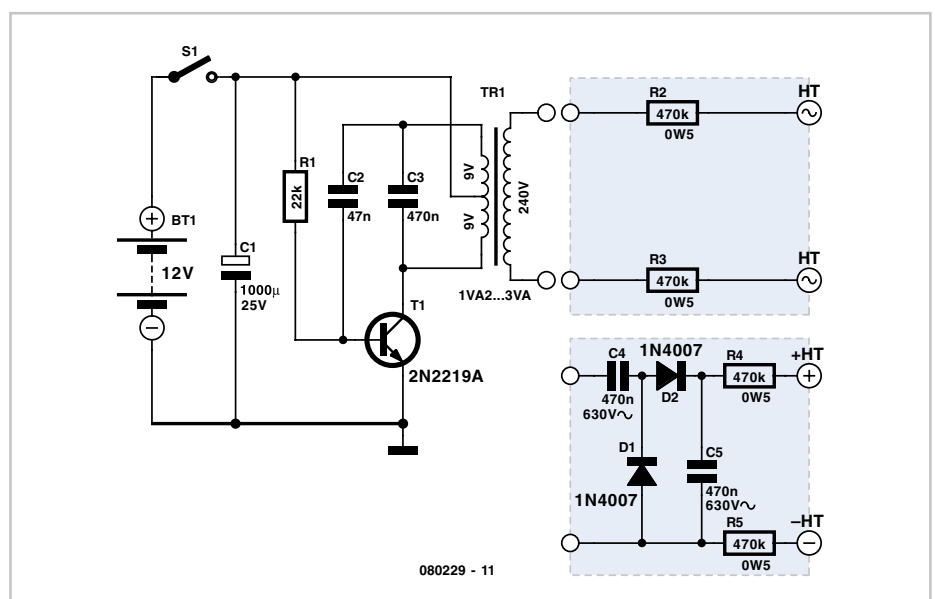
As the circuit diagram shows, the project is extremely simple, as it contains only a

single active element, and then it's only a fairly ordinary transistor. As shown here, it operates as a low-frequency oscillator, making it possible to convert the battery's DC voltage into an AC voltage that can be stepped up via the transformer.

Using a centre-tapped transformer as here makes it possible to build a 'Hartley' oscillator around transistor T1, which as we have indicated above was used a great deal in radio in that distant era when valves reigned supreme and these was no sign of silicon taking over and turning most electronics into 'solid state'. The 'Hartley' is one of a number of L-C oscillator designs that made it to eternal fame and was named after its invertor, Ralph V.L Hartley (1888-1970).

For such an oscillator to work and produce a proper sinewave output, the position of the intermediate tap on the winding used had to be carefully chosen to ensure the proper step-down (voltage reduction) ratio. Here the step-down is obtained inductively.

Here, optimum inductive tapping is not possible since we are using a standard, off-the-shelf transformer. However we're

in luck — as its position in the centre of the winding creates too much feedback, it ensures that the oscillator will always start reliably. However, the excess feedback means that it doesn't generate sinewaves; indeed, far from it. But that's not important for this sort of application, and the transformer copes very well with it.

The output voltage may be used directly, via the two current-limiting resistors R2 an R3, which must not under any circumstances be omitted or modified, as they are what make the circuit safe. You will then get around 200 V peak-to-peak, which is already quite unpleasant to touch. But you can also use a voltage doubler, shown at the bottom right of the figure, which will then produce around 300 V, even more unpleasant to touch. Here too of course, the resistors, now know as R4 and R5, must always be present.

The circuit only consumes around a few tens of mA, regardless of whether it is 'warding off' someone or not! If you have to use it for long periods, we would however recommend powering it from AAA size Ni-MH batteries in groups of ten in a

suitable holder, in order not to ruin you buying dry batteries.

Warning! If you build the version without the voltage doubler and measure the output voltage with your multimeter, you'll see a lower value than stated. This is due to the fact that the waveform is a long way from being a sinewave, and multimeters have trouble interpreting its RMS (root-mean-square) value. However, if you have access to an oscilloscope capable of handling a few hundred volts on its input, you'll be able to see the true values as stated. If you're still not convinced, all you need do is touch the output terminals…

To use this project to protect the handle of your beach bag or your attaché case, for example, all you need do is fix to this two small metallic areas, quite close together, each connected to one output terminal of the circuit. Arrange them in such a way that unwanted hands are bound to touch both of them together; the result is guaranteed! Just take care to avoid getting caught in your own trap when you take your bag to turn the circuit off!

(080229-I)

Programmable Servo Driver

Gilles Clément

The objective of the circuit described in this Summer Circuits article on all things outdoors is to create a servo motor polarity-inverter, to allow the drive to a model servo motor to be inverted with respect to the command from a radio-control receiver channel. Hence this module is inserted between one of the receiver outputs and the servo motor to be driven.

One of the most obvious applications is to reverse the rotation sense of the servo motor output arm. This feature is useful when all the channels of a receiver are used up and you need to control a second servo motor in parallel with the first one (using a 'Y' cable) but inverting the sense of one of them.

Generally, it is also often useful to be able to adjust the end positions of the output arm and the neutral position independently (when the two servo motors aren't

080323 - 11

exactly the same or are mounted differently in the two wings, for example).

The movement of servo motors used in modelling is coded using pulse width modulation (PWM). The width usually varies from 1 ms to 2 ms, with the signal repeating at 20 ms intervals (i.e. 50 Hz).
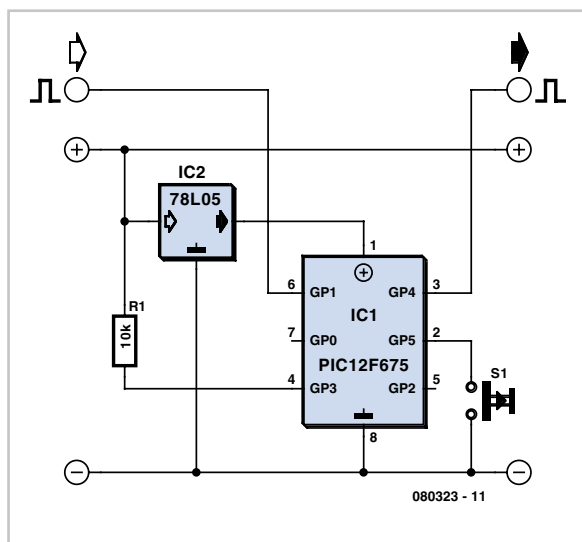
The transmitter controls use potentiometers whose travel defines the pulse width for each channel. These pulses are sent sequentially (as many as there are channels) to the receiver, which decodes them and sends them to the relevant outputs according to the order in which they arrive.

As we've said, the objective here is to invert the travel of a servomotor output arm, while also permitting the whole of the range of movement to be manually shifted so as to adjust the rudder neutral position ('trim').

Let's take a look at the electronics. The microcontroller we've chosen here is the deceptively small 12F675 PIC from Microchip. It's quite extraordinary, a real little eight-legged marvel! Although it is really very small (8-pin DIL), it is capable of doing masses of things.

A 12F675 is in fact the heart of the whole circuit (see circuit diagram).

Of course, for it to work, it needs to have

the required .hex file, extracted from the archive file 080323-11.zip (see Downloads). The microcontroller only needs three additional components (excluding the servomotor extension, the most expensive item in this project): a 5 V regulator (78L05) to provide the supply voltage, a miniature push-button used as a control, and one pull-up resistor.

The electronics will fit onto a piece of prototyping board of 9×6 holes, making it easy to fit into the scale model concerned. Just a word about the calibration of the internal oscillator. The last byte of the 12F675's program memory contains the calibration value for the internal oscillator, which makes it possible to adjust the clock to 4 MHz within ±1%. Right at the start of your operations, you need to go and read this byte (read the memory) and save it as there is a danger of erasing it when you start programming.
One of the most important aspects of this

project is adjusting it (when you are aware of the consequences an error here can have – just try piloting a scale model by reversing the controls!).

Warning: you mustn't touch the transmitter during this stage – i.e. while powering up the receiver – as we are measuring the receiver output signal when the transmitter control is at rest.

We start first of all by confirming the measurement of the input signal, very important in order for the output signal calculation to be correct. Warning: the remark to not touch the transmitter during this stage applies here too, for the same reasons. If the push-button is pressed a second time, the gradual shift of the neutral position starts, then if it is released and immediately pressed again, the movement takes place in the opposite direction. This mode is exited automatically if the push-button hasn't been pressed for 2 seconds. The ser-

vomotor 'flutters' a little to indicate the end of the steps.

One conclusion is called for: it works very well, and it doesn't cost an arm and a leg…

Clemgill@club-internet.fr (080323-I)

Web Links
12F675 datasheet
http://ww1.microchip.com/downloads/en/devicedoc/41190c.pdf

Downloads
The source code and .hex files for this project are available for downloading from the Elektor website at www.elektor.com; archive file 080323-11.zip.

Simple USB AVR-ISP Compatible Programmer

Nand Eeckhout

Modern PCs rarely have a serial or parallel port any more, to the great regret of anyone who experiments with microcontrollers every now and then. In the old days it was very simple to use the parallel port of a standard PC and program just about any type of AVR microcontroller with it. When you want to do that now, you're first obliged to buy a programmer that communicates with the PC via USB, which immediately raises the threshold of getting started with these microcontrollers. The circuit presented here offers a solution to this.

As you can see from the schematic, this is a very simple circuit, built around a cheap, standard AVR microcontroller plus a handful of passive components. You may have already observed that this microcontroller does not have a USB interface and the circuit does not use a USB to serial converter either. The strength of this circuit is found in the firmware. The USB interface has been implemented in software, as we have shown in an earlier article 'AVR drives USB' in the March 2007 issue. The firmware ensures that the circuit is recognised by the PC as a serial port and communicates with
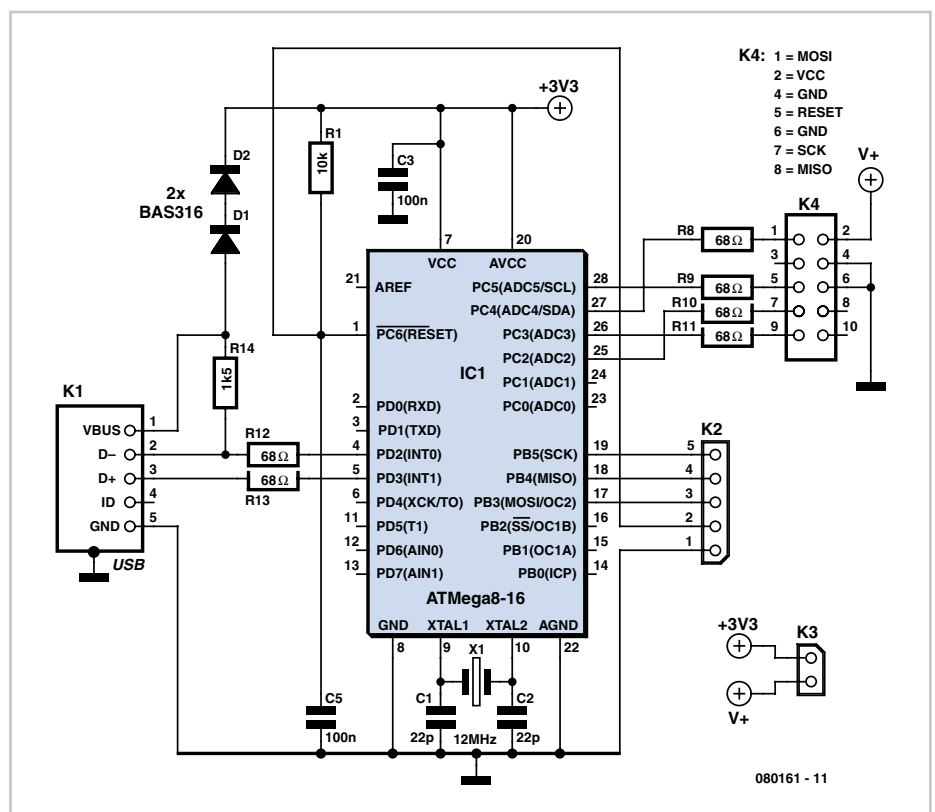
AVR Studio, the standard Atmel development environment, as if it were a 'real' AVR-ISP programmer.

The circuit is easily built on a small piece of prototyping board or even on a breadboard, since the controller is available in

a DIP-28 package. If you are going to program the controller yourself (via connector K2) then make sure that you set the configuration fuses so that the internal oscillator uses the external crystal as the clock source.

Jumper K3 is provided in the event you would like to power the circuit to be programmed from the USB port. We do not recommend that you do this, however, but sometimes there is no other option. K4 is a 10-way box header which has the same standard pinout that Atmel uses everywhere.

123 Game – all MCU-free

Stefan Hoffmann

This electronic game pits a human player against the 'machine'. The opponents use a common 'game token' and take turns moving along a path by one, two or three steps, and the winner is the first one to reach the goal exactly. Incredibly enough, this simple version of the '123' game can be built without a microcontroller, and it's almost impossible to beat.

The electronics for this is built using only diode logic (**Figure 1**). The 'input interface' consists essentially of 30 miniature sockets to which a probe tip can be connected to mark the position of the 'game token'. To make the game more compact, the sockets are arranged in a grid so that the route along the sockets follows a serpentine path (**Figure 2**). The starting position is at the bottom right, and the goal is in the middle of the playing area. The electronics becomes the 'active player' when the button is pressed. The number of steps it wants to move is shown by three LEDs (one, two or three LEDs light up) at the top of the playing area. Naturally, the human player must move the 'game token' for the machine opponent. The winner is the first one to reach the goal exactly.

How can such simple circuitry represent such a formidable opponent? As already mentioned, the path from the start to the goal is formed by 30 sockets. Each socket has an associated ideal next move. There are three possibilities, of course: 1, 2 or 3. As you can see from the schematic diagram, switch S1 closes the circuit (which means the player asks the 'computer' how many steps it

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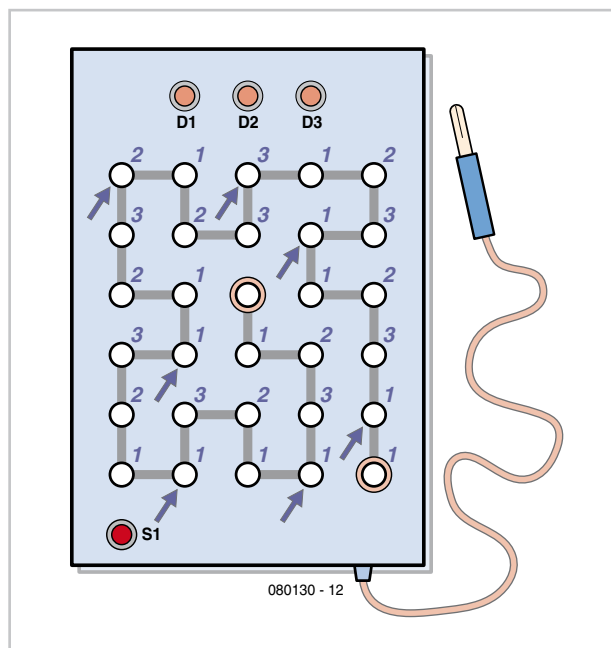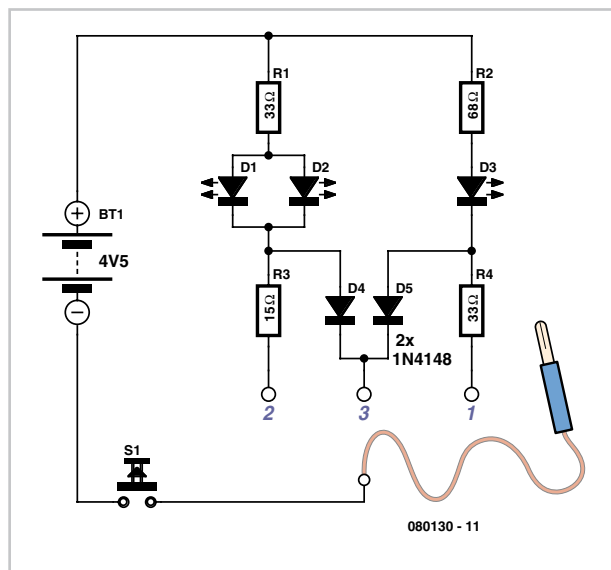
wishes to move) if the probe is touching one of the sockets. All 30 sockets are classified into three types, represented in the schematic diagram by one socket for each type. All sockets belonging to a particular type are simply connected together elec-

trically, which is not shown on the schematic diagram for the sake of clarity.

This is how the LED display works: the player touches the right-hand contact with R4 (only LED D3 lights up), the left-hand contact with R3 (LEDs D1 and D2 light up), or the middle contact with diodes D4 and D5 (all three LEDs light up). The two diodes prevent all three LEDs from lighting up if the player touches the left-hand or right-hand contact.

The key to all this lies in the assignment of the 30 sockets to the three types of logic, which means the three types of ideal next move. Working backward from the goal, no further move is possible when the goal is reached. For this reason, the last socket is not connected to anything. At the socket just before the goal, the 'computer' naturally wants to be exactly one step in front. Consequently, this socket is connected to R4. At the second socket before the goal, the electronics wants to move by two steps. This socket is thus connected to R3. Obviously, three moves before the finish, a three-step is best as it leads to instant victory. Consequently this socket is connected to D4/D5.

The correct response of the 'computer' is shown in **Figure 2** by the number next to each position. As the two opponents take turns playing, the electronics always tries to arrive at a strategically favourable position (marked by the arrows). If the electronics manages to reach one of these positions, it's impossible for the human player to win. This means that the human player can only win by starting first and always making the right move.

Cheap 12 V/230 V Invertor

B. Broussas

Even though today's electrical appliances are increasingly often self-powered, especially the portable ones you carry around when camping or holidaying in summer, you do still sometimes need a source of 230 V AC – and while we're about it, why not at a frequency close to that of the mains?

As long as the power required from such a source remains relatively low – here we've chosen 30 VA – it's very easy to build an invertor with simple, cheap components that many electronics hobbyists may even already have. Though it is possible to build a more powerful circuit, the complexity caused by the very heavy currents to be handled on the low-voltage side leads to circuits that would be out of place in this summer issue. Let's not forget, for example, that just to get a meagre 1 amp at 230 VAC, the battery primary side would have to handle more than 20 ADC!

The circuit duiagram of our project is easy to follow. A classic 555 timer chip, identified as IC1, is configured as an astable multivibrator at a frequency close to 100 Hz, which can be adjusted accurately by means of potentiometer P1. As the mark/space ratio (duty factor) of the 555 output is a long way from being 1:1 (50%), it is used to drive a D-type flip-flop produced using a CMOS type 4013 IC. This produces perfect complementary squarewave signals (i.e. in antiphase) on its Q and $\overline{Q}$ outputs suitable for driving the output power transistors.

As the output current available from the CMOS 4013 is very small, Darlington power transistors are used to arrive at the necessary output current. We have chosen MJ3001s from the now defunct Motorola (only as a semi-conductor manufacturer, of course!) which are cheap and readily available, but any equivalent power Darlington could be used.

These drive a 230 V to 2×9 V centre-tapped transformer used 'backwards' to produce the 230 V output. The presence of the 230 VAC voltage is indicated by a neon light, while a VDR (voltage dependent resistor) type S10K250 or S07K250 clips off the spikes and surges that may appear at the transistor switching points.

The output signal this circuit produces is approximately a squarewave; only approximately, since it is somewhat distorted by passing through the transformer. Fortunately, it is suitable for the majority of electrical devices it is capable of supplying, whether they be light bulbs, small motors, or power supplies for electronic devices.
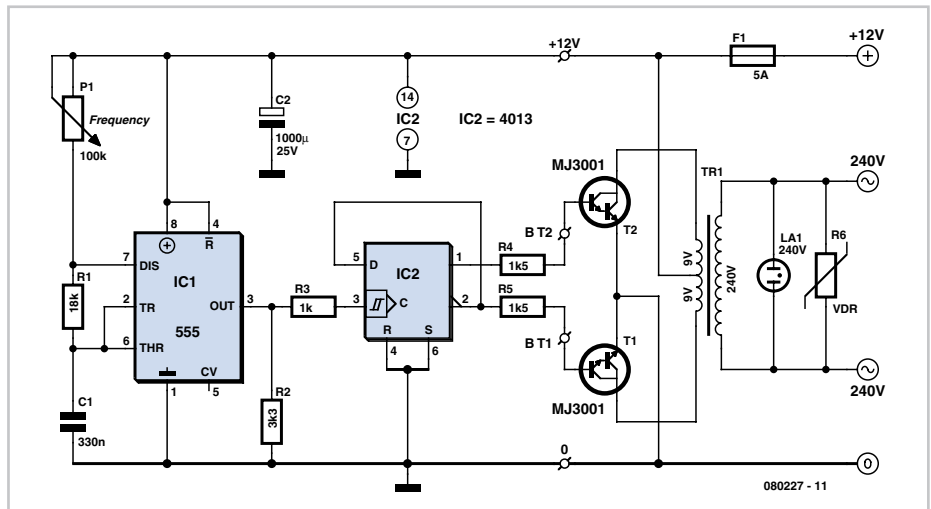
Note that, even though the circuit is intended and designed for powering by a car battery, i.e. from 12 V, the transformer is specified with a 9 V primary. But at full power you need to allow for a voltage drop of around 3 V between the collector and emitter of the power transistors. This relatively high saturation voltage is in fact a 'shortcoming' common to all devices in Darlington configuration, which actually consists of two transistors in one case.

We're suggesting a PCB design to make it easy to construct this project; as the component overlay shows, the PCB only carries the low-power, low-voltage components. The Darlington transistors should be fitted onto a finned anodized aluminium heat-sink using the standard insulating accessories of mica washers and shouldered washers, as their collectors are connected to the metal cans and would otherwise be short-circuited.

An output power of 30 VA implies a current consumption of the order of 3 A from the 12 V battery at the 'primary side'. So the wires connecting the collectors of the MJ3001s [1] T1 and T2 to the transformer primary, the emitters of T1 and T2 to the battery negative terminal, and the battery positive terminal to the transformer primary will need to have a minimum cross-sectional area of 2 mm^2 so as to minimize voltage drop. The transformer can be any 230 V to 2×9 V type, with an E/I iron core
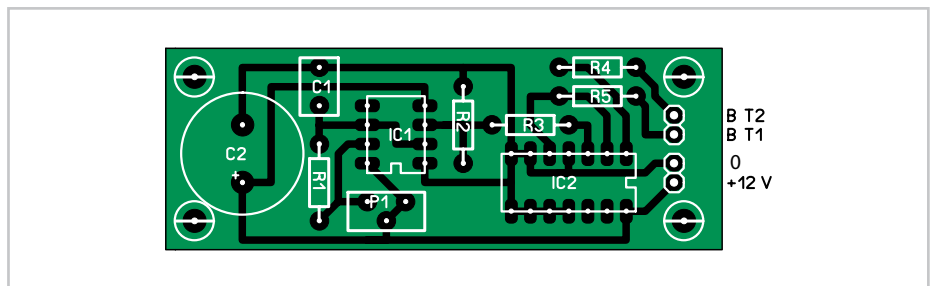
COMPONENTS LIST

Resistors

R1 = 18kΩ
R2 = 3kΩ3
R3 = 1kΩ
R4,R5 = 1kΩ5
R6 = VDR S10K250 (or S07K250)
P1 = 100 kΩ potentiometer

Capacitors

C1 = 330nF

C2 = 1000 µF 25V

Semiconductor

T1,T2 = MJ3001
IC1 = 555
IC2 = 4013

Miscellaneous

LA1 = neon light 230 V
F1 = fuse, 5A
TR1 = mains transformer, 2x9V 40VA (see text)
4 solder pins
PCB, ref. 080227-1 from www.thepsbshop.com

or toroidal, rated at around 40 VA. Properly constructed on the board shown here, the circuit should work at once, the only adjustment being to set the output to a frequency of 50 Hz with P1. You should keep in minds that the frequency stability of the 555 is fairly poor by today's standards, so you shouldn't rely on it to drive your radio-alarm correctly – but is such a device very useful or indeed desirable to have on holiday anyway?

Watch out too for the fact that the output voltage of this invertor is just as dangerous as the mains from your domestic power sockets. So you need to apply just the same safety rules! Also, the project should be enclosed in a sturdy ABS or diecast so no parts can be touched while in operation. The circuit should not be too difficult to adapt to other mains voltages or frequencies, for example 110 V, 115 V or 127 V, 60 Hz. The AC voltage requires a transformer with a different primary voltage (which here becomes the secondary), and the frequency,

some adjusting of P1 and possibly minor changes to the values of timing components R1 and C1 on the 555.

(080227-I)

Web Links

[1] MJ3001
www.st.com/stonline/products/literature/ds/5080.pdf

Downloads

The PCB pattern is available for free download from our website www.elektor.com; file # 0080227-1.zip.

USB <–> RS-232 Cable

output are converted into RS-232 signals on the tiny board described here.

The voltage level adaptor is a MAX3232 from Maxim. This industry-standard part comprises two transmitters and two receivers, ideal for our USB<–>serial convertor, which itself offers the four fundamental signals of an RS-232 standard port, namely TXD (Transmit Data), RTS (Request To Send), RXD (Receive Data) and DTR (Data Terminal
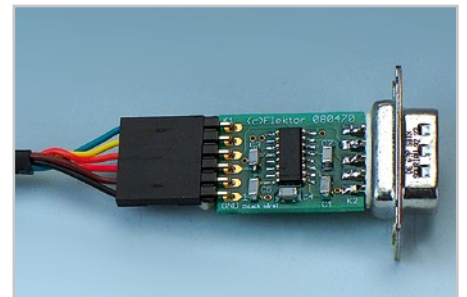
Antoine Authier

This project lets you conveniently connect any computer with USB ports directly to a simple, traditional connector — the 9-pin RS-232 (anyone remembers it?).

It converts the electrical signals from a USB<–>serial TLL convertor to the RS-232 standard. So in a nutshell, it converts a USB port into a standard but basic serial port: only the four basic signals are available.

The USB<–>serial convertor chosen here is the TTL-232R USB to TTL UART cable from FTDI, available as part number 080213-71 and described in the June 2008 issue (see the Elektor website).

The TTL logic signals available on the cable

levels on its logic input and outputs. In theory, it also ought to work correctly with the 3.3 V version of the cable mentioned above, the TTL-232R-3V3 – however, we haven't checked this experimentally in the lab.

Instead of the complete cable, you can use just the TTL-232R-PCB module (or TTL-232R-PCB-3V3 for 3.3 V), currently only the former is available from the Elektor Shop.

The 1206 cases size SMD (surface mount device) components used here make it possible to achieve a compact

Ready).

Charge pumps built into the IC provide the 12 V levels required by the RS-232 standard. This circuit works equally well from 3.3 V as from 5 V supply rails and supports both these

board, while still being easy enough to handle by constructors who may not be very used to this type of component, and who, in building this useful little project, will be able to practice and get an idea

COMPONENTS LIST

Capacitors
C1-C5 = 100nF 25V (SMD 1206)

Semiconductors
IC1 = MAX3232CSE (or -ESE)

Miscellaneous
K1 = 6-way right-angled SIL pinheader
K2 = 9-way cable mount sub-D plug (male)
FTDI TTL-232R cable (5.0 V), Elektor SHOP #
  080213-71
Piece of large diameter heatshrink sleeving
PCB, ref. 080470-I from www.thepcbshop.com
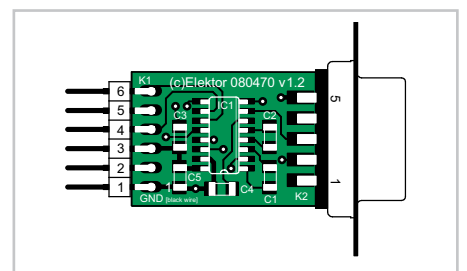
of how nimble-fingered they are before attacking more complex circuits using SMDs.

No surprises in the construction of the project. Start by soldering the IC and the capacitors, then the connectors.

Use a right-angle 0.1-inch SIL pinheader to reduce the pull on the cable. With a straight header, the cable and board would form a cumbersome and inelegant right angle.

The sub-D connector may be cannibalized from an old cable, as long as it's a male one (i.e. a plug, not a socket). Slide the board between the two rows of pins on the connector and solder these directly onto the PCB copper islands provided.

To finish off, you can protect the whole thing by slipping it into a piece of heat-shrink sleeving of suitable diameter.

(080470-I)

Car & Motorcycle Battery Tester

Joseph Zamnit

Going camping nowadays involves taking lots of electronic equipment whether for day to day running or for fun and entertainment. Most of the time a charged lead-acid battery and a power inverter would be used to ensure a smoothly organised holiday where ideally the missus and the children cheerfully use their electric and electronic gear!

With rechargeable lead-acid batteries it's invariably useful — if not essential — to determine whether the power source you're hauling along on your travels is losing capacity and needs to be topped up. The same circuit would also come in handy when going on a car or motorbike trip as it can check the status of a 12 V (car) or a 6 V (motorcycle) battery. Although the circuit draws so little power that it will not noticeably load the battery under test, it should not be left connected permanently.

The circuit employs the familiar LM3914 (IC1) to display the voltage level. The LED readout creates a battery status readout: when the top LED lights, the battery is fully
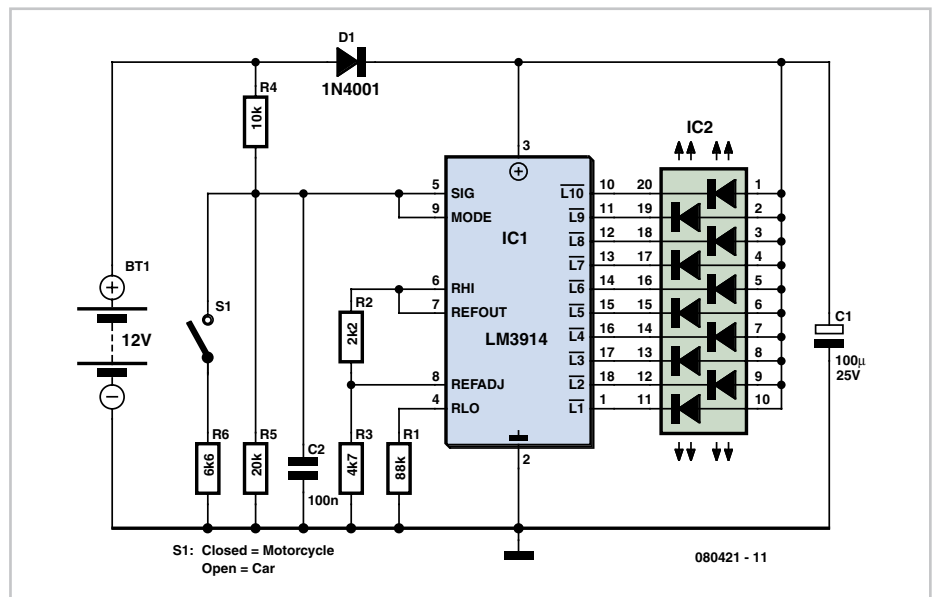
charged. When the bottom LED lights, the battery needs imminent charging!

Switch S1 selects between 12 V and 6 V operation. A series diode, D1, protects the bargraph driver from reverse supply voltage. A colour-coded display with individual

LEDs could be used instead of the common-anode bargraph display for better indication of the state of the battery.

(080421-I)

Mobile Phone Data Cable = Interface Converter

Michael Gaus

Nowadays microcontroller circuits that cannot be connected to a PC are hopelessly old-fashioned. One option is to use one of the many types of ready-made USB to serial interface converters to outfit a microcontroller circuit with a MAX232

level converter. However, in some cases it is not so easy to retrofit a level converter if the circuit is already fitted in an enclosure. An example of this is provided by the various Internet routers that clever users employ for novel purposes (with modified firmware).

If you enjoy plying a soldering iron, you can keep everything simple and inexpensive. This is based on the fact that older-model mobile phones did not have any USB circuitry for connection to a PC. Special cables incorporating an interface converter were (and still are) available for these devices. They even included level conversion from

RS232 to digital logic levels. What could be simpler than to use a data cable of this sort? After all, you can obtain these cables very inexpensively via the Web. Another advantage of these cables is that they supply +5 V from the PC, which can be used to power small circuits. The author has found that a cable with type number KQU08A, which was originally designed for use with Siemens C55 mobile phones, is quite suitable.

The 'remodelling' is very easy in principle: you just cut off the mobile-phone connector and solder a five-way socket header in its place. The photo shows that the author also used a small piece of perforated circuit board for improved mechanical strength. The pin assignments are easy: yellow = +5 V, red = ground, blue = RxD, white = TxD, and green = DCD, although the last signal can be ignored in most cases. You

should always check the wiring scheme just to be sure.

Note that the RxD, TxD and DCD signals are designed for 3.3 V and are active low. If you are driving a circuit with a 5-V supply voltage, no problems will arise if you con-

nect the TxD line of the cable to the RxD input of a 5-V microcontroller, since the MCU will almost always interpret the signal levels correctly. However, you should connect the TxD output of the MCU to the RxD line of the cable via a voltage divider formed by a 1.8-kΩ resistor in series with a 3.3-kΩ resistor. You can also use a 3.3-V Zener diode in place of the 3.3-kΩ resistor. The load on the 5-V line should be kept at 100 mA or less.

Before you start modifying the cable, it's a good idea to connect it to a PC, install the included driver, and see whether a virtual COM port is configured on the PC for the cable. If this is OK, connect TxD and RxD together and check whether your terminal emulator program can properly receive transmitted data (without local echo enabled).

(080321-1)

Intelligent Presence Simulator

C. Tavernier

However effective a domestic alarm system may be, it's invariably better if it never goes off, and the best way to ensure this is to make potential burglars think the premises are occupied. Indeed, unless you own old masters or objects of great value likely to attract 'professional' burglars, it has to be acknowledged that the majority of burglaries are committed by 'petty' thieves who are going to be looking more than anything else for simplicity and will prefer to break into homes whose occupants are away.

Rather than simply not going on holiday – which is also one solution to the problem (!) – we're going to suggest building this intelligent presence simulator which ought to put potential burglars off, even if your home is subjected to close scrutiny.

Like all its counterparts, the proposed circuit turns one or more lights on and off when the ambient light falls, but while many devices are content to generate fixed timings, this one works using randomly variable durations. So while other devices are very soon caught out simply by daily observation (often from a car) because of their too-perfect regularity, this one is much more credible due to the fact that its operating times are irregular.

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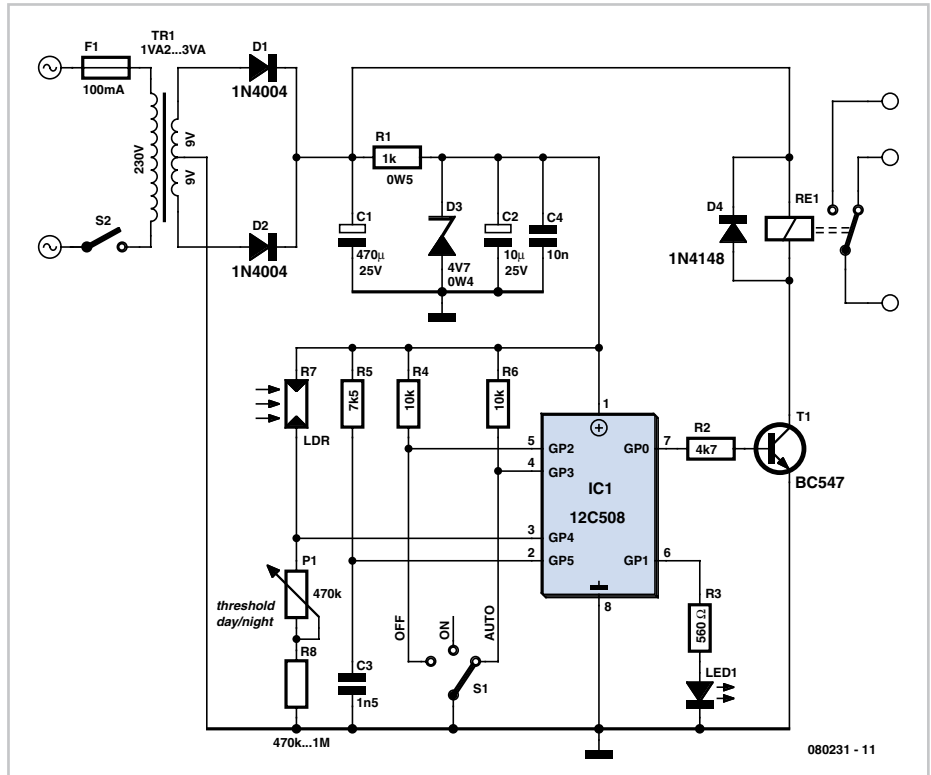
The circuit is very simple, as we have employed a microcontroller – a 'little' 12C508 from Microchip, which is more than adequate for such an application. It is mains powered and uses rudimentary voltage regulation by a zener diode. A relay is

used to control the light(s); though this is less elegant than a triac solution, it does avoid any interference from the mains reaching the microcontroller, for example, during thunderstorms. We mustn't forget this project needs to work very reliably dur-

ing our absence, whatever happens.

The ambient light level is measured by a conventional LDR (light dependent resistor), and the lighting switching threshold is adjustable via P1 to suit the characteristics and positioning of the LDR. Note that input GP4 of the PIC12C508 is not analogue, but its logic switching threshold is very suitable for this kind of use.

The LED connected to GP1 indicates the circuit's operating mode, selected by grounding or not of GP2 or GP3 via override switch S1. So there are three possible states: permanently off, permanently on, and automatic mode, which is the one normally used.

Given the software programmed into the 12C508 ('firmware') and the need to generate very long delays so as to arrive at lighting times or an hour or more, it has been necessary to make the MCU operate at a vastly reduced clock frequency. In that case, a crystal-controlled clock is no longer suitable, so the R-C network R5/C3 is used instead. For sure, such a clock source is less stable than a crystal, but then in an application like this, that may well be what we're after as a degree of randomness is a design target instead of a disadvantage.

Our suggested PCB shown here takes all the components for this project except of course for S1, S2, and the LDR, which will need to be positioned on the front panel of the case in order to sense the ambient light intensity. The PCB has been designed for a Finder relay capable of switching 10 A, which ought to prove adequate for lighting your home, unless you live in a replica of the Palace of Versailles.

The program to be loaded into the 12C508 is available for free download from the Elektor website as file number 080231-11.zip or from the author's own website: www.tavernier-c.com.

On completion of the solder work the circuit should work immediately and can be checked by switching to manual mode. The relay should be released in the 'off' posi-
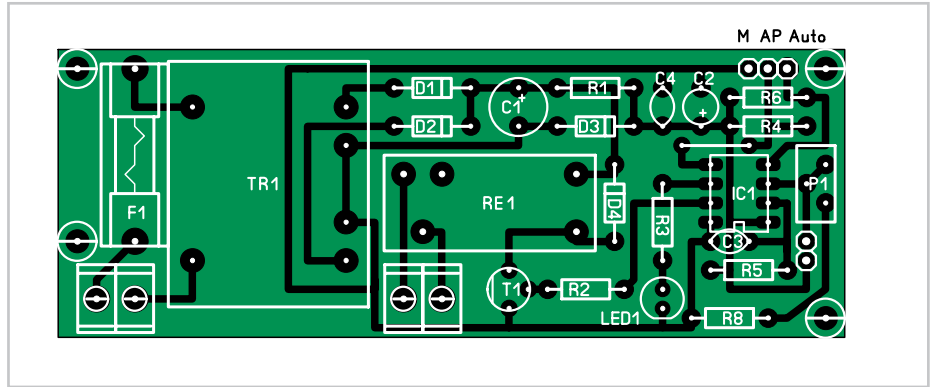
COMPONENTS LIST

Resistors

R1 = 1kΩ 500mW
R2 = 4kΩ7
R3 = 560Ω
R4,R6 = 10kΩ
R5 = 7kΩ5
R 7 = LDR
R8 = 470kΩ to 1 MΩ
P1 = 470 kΩ potentiometer

Capacitors

C1 = 470µF 25V
C2 = 10µF 25V
C3 = 1nF5
C4 = 10nF

Semiconductors

D1,D2 = 1N4004
D3 = diode zener 4V7 400 mW
LED1 = LED, red
D4 = 1N4148
T1 = BC547
IC1 = PIC12C508, programmed, see Downloads

Miscellaneous

RE1 = relay, 10A contact
S1 = 1-pole 3-way rotary switch
F1 = fuse 100 mA
TR1 = Mains transformer 2x9 V, 1.2 -3 VA
4 PCB terminal blocks, 5 mm lead pitch
5 solder pins
PCB, ref. 080231-I from www.thepcbshop.com

tion and energized in the 'on' position. Then all that remains is to adjust the day/night threshold by adjusting potentiometer P1. To do this, you can either use a lot of patience, or else use a voltmeter – digital or analogue, but the latter will need to be electronic so as to be high impedance – connected between GP4 and ground. When the light level below which you want the lighting to be allowed to come on is reached, adjust P1 to read approximately 1.4 V on the voltmeter. If this value cannot be achieved, owing to the characteristics of your LDR, reduce or increase R8 if necessary to achieve it (LDRs are known to have rather wide production tolerances).

Equipped with this inexpensive accessory, your home of course hasn't become an impregnable fortress, but at least it ought to appear less attractive to burglars than houses that are plunged into darkness for long periods of time, especially in the middle of summer.

(www.tavernier-c.com) (080231-I)

Downloads

The PCB layout can be downloaded free from our website www.elektor.com; file # 080231-1.

The source code and .hex files for this project are available free on www.elektor.com; file # 080231-11.zip.

Low-Voltage Step-Down Converter

Steffen Graf

Sometimes you have a situation where you have a 5-V supply voltage but part of the circuit needs a lower supply voltage. A voltage regulator from the Texas Instruments TPS62000 family [1] is a good choice for

this if the current consumption is less than 600 mA.
The essential advantages are:
• small (but still manually solderable) SMD package;
• high operating frequency (750 kHz) => small external inductor;

• integrated power MOSFETs => high efficiency (up to 95 %);
• no external switching diode necessary.

You can thus use this device to build a very compact, highly efficient voltage converter. A sample layout generated by the author

is available as a file on the Elektor website.

The TSOP62000 provides an internal reference potential of 0.45 V, which can be used to set the output voltage in the range of 0.5 V to 5 V by means of resistors R2 and R3. The formula for this is:

$$V_{out} = 0.45 \text{ V} + (0.45 \text{ V}) \times (R2 / R3)$$

For relatively low voltages, the value of inductor L1 should be 10 µH, but a value of 22 µH is better if the output voltage is 3.3 V or more. The input voltage can be anywhere in the range of 2 V to 5.5 V, and of course it has to be higher than the desired output voltage. The output voltage is 3.3 V with the indicated component values and an input voltage of
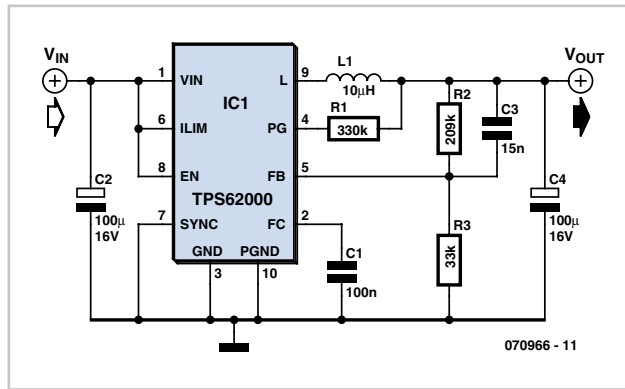
5 V. If you want to reduce the component count even further, you can use a member of the family with a fixed output voltage. The available voltages are 0.9, 1.0, 1.2, 1.5, 1.8, 1.9, 2.5, and 3.3 V. With this approach you can omit R2, R3 and C3, so the output can be connected directly to pin 5.

(070966-1)

Web Link

[1] TPS6200 datasheet
focus.ti.com/lit/ds/symlink/tps62000.pdf

LiPo Manager

Andreas Graff

This circuit performs a managerial role for a three-cell Lithium-Polymer ('LiPo') rechargeable power pack used in a model aircraft. It monitors the voltage of each cell during discharge and cuts power to the motor when any cell dips below a voltage threshold. The R/C receiver is also powered from this battery via a Battery Elimination Circuit (BEC) but it remains operational so that the pilot remains in control and can safely glide the aircraft in to land. LEDs indicate which of the three cells caused the power to be cut. The circuit resets once power is turned off and on again.

The circuit shown in **Figure 1** measures the three voltage levels without the use of any dedicated hardware A/D converter. The A/D conversion is achieved by applying a voltage to an RC network and measuring the time it takes for the voltage to reach a threshold level (a digital '1'). For this application the technique has a number of advantages: the RC network is a low pass filter which removes any spikes and noise from the measured voltage and the hardware required is small, light and inexpensive.

Before measurement all ports are set to O/P and low so that the capacitors discharge. The ports are now configured as inputs and a timer measures how long it takes the three voltages to reach the threshold (see **Figure 2**).

It is a simple job to calibrate the circuit so it is not necessary to define absolute values
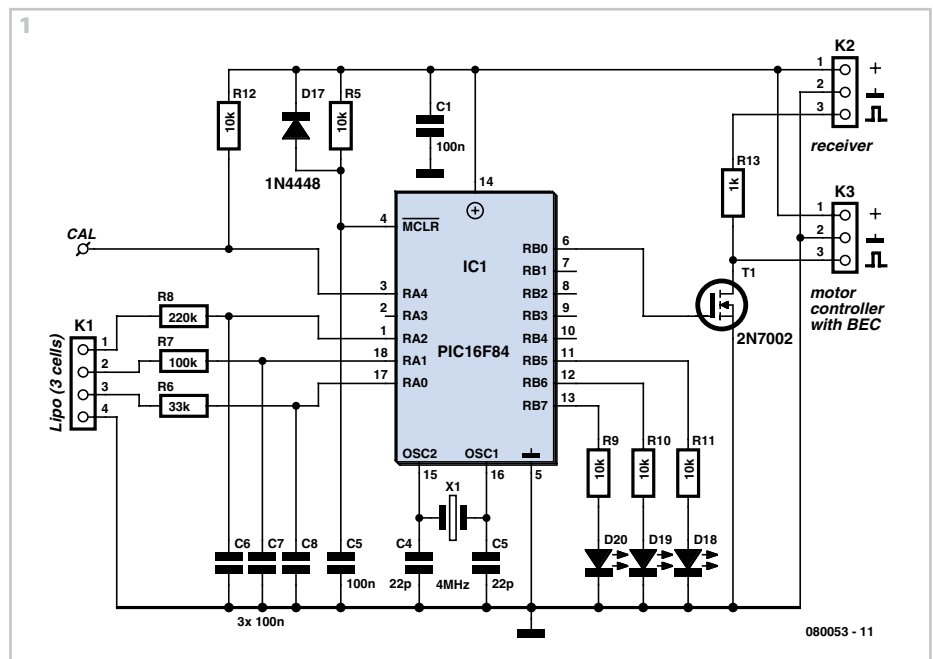
for the trigger points. Only the low-to-high time is measured so it is not necessary to take into account any hysteresis levels. The aircraft is only flown within a fairly limited temperature range so it is valid to assume that small variations in the characteristics due to temperature changes can be ignored.

The time constants for all three inputs are chosen so that the time taken for the three voltages to pass the threshold is roughly of the same order of magnitude. The measurements are made on the steep rising edge of the exponential so the measurement sensitivity for all three levels is about

the same (see **Figure 3**).

Measurement at the 6 V and 9 V tap must take into account the readings from the cell(s) below so that it can be determined which cell was guilty of triggering the shutdown. The result is shown on one of three LEDs.

The Microchip PIC P16F84 controller incorporates protection diodes on its inputs. The high values of the RC networks series resistors ensure there are no problems of latch-up with inputs of 6 V and 9 V.

During program debugging a serial interface (9600,8,n,1) was implemented in software (TxData on RB3, RxData on RB4), there

080053 - 12

080053 - 13
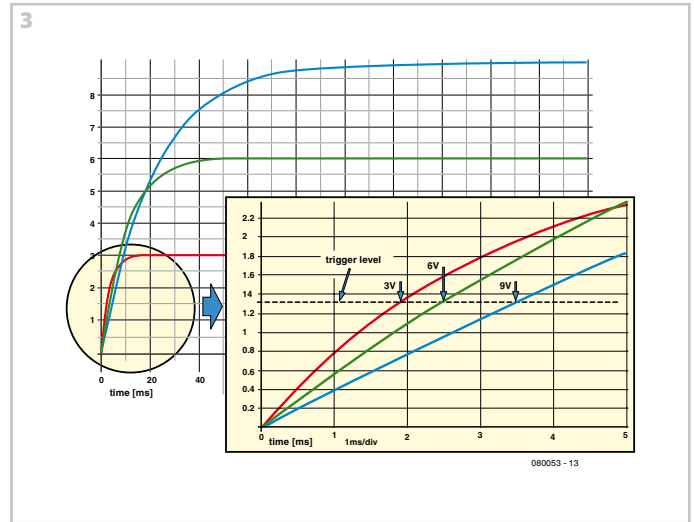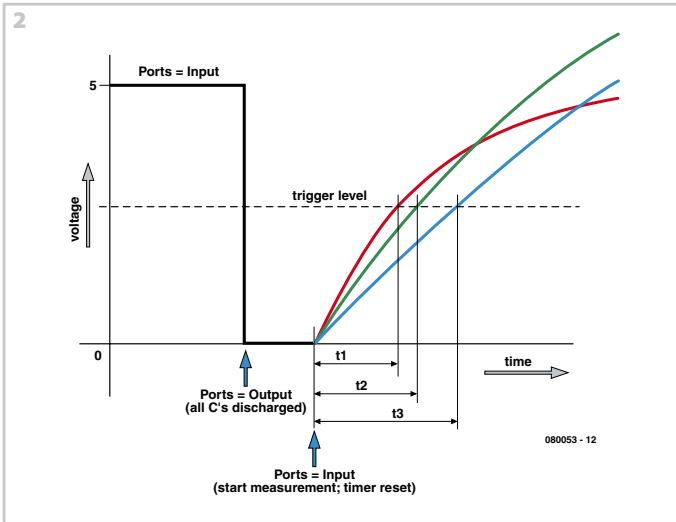
is more than enough memory space in the controller so the routine has been left in the program. The routine outputs the (8–bit) decimal value of the actual measurement for channel 1, channel 2 and channel 3. The controller watchdog is enabled to ensure reliable operation.

All the source and hex files for this project are available to download free of charge from the Elektor website at www.elektor.com; the archive number is 080053-11.zip. To calibrate the circuit it is necessary to short the CAL pin to ground during power up. All three LEDs will light to indicate that it is in calibration mode. All LEDs now extinguish when CAL is released and calibration proceeds as follows:

- LED for Channel 1 (D18) lights. Connect the output of a power supply to channel 1 (pin 3 of K1) and adjust the DC output to the correct level for one cell (2.9 V) then momentarily ground the CAL pin.
- LED for Channel 2 (D19) lights. Connect the output of a power supply to channel 2 (pin 2 of K1) and adjust the DC output to the correct level for two cells (5.8 V) then momentarily ground the CAL pin.
- LED for Channel 3 (D20) lights. Connect the output of a power supply to channel 3 (pin 1 of K1) and adjust the DC output to the correct level for three cells (8.7 V) then momentarily ground the CAL pin.

The LiPo manager is now in normal operational mode and ready to go.

(080053-I)

DCF77 Preamplifier

Rainer Reusch

A popular project among microcontroller aficionados is to build a radio-controlled clock. Tiny receiver boards are available, with a pre-adjusted ferrite antenna, that receive and demodulate the DCF77 time signal broadcast from Mainflingen in Germany. DCF77 has a range of about 1,000 miles.

All the microcontroller need do is decode the signal and output the results on a display. The reception quality achieved by these ready-made boards tends to be proportional to their price. In areas of marginal reception a higher quality receiver is needed, and a small selective preamplifier stage will usually improve the situation further.

The original ferrite antenna is desoldered from the receiver module and connected to the input of the preamplifier. This input consists of a source follower (T1) which has very little damping effect on the resonant

080248 - 11
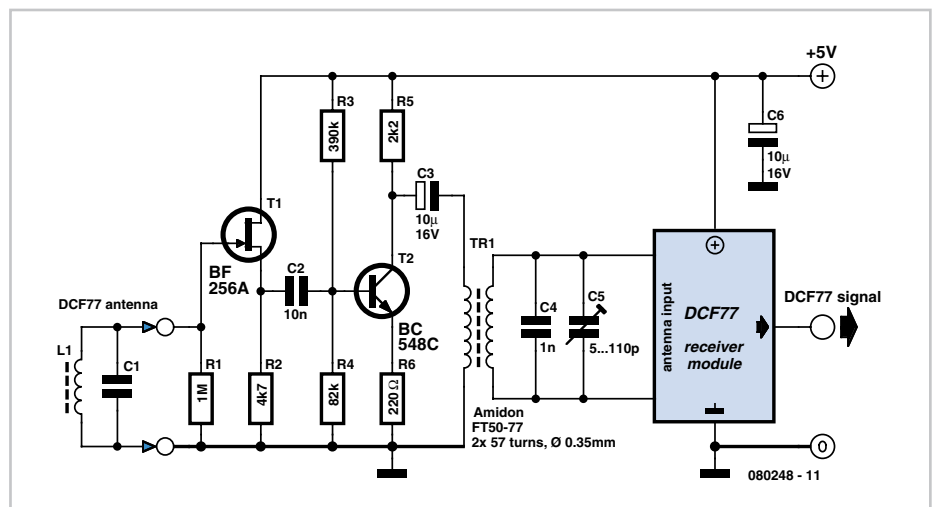
circuit. A bipolar transistor (T2) provides a gain of around 5 dB. The output signal is coupled to the antenna input of the DCF77 module via a transformer. The secondary of the transformer, in conjunction with capacitors C4 and C5, forms a resonant circuit which must be adjusted so that it is centred on the carrier frequency.

An oscilloscope is needed for this adjustment, and a signal generator, set to gene-

rate a 77.5 kHz sine wave, is also very useful. This signal is fed, at an amplitude of a few millivolts, into the antenna input. With the oscilloscope connected across C4 and C5 to monitor the signal on the output resonant circuit, trimmer C5 is adjusted until maximum amplitude is observed.

It is essential that the transformer used is suitable for constructing a resonant circuit at the carrier frequency. Our prototype used a FT50-77 core from Amidon on which we made two 57-turn windings. It is also possible to trim the resonant frequency of the circuit by using a transformer whose core can be adjusted in and out. In this case, of course, the trimmer capacitor can be dispensed with.

(080248-I)

Camera = Data Store

Stefan Hoffmann

Actually this is a travel tip, not a circuit. If you own a digital camera, then you've got a memory card for computer data as well. Camera memory cards are primarily for storing pictures of course but they are also ideal for backing up data you might need on a journey.

Cameras are not fussy about data formats and with today's memory capacities of typically 2 GB on a cheap SD card, these memory cards provide more than enough storage for photos. This makes memory cards ideal for storing all kinds of emergency information such as details of your reservations, handy addresses, PDF copies of air tickets, travel permits and loads more. If you prefer this data to be independent of the camera you could also keep a separate SD card with this information in your pocket in case your luggage is lost, your briefcase is stolen or your wallet goes walkies. These memory cards are so compact that you could even keep one below a padded insole inside your shoe…

(080152-I)

RC Mains Sockets with Feedback

Jens Nickel

When on a trip to his local DIY emporium to buy light bulbs the author found a set of three radio-controlled mains sockets, plus transmitter, at a bargain price. Before the thought 'those will come in handy one day' had even made the journey from mind to mouth, they were in the trolley. On the journey home numerous ideas for what to do with the devices came to mind, most of which, it must be admitted, were rather fanciful in nature. One thing became apparent: for high-availability mission-critical applications, such as arming the (yet to be implemented, natch) home alarm system, or pre-warming the (not yet fully fitted-out) shed, one key fea-ture was lacking. There was just one tiny LED on the remote control transmitter to show whether the on and off commands were being sent. There was no feedback from the receivers to indicate whether the command sent by the transmitter had been correctly received.

Suddenly the author was reminded of one of the first projects on which he worked as a fresh-faced young Elektor editor.
In 2005, his Elektor lab colleague Peter Verhoosel (who is now enjoying a well-earned retirement) put together an interesting article about novel applications for radio controlled switches. The transmitter was modified so that the sockets could be switched on and off under timer control [1].

Suddenly inspiration struck and the author was off to the DIY shop to buy another set of radio controlled mains sockets. With a few more pounds invested in the project, he was ready to start experimenting.
The idea was to use the two systems together to make a remote switch suitable for 'safety critical' applications.
A multi-way extension lead is plugged into the remotely switched socket, and the apparatus to be switched is plugged into one of the sockets on the extension lead. An ordinary mains adaptor is plugged into another of the sockets on the extension lead. Usually an adaptor with a 12 V output will be required.
Now we turn to the second transmitter-receiver set. The transmitter has to be mod-

ified a little by taking the contacts normally used for the battery to a suitable socket so that the unit can be powered from the mains adaptor. One of the 'on' buttons on the transmitter must also be bridged by a small switch. There is the possibility of a small difficulty here if the two transmitter-receiver sets are configured to operate on the same channel. In general this configuration cannot be changed, and so the best solution is to use button 1 on the first set to switch the remote device and button 2 on the second set to send the feedback signal.

The rest is obvious enough: the socket at the receiver end of the second set will now indicate whether the remote appliance has been properly powered up. One possibility would be to use the second receiver socket to power an LED night light or similar device.

The system is armed by closing the switch that shorts the pushbutton on the second transmitter, and (if it has a power switch) turning on the mains adaptor. And amazingly, the prototype worked first time: a press of the 'on' switch of the first trans-

mitter switched on the remote socket, powered up the extension lead, and triggered the second transmitter into sending its feedback. The second receiver socket duly turned on, indicating that the original transmission had been successfully received.

(080500-I)

Web Link

[1] http://www.elektor.com/magazines/2005/october/remote-control-operator.57913.lynkx

Magnetic Flip-Flop

Bernhard Schnurr

The sensitivity of a reed switch can be affected by the judicious nearby placement of small magnets. Also, reed switches exhibit a certain amount of hysteresis: there is a distinct difference between the level to which the magnetic field strength must rise for the switch to pull in and the level to which it must fall for the switch to drop out.

These properties in combination allow us to make an element with two stable states: a flip-flop. All we need is a permanent magnet strategically placed in the vicinity of the switch.

In practice getting the arrangement right is tricky, as the distance from the switch must be correct to within a fraction of a millimetre. However, once the right position is found, we have a bistable element that can be switched using either a second magnet or a small coil. The state of the element is preserved without power.

Since the adjustment required to achieve symmetrical behaviour is so critical, it is simplest to employ a second magnet, somewhat further away than the first. The behaviour of the system can be adjusted over a wide range by carefully rotating this second magnet, and it is now relatively easy to obtain reliable

bistable operation.
The drive coil can be made using about a metre of enamelled copper wire wound

sensitive point along the reed switch. The prototype shown in the photograph switches with a coil current of approximately 40 mA.

It is also possible to obtain other behaviours. One possibility is a normally-on reed contact with the contact broken when the coil current exceeds a certain value, forming a kind of electronic fuse. Equally, we can produce a normally-off contact which makes at a defined coil current: essentially a configurable relay. With the prototype shown we achieved switching currents of up to approximately 180 mA, and with the second magnet correctly adjusted it is possible to achieve switching currents down to just one milliamp.
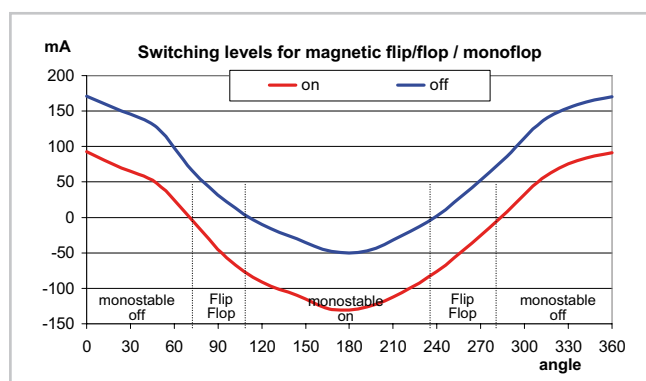
The graph shows the points at which the reed switch changes state, as a function of the angle at which the second magnet is placed and on the coil current. The curve is not particularly smooth, as you might expect from genuine measured data. Without the second magnet the contact pulls in at 63 mA and drops out at –17 mA.

(071158-I)

Switching levels for magnetic flip/flop / monoflop

using a 2.5 mm drill bit as a temporary former. The coil is then fixed at the most

Indicator for Weller Soldering Stations

080121- 11
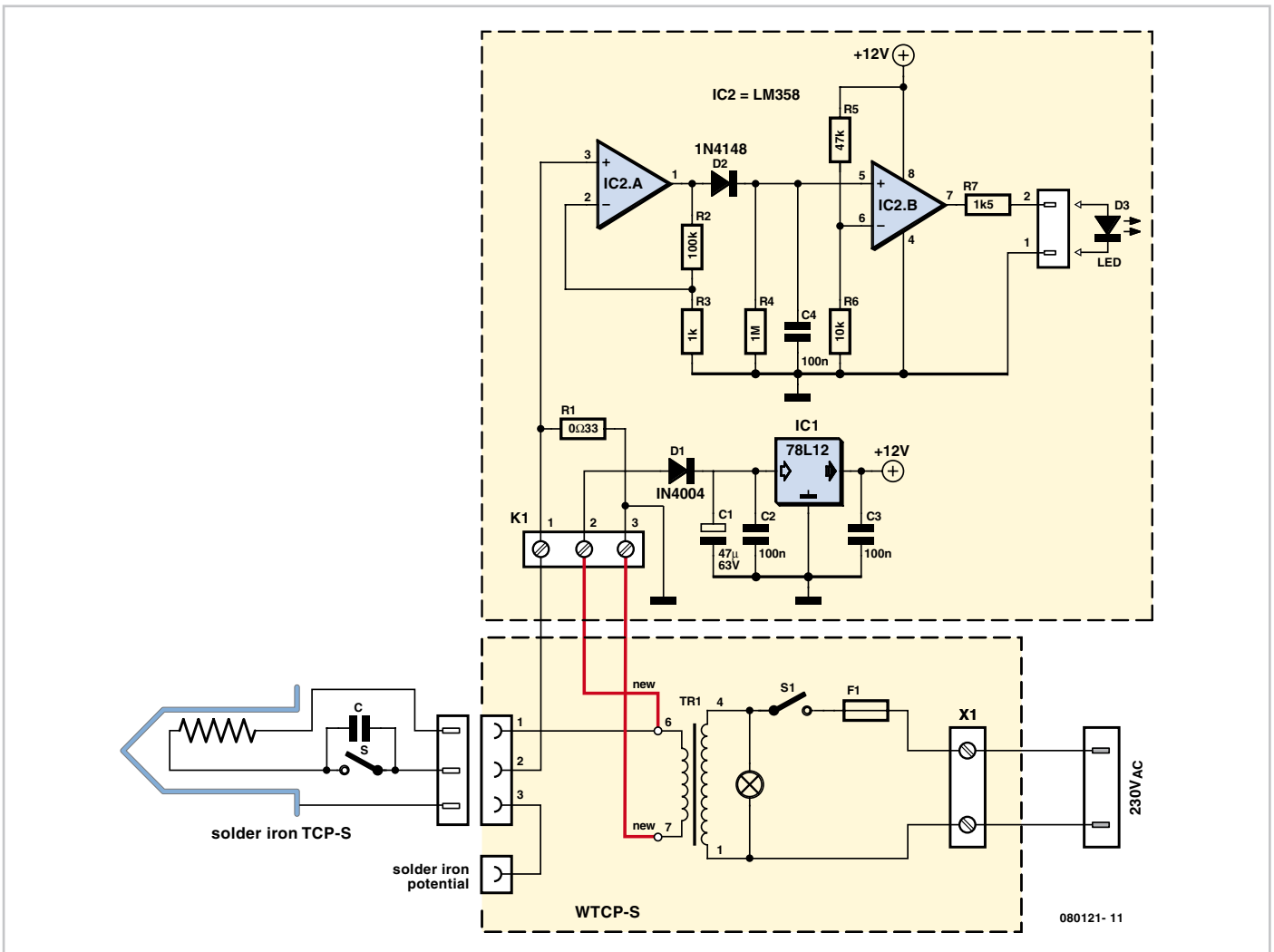
Heinz Kutzer

Many of the soldering stations produced by Weller/Cooper Tools Group use the 'Magnastat' principle to control the bit temperature. The interchangeable bits are fitted with a magnetic cap which pulls on a contact in the iron and completes a circuit to switch power to the heating element. When the magnet in the tip reaches a predefined temperature (the so-called 'Curie temperature') it loses its magnetism and releases the switch contact. The process is reversible so that the contact is remade as the temperature falls. A number stamped on the cap identifies its operating temperature: 5 = 260 °C, 6 = 310 °C, 7 = 370 °C and 8 = 425 °C. When used with lead based solders a 370 °C bit is the usual choice. The heating element is switched on when the tip is below this temperature and off when it is above it, keeping the tip temperature constant.

It is fair to say that the Weller solder station is probably the most commonplace piece of test gear you are likely to encounter in labs and electronics departments up and down the country. They have a good reputation for reliability and the circuit suggested here is an add-on indicator lamp to show when the soldering tip is up to temperature. The circuit described here is intended to be installed in the housing which forms the base of the soldering iron. An LED fitted to the front panel indicates when the iron is heating. The circuit works by measuring the voltage difference dropped across a shunt resistor fitted in series with the heating element in the iron. It is not necessary to carry out any calibration on the circuit. This design can be fitted to the WTCP-S, WTCP 50 and WTCP 51 soldering iron stations from Weller.

The add-on indicator circuit can be seen in the uppermost dashed box of the circuit diagram, the lower box represents the internals of the soldering iron station. A transformer in the base supplies 24 V to the heating element in the iron and is connected via a cable and three pin plug/ socket on the base unit. The heating element has an impedance of 12 Ω which produces an average current of 2 A and a peak value of 2.822 A. Using a 33 mΩ resistor for the shunt (R1) gives a voltage drop of 93 mV (peak) when the element is heating.

IC2 is a LM358 type dual operational amplifier. The amplifiers are powered from a single-ended power supply and IC2.A is configured as an amplifier with a gain of 100. It amplifies the positive half waves of the voltage dropped across the shunt R1. The resulting output signal charges up capacitor C4 to approximately 10 V via diode D1 when the element is on. IC2.B is configured as a comparator and resistors R5 and R6 set the reference voltage to around 2.1 V. When the element is heating the comparator output is positive and the LED lights. As the operating temperature is reached the magnetic switch opens and the voltage across C4 is discharged through R4 (time constant = 100 ms) and the LED turns off. Power for the circuit is derived from the 24 V

transformer in the solder station. Diode D1 performs half wave rectification and C1 is a reservoir capacitor to produce a DC voltage for the 12 V voltage regulator (IC1).

The maximum offset voltage for the LM358 is only 7 mV, with a gain of 100 this can produce an output offset of 0.7 V which is well below the 2.1 V comparator thresh-

old and is not likely to be a problem so it is not necessary to fit any form of offset adjustment.

(080121-I)

Play the Guitar – Recycle Tip

Wisse Hettinga

You'll find a pair in every attic, at every jumble sale you will see a few in a box, every hobbyist has at least about four or so among their collection of bits and pieces: old sets of PC speakers!

After having served commendably for a few years on either side of the monitor they were disconnected and disappeared into the nooks and crannies mentioned above.

This though, does not need to spell the end for these speaker sets. Anyone who calls themselves a bit of a guitar player will always have a need for a practice amplifier.

And especially so if it can work from batteries as well.

The recipe is simple. The little speaker box without the amplifier you still throw away. The speaker with the amplifier can be used as is; connect your guitar with an adapter plug going from jack to mini-jack.

The output of the electric guitar does not match the input of the amplifier very well. But don't panic, a matching network between them, spruce it up a bit with some spray paint (black) and You Play the Guitar!

(080495-I)

Automatic Range Switching

Rainer Reusch

You can pick up a 3½-digit digital voltmeter module nowadays for a little as a couple quid. This is a simple and expensive way to fit out a piece of equipment with an instrument. Most modules are based on the well-known ICL7106 IC. They operate from an ordinary 9-V battery, and they only provide a fixed measuring range (200 mV or 2 V). The accessory circuit described here converts a DVM module into a voltmeter with 20-V and 200-V measuring ranges, with the added bonus of automatic range switching. This requires a ground-referenced symmetrical supply voltage (±5 V) instead of a battery. An inexpensive TL431C is also used to generate an adjustable reference voltage from the supply voltage. The circuit described here uses an LCD module with a fixed measuring range of 200 mV. It has three pins for driving the decimal point; two of them are used here.
This is how the circuit works: IC1 converts

the voltage to be measured by the DVM module into a ground-referenced voltage. This part of the circuit is based on a design idea from Carsten Weber [1] that was published in the June 2005 issue of *Elektor Electronics*.
If the input voltage is less than 20 V, the voltage divider formed by R1 and R4 reduces it by a factor of 100. Transistor T2 is cut off, so R3 has no effect on the division ratio. The voltage at the junction of voltage divider R8/R13 is 200 mV because the open-collector output of comparator IC2A is in the high-impedance state. If the input voltage rises above 20 V, IC2A changes state and the voltage at the junction of voltage divider R8/R13 drops to less than 20 mV. In response to this, the output of comparator IC2B goes high and T2 conducts. R3 is now connected in parallel with R4. This yields a division factor of 1000 (200-V range). Of course, the larger division factor also causes the input voltage of IC2A to drop. To prevent this comparator from changing back to its previ-

ous state (which would cause the circuit to act like a sort of oscillator), the value of R10 must be chosen such that the voltage at the junction of voltage divider R8/R13 is less than 20 mV, as previously mentioned. The calculated value (with R10 in parallel with R13) is approximately 9.6 mV. In practice, the value is around 18 mV due to the resistance of the output transistor of the comparator. This means that the circuit will switch back to the lower voltage range when the input voltage drops below approximately 18 V. The amount of hysteresis can be set by adjusting the value of R10. However, the circuit will oscillate if the value is too high. Film capacitors C1, C3 and C4 suppress noise and create a certain amount of inertia for range switching. This prevents frequent back-and-forth switching in the threshold region.
The other two comparators of IC2 supply mutually complementary output levels that depend on the measuring range. The associated decimal points of the DVM module are driven via p-channel FETs.
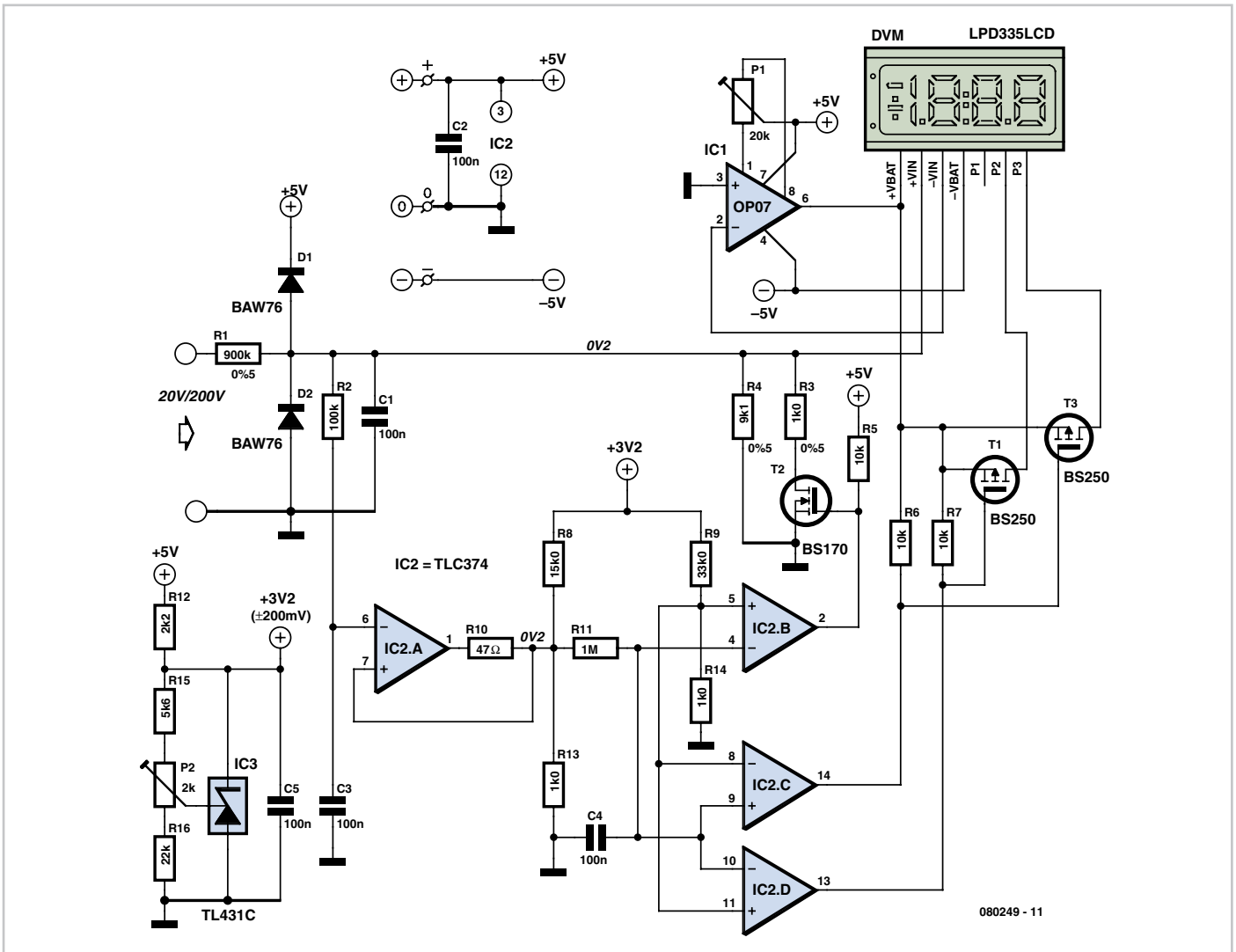
The circuit has two trimpots: P1 is used to correct for the offset voltage of the operational amplifier (IC1), while P2 is used to set the threshold level for range switching. For this purpose, first adjust the trimpot to produce the maximum possible reference voltage (around 3.4 V). Next apply an input voltage that causes a display reading of 19.99 (which ideally means 19.99 V). Now turn P2 until the measuring range switches. As a check, reduce the input voltage to force the measuring range to switch back, and then slowly increase the input voltage again. The ideal setting is reached when the measuring range switches before the DVM module displays an 'overrange' indication.

(080249-1)

Reference
[1] DVM Without Isolation, *Elektor Electronics* June 2005.

Active Rectifier

Dr. Thomas Scherer

Diodes make admirable rectifiers and are simple and economical, but unfortunately they also exhibit forward voltage drop, and hence also power loss. The losses in ordinary silicon diodes are of the order of 0.7 W/A to 1 W/A, and for Schottky diodes the losses are in the region of 0.4 W/A to 0.5 W/A. In a bridge rectifier these losses are doubled, as the current path is always through two diodes in series.

These considerations led to the development by Wolfgang Schubert two years ago of an active rectifier using suitably-driven power MOSFETs, published in the 2006 Summer Circuits issue of *Elektor*. The circuit was highly symmetrical, consisting of a quad opamp and four MOSFETs, forming a bridge rectifier with a very low voltage drop.

However, reports in the *Elektor* online forum indicated that some people had experienced problems with the circuit. Curiosity aroused, the author was prompted to look more closely at the design, and so he built a version in order to test it more thoroughly. It appeared that the outputs of the TL084 did not always swing close enough to the positive and negative rails to switch the FETs off fully. Time for some modifications.

The first thought was, why not use a transformer with a centre tap on its secondary winding? Then we only need to simulate the action of two diodes, reducing circuit complexity and cost, as well as power losses, by nearly a factor of two. It also means that we do not have to find complementary p-channel FETs.

The second thought was, instead of using 1 % resistors, why not use two trimmer potentiometers and allow an adjustment to find the optimal switching voltages for the pseudo-diodes?

The result of these considerations was the circuit shown here, which roughly resembles one half of the original design. AC1 and AC3 are connected to either end of the secondary winding of the mains transformer, and AC2 is connected to its centre tap. Each half of the dual opamp drives its own power MOSFET.

When power is first applied the reservoir capacitors are both discharged, and the parasitic diodes present in each MOSFET are put to positive use: through them the capacitors are initially charged to provide power for the opamp. Usually the circuit will be in normal operation after the first half-cycle of the mains.

Let us suppose for illustration that the input is connected to a transformer with two 12 V secondaries and a power rating of 50 VA, and that at the output of the circuit we connect a load of approximately 5 Ω. Roughly speaking we would expect a rectified output voltage of approximately 15 V and an output current in the region of 3 A. The voltage divider formed by R3 and R4 will provide a reference voltage of 7.5 V. Every 10 ms there will be a negative voltage peak either on AC1 or on AC3. If the voltage at the junction of R1 and R2 or at the junction of R5 and R6 is less than the 7.5 V reference, the output of the corresponding opamp will go high and the connected MOSFET will be turned on. P1 and P2 allow the point where the MOSFETs are turned on to be set individually in terms of the voltage difference between input and output. These voltages can be measured using an oscilloscope (a multimeter will not do the job!) between test points 1 and 2 and between test points 1 and 3.

With the component values given the threshold voltage can be set in the range 0 V to 375 mV in our example. In practice, with a 3 A load and using BUZ11 MOSFETs, a suitable threshold voltage is between 50 mV and 100 mV. Power losses
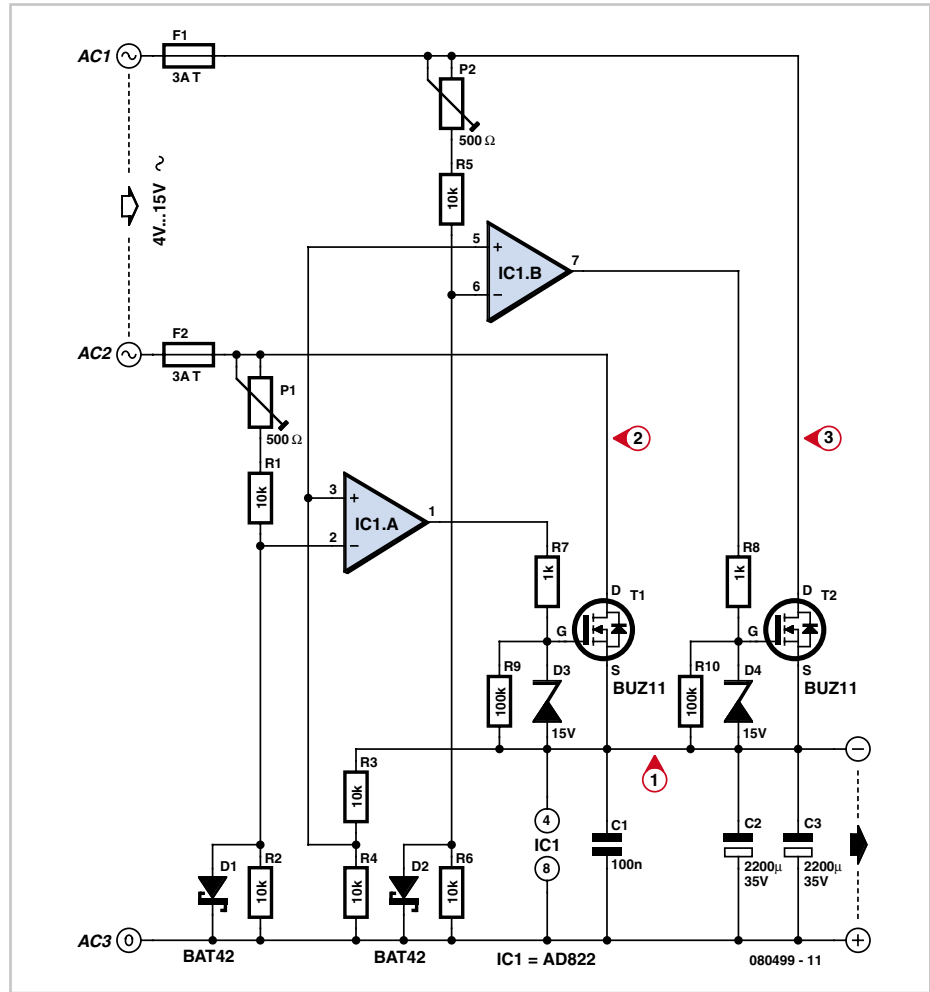
in the MOSFETs are only around 150 mW to 300 mW and so the devices do not need extra cooling. The potentiometers should not be set so that the MOSFETs conduct for longer than necessary, as this leads to brief short circuits of the input, audible as a humming of the transformer. It is best to start with the potentiometers adjusted to the centre of their travel.
D1 and D2 ensure that the inputs to the opamps never see excessive voltages of the wrong polarity. D3 and D4 protect the gates of the power MOSFETs.

With the components shown the active rectifier is suitable for output currents of up to around 5 A. The maximum transformer voltage is 15 V and so the output voltage is limited to about 20 V under load. With no load, a nominally 18 V transformer with poor regulation can give rise to DC voltages of over 32 V, exceeding IC1's maximum rating. Lower-impedance toroidal transformers with secondaries rated at up to 20 V (corresponding to 27 V at the output under load) work fine. The reservoir capacitors should be rated at at least twice the secondary voltage of the transformer. If more current is required (as is quite likely, since the circuit is designed for operation

at low voltages) higher-power (lower 'on' resistance) FETs and larger smoothing capacitors are needed. Using the IRFZ48N and two 4700 µF electrolytics up to 10 A can be delivered with minimal losses. With a small piece of aluminium as a heatsink the FETs barely get warm. The printed circuit board tracks need to be reinforced with soldered wire links, and 6.3 A slow-blow fuses should be fitted for electrical safety.

Other dual opamp ICs besides the AD822 can be used. The author has also had good results using an original Texas Instruments TLC272. The outputs of this device can swing down to very nearly 0 V, which is essential in this circuit. Other suitable types include the OPA2244 and the better-known LM358N.

An Eagle layout file for the printed circuit board is available for free download from the *Elektor* website. The author would like to thank Hans-Jürgen Zons for his help in designing the printed circuit board.

(080499-I)

GPS Receiver

Thierry Duquesne

GPS has many other applications than just satnav in cars and other vehicles. It can also be used, for example, to note the position of a 'secret spot' for finding wild mushrooms out in the woodlands near your holiday chalet in Southern France…

Without seeking to compete with commercial GPS receivers, which employ powerful cartographic software to locate a vehicle or pedestrian in towns, our device quite simply lets us decode the GPS frames transmitted by the satellites and display the decoded latitude and longitude coordinates, which is enough information for finding where you are in the middle of a forest. Besides the cost (£ 65 or so) and the weight, the receiver described here is also interesting because of its powering, since it operates from just a simple 9 V battery, unlike commercial receivers that use a special built-in battery that's usually not removable.

Lastly, the system can very easily be incorporated into a mobile object like a robot etc.

Introduction to the GPS system

The Global Positioning System (GPS) is the main current worldwide satellite positioning system and the only one to be fully operational, while waiting for the European Galileo system. Set up by the US Defense Department in the 1960s, the system allows a person equipped with a receiver for the GPS frames to find out their position on the surface of the Earth. The first experimental satellite was launched in 1978, but the constellation of 24 satellites only really became operational in 1995.

Operating principle

The satellites send out electromagnetic waves that travel at the speed of light. Knowing this and the time the wave takes to arrive, it is possible to calculate the distance between satellite and receiver. To measure the time taken by the wave to reach it, the GPS receiver compares the transmission time (included in the signal) and reception time of the wave transmitted by the satellite. If the receiver has a clock that is perfectly synchronized with that of the satellites, three satellites are enough to determine the position in three dimensions by triangulation. However, if this is not the case, it takes four satellites to be able to resolve the clock issue and receive

Displaying longitude and latitude information

There are three possible formats for displaying longitude and latitude data:

- 'GPS co-ordinates' format (degrees, minutes, and fractions of minutes)   e.g.: 36°35.9159
- 'DDMMSS' format (degrees, minutes, seconds)   e.g.: 36°35 54.95
- 'decimal' format   e.g.: 36.5986°

The author normally uses the 'GPS co-ordinates' format display
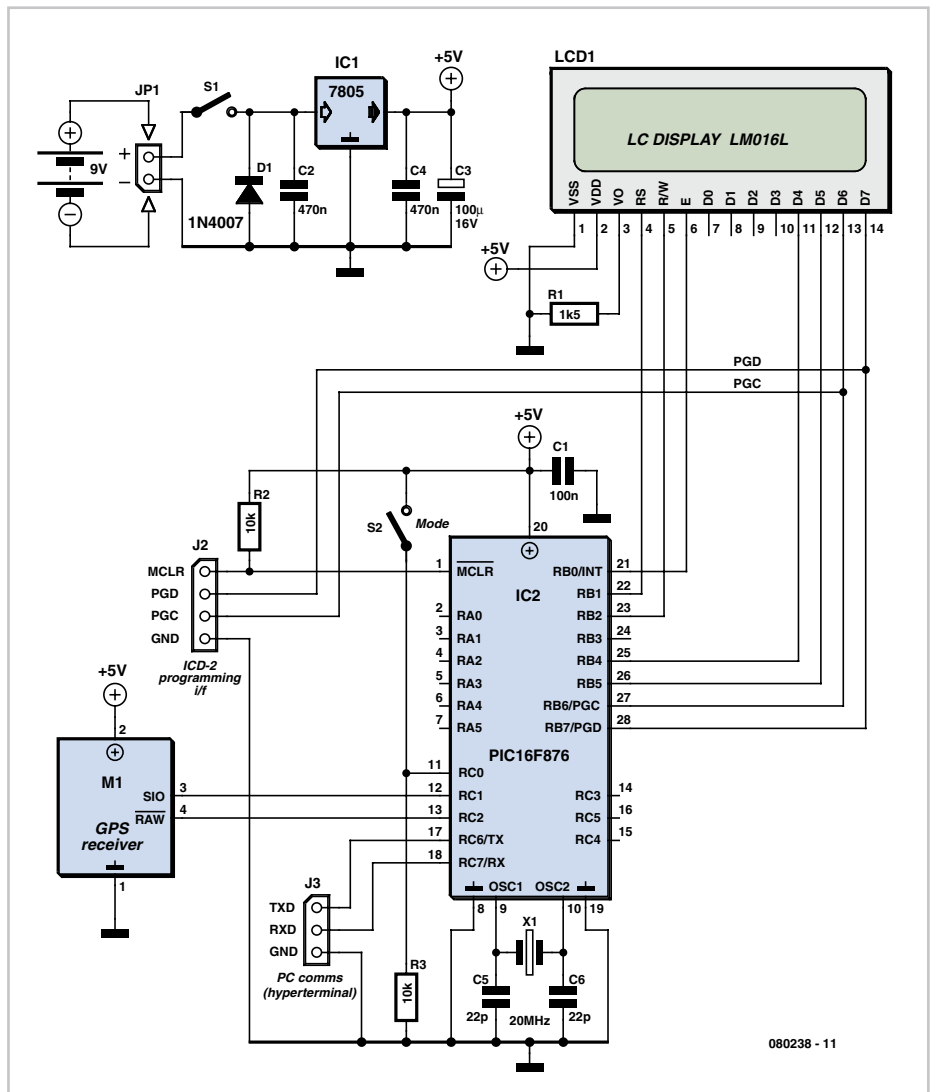
080238 - 11

the data correctly. A GPS can operate anywhere, just as long as it has an unobstructed view of the sky, 24 hours a day, 7 days a week. However, it's important to be aware that the position data may be incorrect in the presence of electromagnetic interference.

NMEA 0183 frames
Most GPS receivers provide data that can be used by other devices. The standard format is NMEA 0183 (National Marine & Electronics Association).

A NMEA 0183 frame is transmitted in the form of ASCII characters, at a rate of 4,800 baud. Each frame is preceded by '$', followed by the two letters 'GP' and three letters to identify the frame (most often GGA). Next come a certain number of comma-separated fields (making it possible to separate the various data).

To end, there is a checksum, preceded by the '*' symbol. This can be used to verify no errors have occurred during the transmission. One frame consists of a maximum of 82 characters. After that, it moves on to a new frame. Thus any microcontroller with a serial port can extract the data from the GPD module.

Here are a few examples of standard frames provided by the GPS module used in this article:

$GPGGA,170834,4124.8963,N,08151.6838 ,W,1,05,1.5,280.2,M,-34.0,M,,,*75 $GPGSA, A,3,19,28,14,18,27,22,31,39,,,,1.7,1.0,1.3*34 $GPGSV,3,2,11,14,25,170,00,16,57,208,39,18 ,67,296,40,19,40,246,00*74 $GPRMC,22051 6,A,5133.82,N,00042.24,W,173.8,231.8,130 694,004.2,W*70

These strings of characters can be exploited to extract the wanted information, including for example the time, date, latitude, longitude, altitude, speed and direction of movement, and even the number of satellites being received or the validity of the received data.

The GPS receiver used is based on the integrated module offered by Parallax Inc. from the USA (or their local distributors). Its principal characteristics are as follows:

• Reception of up to 12 satellites
• Data updated once per second
• 2 operating modes:

– Smart Mode: when the $\overline{RAW}$ pin is open-circuit (internally pulled up to logic high), the default 'Smart Mode' is enabled. In this case, the commands for receiving the special GPS data can be executed and the result returned. Each command is represented by one hexadecimal byte. Depending on the command, a certain number of data bytes will be returned. To send a command to the GPS receiver module, the user must first send the header characters '!GPS' (obviously without the quotes) followed by the specific command of their choice (for example, 0x02 to obtain the number of satellites being received) – in this instance, the receiver module would return one byte of data with the number of satellites.

– Raw Mode: When the $\overline{RAW}$ pin is forced low, the 'RAW Mode' is enabled, the module can then transmit the characters of the standard NMEA 0183 frames (GGA, GSV, GSA, and RMC), making it possible to use the raw GPS frames directly.

Certain devices, like engines, computers, and Wifi links, emit magnetic fields and interference that can prevent the module from receiving the required signals from the satellites and adversely effect its operation and performance. The acquisition time for a minimum of four satellites may take up to five minutes.

In the application described, we're going to be using the GPS module in 'smart mode'.

Electronics
Taking a look at the block diagram, we can see that our receiver revolves around a PIC16F876A microcontroller from Microchip Technology. Amongst its other tasks, it takes care of the transcoding and dialogue between the Parallax GPS receiver and the LCD display.
It's worth noting that the circuit has been

COMPONENTS LIST

Resistors
R1 = 1kΩ5
R2,R3 = 10kΩ

Capacitors
C1 = 100nF
C2,C4 = 470nF
C3 = 100µF 16V
C5,C6 = 22pF

Semiconductors
D1 = 1N4007
IC1 = 7805 (TO220 case)

IC2 = PIC16F876A (20 MHz), programmed with hex file from archive 080238-11.zip

Miscellaneous
X1 = 20 MHz quartz crystal (low profile)
JP1,S1,S2= 2-pin connector, 5mm lead pitch
J2 = 6-way SIL pinheader
J3 = 3-way SIL pinheader
K1 = connector for 9V battery
LCD1 = LCD, 2x16 characters, e.g. LM016L or equivalent
M1 = GPS receiver module type 28146 (Parallax Inc.)
PCB, ref. 080238-1 from www.thepcbshop.com

designed with two operating modes: you can either display just the geographical co-ordinates of latitude and longitude, or scroll through a whole mass of information (received frame validity, number of satellites received, date, GMT, altitude, latitude, longitude, and so on).

Powering is by way of a simple 9 V dry battery (or rechargeable), which connects to terminal block JP1. The 5 V supply voltage is generated by IC3, a 7805 regulator. Connector J3 allows dialogue with a PC via an RS-232 link (make provision for interfacing with a MAX232), while connector J2 allows programming of the PIC and in-circuit debugging thanks to the ICD2 marketed by Microchip.

The on/off switch S1 connects to the S1 terminal block on the board, the mode selec-

tion switch connects to the adjacent S2 terminal block.

PCB
It only takes a few minutes to build this circuit using the circuit board suggested here. The first step consists of soldering the small number of wire links, then the resistors, IC socket, unpolarized capacitors, and then the electrolytic capacitors, taking great care to observe correct polarity. Check for the presence of power on the correct pins of the IC socket. If everything is OK, next fit the programmed PIC (with the power off) into the socket, and finish by fitting the LCD display and the GPS module. The circuit should then work as soon as power is applied.

Selecting the display mode
By default, at power up the receiver displays

the latitude and longitude co-ordinates. If you want to display more information, all you have to do is keep button S2 pressed as you power up the receiver.

(080238-I)

ZigBee-based Wireless Motion Sensor

Sven van Vaerenbergh

It's easy put together a ZigBee wireless system if you use the XBee and XBee Pro modules. In this circuit, they are used to read the signal from a passive infrared PIR) motion sensor. This signal can be sent from one module to the other by using I/O Line Passing. A digital input signal on the DIO1 pin (pin 19) of module A can drive a digital output signal (DIO1) of module B. Similarly, an analogue input signal on AD0 of module A (pin 20) can control a PWM output signal of module B.

The 'master' module receives the sensor information from the 'slave' ZigBee modules. A single PIR sensor (type AMN14112) is connected to each slave. It has a digital output, a detection range of 10 metres, and an operating voltage of 5 V. As the ZigBee modules operate from 3.3 V, the lower supply voltage is obtained by using a 3.3-V regulator (type 1117) in combination with the circuit shown here.

The schematic diagram is simple and consists of only a few components: a 3.3-V voltage regulator with a 9-V battery, the module, the PIR sensor, and a transistor. The transistor pulls the digital input of the ZigBee module to ground when the PIR sensor detects motion. When the PIR sensor does not see anything, the transistor is cut

080166 - 11
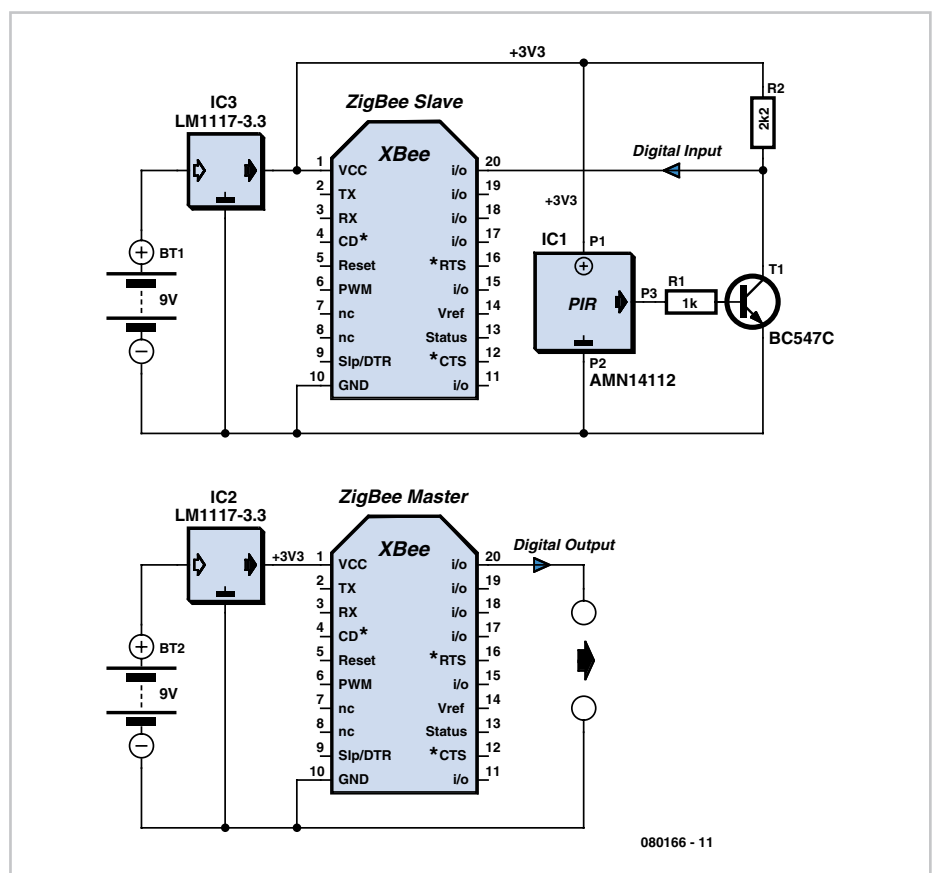
off and the 3.3-V supply voltage is applied to the ZigBee module via a 2.2-kΩ pull-up resistor. Power is provided by the 9-V battery. This compact circuit can be built into

a small case (so it can be placed in the garden, for example).
The modules are programmed using the X-CTU program. The data sheet for the

XBee modules is quite clear, and the commands are simple. The screenshot shows a terminal emulator with the settings for the transmitter module (with the connected PIR sensor).

Be sure to update the ZigBee command set to version 10A2 (v1.xA0*) when you are programming the modules, as otherwise you cannot include parameters with some of the commands and the module will not understand some of the commands.

Also be sure to perform a Read operation first when you update the firmware (from 1083 to 10A2). If you immediately perform a Write with the new version, you will lose communication with the module because the configured parameters will be overwritten.
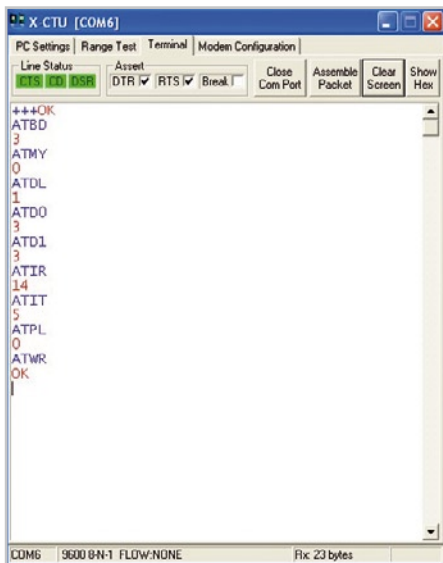
The PIR transmitter module can be placed anywhere within a range of 30 metres from the receiver, such as in the garden. For a larger range, you can use the somewhat more expensive XBee Pro modules.

(080166-1)

Downloads

The source code and hex code for this design are available on www.elektor.com for free downloading; file # 080166-11.zip.

Master ZigBee code (receiver)
```
ATMY = 1 (Master address = 1)
ATDL = 0 (The address of the module it must receive data from is 0)
ATPL = 0 (Low power consumption)
ATIU = 1 (Disable transmission via UART)
ATBD = 3 (Set communication to 9600 baud)
ATD0 = 5 (Digital output on pin 20 of the module)
ATD1 = 5 (Digital output on pin 19 of the module)
ATIA = 0 (The master must change its outputs based on the slave with
    address 0. If ATIA = 0xFFFF, the master will change its outputs
    based on each received packet, independently of the address of
    the transmitter.)
ATWR (Save the settings in the flash memory)
```

Slave ZigBee code (transmitter)
```
ATMY = 1 (Slave address = 0)
ATDL = 0 (The address to which it must transmit is 1)
ATPL = 0 (Low power consumption)
ATIU = 1 (Disable transmission via UART)
ATBD = 3 (Set communication to 9600 baud)
ATD0 = 3 (Read the digital input signal on pin 20)
ATD1 = 3 (Read the digital input signal on pin 19)
ATIR = 14 (Sampling rate = 0x14)
ATWR (Save the settings in the flash memory)
```

Logic Goats

Rob Ives

The central processing unit (CPU) at the heart of every computer or microcontroller system is basically a vast collection of microscopically small switches and logic gates. Unfortunately, the function of the logic gates in particular seems hard to grasp for the not too technically minded (or those who can't read simple tables). Now, through the power of paper (cheap and generally available) these logic gates are available in goat form.

Properly constructed from the DIY guide the AND goat will nod its head only in you press the right button **and** the left button.

The OR goat, then, will nod its head in approval when the left button **or** the right button or **both** buttons are pressed.

The NOT goat, finally, gives a friendly nod of the head when the button is **not** pressed.

These models can be made from paper using delightfully designed cut-and-fold models you can download on the Flying Pig website. Suitable for age range 5 through 105 (some help may be required at the extremes).

(080482-I)

Web Link

www.flying-pig.co.uk/pagesv/logicgoat.html

Simple Capacitive Touch Sensor

080175-1 ©Elektor
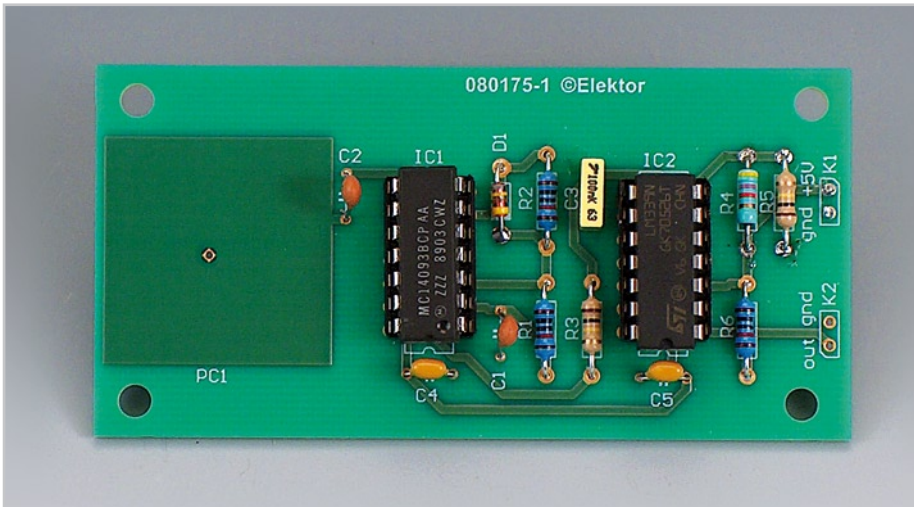
Wim Abuys

Capacitive touch sensors are based on the electrical capacitance of the human body. When, for example, a finger comes close to the sensor, it creates a capacitance to Earth with a value of 30 to 100 pF. This effect can be used for proximity detection and touch-controlled switching.

Capacitive switches have clear advantages compared to other types of touch switches (for example 50 Hz or 60 Hz detection or resistance detection), but are often more complex to implement. Manufacturers such as Microchip have in the past designed specialist ICs for this purpose. However, it is still possible to design a reliable capacitive detector and/or switch using only a limited number of standard components.

In this design we detect the change in the pulsewidth of the signal when the contact is touched. In **Figure 1** the following stages can be recognised, from left to right:

- a square-wave generator with a frequency of 300 kHz, using a Schmitt trigger IC (CD4093);
- an RC network with a flyback diode, followed by a Schmitt trigger/contact plate with an isolation capacitor of 470 pF;
- an RC network that converts the change in pulsewidth into a voltage. This voltage is about 2.9-3.2 V when the plate is touched (and 2.6 V when it isn't touched);
- an LM339 comparator is used to compare the voltage at point C with a reference voltage (D). The latter is set to about 2.8 V using a potential divider.
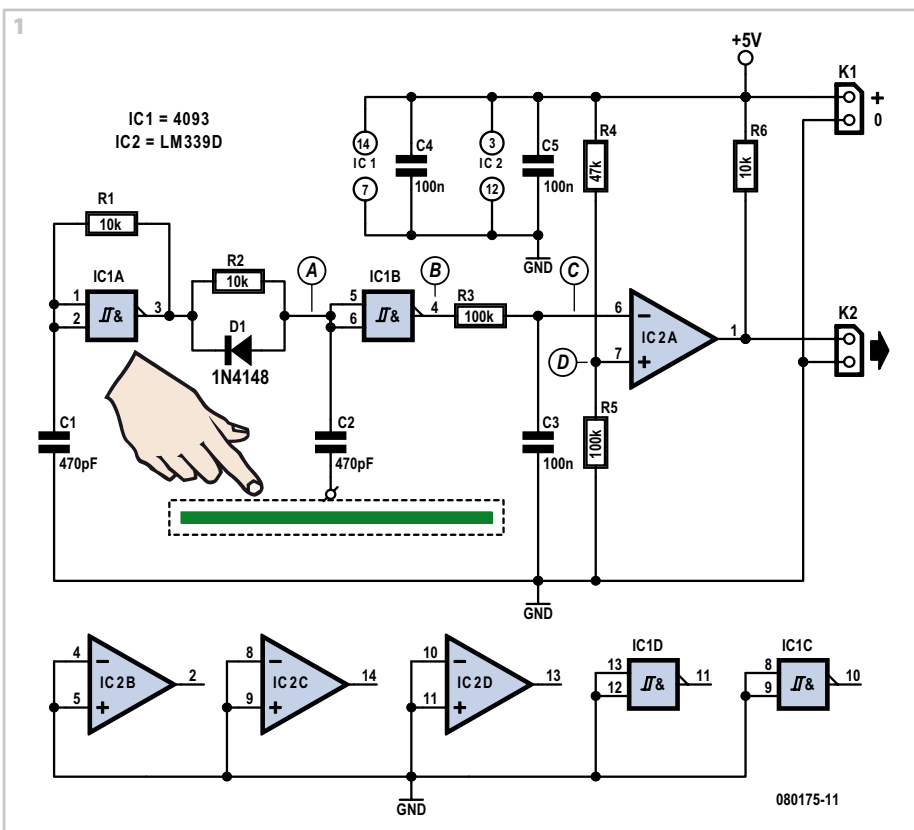
As long as the contact plate is touched the output of the circuit will be active. To make the operation of the circuit clearer we have

080175 - 12
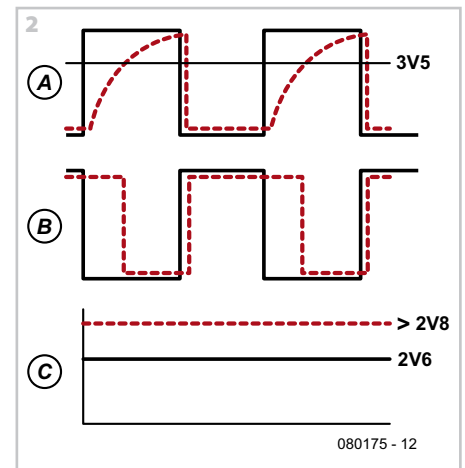
shown the signals at various points in **Figure 2**. The dotted line represents the signal when the plate is touched, the solid line when it isn't touched.
The reference voltage at D has to be set up once via potential divider R4/R5 (change the value of R4). The required value is strongly dependent on the surface area of the contact plate (this is usually a few square centimetres). Larger surfaces increase the capacitance and the voltage at C will therefore be greater when the plate isn't touched. The reference voltage at D should then be set closer to 3.4 V. The touch sensor can therefore also be made to work with larger areas (such as the complete metal enclosure of a device).

The circuit only works when a connection for higher frequencies (300 kHz) is made to Earth in some way. The circuit therefore doesn't work in battery-powered systems without a connection to Earth. In many systems without a direct connection to Earth there is sufficient parasitic capacitance to the mains Earth. In some cases it will be necessary to add an extra capacitor

080175-11
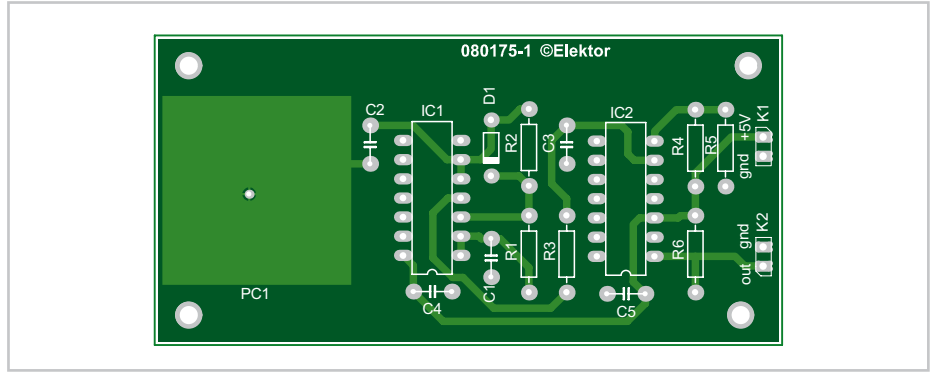
between the mains Earth and the Ground of the circuit. To comply with safety regulations this capacitor should be rated for >3-4 kV (i.e. a Class Y capacitor).

The output signal can be used in various ways to switch on systems. The addition of an extra Schmitt trigger to the output is recommended in many cases, especially if the output connects to a digital input.

(080175-I)

Downloads

The layout for the printed circuit board is available from the Elektor Electronics website as a free download; ref. 080175-1.zip.

TV Muter

Michael Hölzl

Many households are still graced by tube-type television sets. If you want to connect one of these large tellies to your stereo system to improve the sound quality, this is usually not a problem because there are plenty of SCART to Cinch adapters available in accessory shops.

However, with some sets your pleasure is spoiled by the fact that the audio outputs of the SCART connector are not muted during channel switching. This can sometimes lead to nasty signal spikes, which can cause the loudspeakers of your stereo system to emit irritating popping and cracking noises. In such cases it is a good idea to fit your system with a mute circuit.

Fortunately, the right time to activate the mute circuit is defined by the fact that the happy zapper presses buttons on the remote control to switch channels, and the remote control emits IR signals. There are even inexpensive ready-made IR receiver modules available, such as the TSOP1136 used here, which produce trains of active-low pulses in response to such signals. About the circuit: when no IR signal is present, a capacitor is charged via P2 and a diode. IC1 is a comparator that compares this IR voltage (applied to its non-inverting input on pin 3) to a voltage applied to its
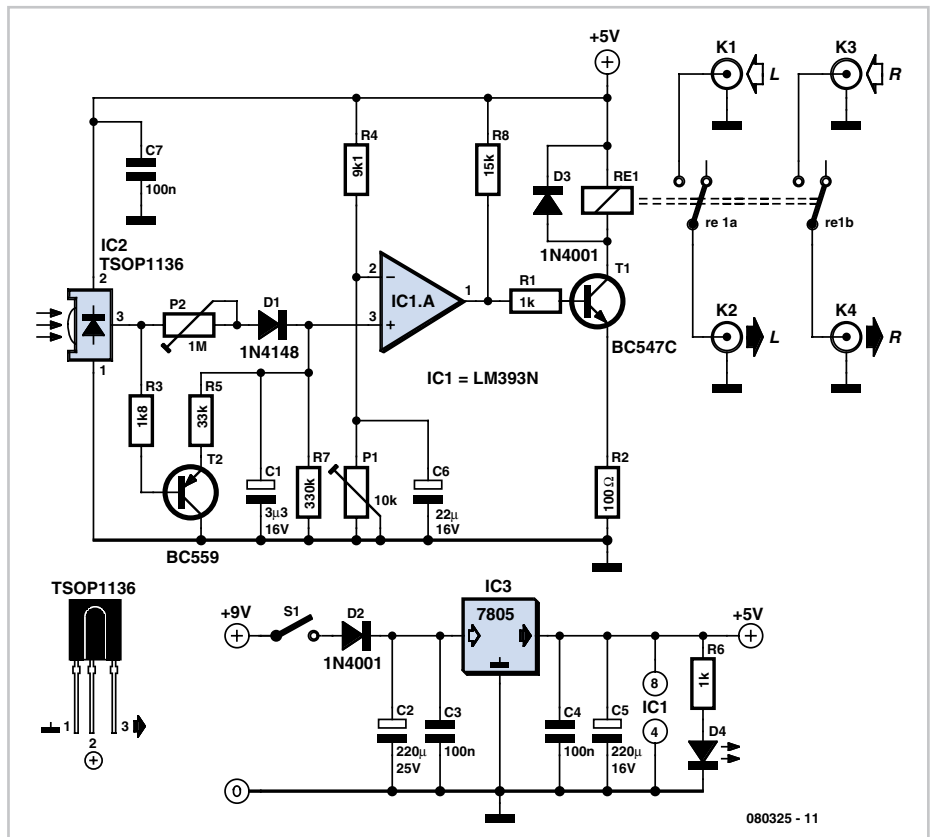
other input on pin 2. This reference voltage, which can be adjusted with P1, determines the switching threshold of the comparator. If IC2 receives an IR signal, T2 conducts, and as a result the voltage on C1 drops rapidly

below the threshold level set by P1. This causes T1 to change from its previous 'on' state to the 'off' state. As a result, the relay drops out and the audio link to the stereo system is interrupted for the duration of

the noise interval. It's all quite simple, as you can see.

If you do not have a stabilised 5-V supply voltage available, you can use the circuit at the of the schematic diagram (with a 5-V voltage regulator) together with a simple (unstabilised) AC mains adapter that supplies a voltage in the range of 9 V to 12 V

to the 7805 (IC3).

You can also use a relay with normally-closed contacts instead of normally-open contacts. In this case, simply swap the signals on pins 2 and 3 of IC1 so the relay pulls in when an IR signal is received instead of dropping out. This saves a bit of power because the relay is only energised during

zapping. If you can't find any worthwhile use for the second comparator of IC1, it's a good idea to connect pin 6 to +5 V and pin 5 to ground.

To improve noise immunity, you should shield the IR sensor so it is not exposed directly to light from a fluorescent fixture.

(080325-1)

Universal Thermostat
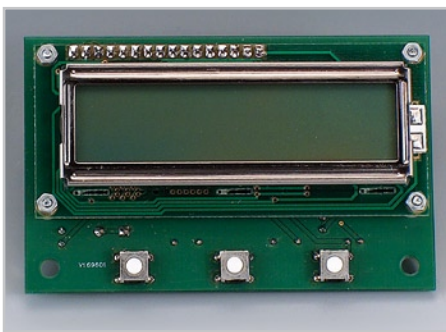
Ruud van Steenis

This circuit came about because of the dissatisfaction regarding the operation of the thermostat in a refrigerator. When using the built-in thermostat, it turned out that it was necessary to reduce the temperature setting in the summer in order to keep everything cold, compared to the setting in winter. This is probably as a result of a temperature sensor that is mounted too close to the cooling element, which means that phenomena such as thermal leaks and the average temperature in the fridge are not sufficiently accounted for in the control loop.

While designing the circuit for this electronic thermostat a decision was made to increase the control range so that it would also be suitable for other applications. Potential applications are the temperature control of a (living) room, heating of a flower box and obviously the etching tank!

The control range is adjustable from -25 °C to +75 °C in steps of 0.25 °C. The hysteresis is also adjustable. Hysteresis is the temperature error at which the system will turn on or off. A very small hysteresis results in a very stable temperature but has as disadvantage that the heating or cooling system turns on and off at a high rate, which generally leads to extra wear and tear in the

compressor (cooling) or pump (heating). The hysteresis can be adjusted from 0.1 °C (very stable temperature) to 10 °C (practically no control at all...) in steps of 0.1 °C. The settings can be changed with 3 push buttons and the information is displayed on a 2×16 character LCD. The settings are stored in the EEPROM inside the PIC. During normal operation the LCD is used to display the actual temperature.
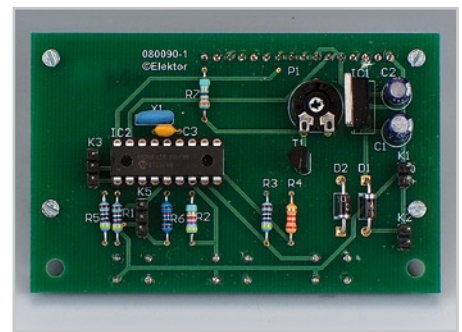
The main component in this circuit consists of a PIC 16F628. In addition to the afore-

mentioned 2×16 character LC display, the
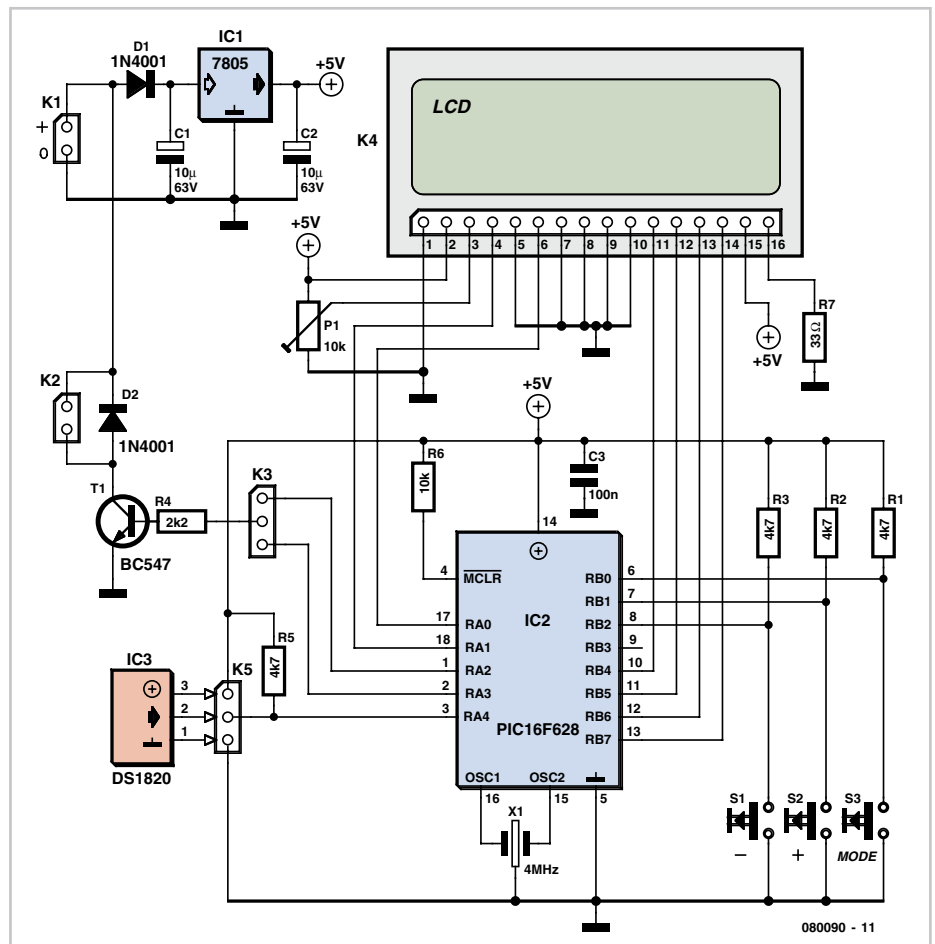
080090 - 11
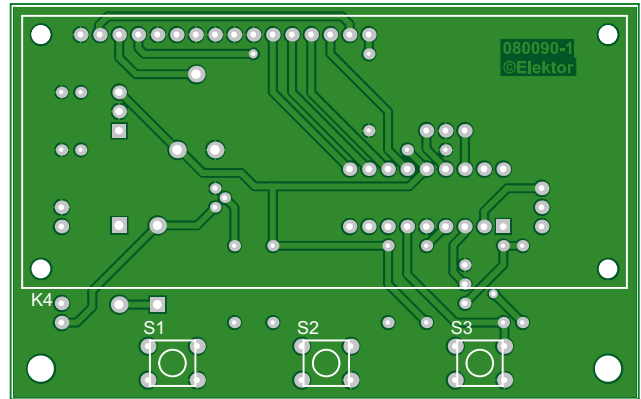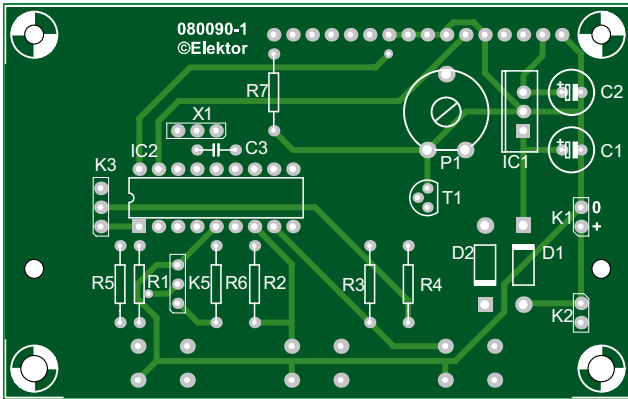
temperature sensor, type DS1820, also serves an important role in the circuit (connected to K5). Fortunately the DS1820 is already factory calibrated, so this saves us from a difficult task. A classic 7805-regulator and a common transistor pretty much complete the circuit. The clock source for the PIC is supplied by a 4 MHz ceramic resonator with built-in capacitors (Conrad Electronics order number 726406/726507).

There are two switching outputs from the PIC, one for cooling applications and another one when heating is called for. When cooling, the refrigeration system obviously has to be turned on when the temperature is too high, while when heating, the appropriate action needs to be taken when the temperature threatens to become too low. A jumper in this circuit makes the selection between cooling (jumper 2-3 on K3) and heating (jumper 1-2 on K3) possible.

When the circuit is turned on, the display shows 'TEMPERATURE' with underneath that the actual temperature in degrees Celsius. If the sensor is not connected then an error message will be displayed. By holding down the 'Mode' button until an asterisk appears, the text 'SET TEMPERATURE' appears and you can set the desired temperature in steps with the + and - buttons. By pressing the Mode-button again it is possible to set the desired hysteresis with the + and – buttons.

A hysteresis of 1 °C means that with a temperature setpoint of 20 °C and when heating, the output becomes active when the temperature drops below 19 °C (20–1), while everything turns off when the temperature reaches 21 °C (20+1).

To connect the circuit to external equipment a relay control (via K2) was chosen because of safety considerations. The transistor can easily handle currents up to 100 mA and a free-wheeling diode suppresses the back-emf from the relay coil. The power supply voltage can be selected

based on the rated coil voltage of the relay that is used, 12 V, for example.
Keep in mind that when using this circuit to replace the thermostat in a fridge, the compressor motor which is to be controlled is directly connected to the mains and **a safe implementation of the complete circuit is therefore absolutely essential.**

If this circuit is used to heat, for example, a flower box, it can be useful to replace the switching transistor with a HEXFET. A prototype circuit with an IRFP3710, supplied a 12-V heating element with 1.5 A without any trouble at all, while the losses where so small that no heatsink was required. The 5-V output voltage from the PIC was in this case sufficient to turn the FET on properly.

The program in the 16F628 fills only about half of the available program memory space. Because there was no compelling need to program the whole thing in a particularly 'compact' way, the PicBasic Pro compiler was used for generating the hex file for the PIC.
Both the source file (1820THER.BAS) as well as the hex file to be programmed into the 16F628 (1820THER.HEX) are available free from the Elektor website as file number 080090-11.zip.
The source code is liberally commented, so that making changes (changing the temperature range, for example) is quite straightforward.
The temperature is initially set to 20 °C and the hysteresis to 2 °C.

For the sensor it is best if you use a 'plain' DS1820 and fit it with a length of 3-way ribbon cable. When using it with a refrigerator this has the advantage that the sensor cable can be easily routed to the outside because the rubber seal on the fridge door still closes sufficiently well to seal around the cable. Once the ribbon

cable is connected to the DS1820, you can cover the sensor entirely with a thin layer of two-part epoxy glue and (before the glue has set) shrink a small length of heatshrink tubing around it. This gives a good, waterproof seal.

Alternatively you can buy a ready-made waterproof DS1820 sensor (for example Conrad Electronics # 184037/184052). These have, however, a type of telephone cable that is somewhat thicker than the ribbon cable.

(080090-I)

Downloads

The source- and hex-code for this project, 080090-11.zip, as well as the layout for the PCB (080090-1.zip) are available as a free download from the Elektor website.

COMPONENTS LIST

Resistors
R1,R2,R3,R5 = 4kΩ7
R4 = 2kΩ2
R6 = 10kΩ
R7 = 33Ω
P1 = 10kΩ preset

Capacitor
C1,C2 = 10µF 63V
C3 = 100nF

Semiconductors
D1,D2 = 1N4001
T1 = BC547
IC1 = 7805
IC2 = PIC16F628-04/P (programmed, with software # 080090-11)

Miscellaneous
X1 = 4MHz ceramic resonator
S1...S3 = miniature push button
K1,K2 = 2-way pinheader
K3,K5 = 3-way pinheader
K4 = 16-way pinheader
DS1820 and 3-way ribbon cable
LCD with 2x16 characters
PCB #080090-1 from www.thepcbshop.com

DTMF-controlled Home Appliance Switcher

Features

- ● Controls 6 high-power DC devices Five digits password security
- ● User-defined password
- ● Feedback to user by sounds
- ● Password and device status retained in EEPROM
- ● Device status on LED panel

Hesam Moshiri

Caution. This circuit is not approved for connection to the public switched telephone network (PSTN).

Caution. Observe electrical safety precautions when connecting mains-operated loads to the circuit.

This circuit can be called using your mobile or a regular telephone set (with DTMF keys) and after passing some procedures, you can control DC-powered appliances installed in your home. Examples include the front door latch and the pump of a plant watering system.

You call the circuit and after three rings, it will answer your call and you will hear two little beeps. Next you enter your password. The default password for the circuit is: **12345**. Finish the password number with a hash (**#**) character. If your password is correct, you will hear two short beeps and you can control your devices or change a password. If you push the character * you will enter the password menu. Enter a new password using numbers (0-9) and with five digits length. Close off with a # at the end of the new password (e.g. 54321#). You will hear one long beep indicating that your new password is stored in memory and the circuit will disconnect the phone connection. If you do not push *, you can control your devices by entering pre-assigned numbers. For example, the number '1' is for home front or rear door and every time you push it the door will open. Numbers 2-6 are for controlling five other devices. With every key push you change a device status and you will hear appropriate sounds that relate to the device status (see flowchart). After every command, the new device status will be stored in EEPROM. Once all devices have been controlled, simply hang up.
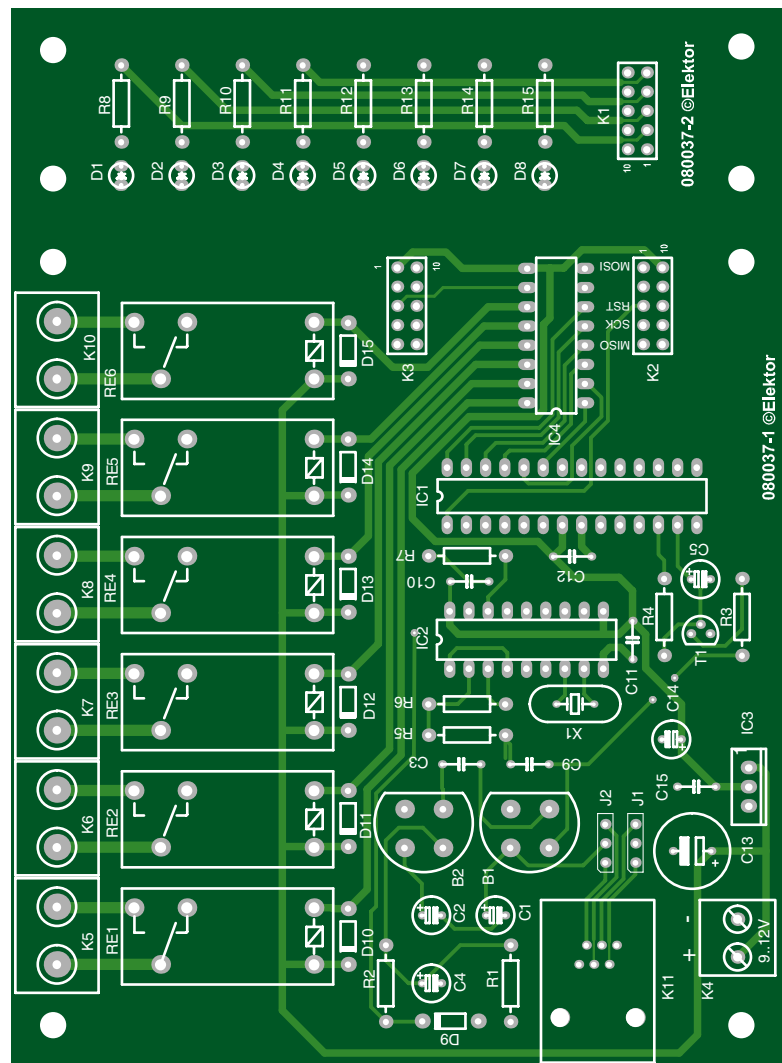
If the circuit is called but the user doesn't enter any numbers, the circuit will hang up after 7 seconds. In all of these procedures, when you enter any number, the circuit

COMPONENTS LIST

Resistors
R1 = 68kΩ
R2,R4 = 1kΩ
R3 = 330Ω
R5 = 10kΩ
R6 = 100kΩ
R7 = 220kΩ
R8-R15 = 220Ω

Capacitors
C1,C2,C3,C5,C9-C12,C15 = 100nF
C4 = 2µF2 40V radial
C13 = 1000µF 40V radial
C14 = 100µF 40V radial

Semiconductors
B1,B2 = B40C1500 (80Vpiv, 1.5A)
D1-D8 = LED, low current, 3mm
D9 = zener diode 4V7 400mW
D10-D15 = 1N4001
T1 = BD139
IC1 = Atmega8-16PC, programmed, Elektor Shop #080037-41
IC2 = MT8870
IC3 = 7805
IC4 = ULN2004

Miscellaneous
RE1-RE6 = 12V coil, e.g.V23057
X1 = 3.5795MHz quartz crystal
K1,K2,K3 = 10-way boxheader
K4 = PCB terminal block, lead pitch 5mm
K5-K10 = PCB terminal block, lead pitch 7.5mm
K11 = RJ11 connector, PCB mount, Hirose TM5RE1-64 (Digikey # H11257-ND)
J1,J2 = 3-way SIL pinheader with jumper
PCB, ref. 080037-1 from www.thepcbshop.com
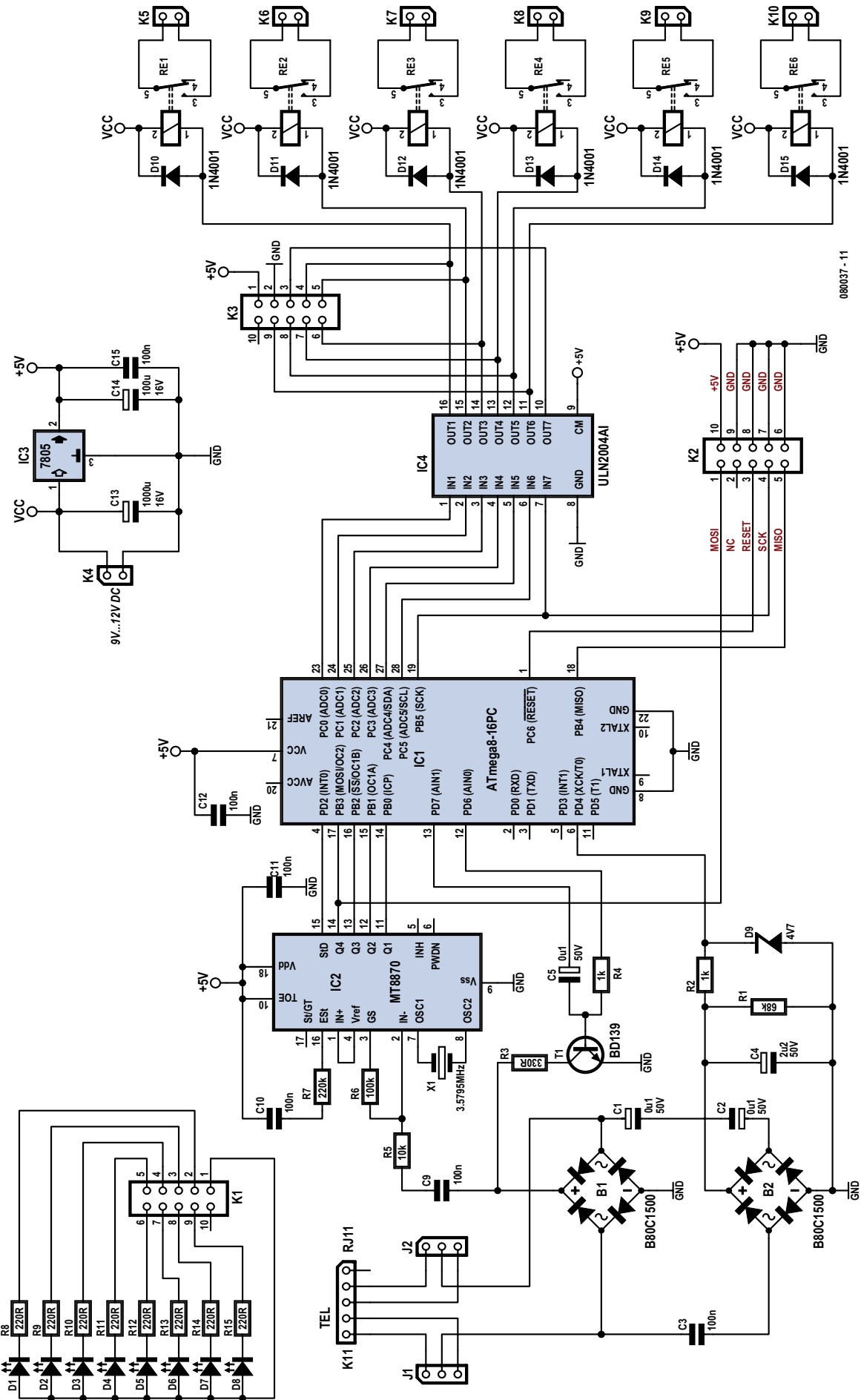
will acknowledge reception with one short beep. Please wait briefly for the circuit to receive and process the number pressed.

A maximum of three wrong password entries is accepted. With every wrong password you enter, you will hear one long beep and if you enter a wrong password thrice, you will hear one long beep again and the circuit will hang up on you.

The circuit shows the status of all devices by its LED panel. D1 indicates the circuit power, D2 the answer status (ON: phone line is busy; OFF: phone line is free). The other LEDs indicate the status of the controlled devices (LED ON: device = ON, LED OFF: device = OFF).

The schematic diagram **Figure 1** has these main parts: power supply, ring detector, answering circuit, tone decoder, microcontroller, output relays and LED panel driver. The power supply includes IC3, C6, C7 and C8 producing the +5 V supply voltage for the circuit. The ring detector comprises B2, C1-C4, R1, R2 and D9. C1, C2 and C3 pick up the ring (AC) voltage of between 80 V and 100V, 25 Hz. B2 converts the ring voltage to DC. C4 serves for noise reduction and R1, R2 and D9 create a suitable voltage level at the PD4 pin of the microcontroller.

When you call the circuit, one +5 V ring pulse appears at the cathode D9. The answer circuit includes B1, C5, R4, R3 and T1. If you want the circuit to answer to one ring, put one resistor in parallel with the telephone line, reducing the line voltage to approxi-

| Table 1. ATmega8 programming settings	
CKSEL0	0
CKSEL1	0
CKSEL2	1
CKSEL3	0
CKOPT	1
1: Unprogrammed, 0: Programmed	

mately 15 VDC and passing about 20 mA through the resistor. Answering the call implies driving T1 into saturation. Therefore the telephone line current will pass through R3. To hang up, T1 is switched off. The function of C5 is to inject a sound produced by the microcontroller. The DTMF tone decoder circuit includes R5, R6, R7, C9, C10, C11, X1 and IC2.

IC2 (an MT8870) is a DTMF tone decoder IC. It receives the DTMF tones via R5, R6 and C9. The corresponding binary data of each code appears on the Q1-Q4 pins. An incoming code is indicated by a rising edge on the STD pin. The event is fed to the INT0 pin of the microcontroller. A High level on the TOE pin of the MV8870 enables the outputs Q1-Q4. Here it is strapped to the +5 V rail.

The micro is an ATMega8 from Atmel. The final stage has a ULN2003 high voltage and high current Darlington transistor array IC, that easily copes with the relay and LED panel currents. Each output pin of this IC can drive up to 500 mA. The LED panel includes D1-D8 that indicate circuit acti-

vity and status of all devices. Caps C11 and C12 are included for noise reduction and it is to use multilayer capacitors ceramic for this purpose.

The PCB for the controller is shown in **Figure 2**. One PCB section comprises the main circuit the other is for the LED panel. The two PCBs are interconnected with a 10-way (2x5) IDC connector.

Once the circuit has been built up, the micro has to be programmed with the firmware hex file from free download archive **080037-11.zip** found on the Elektor website. The source code is also available: it was produced using MikroC from MikroElektronika.

Connect the 9-12 VDC mains adapter to J1. Next, program the microcontroller by means of the ISP socket, K2. Select an 8-MHz internal clock source for the micro by setting the fuse bits per **Table 1**. Don't forget to program both the Flash (filename.hex) and the EEPROM (filename.eep) file! Connect your electrical appliances to the circuit observing all relevant electrical safety precautions. The EEPROM in the circuit ensures that settings are not lost after a reset or when a mains power interruption occurs.

Finally, we can calculate the security of the system. With a five-digit password, we have a 1 in 100,000 probability of hitting the correct code by chance, which seems adequate for such a simple system.

(080037-I)

USB Standby Killer

Wim Abuys

When turning a computer on and off, various peripherals (such as printers, screen, scanner, etc.) often have to be turned on and off as well. By using the 5-V supply voltage from the USB interface on the PC, all these peripherals can easily be switched on and off at the same time as the PC. This principle can also be used with other appliances that have a USB interface (such as modern TVs and radios).

This so-called 'USB-standby-killer' can be realised with just 5 components.

The USB output voltage provides for the activation of the triac opto-driver (MOC3043) which has zero-crossing detection. This, in turn, drives the TRIAC, type BT126.
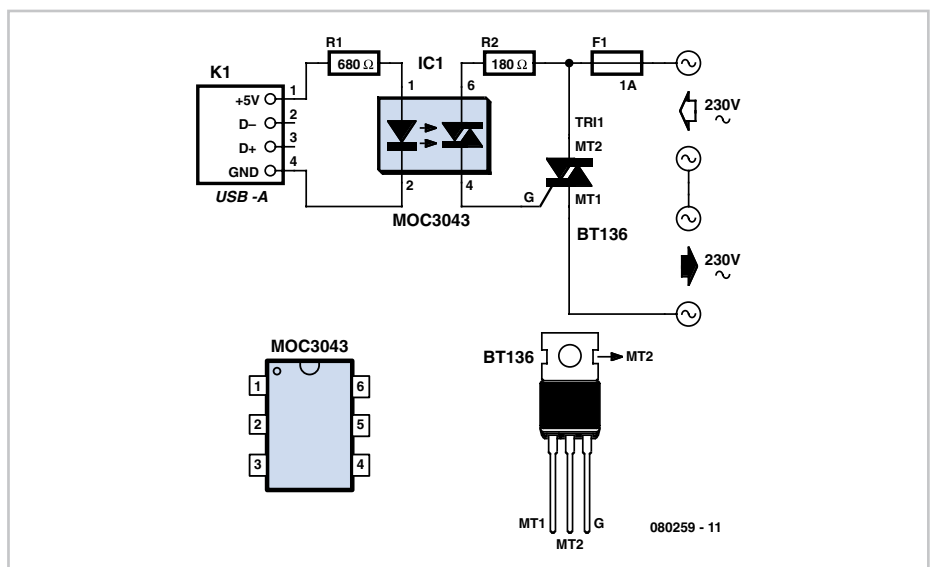
The circuit shown is used by the author for switching loads with a total power of about 150 W and is protected with a 1-A fuse. The circuit can easily handle much larger loads however. In that case and/or when using a very inductive load a so-called snubber network is required across the triac. The value of the fuse will also need to be changed as appropriate.

The circuit can easily be built into a mains multi-way powerboard. Make sure you have good isolation between the USB and mains sections (refer to the Electrical Safety page published regularly in this magazine).

(080259-I)

Fog Lamp Switch

J. Geene

In most countries it is now mandatory or at least recommended to have a rear fog light on a trailer with the additional requirement that, when the trailer is coupled to the car, the rear fog light of the towing car has to be off. The circuit shown here is eminently suitable for this application.

The circuit is placed near the rear fog light of the car. The 12-V connection to the lamp has to be interrupted and is instead connected to relay contacts 30 and 87A (K1, K3). When the rear fog light is turned on it will continue to operate normally. If a trailer with fog light is now connected to the trailer connector (7- or 13-way, K2), a current
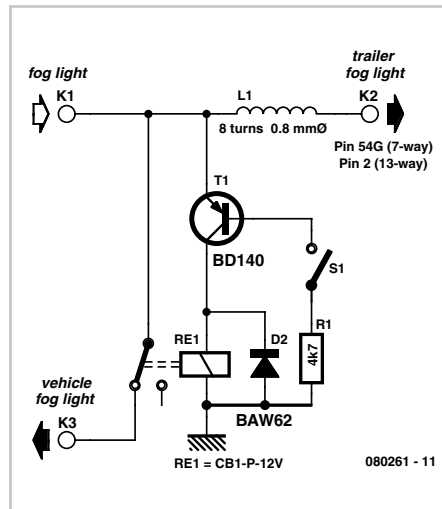
will flow through L1. L1 is a coil with about 8 turns, wound around reed contact S1. S1 will close because of the current through L1, which in turn energises relay Re1 and the rear fog light of the car is switched off. The fog light of the trailer is on, obviously. The size of L1 depends on reed contact S1. The fog lamp is 21 W, so at 12 V there is a current of 1.75 A. L1 is sized for a current between 1.0 and 1.5 A, so that it is certain that the contact closes. The wire size has to be about 0.8 mm. The relay Re1 is an automotive relay that is capable of switching the lamp current. The voltage drop across L1 is negligible.

(080261-I)

22-bit A/D Converters

Steffen Graf

When accuracy matters more than speed, the MCP3550 series of analogue-to-digital converters from Microchip [1] is worth a look. They are ideal for accurately measuring DC voltages that only change slowly over time, offering an extremely high resolution of 22 bits while only drawing a paltry 150 µA from a 5 V power supply.

With the addition of a low power voltage reference such as the MAX6520 [2] as shown in the circuit diagram we have an ultra-precise analogue-to-digital converter with a total current consumption of around 0.2 mA, using only a minimum number of components. The conversion results are output using a serial interface that is easy to connect to the SPI port of a microcontroller. A file containing a printed circuit board layout for this design is available for free download from http://www.elektor.com.
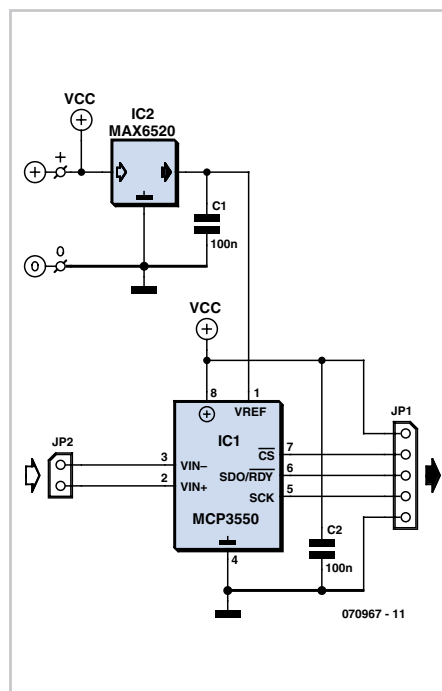
Part	Notch frequency (Hz)	F_S (Hz)	Effective resolution (bit)
MCP3550-50	50	12.5	21.9
MCP3550-60	60	15	21.9
MCP3551	50 & 60	13.75	21.9
MCP3553	-	60	20.6

Microchip make four versions of these ICs. As the table shows, they differ in the frequency of the built-in notch filter, which is designed to help suppress mains hum. They also have different sample frequencies, as well as different effective resolutions.

(070967-I)

Web Links

[1] http://ww1.microchip.com/downloads/en/DeviceDoc/21950d.pdf

[2] http://datasheets.maxim-ic.com/en/ds/MAX6520.pdf

Solar-powered Battery Charger

080225 - 11

C. Tavernier

Long before the current fashion for sustainable development caused solar panels to blossom on roofs and terraces in non sun drenched areas of the world, numerous nomadic and Route 66 users were already using them on motor-homes or pleasure craft. In these situations, the primary rôle of a solar panel is not to sell power back to the local electricity board or utility, but to charge an array of batteries in our on the vehicle or craft to provide a source of electricity after dark.

Even though such an operation might appear trivial, all the more so if you look at certain 'charger' circuits, it really is nothing of the sort, if you're keen to look after your batteries. Even though it does work, the solution of wiring batteries, supplied load, and solar panels in parallel is far from being satisfactory in at least two situations, which we'll discuss below.

When the load powered by the batteries consumes little or nothing at all, and the batteries are already well charged, and it's also a sunny day, the batteries are in serious danger of being over-charged, which as everyone knows will severely shorten their life — and possibly your travelling distance.

On the other hand, when the load powered by the batteries is drawing a lot of current

and there is little or no sun, the batteries can end up completely discharged, which as it may turn out is just as detrimental to their life as over-charging.

Yet it takes only a handful of components to build our intelligent regulator, the circuit of which is given in **Figure 1**. It uses a PIC 12C671 microcontroller, which has the double advantage of being housed in an 8-pin DIL package and containing a multi-input analogue/digital converter (DAC).

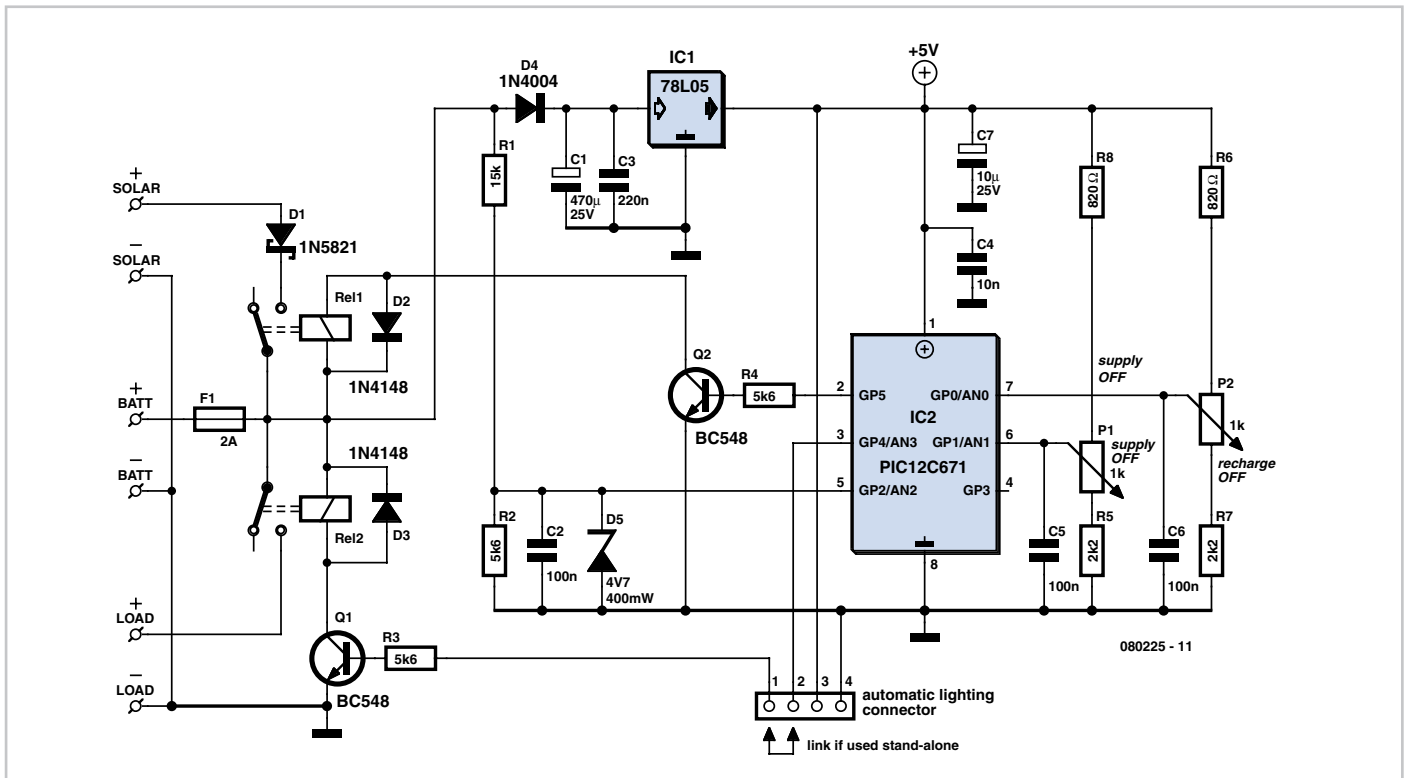Potential divider R6-P2-R7 feeds a discrete voltage level to AN0 to set the battery voltage at which charging should be stopped, to prevent any risk of over-charging. Potential divider R8-P1 and R5, feeding PIC analogue input line AN1, this time defines the battery voltage below which the load should be disconnected to avoid excessive discharge. In this way, a voltage window is created for the PIC to maintain in the interest of the battery's health and lifetime — and your peace of mind, of course.

The voltage present at the battery terminals is measured via the potential divider – fixed this time – R1 and R2, feeding PIC port line AN2. Zener diode D5 protects the microcontroller from any spurious external voltage that might appear on the terminals of the solar panels – during thunderstorms, for example.

Depending on the above mentioned voltage thresholds, the circuit controls relays

Re1 and Re2, via transistors T1 and T2. The first is used to connect the solar panels to the battery. Hence it is energized as long as the battery is not being over-charged, otherwise it is off. The second, T2, is used to connect the battery to the load being powered. So it is energized as long as the battery is not too deeply discharged, otherwise it is off.

Diode D1, which must be a Schottky type to minimize the forward voltage drop, avoids the battery discharging through the solar panel in periods of weak sunshine. A normal silicon diode in this position will have a too high forward drop (about 0.6-0.7 V) to ensure optimum results hence is not recommended.

Note the 4-pin connector at the bottom of the circuit diagram. This allows the present charger to be connected to the Solar-powered Automatic Lighting Module described elsewhere in this issue. If this module is not being used, all you need do is connect a jumper across pins 1 and 2, as indicated in the diagram.

To make this project easy to build, we've designed the PCB shown here. As usual, the copper track layout is contained in the free download available from the Elektor website. This PCB has been designed for 10 A Finder SPDT relays, which leaves plenty of freedom in terms of choice of panels and battery. When designing this charger, we

COMPONENTS LIST

Resistors
R1 = 15kΩ
R2-R4 = 5kΩ6
R5,R7 = 2kΩ2
R6,R8 = 820Ω
P1,P2 = 1kΩ potentiometer

Capacitors
C1 = 470 µF 25V
C2,C5,C6 = 100nF
C3 = 220nF
C4 = 10nF
C7 = 10µF 25 V

Semiconductors
D1= 1N5821
D2,D3 = 1N4148
D4 = 1N4004
D5 = zener diode 4V7 400mW
Q1,Q2 = BC548
IC1 = 78L05
IC2 = PIC12C671, programmed, see Downloads

Miscellaneous
Rel1,Rel2 = relay, 10A contact
F1 = fuse, 2A
4-way SIL pinheader
6 PCB terminal blocks, 5mm lead pitch
1 wire bridge
PCB, ref. 080225-I from www.thepcbshop.com

on the Elektor server, as well as from the author's own website (see end of article). Once built, the project is elementary to adjust, and only requires a DC voltmeter and an adjustable PSU, even a very simple one. Do not connect any of the external elements to the charger, and replace the battery by your stabilized PSU set to 12 V, with a voltmeter across it.

Then increase the voltage to 14.5 V and adjust P2 so that Rel1 just drops out. Then reduce this voltage to confirm that Rel1 is energized again at around 12.8–13 V (depending on component tolerances). Continue to reduce the voltage down to 10.5 V and then adjust P1 so that Rel2 drops out. Increase the voltage again to check that Rel2 is energized again around 12 V or just under. P1 and P2 do not interact, so it is easy to adjust them independently.

Lock the wipers of P1 and P2 with a little sealant and fit your project into a case, taking care to protect it from damp if it is to be used outdoors. A sealed electrical junction box is ideal for this, at a ridiculously cheap price.

(www.tavernier-c.com) (080225-I)

Downloads
The source code and .hex files for this project are available for free from www.elektor.com; file # 080225-11.zip.

The PCB design is available for free download from our website www.elektor.com; file # 080225-1.zip.

planned for a maximum battery current of 2 A, as indicated by the fuse value given, but there's nothing – apart, perhaps, from your wallet, for the cost of the battery and solar panels – to stop you from going higher.

The .hex file to be programmed into the PIC 12C671 is available free to download

Simple LED Bike Light

Gatze Labordus

On my mountain bike I always used to have one of those well-known flashing LED lights from the highstreet shop. These often gave me trouble with flat batteries and lights that fell off. As an electronics student I thought: "this can be done better".
First I bought another front wheel, one which has a dynamo already built in the hub. This supplied a nice sine wave of 30 Vpp (at no load).
With this knowledge I designed a simple power supply. The transistors that are used are type BD911. These are a bit of an overkill, but there were plenty of these at my school, so that is why I used them. Something a little smaller will also work.
The power supply is connected to an astable multi-vibrator. This alternately drives
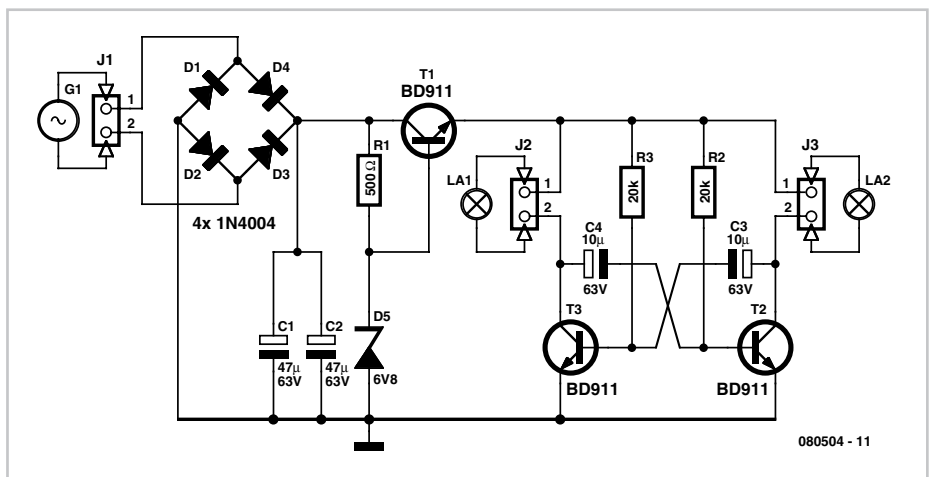
the front light and the rear light. The frequency is determined by the RC time-constant of R3 and C3, and R2 and C4. This time can be calculated with the formula:

$$t = R3 \times C3 = 20 \times 10^3 \times 10 \times 10^{-6} = 0.2 \text{ s}$$

You can use a 22 kΩ (common value) for R2 and R3, that doesn't make much difference.

On a small piece of prototyping board are six LEDs with a voltage dropping resistor in series with each pair of LEDs. Such a PCB is used for both the front and the rear of the bike. Of course, you use white LEDs for the front and red ones for the rear. The PCB with the main circuit is mounted under the seat, where it is safe and has been working for more than a year now.

There are a few things I would change for the next revision. An on/off switch would be nice. And if the whole circuit was built with SMD parts it could be mounted near the front light. This would also be more convenient when routing the wiring. Now the cable from the dynamo goes all the way to the seat and from there to the front and rear lights.

(080504-I)

Solar-powered Uninterruptible PSU

C. Tavernier

When you want to power an electronic device from solar panels, broadly speaking there are currently two approaches. The first, very conventional method (described elsewhere in this double issue) consists of employing a combination of solar panels (or an array), an automatic charger, and a battery (or an array). This combination then powers the device concerned, which has its own voltage regulating circuits. The second, which we are proposing in this project, consists of building a 'solar' PSU directly. It is of course based on the same concept as the one described above, but having been designed for this purpose right from the start, the elements it composes are integrated to a higher extent, leading to improved efficiency.

Our suggested circuit is intended to power a number of current electronic devices directly, and can provide three different voltages: 3.3 V, 5 V or 12 V, depending on component selection; all at a current of 400 mA, which can even be increased to 1 A if necessary (details below).

It's primarily based around IC3, a high-performance switching regulator from Linear Technology. Depending on whether you choose an LT1300 [1] or an LT1301 (*) [2] you will have a choice of two output voltages: 3.3 or 5 V for the former, and 5 or 12 V for the latter. For both ICs, the voltage is selected by fitting jumper S1 or not, as indicated in **Table 1**. Look carefully into the output voltages you will require and then select the appropriate ICs for the project.

When jumper S2 is fitted, the output current of these ICs is internally limited to 400 mA. It can be increased to 1 A by omitting the jumper, but we don't really recommend this as the rest of the circuit has been optimized for an output current from a few mA to 400 mA maximum.

The primary power source is the NiMH rechargeable battery pack, which in the

080223 - 11
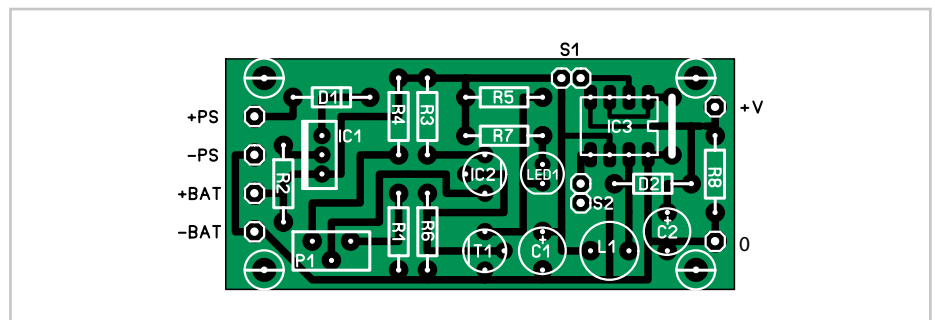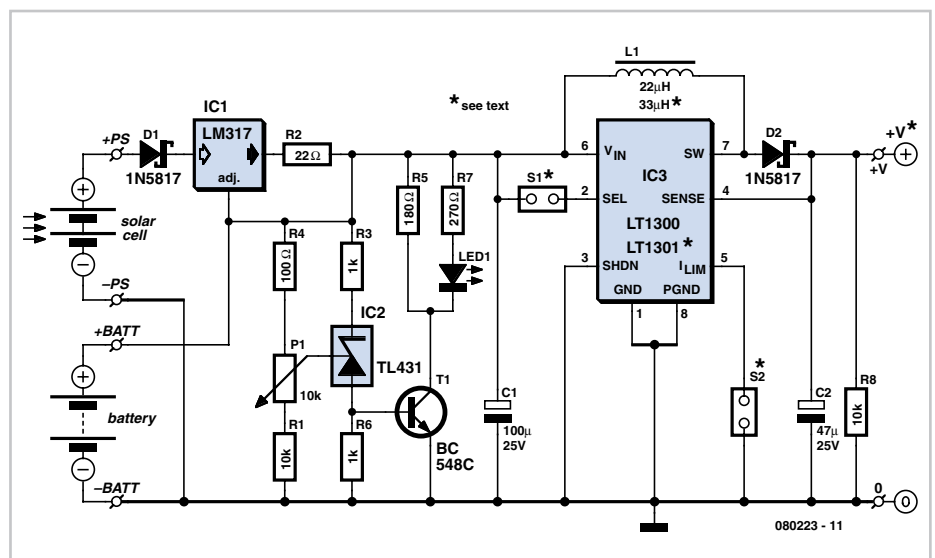
COMPONENTS LIST

Resistors
R1,R8 = 10kΩ
R2 = 22Ω
R3,R6 = 1kΩ
R4 = 100Ω
R5 = 180Ω
R7 = 270Ω
P1 = 10 kΩ potentiometer

Inductors
L1 = 22 µH (or 33 µH, see text)

Capacitors
C1 = 100µF 25V

C2 = 47µF 25V

Semiconductors
D1,D2 = 1N5817
T1 = BC548C
IC1 = LM317
IC2 = TL431
IC3 = LT1300 (or LT1301, see text)
LED1 = LED

Miscellaneous
S1,S2 = 2-way pinheader, lead pitch 2.54 mm, with jumper
6 solder pins
PCB, ref. 080223-1 from www.thepcbshop.com

case of the LT1300 will comprise two 1.2 V cells, or three cells in the case of the LT1301. The solar panel should be chosen to deliver a voltage of the order of 9 V at an output current of around 100 mA. Such panels are available commercially.

IC1 acts as a constant current charger to limit the current to around 60 mA. To avoid overcharging the battery in the event of low current draw by the device powered on the one hand and constant sunshine on the other, the circuitry around IC2 and T1 has been added. IC2 is just a variable zener which will turn on T1 harder as the voltage at the wiper of P1 increases. In this way, when the voltage at the battery terminals rises too high, as at the end of charging, T1 will be turned on harder and harder, bypassing part or all of the charging current to ground via R5 and R7, and lighting the LED as it does so. This is simply a contemporary variation of the traditional shunt voltage regulator.

The whole of the project fits easily onto a compact printed circuit board of which the component mounting plan reproduced here. The copper track layout is a free pdf download as usual. Building up the board should not present problems as there are no oddball components to solder

Table 1.		
IC3	LT1300	LT1301
L1	22 μH	33 μH
S1 fitted	+V = +5 V	+V = +12 V
S1 absent	+V = +3.3 V	+V = +5 V
S2 fitted	I_{max} = 400 mA	I_{max} = 400 mA
S2 absent	I_{max} = 1 A	I_{max} = 1 A

or mount.

An 8-pin DIL socket should be soldered in the IC3 position to allow fitting of one or the other of the intended ICs. If your usual retailer doesn't have them in stock, you should be able to obtain them from mail order suppliers, for example, from Farnell. Take care choosing the choke L1 (22 μH for the LT1300 or 33 μH for the LT1301). It must be able to handle a current of 800 mA without saturating, which is far from being the case with many ordinary moulded types. Our 22 μH one comes from Radiospares (RS Components) and is an ELC08D from Panasonic.

It is vital that diodes D1 and D2 are Schottky types, to minimize forward voltage drop, and in the case of D2, to be fast enough in terms of recovery. AA or even AAA 1.2 V batteries will be suitable, given

the impressive capacity of current types on the market.

The circuit should work the moment it is powered; all that remains is to adjust potentiometer P1. To do this, temporarily disconnect the solar panel and batteries, replacing the latter with an adjustable stabilized power supply unit, across which you should also connect a voltmeter. If you are using the LT1300 version, i.e. with two 1.2 V cells, set your PSU to 3.2 volts and then adjust P1 to obtain definite illumination of the LED. If you use the LT1301 version (and hence three 1.2 V rechargeable cells), you'll need to set your PSU to 4.8 V and again adjust P1 till the LED lights.

(www.tavernier-c.com) (080223-I)

Web Links

[1] LT1300
www.linear.com/pc/downloadDocument.
do?navId=H0,C1,C1003,C1042,C1035,P1449,D2742

[2] LT1301
www.linear.com/pc/downloadDocument.do?navId=
H0,C1,C1003,C1042,C1031,C1060,P1450,D3451

Downloads

The PCB design for the project is available to download from the www.elektor.com; file # 080223-1.zip.

RGB Lights

Joseph A. Zamnit

The overall effect produced by this project is a glowing sequence of lights changing slowly from one colour to the next. The microcontroller cycles through randomly generated values of red, green and blue hues of light to produce a variety of nice colours.

The software implemented on the controller interpolates from one shade to another, each colour channel being treated independently. Light intensity is controlled by means of pulse width modulation (PWM) for each colour. A high frequency of approximately 60 Hz is used to modify the light intensity and eliminate any flicker that might arise.

One major problem that had to be overcome was unequal brightness of the LEDs used, the result of which is a tendency for one particular colour to dominate in the overall hue produced. It was found that

080419 - 11
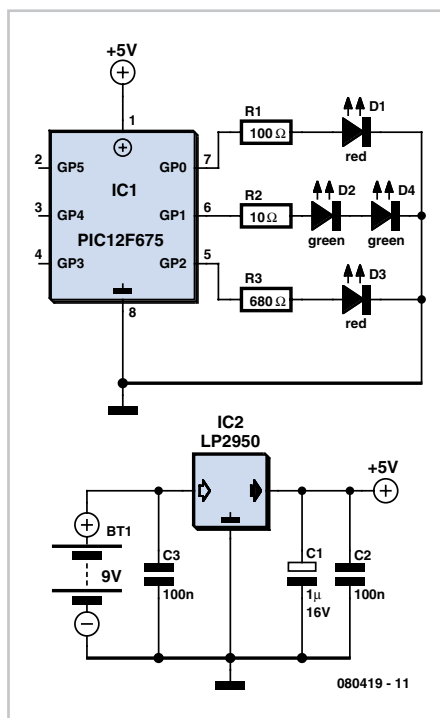
blue LEDs are perceived to have the largest intensity and green, the lowest. This was compensated for by using a large resistor for blue and a low resistor for green, together with two green diodes in series for higher green colour intensity. The values of the resistors may have to be tweaked to achieve the best balanced colour intensity. A diffused glow was achieved by cutting the lens of the ultra bright LEDs used and using a ping pong ball as a basic diffuser. This very simple project is perfect for a rainy day and can be built in a couple of hours. Despite its simplicity it will produce a very interesting and glowing effect. Several units may be built and they will mix a variety of colours randomly.

The source and hex code files for the PIC12F675 device are available as free download # 080419-11.zip from the Elektor website. The code was developed using CCS C.

(080419-I)

FM Microbug

Thijs Beckers

Although the idea has been around for a good while already, it's still cute: a tiny circuit that you can hide just about anywhere for all sorts of eavesdropping activities. Fun for at work, but also usable as a babyphone. The basic necessities are a small microphone and a little transmitter. This can be realised using very simple resources.

This bug circuit operates in the normal VHF FM band and can thus be received using any ordinary radio. The schematic is based on a somewhat uncommon IC, the 74LS13, but with a bit of searching you can still manage to find one somewhere. The other five components (that's all!) are all readily available. You might already have them in your parts drawer.

Here we use an electret capsule for the microphone. The necessary bias voltage is tapped off from the supply voltage via R1. If you use a crystal microphone instead, you can omit R1 and C3.
The microphone signal is fed to pin 5 of the IC. C2 is included to slightly improve the
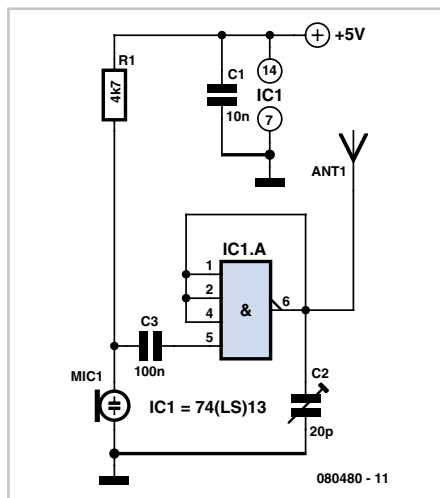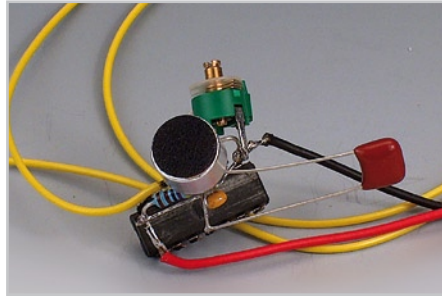
performance and sensitivity of the circuit. C1 serves to decouple the supply voltage so any spikes that may be present are suppressed. Just about any short length of wire makes a suitable antenna.

The circuit operates on the third harmonic at around 100 MHz. It takes a bit of experimenting to find the right frequency on the radio, but within a range of a few metres the circuit can even overpower signals from relatively powerful transmitters. Of course, this circuit is not entirely legal, so you shouldn't try to boost the power too much. A range of 20 metres is certainly possible with the circuit as shown.

This very simple circuit is highly sensitive and somewhat prone to positive feedback, especially if you hold it in your hand. The best approach is to put it down somewhere and stay away from it; then it works fine. If you want to experiment with the circuit, feel free!

(080480-1)

Energy-efficient Backlight

Rainer Reusch

The backlights used in some LCD panels are not exactly economical: typical current draws of 20 mA to 100 mA are common. Normally the current is determined by a series resistor, which leads to additional power losses. It is considerably more efficient, if a little more complex, to use a switching regulator IC. Alternatively, it is often the case that driving the LCD panel is a microcontroller, which we can press into service to provide regulation in software. Fortunately, the regulation does not need to be exceptionally precise.

At the heart of our circuit is T1, a p-channel MOSFET, which is driven by an inverted (active low) pulse-width modulated signal from the
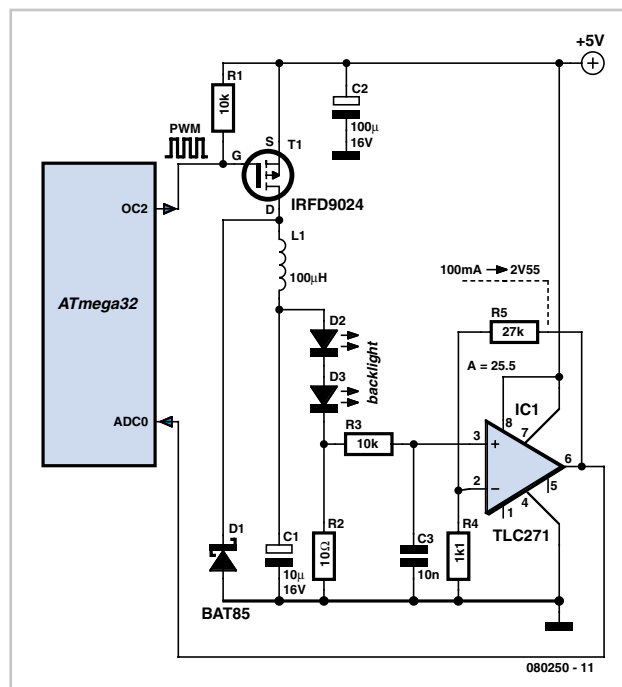
microcontroller. Components D1, L1 and C1 form the remainder of the standard step-down switching regulator configuration. In the circuit diagram the LCD backlight is represented by two LEDs; the current flowing through these LEDs is measured by a shunt resistor, filtered, and finally amplified to a level suitable for input to the A/D converter in the microcontroller using an operational amplifier. R1 ensures that the transistor switches off completely when the microcontroller is reset (at which time all ports become inputs).
The circuit can be used with any microcontroller that can generate an inverted PWM signal at a frequency in the range 10 kHz to 100 kHz. We have developed a demonstration program and code module for the Atmel ATmega32

using GNU C. The source code can be downloaded from the *Elektor* website at http://www.elektor.com or from the author's site at http://reweb.fh-weingarten.de/elektor.

The program generates the PWM signal at 31.25 kHz (if the processor clock is 8 MHz) on the OC2 output (PD2) of the ATmega32 microcontroller. The pulse width can be adjusted in 256 steps. If the gain of the operational amplifier is 25.5 a current of 100 mA through the LEDs will correspond to a voltage of 2.55 V at the input to the A/D converter. The internal reference voltage of the ATmega32 is nominally 2.56 V, and so an LED current of 100 mA will lead to a ten-bit conversion result of 03FFh. It is sufficient to monitor only the top eight bits of this value, and depending on the error from the desired value, increment or decrement the pulse width of the PWM signal. This forms an integral controller.

As it stands, this solution cannot compete on simplicity with a series resistor. However, we can make some simplifications to the circuit by eliminating the regulation feedback loop. Dispense with the operational amplifier and surrounding circuitry, and have the software output a fixed PWM signal. This loses the ability of the circuit to compensate for part-to-part variation in the components and for temperature, but in practice such compensation is rarely necessary. The software also supports the simplified version of the circuit.

(080250-I)

SimpleProg

Easy ISP for AVR microcontrollers

Dr. Thomas Scherer

A trawl of the Internet will reveal no end of simple AVR microcontroller programmer designs for connection to the parallel port of a PC. Here at Elektor we have also published a few variations on this particular theme. One thing that is perhaps surprising is how different the various designs are from one another. One of the main reasons for the differences is that the programmers are intended for use with different AVR microcontroller development environments, although in some cases it is perhaps not always made as clear as it ought to be which one this is.

The circuit shown here was developed as part of the current Elektor AVR-ATM18 project series. Troubled by a nagging feeling that a circuit is not a proper cir-

cuit unless it contains at least one active component, the author added an LED to show when data transfer is occurring. In fact, this visual feedback is extremely helpful when troubleshooting, and is a worthwhile addition even if our aim is to make the simplest possible programmer.

Construction is very straightforward. The circuit can be built on a small piece of perforated board, using a flat cable with a 25-way sub-D plug crimped to one end and a 26-way IDC header crimped to the other to connect to the PC's parallel interface. The six-way ISP cable is plugged into a suitable box header on the perforated board. If six-way headers prove hard to get hold of, a ten-way type as shown in the pho-

tograph can be used instead with just the middle six pins wired.
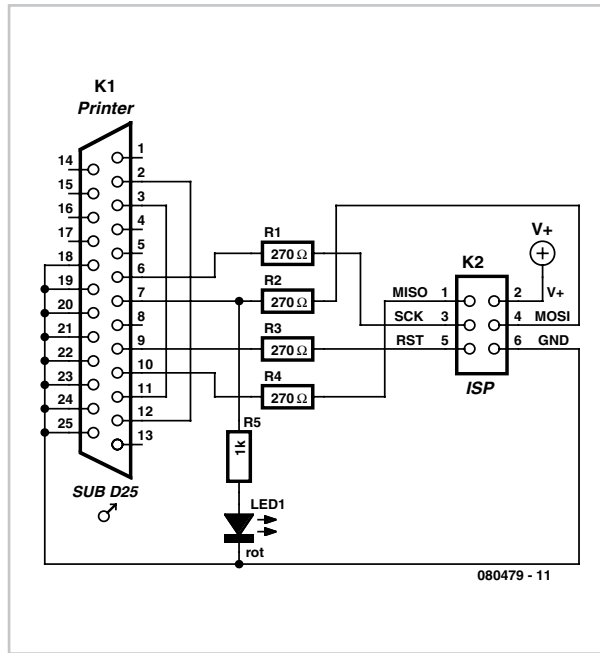
The programmer is compatible with the STK200 and STK300 from Kanda and will therefore work in conjunction with any program that offers those devices as options. It works perfectly with BASCOM [1], and Kanda also offers excellent (and free) programming software [2]. Observe that this unit uses 5 V signal levels. The target microcontroller should therefore also be powered from a 5 V supply, at least while it is being programmed.

(080479-I)

[1] BASCOM: http://www.mcselec.com

[2] http://www.kanda.com/avr-isp-software.html

Radio Control Signal Frame-rate Divider
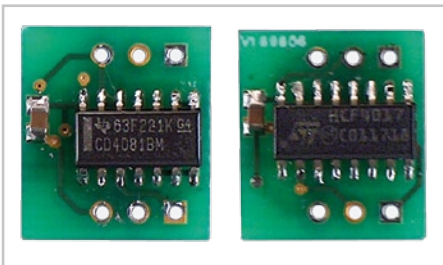
Mike Mobbs

Model radio-control equipment has evolved considerably over the years, and the humble servo has grown from the 1.5 ms at 50 fps (frames per second) format, to the more precise and powerful
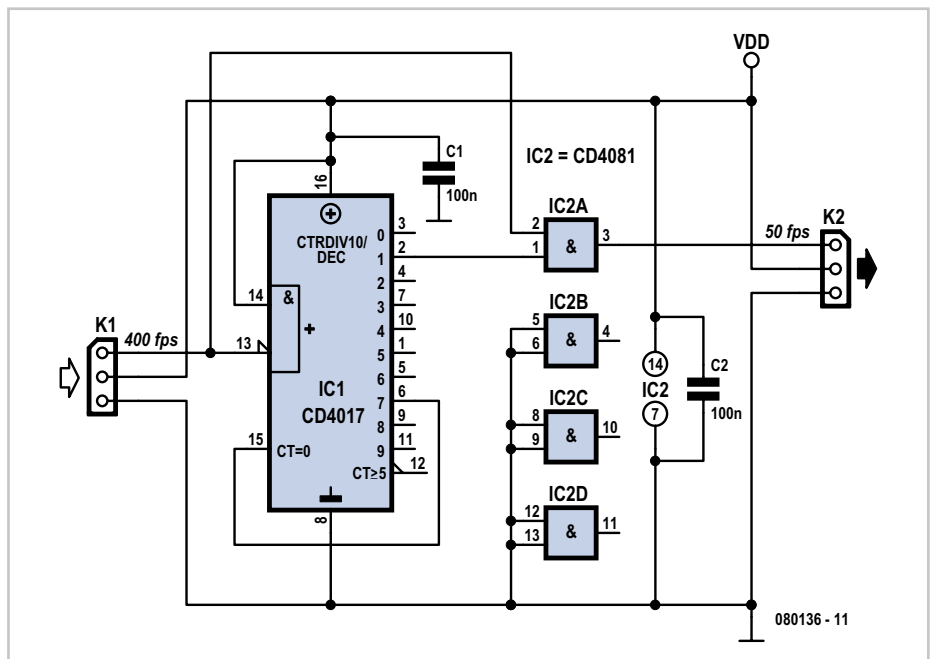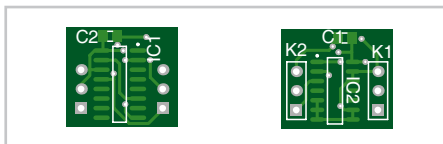
COMPONENTS LIST

C1 = 100nF
C2 = 100nF
IC1 = CD4017 (SMD)
IC2 = CD4081 (SMD)
K1 = 3-wire cable with 3-way socket
K2 = 3-wires cable with 3-pin plug
PCB, ref. 080136-1 from
   www.thepcbshop.com

digital variety using, typically, 400 fps, and accessories such as helicopter gyros have evolved to make use of these improved servos. As a result, the later generations of gyros often only provide the 400 fps 'digital' signal, which is not suitable for use with the older 'analogue' servos. All is not lost, as this circuit allows only one frame in eight to reach the servo, replicating the 50 fps sys-

tem. The prototype version was built using standard ICs, and sits neatly under the gyro (a CSM720 in the test setup) to provide the analogue output.

The circuit uses a Type 4017 CMOS decade ring counter, which is clocked by the falling edge of the input via the CP1 (enable) pin, and reset by output 7. The first input pulse

after reset sets output 1 high, which allows the next input pulse through to the output via a CMOS 4081 OR gate. Thus only one pulse in every eight is fed to the output. The use of negative logic to provide the AND function removes any risk of timing glitches, as the gating signal is established before the input pulse, and is stable for the duration of this pulse.

Other divider ratios can be used by choosing the relevant output for the reset.
A miniature PCB with SMD parts on it was designed for the converter to enable it to be incorporated into a model where space is always at a premium! The circuit is best encapsulated in heatshrink sleeving.

FL Twilight Switch

Peter Herlitz

This light dimmer has been especially designed for use with fluorescent lamps (FLs). The circuit contains only a few components and can be built on a circuit board of only 2 by 3 cm if you use SMD components.
The mains voltage is rectified by D1 to D4 and this waveform goes to the in series connected fluorescent lamp and a thyristor. During the day the thyristor will not receive any gate current so that the lamp will remain off. At night the thyristor will receive a continuous gate current so that the fluorescent lamp stays fully on.
The light/dark detection circuit is built around T1 to T4. This part is fed directly from the rectified mains voltage via R1/D5/C1.
Photo transistor T1 measures the amount of ambient light. During the day, when there is sufficient light, T1 conducts. In that case T2 and T3 will block and T4 conducts so that the thyristor does not receive any current.

When dusk falls the voltage across electrolytic capacitor C2 increases. At some point

070895 - 11
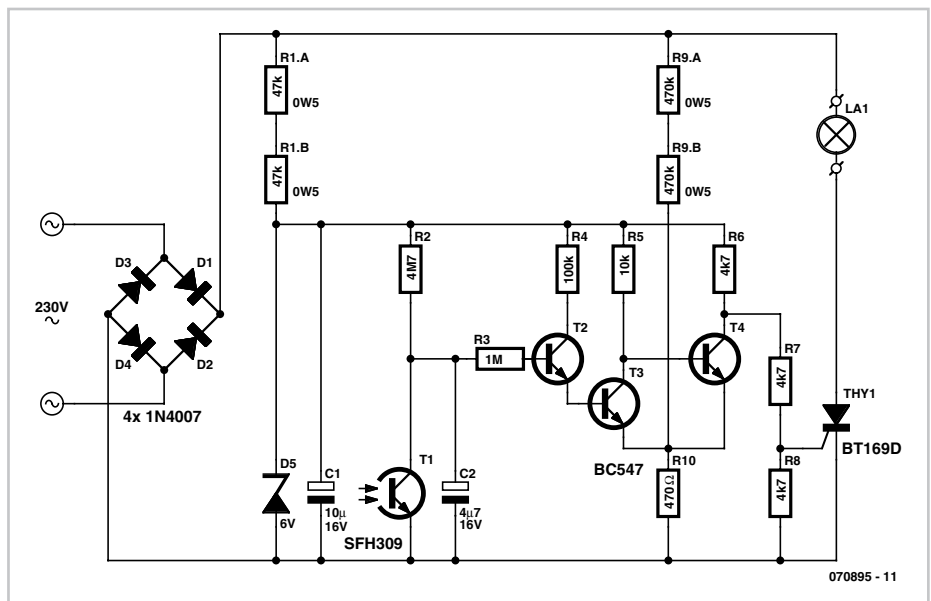
this will become high enough so that T2 and T3 will conduct. T4 will not receive any base current any more and blocks, so that the thyristor will receive continuous gate current via voltage divider R6/R7/R8 and the lamp will light up. R9 and R10 provide for some hysteresis in the switching behaviour of T2 and T3, so that the circuit does not repeatedly turn on and off when dusk falls.
When building the circuit make sure that it is electrically safe, since it is directly connected to the mains voltage.

The OC171 Mystery (solved)

grease filling
alloy-diffused Ge junction
conductive hairs in air space
solder seal
glass header
080473 - 11
E B S C
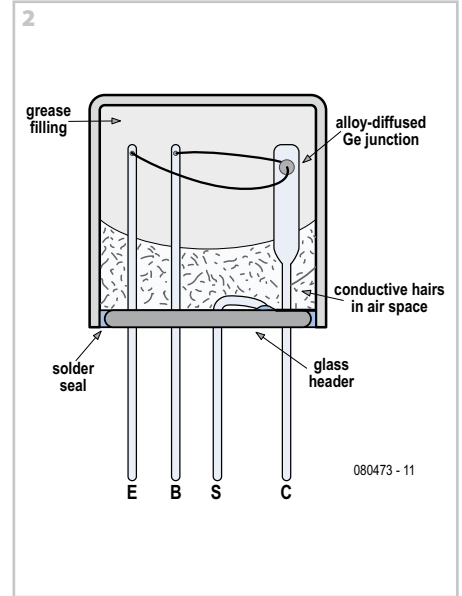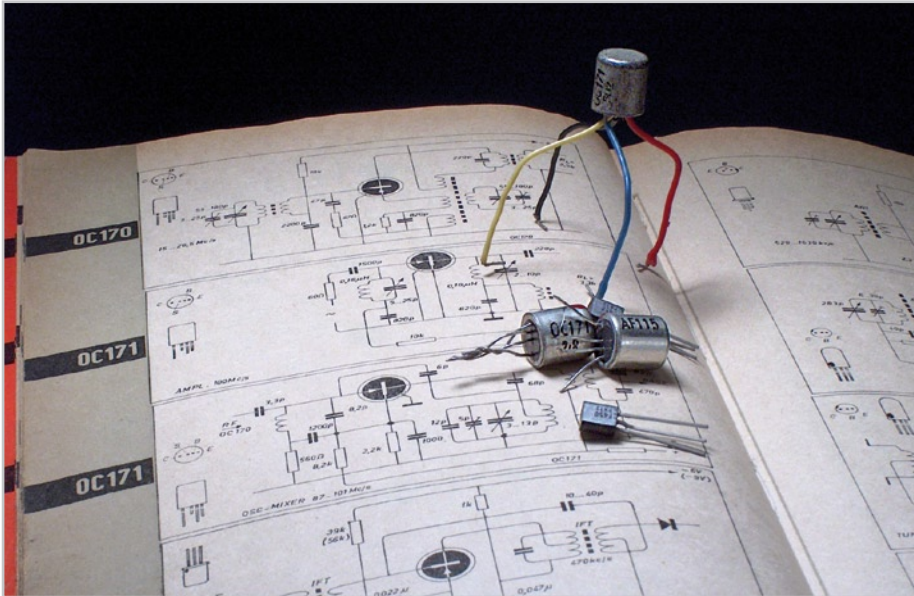
Jan Buiting, PE1CSI

The OC170 and OC171 transistors are germanium p-n-p alloy-diffused transistors in a TO-7 metal case. They were designed by Philips in the early 1960s as RF transistors with a (then spectacular) transition frequency of about 70 MHz. At the time, these devices marked a transition from the old 'grown alloy' to the new 'alloy-diffused' junction manufacturing, at the verge of the silicon age that was about to begin.

The OC170 and OC171 were a good success and got widespread use as RF and IF amplifiers, oscillators and mixers in early MW/LW portable radios as well as TV sets. When Philips phased out their 'OC' type prefix to comply with the Pro Electron semiconductor type designation system, successors of the OC170/171 called AF114, AF115, AF116 and AF117 appeared on the market. Both the OC and the AF devices carry a 'terrible secret' inside their TO-7 metal can.

If you switch on a 'dead' 1960s transistor radio containing one or more of the above mentioned trannies, try gently tapping them with a small screwdriver. In many cases the radio will crackle, burst to life or work intermittently and drop silent again after a while.

Surprisingly, unsoldering a suspect OC171 from the circuit and checking its junctions using an ohmmeter will not reveal faults in the junction proper. The device will also achieve its normal electrical specifications. However, an unexpected short-circuit may be measured between the shield wire (S) and the emitter or collector. In the 455 kHz IF amplifier shown in **Figure 1**, a domino-effect with all transistor biasing occurs if, say, the collector of the first OC171 is shorted to the shield, hence to ground. This was a practical case and a trigger to start a research.

In reference [1] Andrew Emmerson explains that these short-circuits are caused by microscopic conductive 'hairs' growing from the inside of the can in the air space under the grease filling (probably petroleum jelly or an early form of silicone grease). The phenomenon is illustrated in **Figure 2**. Typically the hairs will reach the emitter or collector wire. The nature of the growth is unknown; some suggest it's due to an electrochemical effect between the can metal and the wire metal, with the air and the slightest trace of acid in the grease interacting in the process. Others claim it's a 'Philips nasty' — a chemically engineered time bomb to generate sales of new radios. An even more unlikely suggestion is one of Philips' US competitors having supplied the grease through a sub-contractor 'in the plot'.

Interestingly, reference [2] confirms that the much dreaded 'Qual. Lab.' at Philips Semiconductors had expressed doubts about the use of a grease sealant around the diffused Ge junction used in OC17x and the later AF11x devices. It is not known if the air pocket beneath the grease filling is intentional or a production flaw.

1

080473 - 12
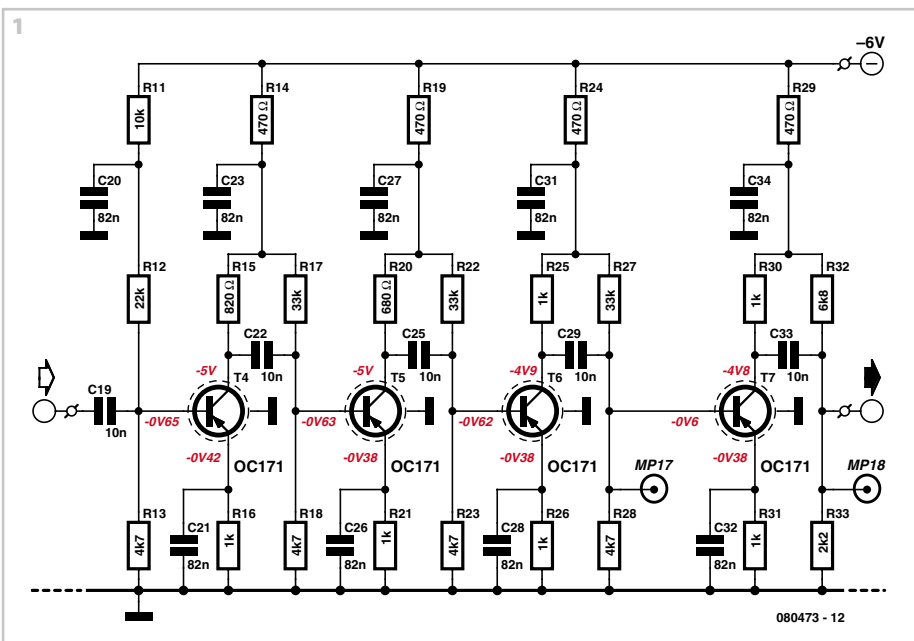
A well established trick applied by radio & TV service engineers was to cut the shield lead (S), isolating it from the circuit ground but if you were unlucky a hair would land between the E and B wires. Another disadvantage is the transistor case then being at the emitter or collector potential, causing RF radiation and the magical but unwanted 'hand effect' — the TO-7 is a relatively large case!

The hairs may be 'zapped' using a 47 μF electrolytic charged to about 50 V and connected between the S (shield) wire and the E, B and C wires twisted together. Although this method is good to retain the originality of your radio, the fault may occur again after some time as the hair growth continues.

Germanium transistors have a bias voltage of 0.2-0.3 V, so if an OC171 or one its sib-

3

BF450/451

C E B
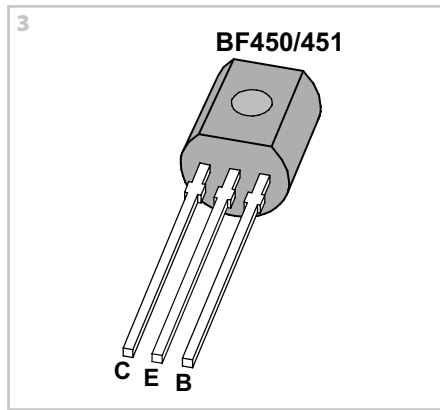
lings is replaced by a modern silicon p-n-p RF transistor like the BF450 or BF451 (**Figure 3**), resistors may have to be changed to get 0.6-0.7 V V_{B-E} bias levels in the circuit. Also, almost all silicon transistors will

have a much higher transition frequency than the old 'geranium grot', so due attention should be given to RF decoupling and changed internal capacitances.

There is no point in buying NOS (new old stock) OC17x or AF11x transistors on EBay as the shiny devices you'll get will have the problem too.

Reportedly some audio transistors like the AC127, AC128, AC176, AC187 and AC188 also suffer from unwanted hair growth in invisible places.

(080473-I)

[1] Electronic Classics, Collecting, Restauration and Repair, Andrew Emmerson. ISBN 0-7506-3788-9.

[2] 50 Jaar Herkennen (Recognising 50 Years). Philips Semiconductors Nijmegen, C. van Anrooij, F. Geersten. H. Jacobs, P. Willemsen, G. de Wind (Editors). ISBN 90-90-17050-2.

Pseudo-random Glitter

Hans-Jürgen Zons

A question recently asked on the Elektor website forum was how to make several white LEDs 'sparkle'. The helpful author has not only provided a useful suggestion (use a random effect), but also developed a suitable circuit and even designed a PCB layout. You can download the Eagle files for this from the Elektor website page for this article (www.elektor.com, archive # 080329-1.zip).

But first let's consider the basic question: artificial sparkling or glittering can best be simulated by having the different light sources switch on randomly at a particular frequency. Surprisingly enough, it is not all that easy to generate truly random sequences electronically. However, the electronic randomness does not necessarily have to be perfect for glitter applications. Patterns that appear to be random are sufficient for the desired visual impression.

Based on this principle, the author uses two 556 timer
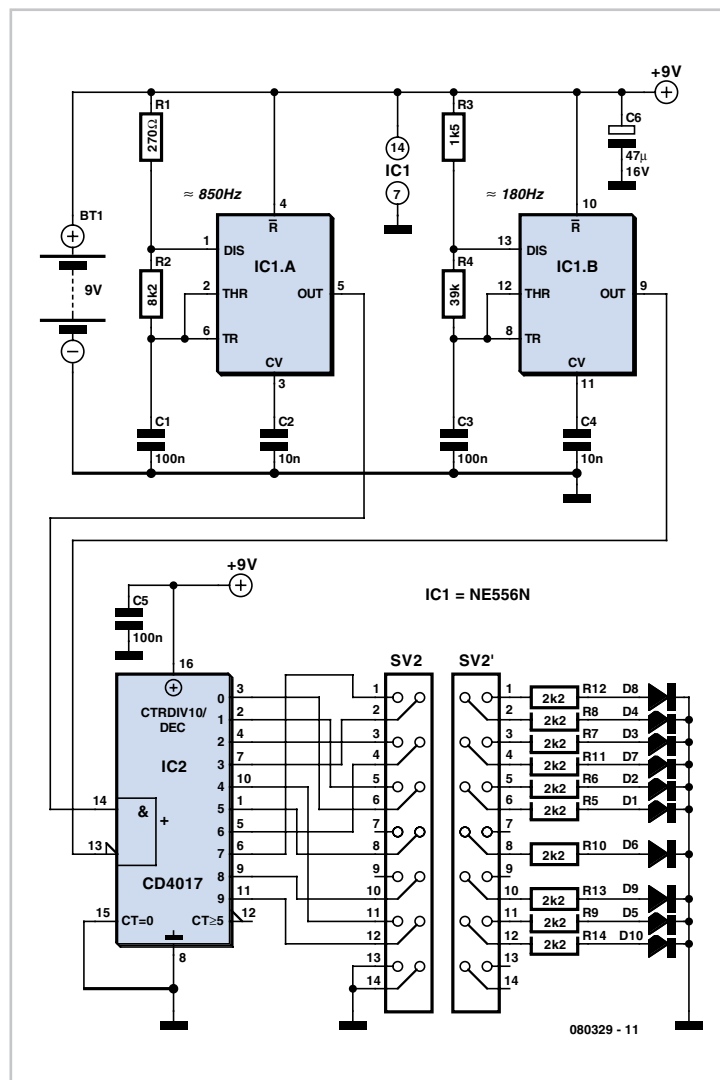
ICs to generate signals whose frequencies (850 Hz for IC1a and 180 Hz for IC1b) can be divided by each other without yielding an integer divisor. A decimal counter operated in an unconventional manner uses these two signals to produce a constantly pseudo-random pattern on its ten outputs, which repeats itself only very infrequently. This behaviour is obtained by applying the higher-frequency signal to the CLK input of counter IC2, with the CLK Inhibit input on pin 13 being driven by the lower-frequency signal. The result is 'genuine pseudo-random' blinking.

LEDs can be connected directly to the ten outputs, since a CMOS output can anyhow only supply a few milli-ampères. However, it is recommended to use series resistors (2.2 kΩ to 4.7 kΩ) to reduce the load on the IC outputs if the supply voltage is higher than 10 V. If you want to have more than ten LEDs glitter, you can naturally build several copies of this circuit.

(080329-1)

Microlight Fuel Gauge

Jean-Pierre Duval

Over the Internet, a microlight owner asked me to make him a fuel gauge for his ultra light aircraft. This seemed to me to offer various very interesting aspects, so I decided to take up the challenge.

I started by gathering some basic information to define the specifications that would be required for this measuring instrument, so vital for any craft moving in the third dimension where a good supply of fuel is absolutely vital to prevent accidents and embarrassment. Here are the key details:

– a microlight always takes off with the fuel tank full;
– fuel consumption is usually between 7 and 9 litres/hour;
– it's important for the gauge to be perfectly readable in all circumstances, e.g. in the form of a bargraph;
– an indication of the amount of fuel remaining, expressed in litres;
– an indication of the instantaneous fuel consumption (l/h);
– it must be possible to have complete confidence in the gauge, so provision needs to be made for a warning in the event of it going wrong;
– for the transducer, we use the manufacturer's data (in this case Digmesa); for greater safety, all data used are taken at minimum values;
– two alerts need to be provided: 3.5 litres and 2 litres of fuel reserve remaining.

All these conditions are taken into account by the firmware – the program burned into the microprocessor – more than by the hardware, which can thus remain relatively simple.

Apart from the fuel flow sensor, an Atmel ATmega8 microcontroller, and the display, all it takes is a few capacitors and a very small number of resistors.

Time now to take a look at the circuit. Let's start with the power supply.

Totally conventional, we start out with the 12 V supplied by the battery, dropped to 5 V by a 7805 regulator. Upstream of this, a fuse, not shown on the circuit, protects the whole unit. Diode D1 protects the regulator against unintentional polarity reversal of the voltage at the power supply input. LED D2 indicates the presence of the output supply rail from the regulator IC1.
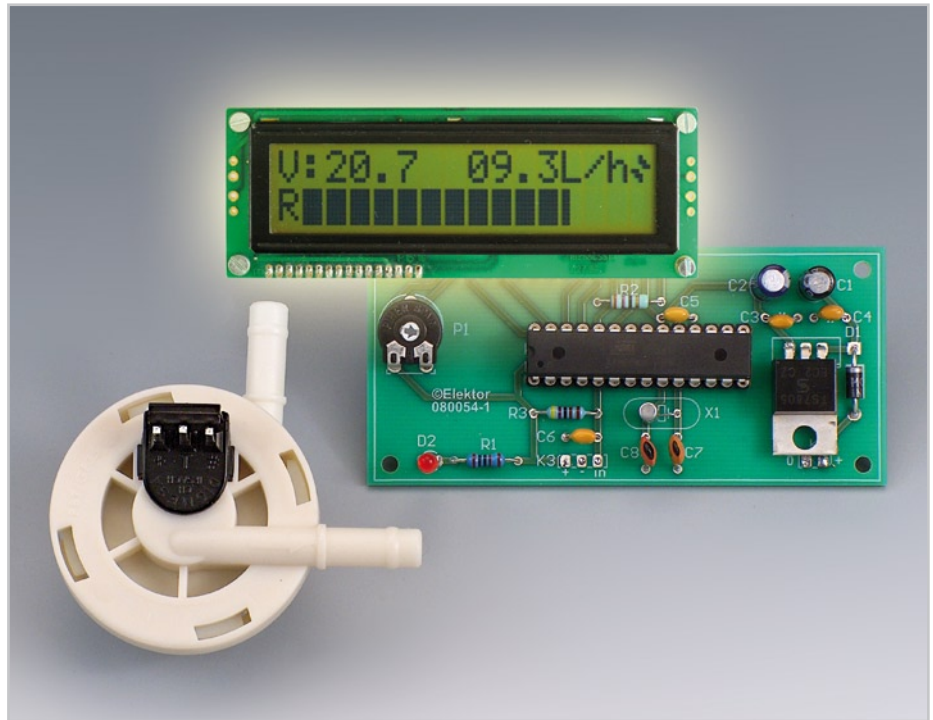
Now let's move on to the more interesting bit, which is the electronics of the virtual fuel gauge proper.

Leaving aside the microcontroller, the most important component in this project is the flow sensor. This is an FHKSC 932-8501 from Digmesa [1] & [2]. This detector can measure fluid flows from 0.03 to 2.0 l/min, equivalent to a range of 1.8 to 120 l/hr — more than sufficient for the application envis-

aged. Originally developed for measuring water flow in coffee machines, it is equally capable of measuring other fluids, as long as they are not too chemically aggressive (alcohols, petrol, wines, etc.). The ability to set the sensor port connections at different angles gives it unquestionable installation flexibility.
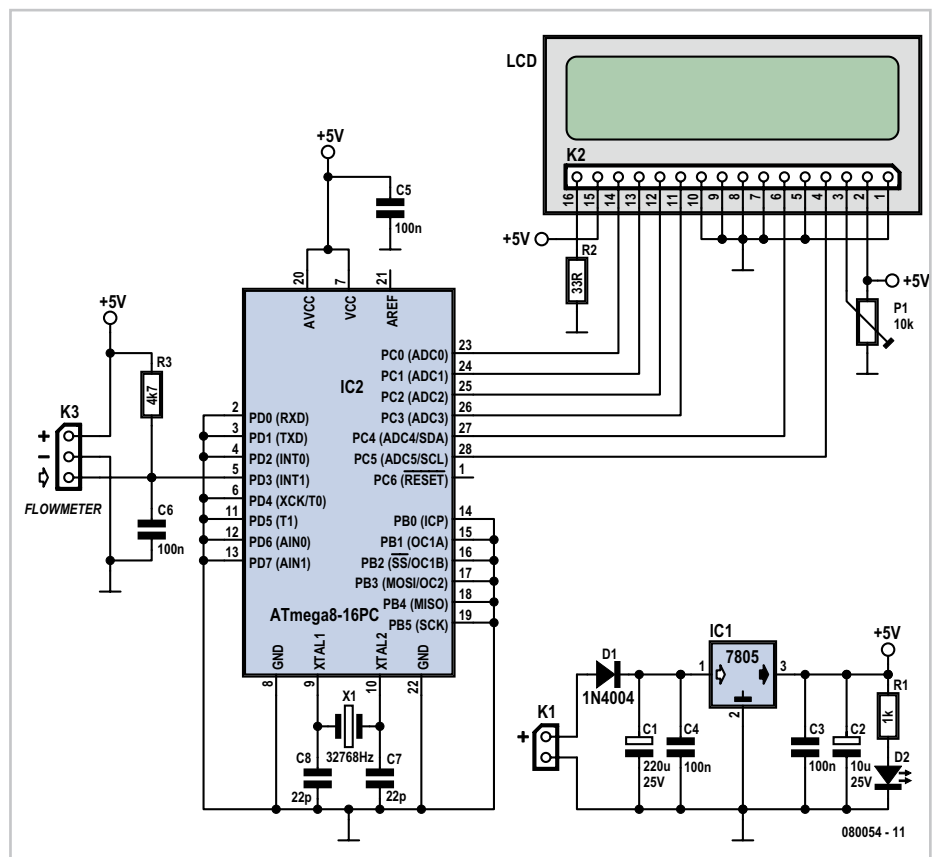
After that, we are interested in the (artificial) heart of the circuit — now it's time to get down to the really clever stuff.

The microcontroller used here, IC2, is an ATmega8 from the Atmel stable [3]. We shouldn't underestimate it — despite its name, this is a powerful component that we are far from pushing to its limits. It uses its internal 8 MHz oscillator to run the program and an external 32.768 kHz clock crystal to measure the instantaneous consumption. The crystal frequency is common, by the way, from the use in watches where it's one on the easiest ways of creating a stable source for seconds pulses. This ATmega8 microcontroller has 24 I/O ports, of which we are only going to be using a few, for the following functions:
• six ports are used for the LCD display, i.e. almost the whole of port C (PC0–PC5);
• one INT1 port (PD.3) as an input for the pulses supplied by the flow sensor;
• two ports, PB.6 and PB.7, are devoted to the above mentioned clock crystal.

For Reset we use the microcontroller 'Brown-out' programmed via the microcontroller 'fuses'. 'Brown-out' defines the supply voltage level at which the program starts — in our case the minimum voltage is 2.7 V.
The Reset pin has an internal pull-up, so no external one is needed.
BASCOM Basic includes the tools needed to configure the fuses.
All unused ports are configured in the program as inputs, and from an electrical point of view are tied to ground on the board.

The liquid flow sensor produces very clean 5 V (TTL) pulses which trigger an interrupt (INT1) used to measure the engine's fuel consumption. Here, it is wired in accordance with the manufacturer's data (see [1]) www.digmesa.com, i.e. by adding a 4.7 kΩ pull-up resistor and a 100 nF capacitor between the signal output and ground (TTL-mode output).
Preset P1 allows adjustment of the LCD display contrast by adjusting the voltage V_{EE}.

The program is written in BASCOM BASIC, a powerful, economical programming language that's all the same very easy to imple-
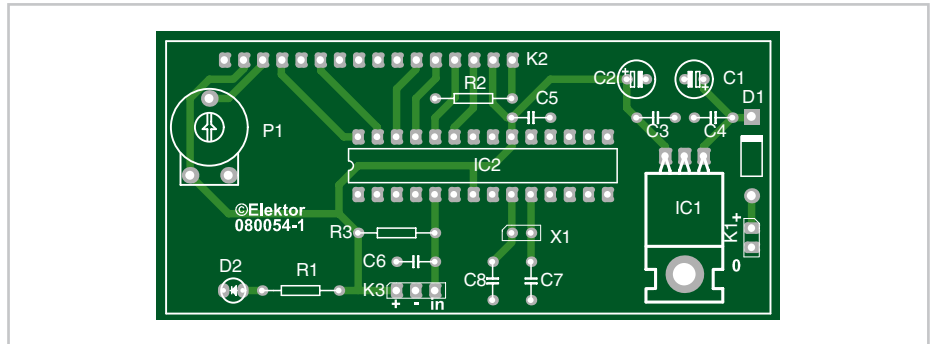
COMPONENTS LIST

Resistors
R1 = 1kΩ
R2 = 33Ω
R3 = 4kΩ7
P1 = 10 kΩ preset

Capacitors
C1 = 220µF 25V
C2 = 10µF 25V
C3-C6 = 100nF
C7,C8 = 22pF

Semiconductors
D1 = 1N4004
D2 = LED, red

IC1 = 7805
IC2 = ATMEGA8, programmed with hex file from archive 080054-11.zip

Miscellaneous
X1 = 32.768 kHz quartz crystal
K1 = 2-way pinheader
K2 = 16-way SIL pinheader
K3 = 3-way pinheader
LCD, 2 x 16 characters with backlight, general purpose
F1 = flow meter, Digmesa type FHKSC 932-8501 (Conrad Electronics)
PCB, ref. 080054-1 from www.thepcbshop.com

ment. There is a free version available that is capable of producing up to 4 k of code [4]. The irreproachable operation of this fuel gauge relies on a plethora of arithmetic calculations going on inside the microcontroller. We'll describe the most important ones so that if necessary you can adapt the characteristics of this flowmeter so as to use it for other applications.
Let's suppose that our fuel tank has a capacity of 29 litres. If we assume that the sensor provides 1,800 pulses per litre (we measured over ten tanks and were at between 1,900 and 2,000 pulses per litre – in accordance with the manufacturer's data, but reduced down to 1,800); that gives us a maximum of:

1,800 × 29 = 52,200 pulses

for a completely full tank; in order to maintain a degree of safety margin (poorly-filled tank, leaks, and so on) we'll give ourselves a margin of 10%, and so will only count 48,000 pulses. Each pulse corresponds to 1,000/1,800, i.e. 0.555 ml.

The calculation of the instantaneous consumption expressed in litres/hour is a weighted value, recalculated every 10 seconds

The TIMER interrupt is used here in the Clock configuration to generate a very pre-

cise second value, so even with very low consumptions, the response is very close to the true value. The calculation of the volume remaining in the tank is performed by decrementing the amount consumed per unit of time from the volume remaining (see inset 'Procedure for calculating volume of fuel remaining').

All that remains to mention is the alert thresholds, at 3.5 and 2 litres, defined in the firmware. Again, if you want to adapt thee values to your personal requirements,

Procedure for calculating volume of fuel remaining:

Once again, the calculation is extremely simple :

If, at the outset, volume=48000

```
------interrupt routine------
rem     at each interrupt, the
    volume is decremented
DECR volume
--------display--------------
rem     after a formatting step
volume_remaining=volume
Tank = Str(volumeremaining)
Tank = Format(tank , "00.0")
Locate 1 , 1 : Lcd "V:" ; Tank
```

do feel free to edit the microcontroller source code.

These calculations refer to the amount remaining; when one of the thresholds is reached, it causes the LCD display to blink at a fast rate.

One of the most interesting aspects of this project is the very customized way the display is used. It's worth taking a slightly closer look at it.

Some display tricks are used to display the values. The top line of our display (two lines of 16 characters) is used to show the numeric information about the volume remaining (V) and instantaneous consumption (l/h).

The character at the extreme right of this top line is a user character intended to symbolize the flowmeter. As long as the latter is working, this character changes shape, giving the impression of rotation. This is what we've called the 'operation indicator'. In the measuring second, we make it change between two characters symbolizing the flowmeter. If the flowmeter isn't working, there is no variation in volume during the measuring period, and so this right-hand end character remains static.
Let's see now what the bottom line does. It's used to indicate the tank status in graphical form. When it is full, we will have 15 solid blocks to the right of the R (for 'Reservoir' = Tank).

The characters on the LCD display are each made up of an 8 row by 5 column matrix of pixels. To be able to display the gradual reduction in the amount of fuel available, we have created several special user characters. The solid block of 5 columns is part of the LCD display's own character set. We're going to create a block with just 4 columns, then one with 3, then 2, and then 1. After that, the block in question just goes blank. Let's move on now to the calculations. We have 15 characters, each with 5 columns, giving us 80 columns in all. We have taken 48,000 as our starting point (allowing for our safety margin). Hence by division, 48,000/80 = 600. So, we can see that we need to lose one column every 600 pulses.

So we display the appropriate number and type of characters corresponding to the information to be displayed. In the photo of the display, the last character consists of two columns.

A printed circuit board was designed for this project. It's approximately the same size as the display, which can be mounted onto the board piggyback-fashion. The component layout needs no special mention. You should start with the smaller components, resistors, capacitors, headers, and diodes, finishing off with the socket for IC2. Don't fit the processor into its socket until you have first checked that the required voltage (5 V) is present on the relevant pins (7, 20, referenced to one of the pins connected to earth, 2,3 etc. refer to the circuit diagram).

It only remains to fit the flow sensor into the fluid (whatever it is) supply pipe. Header K3 is used for its supply and output signal. The LCD display connects to header K2. Take care to get it the right way round!

We're very curious to know what applications readers are going to find for the virtual gauge described here!

jeanpierre.duval2@orange.fr   (080054-I)

Downloads

The source code and .hex files for this project, along with the board design are available on www.elektor.com. The respective file names are 080054-11.zip and 080054-1.zip.

Web Links

[1] Flow sensor source
www.digmesa.com/

[2] Flow sensor data sheet
www.digmesa.com/digmesa/upload/pdf/FHKSC/932-850xxxx_GB.pdf

[3] ATmega8 data sheet
www.atmel.com/dyn/resources/prod_documents/doc2486.pdf

[4] BASCOM BASIC (MCS)
www.mcselec.com/index.php?option=com_docman&task=cat_view&gid=99&Itemid=54

PWM Control for Permanent Magnet Motors

Franz P. Zantis

DC motors with permanent magnets are widely used and popular among model builders. A particular characteristic of these motors is a large discrepancy between the startup torque and the nominal torque.

If a permanent magnet motor is to be powered from a DC supply and a constant, high torque is required at a variable operating speed, a pulsewidth modulator (PWM) of the type described here is needed.
We construct an astable multivibrator with the help of a couple of gates from a 40106 hex Schmitt trigger IC. The multivibrator has a mark-space ratio ('duty factor') that can be adjusted over a very wide range, independent of its operating frequency. Adjusting the potentiometer changes the
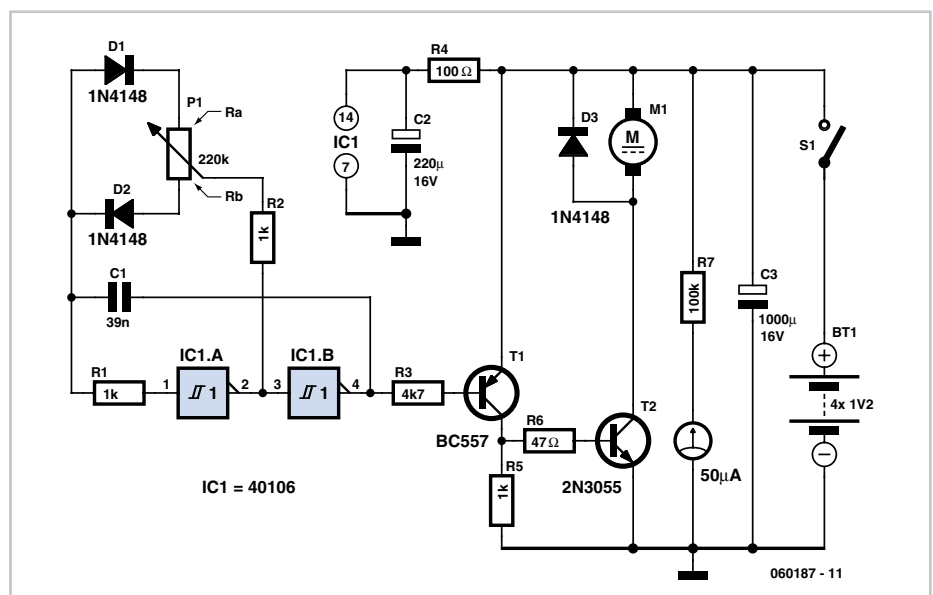
ratio between R_a and R_b, which together make up the total resistance of the potentiometer. Capacitor C1 is charged via R_b and is discharged via R_a. The corresponding mark-space ratio is present at the output of the oscillator on pin 4 of the 40106. The output high time is determined by R_a, while the output low time is determined by R_b. The oscillator frequency is constant at approximately 115 Hz. Transistor T1 provides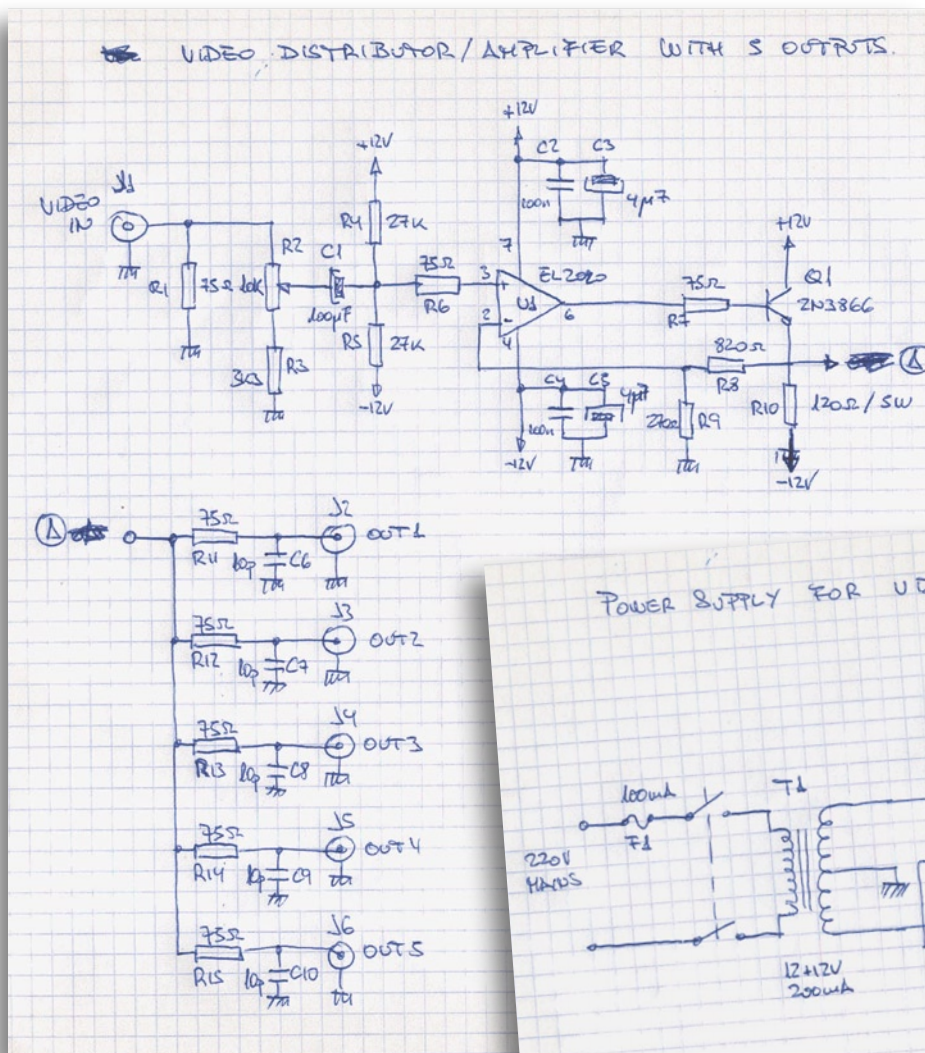 current gain: when pin 4 of the 40106 is low, T1 turns on, and when the output is high, T1 is turned off. Sufficient current is available at the collector of this transistor to drive the base of the 2N3055 power transistor. R4 and C2 provide decoupling for the oscillator from the large currents switched by the power output stage. The moving-coil meter connected via R7 serves to monitor the state of the battery, which is useful when rechargeable cells are used. The circuit has been used by the author to drive a motor salvaged from an old cassette tape recorder. In this case the 2N3055 did not require a heatsink.

Interested readers will find that a search of the Internet turns up plenty of information on the theory and practice of driving DC motors using pulsewidth modulation.

(060187-I)

Five-output Video Distribution Amplifier

Eduardo Corral

Video fans and professionals in the field will find in this small signal distributor/amplifier an excellent ally when it's necessary to distribute a single video signal across several equipments. The circuit shown here should have a lot of applications.

Basically, the distribution amplifier takes the composite video signal from a video player (VCR) or a video generator (analogue output) and buffers it in such a way that it can be simultaneously applied to up to five different video equipment inputs, like monitors, TV sets, other VCRs and so on. For example, in a hall, the image produced by a central DVD player can be shown on five different TV screens with the sound reproduced through a separate amplifier.

The circuit is based on the type EL2020 (or similar) operational amplifier which is marled by large bandwidth. The LL2020 amplifies the video signal applied to the input stage, with a gain adjustment range of ±6 dB. Output transistor Q1, a 2N3866, applies the video signal to the five outputs designed to drive loads with 75-Ω impedance.

The circuit requires a ±12 V symmetrical supply voltage, which can be obtained from a conventional power supply as shown by the schematic.

(080478-I)

Turbo BDM Lite ColdFire Interface

Luc Lemmens

In the April and May 2008 issues of Elektor the DigiButler was introduced, which is a simple, low-cost Home Automation Server built around the MCP52231, a ColdFire microcontroller made by Freescale. The two article instalments also mentioned Daniel Malik's Turbo BDM Lite ColdFire interface (TBLCF), a low-cost programming interface that is fully open source. Although we referred to the extensive TBLCF documentation, we didn't have enough time during the preparations of the DigiButler project to fully test this interface, and there wasn't an RoHS compliant replacement for the microcontroller in that circuit. This is now available, however, and may be obtained as a free sample via the Freescale website.

The software and firmware for the TBLCF can be found via the link at the end of this article, and tblcf_v10.zip is the file that we need. This can also be found as part of the free download (071102-11.zip) that we've added to the Elektor website. The .zip file contains a manual (manual_v14.pdf), which clearly explains how the drivers should be installed and how the controller for the interface should be programmed. It's just a matter of figuring out where the various files are stored.

The USB drivers (page 13 of the manual) are contained in usb_drivers_v10.zip. Extract all the files from this .zip file into a new folder on the hard drive. You can then connect the interface to the PC, which should result in a message stating that a new hardware device has been found. If that doesn't happen it's a case of carefully checking all soldering on the TBLCF board. Note that the LED on the interface won't turn on yet at this stage. Next, follow the instructions given in the manual to install the drivers. To program the firmware you need the files tblcf_bt.exe and tblcf.abs.s19. These can be found inside pc_binaries_v10.zip and tblcf_firmware_v04.zip\bin respectively. When the programming of the firmware has been completed Windows will start another procedure to install the new drivers, after which the PC has to be restarted. Once this has been done the LED on the TBLCF should be lit continuously if it has been correctly recognised by Windows. Whenever communications take place between the PC and the target system the LED flashes.
Adding the TBLCF to the CodeWarrior 6.3
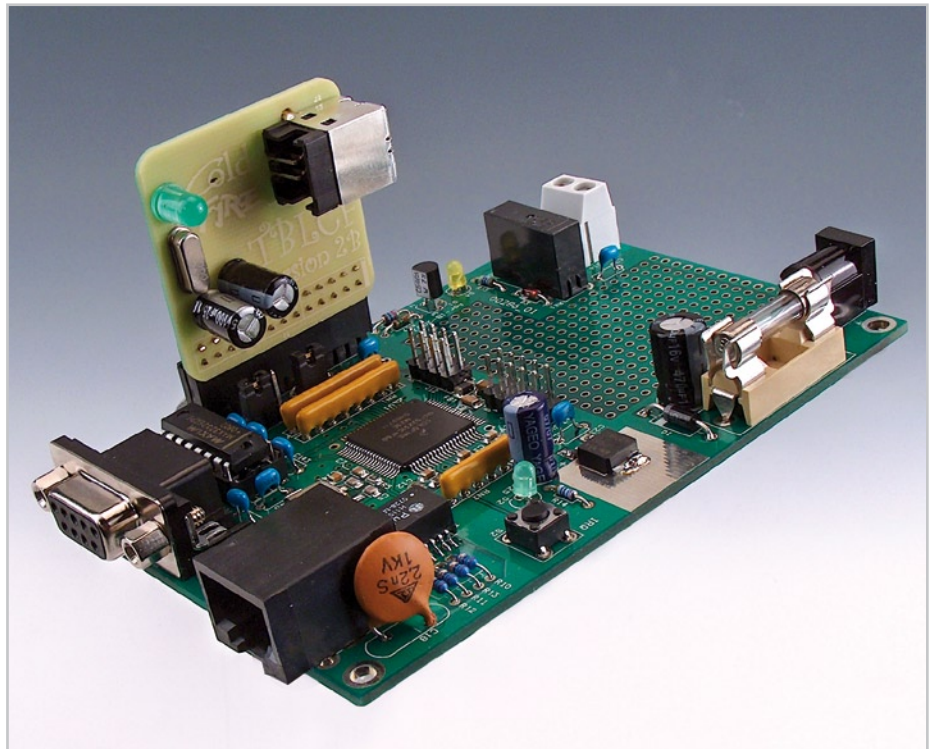
IDE is clearly explained in the manual, and tblcf_gdi.dll can be found inside pc_binaries_v10.zip. The item 'Startup file' can be left blank.
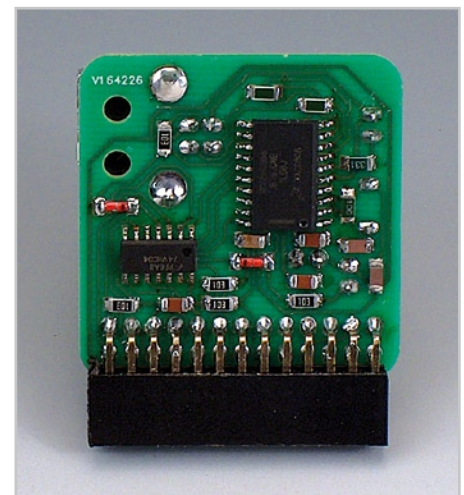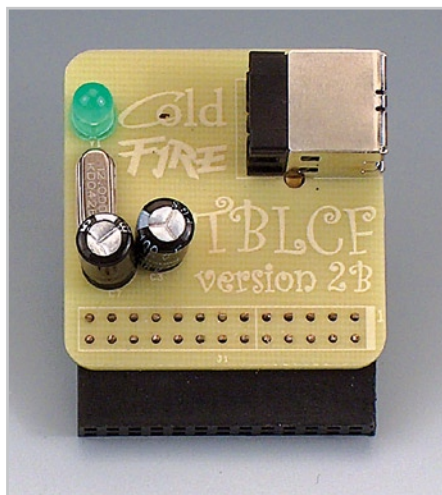
Up to this point the manual has held our hand through the installation process, but there is (as with the parallel programmer interface from the May issue) a section that requires extra attention: the settings for the flash programmer. From CodeWarrior, open the menu *Tools -> Flash Programmer*. Click on *Load Settings* and load the file setup.xml, which can be found in the folder DigiButler software\SW_Main_Board (see archive 071102-11.zip). Check that the *Target Processor* in this window is set to: 5223x. For the *Connection* choose TBLCF and make sure that the *target initialisation file* is M52235EVB_PnE.cfg. Then click on *Flash Configuration* and from the *Device* table select the CFM_MCF5220_25MHz. Then overwrite setup.xml using *Save Settings* to keep the new settings.

(080448-I)

Web Link

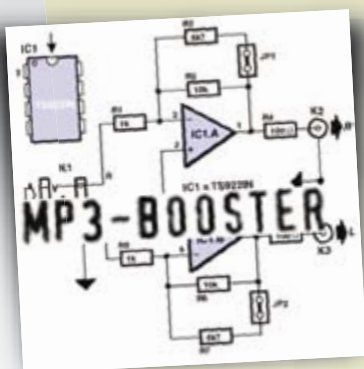http://forums.freescale.com/freescale/board/message?board.id=CFCOMM&thread.id=624
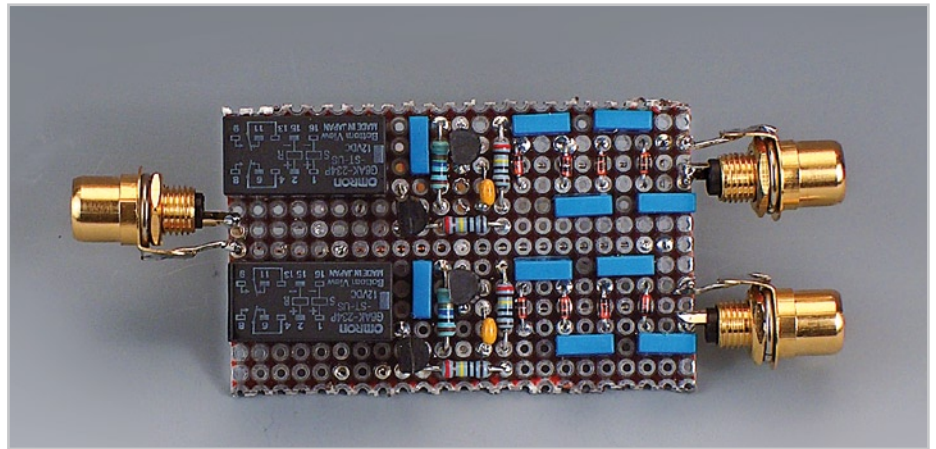
Automatic S/PDIF Selector

Ton Giesberts

These days there is an increasing number of devices that have a digital audio output, for example digital cable tuners, satellite receivers, DVD players/recorders or game consoles/computers. It is often the case that the existing receiver doesn't have enough coaxial S/PDIF inputs to accommodate all these devices, or the receiver is at the other side of the room from the TV and other equipment, and we'd rather not lay three or four separate S/PDIF cables along the skirting boards. This clever little circuit gets round these problems in an ingenious way. It doesn't need a mains supply nor does it have any external switches. The latter makes it possible to hide the device behind the equipment.

The circuit detects the appearance of a new S/PDIF signal on one of its two inputs and switches this to its output, so that only one connecting cable is required to connect two devices with S/PDIF outputs to the receiver. When several devices are turned on that output a continuous S/PDIF signal, the required device needs to be momentarily turned off and then on again to select it. It is relatively easy to expand the circuit with more inputs.

Because we wanted to avoid the use of a mains adaptor for this circuit we decided to make it battery-powered. For the design we therefore strived to keep the current consumption as low as possible. That meant that we didn't use buffer stages or comparators to detect the input signals. Instead we used bistable relays, which only require a short pulse to change their state, which is then latched.

080484 - 11
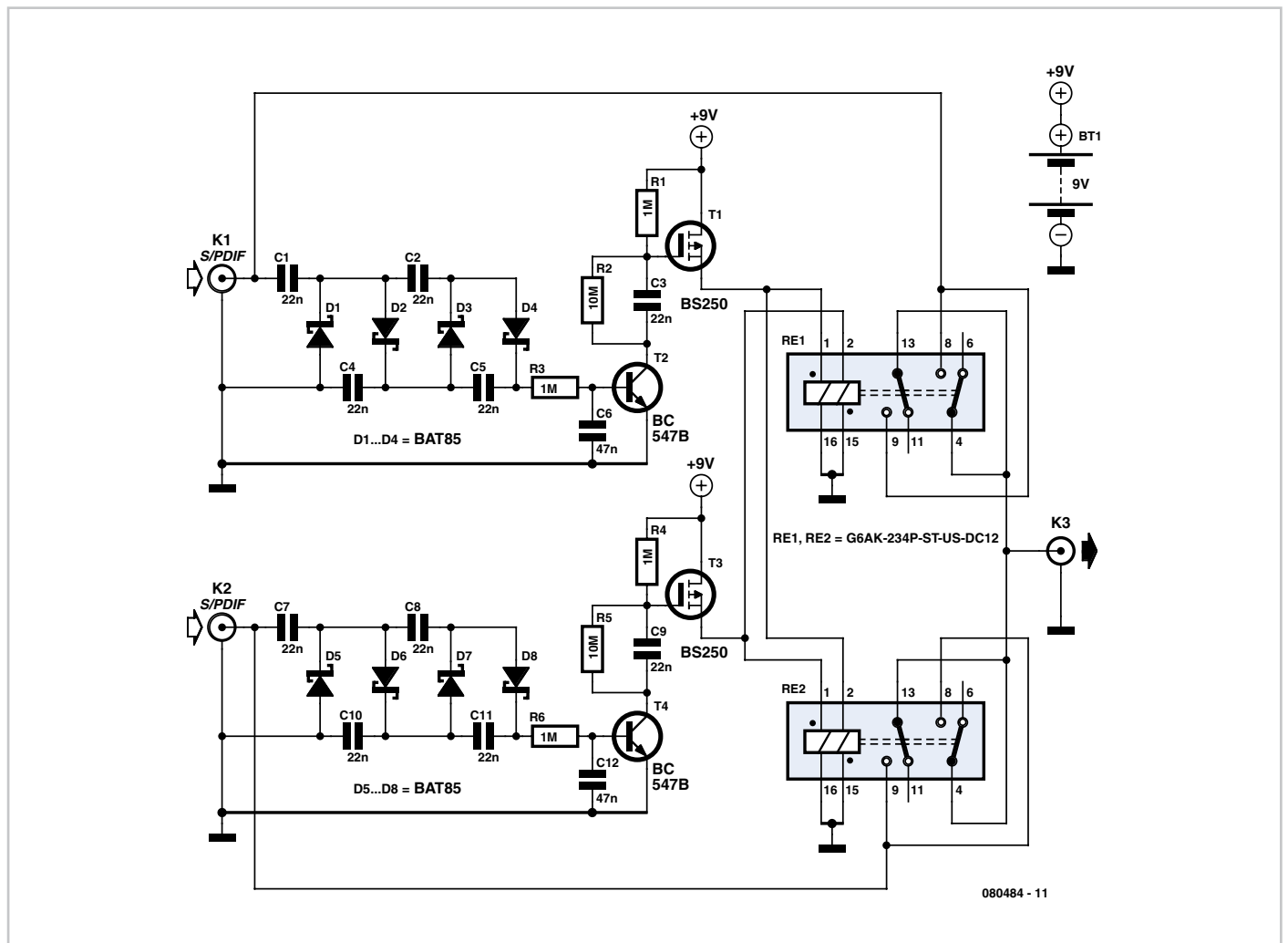
When an S/PDIF signal appears on one of the inputs, a cascade circuit is used to derive a DC voltage from it. Because the nominal voltage of S/PDIF signals is only 0.5 V_{pp} (when terminated by 75 Ω), each input has a cascade stage with four diodes and four capacitors. The generated voltage then becomes twice the peak-to-peak value, which in this case results in nearly 1 V. In order to keep the threshold voltage as low as possible the cascade stage is loaded as little as possible, the capacitors are as small as possible and for the diodes we've used special Schottky types (BAT85).

This signal is then fed to a bipolar transistor that requires about 0.5 V to 0.6 V for it to conduct. A base resistor of 1 MΩ and a capacitor are used for interference suppression. The bipolar transistor drives a differentiator C3/R1 (C9/R4 for the other channel) to create a short pulse for the relay. The gate of the following P-channel MOSFET is momentarily connected to ground via capacitor C3 and transistor T2. This FET then drives the set-coil of one relay and the reset-coil of the other relay. The BS250 used here can switch a direct current of 250 mA without any problems, and has an even high peak-current capacity (up to 500 mA).

The number of inputs can be increased by adding more of these stages. Note that when there are more than two stages you need to connect each reset-coil via diodes (e.g. BAT85) to the FETs. In that way the voltage on the reset-coils doesn't end up at the set-coils of the other relays. Depending on the type of relay used, you typically need about 15 mA to energise each coil. This means that the maximum possible number of inputs is much more than you're ever likely to need.

It is possible to use 12 V types for the relays. The G6A series made by Omron are guaranteed to switch at 8.4 V, for example the G6AK-234P-ST-US-DC12. The coil resistance is 800 Ω, which means that it requires only 11 mA. If you find you have some 'hesitant' relays when you're using more inputs and switch the relays via diodes, you can always use 5 V types. The switching current will then be higher, but in practice this has little effect on the battery life.

The current consumption of the circuit with signals present at both input is about 1.6 µA. This implies that the maximum theoretical battery life could be 35 years for a standard 9 V battery (500 mAh), which is much longer than its expected shelf life. Another option is to use three or four Lithium cells in series. These probably will give the circuit 'near-eternal life'.
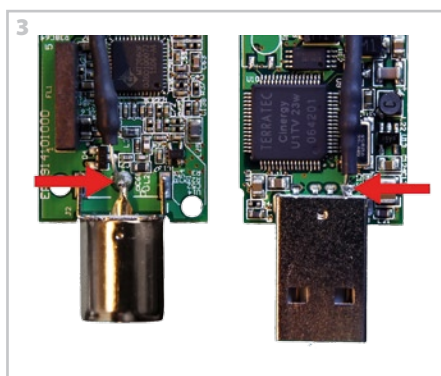
Phantom Supply for TV Antenna

Dr. Thomas Scherer

The author gave his father-in-law a USB TV stick as a present. After experimenting with it for a little while, they concluded that the performance of the device when used with a passive antenna was very poor. An active antenna, unfortunately, requires an extra power supply, which is not really practical when used with a laptop. Reason enough, then, to solve the problem properly; and in any case the author wanted to try to shake off his unwanted reputation with his father-in-law as an amateur engineer!

The author took the USB stick home with him, with the idea of somehow or other adding the needed phantom power output to the device. Fortunately things turned out considerably simpler than he had expected.
As **Figure 1** shows, the stick is held together by a few screws, and so getting it apart is straightforward. So how does a phantom power supply work? Normally the antenna input is decoupled, as far as DC is concerned, from the main electronics by a capacitor. If we can somehow get 5 V onto the input in such a way that it does not short out the HF signal, we can provide a power supply to an active antenna. The current consumpdion of the amplifier in such an antenna is typically between 20 mA and 50 mA. This current (at +5 V) can easily be sourced from the computer's USB connector. If we connect this supply via a coil to the antenna input the problem is solved: the coil will present a high impedance to the high frequencies in the TV signal.
In order to make the antenna input short-circuit proof it is a good idea to add a 10 Ω metal film resistor in series with the coil. Using this type of resistor has the advantage that it will fail to an open circuit if overloaded for a prolonged period, and thus acts as a kind of fuse. The author used a 220 µH fixed inductor (any value above about 10 µH will do) with a DC resistance of 5.6 Ω. At a measured current draw of 30 mA the total voltage drop is around 0.5 V, which is entirely acceptable.
The two components were simply soldered together (**Figure 2**) and shrouded in heat-shrink tubing. The 'module' was then soldered into the USB stick: the red arrows in **Figure 3** show where the solder connections were made. The 5 V pin of the USB plug is opposite the ground pin, which in turn is easy to identify as it is electrically joined to the shield of the plug. The final construction is shown at the bottom of Figure 1.

The modification should work with all types of USB TV sticks: analogue tuners can benefit as much as digital tuners from an active antenna.

Mini Bench Supply
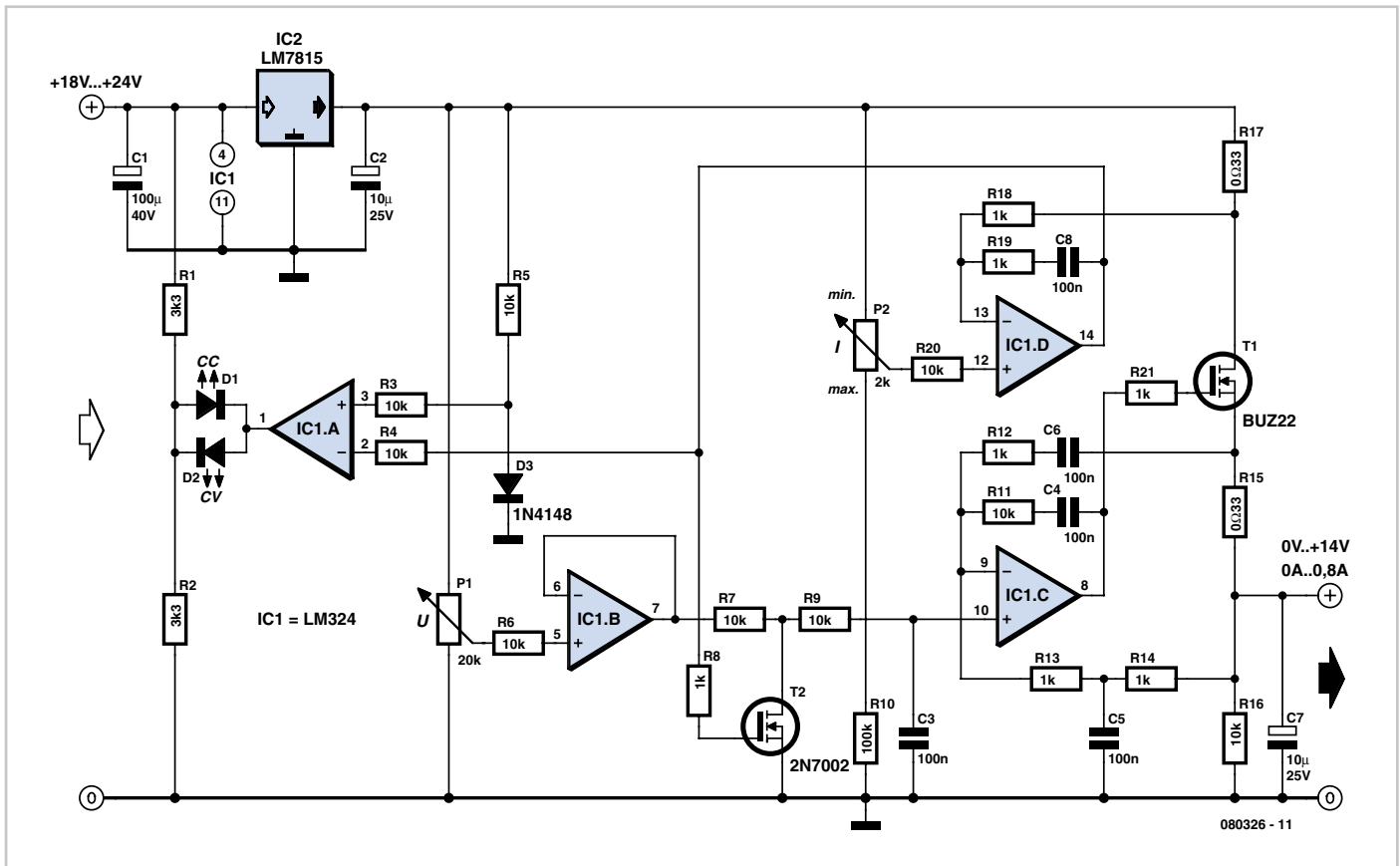
Alexander Mumm

Every electronics engineer is familiar with the anxiety of the moment when power is first applied to a newly-built circuit, wondering whether hours of work are about to be destroyed in a puff of smoke. A high-quality power supply with an adjustable current limit function is an excellent aid to steadying the nerves.

Unfortunately power supplies with good regulation performance are expensive and homebrew construction is not always straightforward. Many of the 'laboratory power supplies' currently on the market are low-cost units based on switching regulators which, although certainly capable of delivering high currents, have rather poor ripple performance. Large output capacitors (which, in the case of a fault, will discharge into your circuit) and voltage overshoot are other problems.

The power supply described here is a simple unit, easily constructed from standard components. It is only suitable for small loads but otherwise has all the characteristics of its bigger brethren. Between 18 V and 24 V is applied to the input, for example from a laptop power supply. This avoids

the need for an expensive transformer and accompanying smoothing. No negative supply is needed, but the output voltage is nevertheless adjustable down to 0 V.

A difficulty in the design of power supplies with current limiting is the shunt resistor needed to measure the output current, normally connected to a differential amplifier. Frequently in simple designs the amplifier is not powered from a regulated supply, which can lead to an unstable current regulation loop. This circuit avoids the difficulty by using a low-cost fixed voltage regulator to supply the feedback circuit with a stable voltage. This arrangement greatly simplifies current measurement and regulation.

To generate this intermediate supply voltage we use an LM7815. Its output passes through R17, which measures the output current, to MOSFET T1 which is driven by the voltage regulation opamp IC1C. Here R11 and C4 determine the bandwidth of the control loop, preventing oscillation at high frequencies. R15 ensures that capacitive loads with low effective resistance do not make the control loop unstable. The negative feedback of AC components of the current via R12 and C5 makes the cir-

cuit reliable even with a large capacitor at its output, and negative feedback of the DC component is via the low-pass filter formed by R14 and C6. This ensures that the voltage drop across R15 is correctly compensated for. C7 at the output provides a low impedance source for high-frequency loads, and R16 provides for the discharge of C17 when the set voltage is reduced with no load attached.

Current regulation is carried out by IC1D. Again to ensure stability, the bandwidth of the feedback loop is restricted by R19 and C8. If the voltage dropped across R17 exceeds the value set by P2, the current limit function comes into action and T2 begins to conduct. This in turn reduces the input voltage to the voltage regulation circuit until the desired current is reached. R7, R9 and C3 ensure that current regulation does not lead to output voltage overshoots and that resonance does not occur with inductive loads.

The controls of the power supply are all voltage-based. This means, for example, that P1 and P2 can be replaced by digital-to-analogue converters or digital potentiometers so that the whole unit can be

driven by a microcontroller. IC1B acts as a buffer to ensure that the dynamic characteristics of the circuit are not affected by the setting of P1.

IC1A is used as a comparator whose output is used to drive two LEDs that indicate whether the supply is in voltage regulation or current regulation mode. If D2 lights the supply is in constant voltage mode; if D1 lights it is in constant current mode, for example if the output has been short-circuited. The power supply thus boasts all the features of a top-class bench supply. IC1A and its surrounding circuitry can be dispensed with if the mode indication is not wanted.

A type LM324 operational amplifier is suggested as, in contrast to many other similar devices, it operates reliably with input voltages down to 0 V. Other rail-to-rail opamps could equally well be used. The particular n-channel MOSFET devices used are not critical: a BUZ21, IRF540, IRF542 or 2SK1428 could be used for T1, for example, and a BS170 could be used in place of the 2N7002. The capacitors should all be rated for a voltage of 35 V or higher, and R15 and R17 must be at least 0.5 W types. The fixed voltage regulator and T1 must both be equipped with an adequate heatsink. If they are mounted on the same heatsink, they must be isolated from it as the tabs of the two devices are at different potentials.
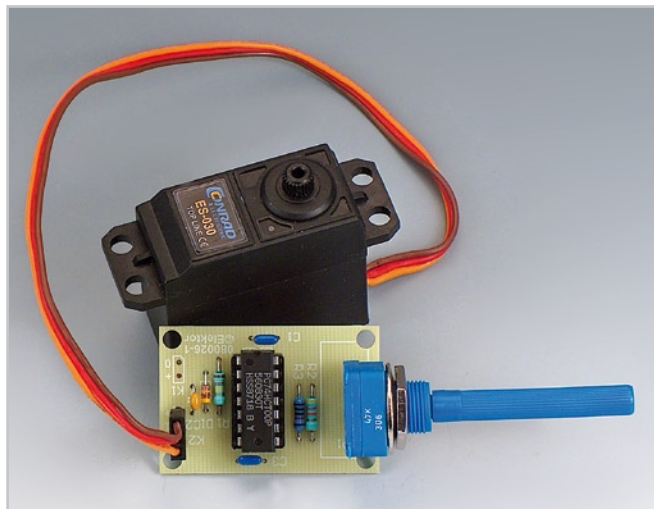
(080326-I)

Servo Control

G. Baars

This circuit lets you control a servo in a simple way. It is built around a cheap and common logic IC. Together with a few resistors, capacitors and a diode this circuit can certainly be called simple and can be built on a small circuit board.

NAND gates IC1A and IC1D are used to build an oscillator which produces negative pulses with a repetition frequency of about 50 Hz. These very narrow pulses are used to toggle the output of the SR (set/reset) flipflop, which is built with gates IC.1B and IC.1C, every 20 ms. With every set-pulse the output of IC1C goes low, which causes C3 to be discharged via P1, after which the situation reverses. This results in a pulse at the output of IC1B, which repeats every 20 ms and the duration of which can be adjusted with P1. From experimenting with this circuit and an S3003 servo from Futaba it was observed that with a pulse duration of 1-2 ms it rotated through an angle of 90 degrees. However, by shortening the pulse duration a little more, to about 0.6 ms, there was a further 30 degrees of rotation. The component values in the circuit were chosen so that the pulse duration can be set from 0.6 to 2 ms with P1 and the total rotation amounts to about 120 degrees. Since the S3003 servo has a not inconsiderable torque of 4 kg·cm, at can be used, for example, to remote control the tuning capacitor of a so-called 'magnetic-loop' RF antenna. The current consumption of the servo depends on the torque that needs to be delivered and varies from a few tens to several hundreds of milliamps.

(080026-I)
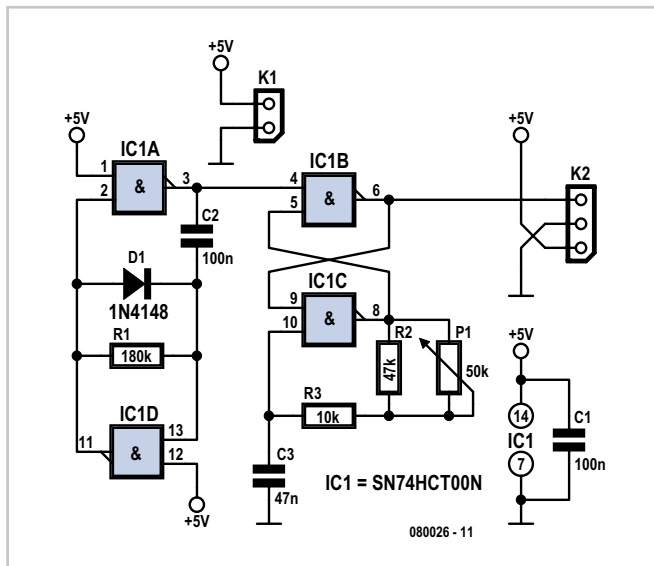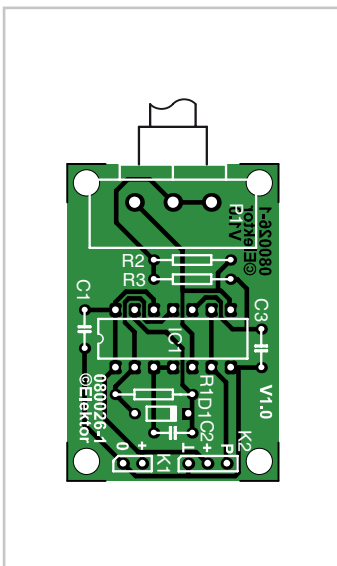
COMPONENTS LIST

Resistors:
R1 = 180kΩ
R2 = 47kΩ
R3 = 10kΩ
P1 = 50kΩ linear potentiometer

Capacitors
C1,C2 = 100nF
C3 = 47nF

Semiconductors
D1 = 1N4148
IC1 = 74HCT00

Miscellaneous
K1 = 2-way SIL pinheader
K2 = 3-way SIL pinheader
PCB, # 080026-1 from www. thepcbshop.com

Software-defined Valve Radio

Burkhard Kainka

Software-defined radio (SDR) is all the rage. The idea is this: a very simple radio receiver is given top-of-the-range performance with the aid of a little software.

Even newer is SDVR (software-defined valve radio), where a single-valve radio is turned into a world receiver with some help from a PC. Power comes from four AA cells for the heaters, and a 9 V battery provides the anode supply.

The circuit is very simple: a PC900 (EC900) triode is used in a homodyne regenerative (Audion) configuration. Adjustment of the feedback is not necessary as the receiver always oscillates at high amplitude. A tuning capacitor can also be dispensed with as fine tuning is done in software. Coarse adjustment of the received band is possible by screwing the inductor core in and out. The receiver works in the 49 m band using a 30-turn coil on an 8 mm former.

080384 - 11
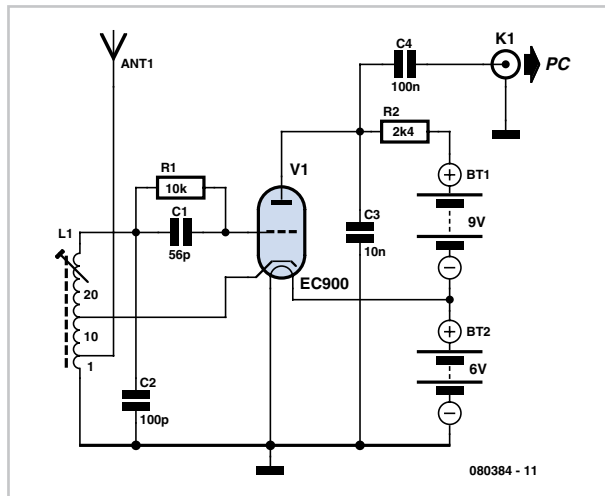
The SDRadio program by Alberto (http://digilander.libero.it/i2phd/sdradio) is used as the decoder. The illustration shows an AM station being received. The sound card used (a USB Sound Blaster) has a sample rate of 96 kHz, giving a tuneable range of 48 kHz. In the illustration we can see three further transmissions.

A weakness of the receiver is that it only has one output channel. This means that each transmitter can be seen twice in the spectrum display, and there is no suppression of image frequencies as would be expected in a fully-featured SDR. Sometimes this can result in audible interference, in which case the only remedy is to tune to another transmitter. And if none of the channels appeals, you can simply move to another band with a twist of the screwdriver.
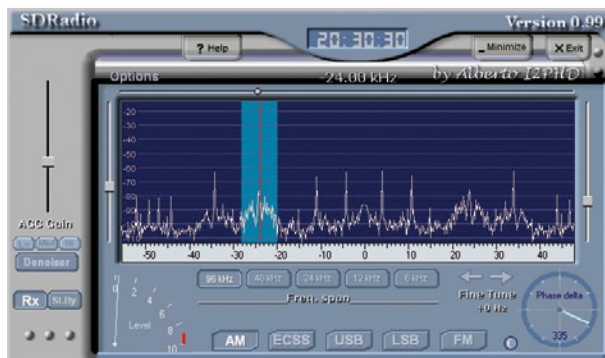
(080384-I)

Detector with Amplification

Burkhard Kainka

A simple shortwave radio detector is neither very sensitive nor very selective. However, with a little extra amplification we can improve the reception performance significantly.

The additional circuit is designed to compensate for the losses in the resonant circuit. A transistor is used to amplify the RF signal and feed it back into the resonant circuit. When the gain is set correctly we can make the amount of this feedback exactly equal to the losses. The resonant circuit is then critically damped and has a very high *Q* factor. Now we can separate transmissions that are just 10 kHz apart, and we can

080387 - 11
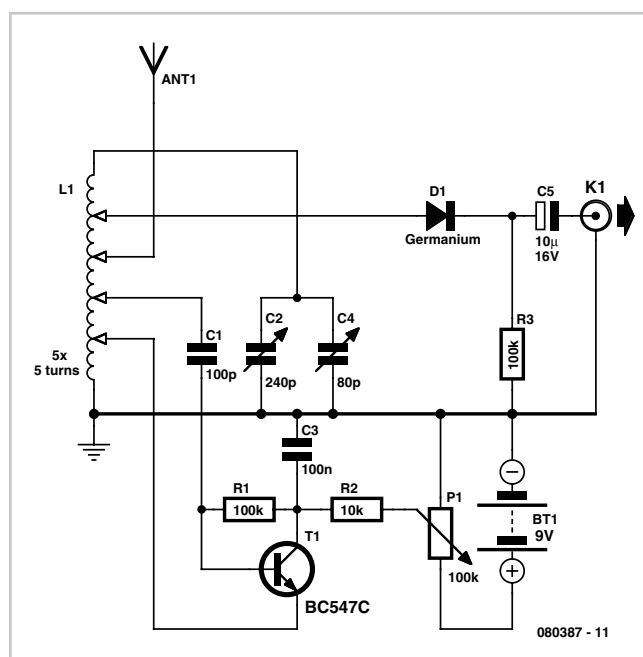
tune in to very weak stations. The tuning capacitor used has two gangs of vanes with capacitances of 240 pF and 80 pF. These two gangs are connected in parallel to make a 320 pF variable capacitance. The air-cored inductor has 25 turns on a diameter of 10 mm, with taps at 5-turn intervals. The resonant circuit so formed is capable of covering the full shortwave band from 5 MHz to 25 MHz.

The shortwave detector can be connected to a power amplifier, or, for example, amplified PC loudspeakers. The antenna does not have to be very long: in experiments we used a one-metre length of wire. Tuning the radio involves adjusting the vari-

able capacitor to bring in the station and then adjusting the gain of the feedback circuit for optimal output volume. If the potentiometer is turned up too far, the receiver will go into self-oscillation and become a mini-transmitter. At the optimal setting the sound quality is very pleasant and certainly no worse than many ordinary shortwave radios.

If you find shortwave detectors that use a battery and an amplifier a little new-fangled, you can get your fix of nostalgia by dispensing with the battery and connecting a crystal earpiece to the detector's output. The radio will of course also work without the feedback circuit, but with rather poorer performance.

(080387-I)

Piezo-powered Lamp

Burkhard Kainka

Energy is becoming ever more expensive, and some fresh ideas are needed. There are already human-powered devices on the market, most of which employ a dynamo to generate power. It is also possible to recover energy from a piezo crystal of the sort found, for example, in the loudspeakers in greetings cards. Making use of this device is relatively straightforward.

Piezo crystals can generate voltages of many tens of volts when given a firm enough prod with a finger to bend the baseplate. The charge moved, however,

080385 - 11
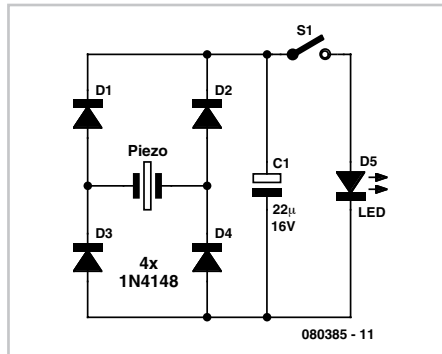
is relatively small and the crystal is effectively a capacitor with a capacitance of only around 20 nF to 50 nF. This means that we need larger-scale storage in the form of an electrolytic capacitor.

The piezo crystal can be treated as an alternating current source. We therefore need a rectifier and a reservoir capacitor. Pressing the metal surface of the transducer ten or twenty times with a finger will charge the electrolytic in steps to the point where it has enough charge to drive a LED. The circuit is a 'charge pump' in the full sense of the term.

When the button is pressed the electrolytic discharges into the LED, which emits a brief, but bright, flash of light.

(080385-I)

Digital Rev Counter for (Older) Diesels

Romain Liévin

Current diesel vehicles are (practically) all fitted with a rev counter. But diesel-engined cars tend to 'last' longer than their counterparts with petrol engines, so it is more than likely that there are still a fair number of older diesel cars around without such an instrument for measuring engine speed. We're going to enable you to fit them with one.

On a petrol engine (motorbike or car), it's very easy to pick up pulses that reflect the engine revs. The number of articles that have appeared in Elektor are proof of this. Most circuits confine themselves to detecting the pulses generated by the ignition, either by magnetic coupling or directly, after shaping of an electrical signal. Since diesel engines by their very nature don't have spark plugs, an alternative method has to be found. Here, it takes the form of a logic Hall-effect sensor (UGN3140) that delivers a pulse every time a magnet passes in front of it. You could equally well use a reflective photodetector… The biggest difficulty lies in finding a spot to fit one or more magnets. The timing belt pulleys would be a
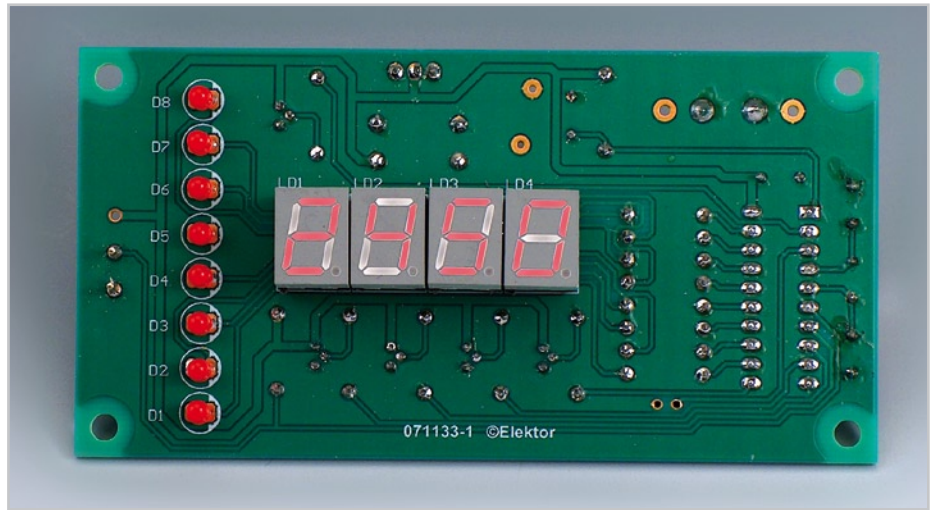
good location, but the whole assembly is always protected by a cover. Diesel vehicles are often fitted with a vacuum pump for the brake servo system. This pump is connected to the camshaft via a belt. The ideal spot for fitting two magnets and the sensor! Why two magnets? Any good mechanic knows that a 4-stroke engine has to make two revolutions for each engine cycle. But the camshaft controls this cycle in just a single revolution, and hence it turns at half the engine speed.

So using two magnets enables us to obtain the correct number of pulses.

As you can see, the circuit amounts to just a single IC, an AVR microcontroller from Atmel. Long gone are the days when it took no less than six ICs to produce even a two-digit a rev counter! What's more, using a microcontroller with a crystal-controlled clock makes it possible to dispense with any form of calibration. The microcontroller contains everything needed to count pulses, using its interrupt
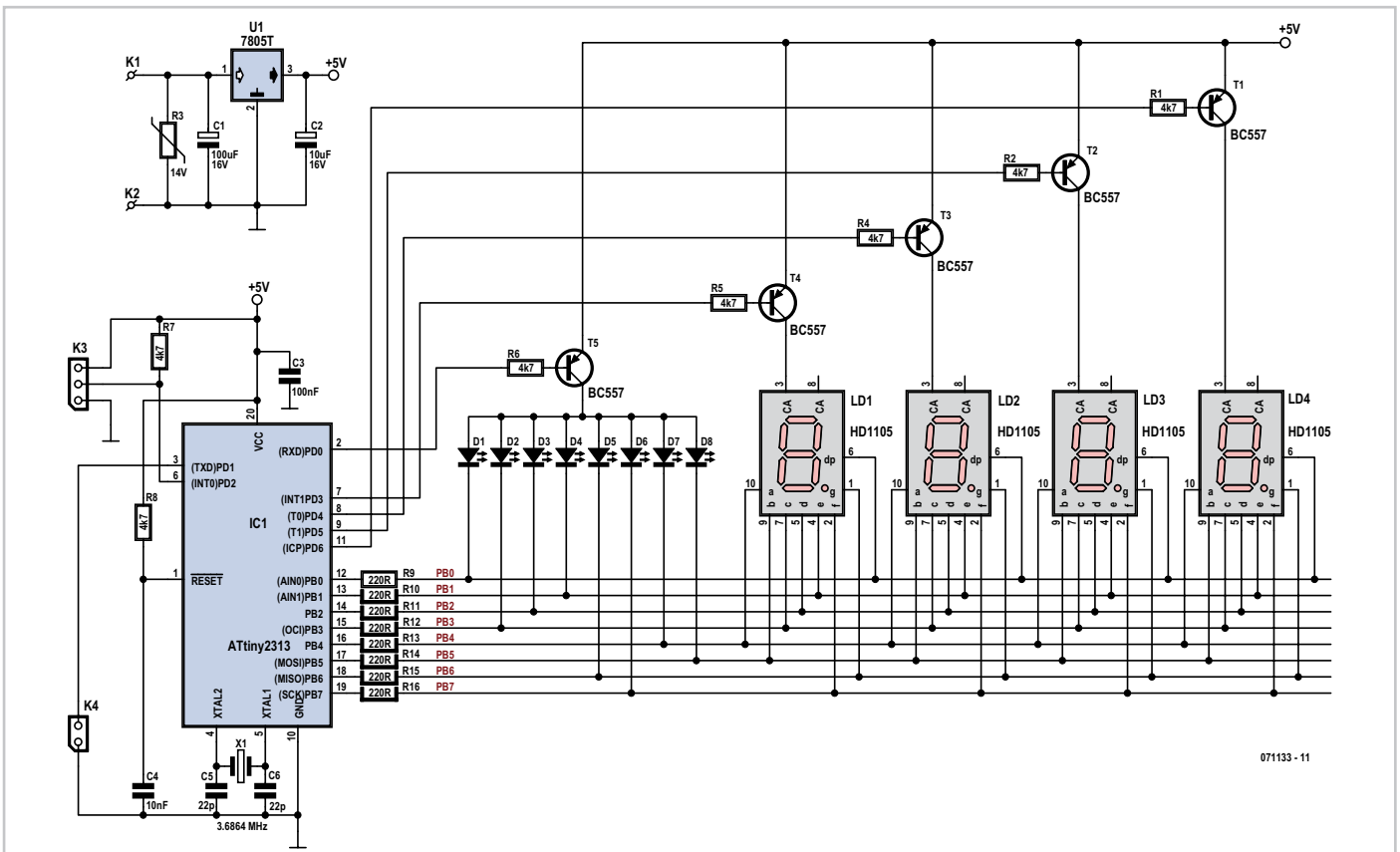
input, and directly drive a multiplexed display, using its I/O lines that can sinking up to 20 mA. The display comprises four digits, to count from 60 to 9,999 revs. The bargraph is just a little gimmick that makes it easy to visualize engine acceleration or deceleration over a range of 1,000 rpm. It consists of eight LEDs, so offers a resolution of 125 rpm. To improve display accuracy, we recommend using two additional intermediate magnets (i.e. a total of four magnets on the camshaft). Because of the way the software has been designed (see software paragraph), the device needs at least one pulse every 0.5 second, i.e. 2 Hz, and hence a resolution of 120 rpm, which is not really enough and leads to an unstable display.

The Hall-effect sensor is connected to header K3.

Two additional magnets make it possible to increase the resolution to 60 rpm. The number of magnets fitted can be configured by means of the jumper fitted to header K4 (which may, as applicable take the form of a:
– no jumper = two magnets,
– jumper fitted = one magnet.

Not much needs be said about the power supply, except that:
– the regulator might need a heatsink, as the vehicle on-board voltage can reach 14 V, which represents a volts drop of 9 V with a current consumption of 30 mA, i.e. ≈ 0.3 W;
– the (vital) presence of a special car varistor to protect the regulator from voltage spikes. Otherwise, it's goodbye to the regulator the first time you start up!

This project requires relatively few resources, whence the use of a small microcontroller: the Atmel AT90S2313, which by now is an old faithful in Elektor. It has two timers, I/O lines capable of driving LEDs directly, and an interrupt input. The interrupt input is used to count pulses by incrementing a software pulse counter (cntH:cntL). The timer is set to generate an interrupt every 2.5 ms. This interrupt is used to:
– multiplex the display: each display is refreshed every 2.5 ms; hence the whole display is refreshed at a frequency of 80 Hz;
- increment a software counter up to 250 ms (= one tick).

At each tick, the value of the pulse counter is stored alternately in counter 0 or counter 1. This tick is also used in the primary loop to trigger counter processing and display refresh. In the primary loop, counters 0 and 1 are added together to obtain the number of pulses seen during the last two consecu-

071133-1 ©Elektor
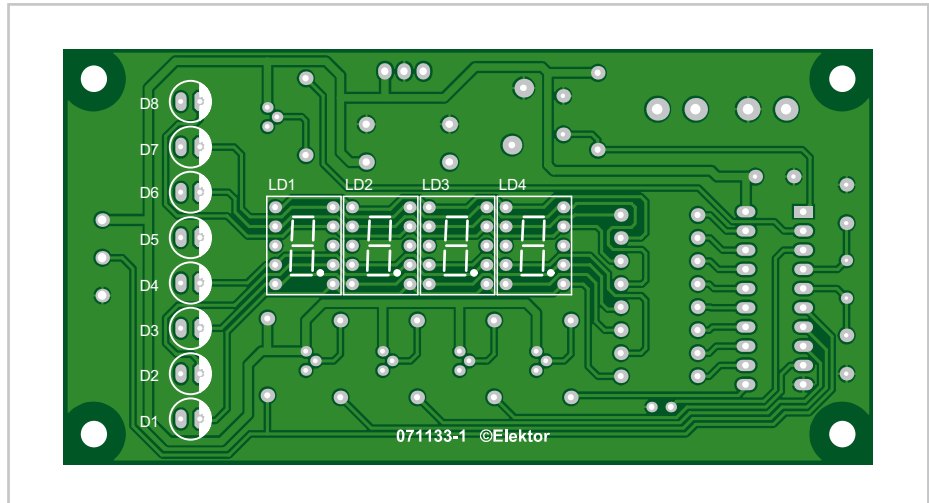
COMPONENTS LIST

Resistors
R1,R2,R4-R8 = 4kΩ7
R3 = S14K14 varistor
R9-R16 = 220Ω

Capacitors
C1 = 100µF 25V
C2 = 10µF 25V
C3 = 100nF
C4 = 10nF
C5,C6 = 22pF

Semiconductors
D1-D8 = LED, red, rectangular

LD1-LD4 = 7-segment LED display, common anode, e.g. HD1105
T1-T5 = BC557
IC1 = AT90S2313, programmed with hex file from archive 080238-11
IC2 = 7805T

Miscellaneous
X1 = 3.6864 MHz quartz crystal
K1,K2 = solder pin
K3 = 3-way pinheader
K4 = 2-way pinheader with jumper
UGN31 Hall-effect sensor
PCB, ref. 071133-1 from www.thepcbshop.com

tive 250 ms time slots, i.e. 0.5 s. This trick makes it possible to update the display more frequently (250 ms) without having to wait for the end of the measurement (0.5 s). This makes it possible to increase the speed of the digital chain without compromising accuracy. The remainder of the software consists of converting the number of pulses into rpm. Everything is implemented in integer arithmetic. Given that the measurement is performed over 0.5 s, the result has to be multiplied by two to obtain the frequency, and then by 60 to obtain a value in revs per minute.

All that then remains is to convert the binary result into a decimal value, which is achieved using Atmel's binary-to-BCD conversion routines (AVR204 Application Note). The most significant digit (MSD) is set to 0, and the result is then converted back to binary. This is a crafty method for calculating a remainder out of 1,000 (modulo) for the bargraph. This value then has to be divided by eight, as the bargraph has eight LEDs (coded by subtraction and a loop). The result is used as an index for a decimal-to-7-segment transcoding routine. As supplied, the software occupies about 75% of the program flash memory.

The software has been developed to work on an AT90S1200 or an AT90S2313. With a bit of luck it should also work on an AT90S1200, but although we haven't actually tried that, we're sure there are Atmel programming enthusiasts among our readers capable of doing it. Let us know!

The small inset schematic is that of a test generator specially designed for the rev counter.

(071133-I)

Downloads
The PCB artwork file is available for free downloading from our website www.elektor.com; archive # (071133-1.zip.

The source code and .hex files for this project are also available from www.elektor.com; archive # 071133-11.zip.

Web Links
AT90S2313 datasheet:
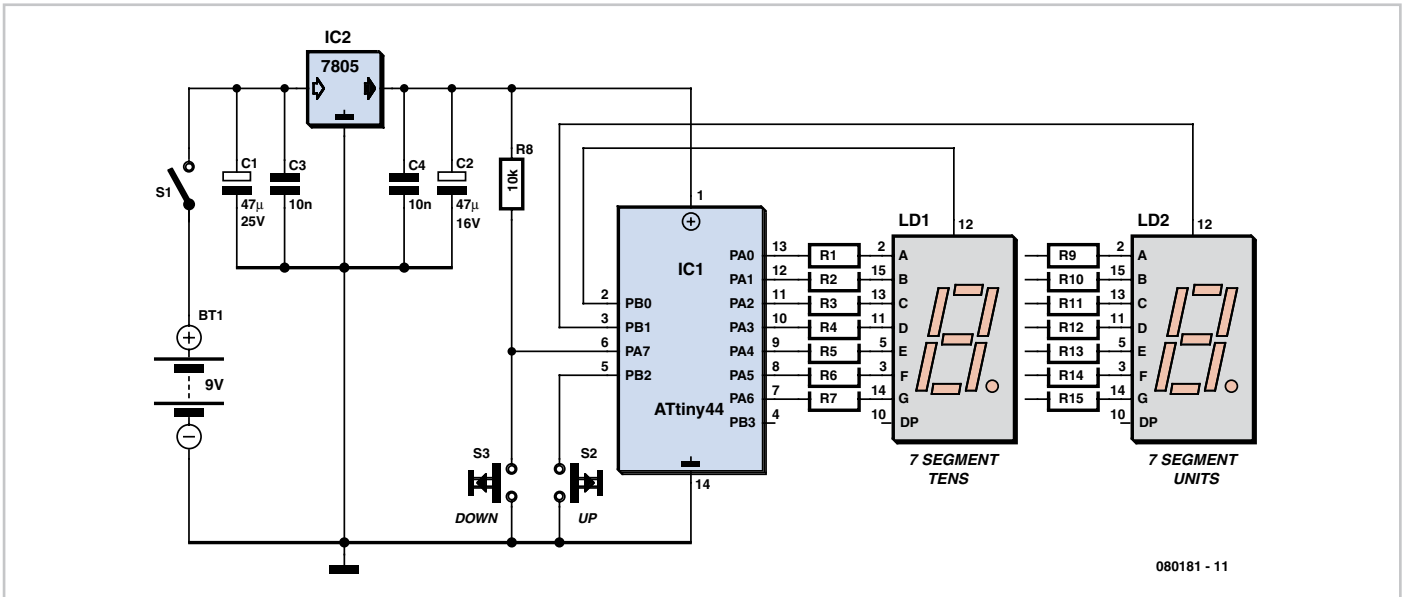www.atmel.com/dyn/resources/prod_documents/doc0839.pdf

S14K14 varistor datasheet:
www.datasheetarchive.com/preview/3078060.html

UGN3140 Hall-effect sensor datasheet:
www.datasheetarchive.com/preview/3527952.html

Golf Tally

080181 - 11

Stefan Hoffmann

For electronics enthusiasts building your own golf scorekeeper is a must (buying one is degrading – far too easy!). Then you can keep an eye on your total strokes on the course (and impress the other players naturally).

This example is based on an ATtiny44 microcontroller, equipped with just two seven-segment displays and two data entry keys (to minimise power needs).

The three EEPROM variables (18 arrays) used in the Bascom software are: Course-Par, the par for the course per hole, PersPar, for your personal score (par for the course plus handicap) and Score for the current total of strokes during the round. Since people play mainly at the same course and their handicap alters seldom (unfortunately far too seldom), the first two variables do not need to be entered into the EEPROM very often. Program source code and hex-file can be downloaded free of charge from www.elektor.com.

At the golf course for each round you enter the number of strokes made at each hole and save this as the third array. When you get to the 'debriefing' afterwards at the nineteenth hole you can display the par for the course, your personal score and number of strokes for each hole.

At power-up you need to set the user mode by pressing keys as follows:

1. S1 and S2 pressed:
Enter Par for the Course and Personal Score

2. S1 pressed:
Display Par for the Course and Personal Score

3. S2 pressed:
Display Score (number of strokes) and Stableford points

4. No key pressed:
Play a round – starts automatically, using the same mode as the last round.

The middle decimal point appears when the hole number is displayed; only the upper bar is shown for the CoursePar in the left-hand display with the corresponding Par figure in the right-hand display. When PersPar is shown the middle horizontal bar appears in the left-hand display, whilst the strokes total is indicated by the bottom bar. Stableford points are signified by three horizontal bars in the left-hand display.

The table gives a summary of the modes and the displays. It's a good idea to practise a bit before using the scorekeeper in earnest, if only to avoid irritation on the actual course…

(080181-1)

080181 - 12
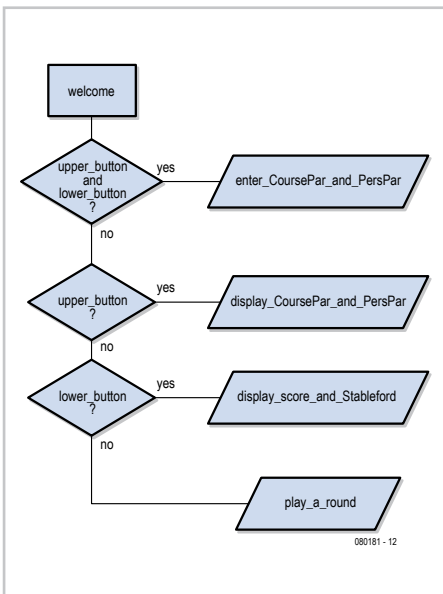
Inputs and displays

Input CoursePar and PersPar
Alternating input (press keys to increase or reduce): Hole/ CoursePar (e.g. 1.1 ⁻5)

After 3 seconds next Hole

After the 18th Hole:

Alternating input (press keys to increase or reduce): Hole/PersPar (e.g. 1.3 –7)

After 3 seconds next Hole

Display CoursePar and PersPar
Alternating display: Hole/PersPar (e.g.1.1 ⁻5

After the 18th Hole

Alternating display: Hole/PersPar (e.g. 1.3 –7)

Press keys for next/previous hole (in rotation)

Score and Stableford display
For each hole

Alternating display: Hole/Score (e.g. 1.1 _ 5)

After the 18th Hole

Alternating display: Hole/Stableford points (e.g. 1.3 ≡ S2)

Play a round
Alternating display: Hole/Score (e.g. 1.1 _5)

Press keys to increase/decrease

Solar Cell Array Charger with Regulator

070894 - 11
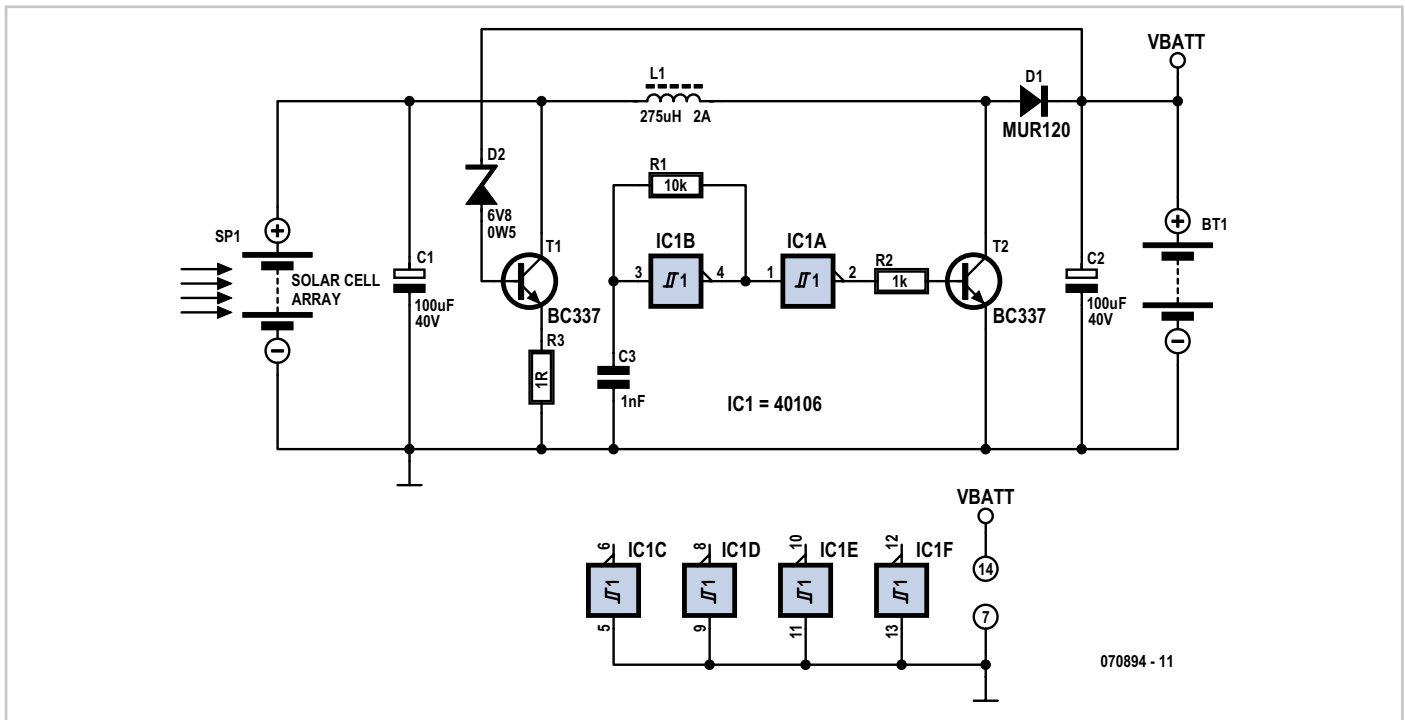
Lars Näs

This simple circuit can be used to charge batteries from a solar cell array. The circuit consists of an oscillator, a DC-DC step-up or 'boost' converter and a regulator that provides regulation of the output voltage.

The oscillator is built around a hex Schmitt trigger inverter IC, the 40106B, one resistor, R1, inserted between the input and the output of one of the gates in the 40106 to supply charge to C3. Depending on the values of resistor R1 and capacitor C3 you're using in the circuit, the oscillator will operate at different frequencies, but a frequency below 100 kHz is recommended. By consequence, the oscillator frequency should not exceed the maximum ripple frequency of capacitor C2 connected on the output. C2 should be an electrolytic capacitor with a DC working voltage larger than the desired output voltage. Besides, it should have a low ESR (equivalent series resistance).

IC1A is used as a buffer, ensuring that the oscillator sees a light, fairly constant load and so guaranteeing that the output frequency remains stable (within limits, of course). VCC of the Schmitt trigger can be connected directly to the battery charged, provided the charged battery voltage does not exceed the max. or min. limits of the Schmitt trigger's supply voltage. This ensures the Schmitt trigger can operate even if little power is obtained from the solar cell array.

When transistor T2 is turned on, (output from oscillator buffer IC1A is high), a collector current flows through inductor L1 which stores the energy as a magnetic field and creates a negative voltage V_{L1}. When transistor T2 is switched off, (output from oscillator buffer IC1A is low), the negative voltage V_{L1} switches polarity and adds to the voltage from the solar cell array. Consequently, current will now flow trough the inductor coil L1 via diode D1 to the load (capacitor C2 and possibly the battery), irrespective of the output voltage level. Capacitor C2 and/or the battery will then be charged. So, in the steady state the output voltage is higher than the input voltage and the coil voltage V_{L1} is negative, which leads to a linear drop in the current flowing through the coil. In this phase, energy is again transferred from the coils to the output. Transistor T2 is turned on again and the process is repeated. A type BC337 (or 2N2222) is suggested for T2 as it achieves a high switching frequency. Inductor L1 should have a saturation current larger than the peak current; have a core material like ferrite (i.e. high-frequency) and low-resistance. Diode D1 should be able to sustain a forward current larger than the maximum anticipated current from the source. It should also exhibit a small forward drop and a reverse voltage spec that's higher than the output voltage. If you can find an equivalent Schottky diode in the junk box, do feel free to use it.

The most important function of the shunt regulator around T1 is to protect the batteries from taking damage due to overcharging. Besides, it allows the output voltage to be regulated. Low-value resistor R3 is switched in parallel with the solar cell array by T1 so that the current from the solar cell array flows through it. Zener diode D2 is of course essential in this circuit as its zener voltage limits the output voltage when T1 should be turned on, connecting the solar cell array to ground via R3. In this way, there is no input voltage to the boost converter and the battery cannot be overcharged.

Sealed lead-acid (SLA) batteries with a liquid electrolyte produce gas when overcharged, which can ultimately result in damage to the battery. So, it's important to choose the right value for zener diode D2. Special lead-acid batteries for solar use are available, with improved charge-discharge cycle reliability and lower self-discharge than commercially-available automotive batteries.

Finally, never measure directly on the output without a load connected — the ripple current can damage your voltmeter (unless it's a 1948 AVO mk2).

(070894-I)

Web Link
www.electronicia.se

Assistance for BASCOM Programmers

Jochen Brüning

It is often useful to be able to display the values of certain variables or intermediate results during program execution when developing microcontroller software. This information can be invaluable especially when the program is not behaving entirely as you had anticipated.

Applications using larger microcontrollers often already incorporate some form of liquid crystal display in the design so in this case it is reasonably easy to write a routine to display these intermediate values just for the purposes of program development. When your design uses one of the smaller microcontrollers like the ATtiny 25/45/85 series there are so few I/O pins available that it is impossible without additional hardware to provide a connection to an additional LCD even by using 4-bit addressing.

For designs using these tiny controllers the BASCOM programming environment can offer significant advantages; its compiler includes a software UART which provides a simple, flexible and 'reusable' solution to the problem by enabling data to be sent to and from the controller using its built-in terminal emulator program. It is only necessary to assign a single controller pin for the send and another for the receive serial data path. This approach gives far greater flexibility for the circuit layout when compared to microcontroller designs which use a hardware USART with its predefined pin assignments.
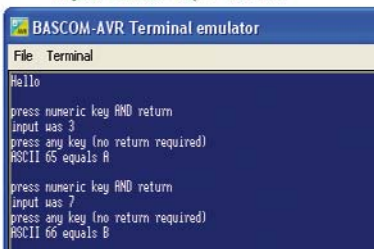
The connection between the controller and PC can be made using a USB port where it will be necessary to use a USB to TTL adapter cable like the one manufactured by FTDI and featured in the June 2008 edition of *Elektor* (page 48). An even simpler solution is to use the spare serial port (RS232) on the PC, it will only be necessary to convert the signals from the TTL levels required by the controller to the RS232 levels used by the PC.

A suitable circuit can be built using a MAX232 IC together with four capacitors. The author was able to make use of a cable taken from a redundant serial PC mouse. The 9-way D-type connector was fully encapsulated so it was necessary to solder the IC together with the capacitors into the cable and protect the circuit with

a length of heat-shrink sleeving. Details of the construction can be found in a PDF document which is available from the Elektor website.

The only additional software required by the controller are the OPEN instructions which are used to configure the software UART. This instruction sets parameters such as baud rate, parity and the number of stop bits for the serial communication channel. In addition it defines which controller pin is used for communications and also the data direction (send or receive). Two OPEN statements are therefore necessary; one to set up the transmitted data path and the other for the received data.

For example an instruction to configure data transfer from the controller to the terminal emulator:

```
Open „COMB.3:9600,8,N,1" For
    Output As #1
```

B.3 : indicates that port B.3 is used which is pin 2 of a ATtiny25 controller.

Output: indicates that data is sent from port B.3.

#1 : File handle, used in the following Print command.

Data can now be sent using the normal Print command:

```
Print #1 , „Hello" ;
    The variable to display
```

#1 : references the corresponding Open

statement above

It is helpful to use a simple test program just to output some text. This will determine whether the parameters defined in the Open-statement and the terminal emulator (found under 'Tools' along the top of the screen or invoked with ctrl + t) are correctly configured and also if the cable is connected to the correct controller pin. There are different ways of sending variables to the controller; firstly it is necessary to use the Open statement to configure the Input and choose a different file handle (e.g. #2) in the Input or Inkey statements as in:

```
Open "COMB.1:9600,8,N,1" For
    Input As #2 'PB1 (=Pin 6 of the
    ATtiny25) for the serial input

Input #2 , Variable store       or

Variable store = Inkey(#2)
```

The input of data must be terminated with a RETURN. Inkey will return a value of 0 if there is no character waiting i.e. no key has been pressed. For further information refer to the BASCOM online help pages.

The screenshot shows a small test program listing together with the program output in the terminal emulator window. The hex file of this program is available for free download from the Elektor website, the file number is 080370-11.zip.

(080370e)

# LED Spinning Top

Volker Ludwig DD0EU

Commercially available plastic LED spinning tops consist of one or more LEDs powered from two button cells and activated using a switch actuated by centrifugal force. More elaborate devices, according to the author's research, also include a microcontroller to provide an ever-changing light display. It is entirely unacceptable, on both pedagogical and environmental grounds, that it is almost always impossible to replace the batteries without damaging the top. This gives us motivation enough to build or own version.

First of all a few craft skills are called for to turn up a wooden top on the lathe. If you feel slightly unwell at the thought of showing off your woodworking skills to your children, then the author (e-mail address email@dd0eu.de) is willing to help you out by supplying ready-made tops like the one illustrated here which, thanks to their long handle, spin very satisfyingly.

The circuit employs very few components and there is not a microcontroller in sight. The magic is down to the use of a high-brightness so-called 'rainbow LED' as mass produced for use in continuously-changing coloured 'mood' lights intended for domestic lighting applications. This device includes not only an RGB LED but also a control chip that causes it to change from colour to colour.

Normally this colour changing is too slow to make a pretty effect when the LED is mounted on a spinning top. However, there is an interesting effect that occurs when using these slowly changing LEDs as the smooth colour transitions are produced using pulse width modulation. When the top is spun quickly the pulses of light give
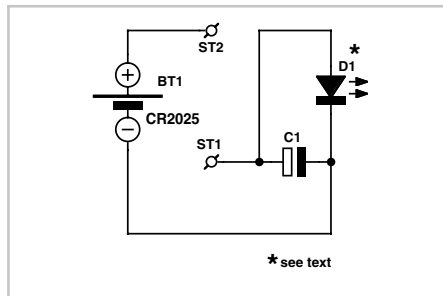
an attractive visual effect, as the author's photograph shows.

The circuit is very simple, with the main components being just the colour-changing LED and a 3 V button cell. It is impor-

tant not to forget the centrifugal force switch, as otherwise the recipient of the toy may be rather disappointed to discover that the battery is flat!

In order to simplify construction still further, the author has designed a printed circuit board for the project. Once the board is populated the central hole provided can be used to locate it correctly over the handle of the top. The printed circuit board layout is available for download from http://www.elektor.com.

So that the top can be balanced correctly when construction is complete, it is important that it has no loose parts.

The two terminal pins ST1 and ST2 form the contacts for the centrifugal force switch. A sprung contact can be improvised by soldering one end of a spring salvaged from an old ballpoint pen (you may need to try more than one to find one that works) to one of the pins and a length of tinned copper wire to the other end of the spring. The wire and the other pin then form the switch contacts, which are closed when the top is spun (see the photograph).

Things should be arranged so that there is a gap of about 1 mm between wire and pin when the top is stationary.

The bottom contact pad for the button cell can be made by soldering a small drawing pin in the middle of the battery holder area.

The counterweight is made from an M3x10 screw with nut and a 4 mm washer, which allows for a little adjustment to be made. If more weight proves necessary, further washers or nuts can be added.

(070916-I)
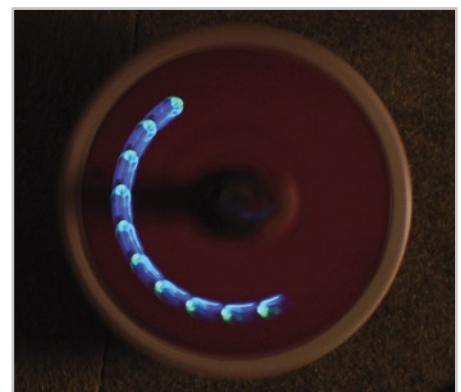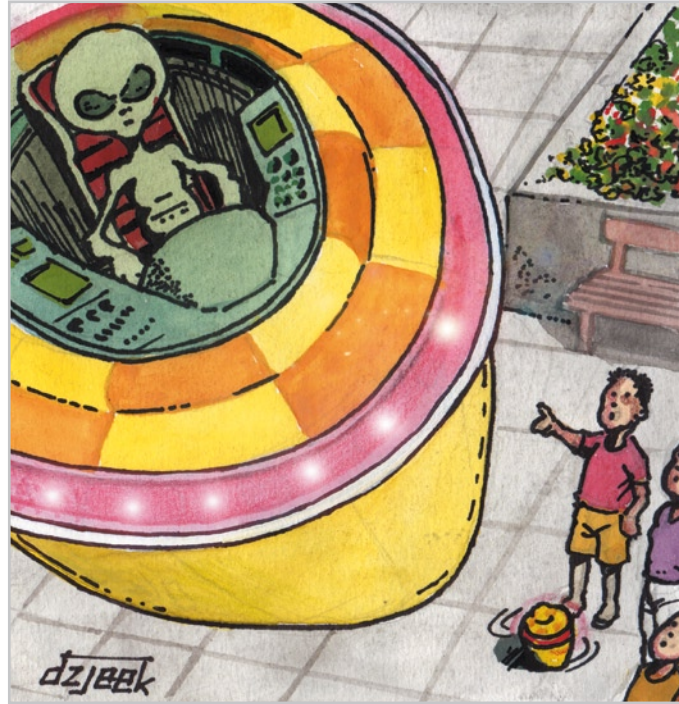
Cigarette-lighter Battery Charger

B. Broussas

This fine Summer's day, you've decided to go out for a breath of fresh air – but without wanting to give up your 'hi-tech toys' — whether it's your son's radio-controlled car, your daughter's MP3 player (all borrowed of course after due negotiations), or your own favourite portable DVD player. All these appliances share the feature of usually operating on rechargeable batteries – which is of course no problem when the mains is at hand, as they all come with their own chargers.

But the problem gets a bit more complicated out in the country, and as Murphy's Law has it, that's always just the moment you find your batteries are flat or nearly so. If your car is parked nearby, we can suggest a solution in the form of this very simple project – and what's more, it will cost you practically nothing, since it uses mostly components that any good electronics enthusiast is likely to already have in a drawer or the junk box. Even if you did have to buy everything, the whole thing shouldn't cost more than about £ 10.

As **Figure 1** shows, it's a project that smacks of good old-fashioned – we almost said granddad's – electronics, as it doesn't use a microcontroller, nor even the slightest specialized integrated circuit (IC). In spite of this, it will look after your batteries, especially if you are reasonable about the charging time.

Whether they are old nicads (NiCd) – becoming extinct these days because of their many shortcomings and toxicity – or the omnipresent nickel-metal-hydrides (NiMH), these types of battery have to be charged at constant current. This charging current should be 10% of their rated capacity (printed on the label) for a normal or slow charge, or a maximum of 100% of their capacity, if you want a fast charge.

So, to recharge the NiMH or NiCd batteries in our various portable devices from a car battery – for that's what it's all about – all you have to do is build a constant current generator. To achieve this takes just two common or garden transistors, T2 and T3. The latter is turned on to a greater or lesser extent by way of R3 and T2. By virtue of the very principle of transistors, there cannot be more than about 0.6 V between the base and emitter of T2. If this voltage tends to drop, T2 will tend to turn off, which will then increase the conduction of T3 – and vice-versa. In other words, the base-emitter voltage of T2 will virtually always remain at 0.6 V.

Now this voltage is produced by the cur-

1

2

rent passing through one of the resistors R4–R7, and hence also the battery to be charged. So it's easy to see that this current is quite simply given by $I_{ch} = 0.6 / R$ where I_{ch} is the desired charging current and R is one of the resistors R4–R7.
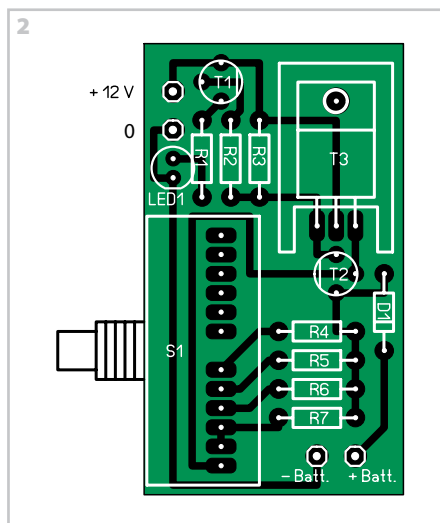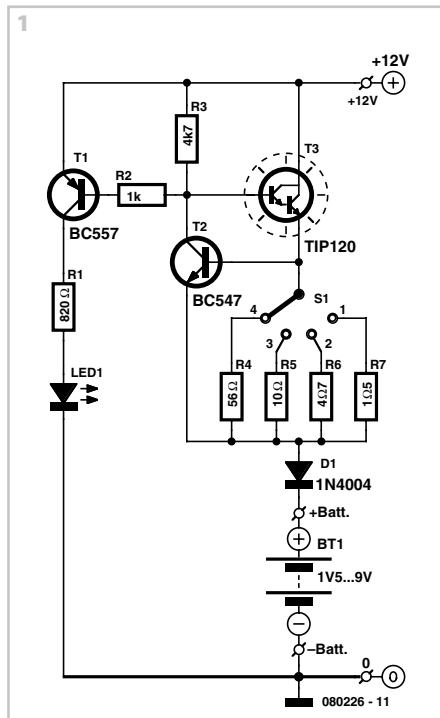
As T2 turns on (and hence the battery is charging), transistor T1 increasingly saturates. If this current drops too much, or falls to zero in the event of a poor contact or faulty battery, the LED goes out to indicate a problem. Diode D1 protects the circuit from possible reversed polarity of the battery being charged.

We have designed a small PCB for this project with provision for direct mounting of a rotary switch to be mounted, thereby reducing the wiring needed to nothing. This switch is Lorlin part no. PT6422/BMH and is available, for example, from Farnell under product ref. 1123675. However any other equivalent may be used if it can be adapted to the circuit board. In most case, that means installing some extra wires between the PCB and the switch pole and contacts. Transistor T2 may be required to dissipate quite a lot of heat for low-voltage batteries being charged at high currents, so space has been provided to fit it with a U-shaped heatsink. The various designed charging currents are 400, 130, 60, and 10 mA for positions 1–4 of the switch. The unavoidable voltage drop across T2 means the maximum voltage of the battery to be recharged cannot exceed 9.6 V.

If you want different charging currents from those designed, all you need do is simply replace one or other of R4–R7 by a resistor whose value has been calculated as above ($R = 0.6 / I_{ch}$) and whose power is given by $P = 0.36 / R$.

As a constant-current generator, the circuit is naturally protected against short-circuits, but do take care all the same if you increase the charging current too much not to exceed the maximum power dissipation in T3 (65 W) and more importantly, the power allowed by the small heatsink provided for on the PCB. A current of 500 mA seems to us a reasonable maximum value to not exceed. The value should cater for most NIMH and NiCd batteries if a few hours are allowed to charge them. But then it was a sunny day so that shouldn't be a serious concern.

(080226-I)

Downloads

The PCB copper track and component mounting plan can be downloaded from www.elektor.com; file # 080226-1.zip

AlphaSudoku – supersize mind boggler

Puzzle designed by Claude Ghyselen

Elektor's Summer Circuits differing widely from the regular monthly editions, we thought it would make a nice change to publish a distinctly dissimilar type of puzzle this month, not just in regard of size but also complexity and diversity. We bet you've never seen one of these before and challenge you to solve it and enter a prize draw for an E-Blocks Professional starter kit and three Elektor Shop vouchers.
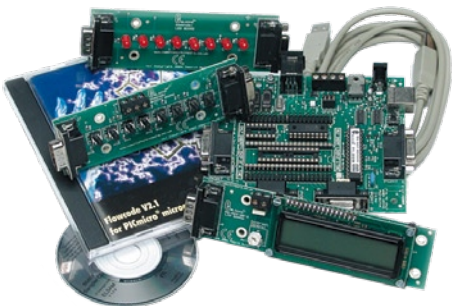
The method of solving the AlphaSudoku puzzle is basically the same as for a classic Sudoku, with some modifications! AlphaSudoku has a 25×25 cell structure and takes numbers 1 through 9 and letters A through P (i.e. including the letter 'O', hence the absence of the '0' in the numbers). The puzzle is essentially a (16×16) Alphadoku comprising nine classic (9×9) Sudokus using numbers 1 trough 9.

In AlphaSudoku, complete the diagram composed of 25×25 cells such that all letters A through P and all numbers 1 through 9 occur **only once** in every line, in every column and in every box (5×5; identified by a coloured outline). A number of clues are given in the puzzle and these represent the start situation. The nine embedded Sudokus have a background colour. All correct entries received for the puzzle go into a draw for a main prize and three lesser prizes. All you need to do is send us the **combination of six numbers in the grey boxes**. The puzzle is also available as a **free download** from our website.

Solve AlphaSudoku and win!
Correct solutions received enter a prize draw for an **E-blocks Starter Kit Professional** worth **£ 249** and three **Elektor Electronics SHOP Vouchers** worth **£ 35.00 each**. We believe these prizes should encourage all our readers to participate!

Participate!
Please send your solution (the numbers in the grey boxes) by email to: editor@elektor.com.
Subject: alphasudoku 7-2008 (please copy exactly**).**

Puzzle grid (25×25)

D	5		E	G	2			K	7		I	O		9	P		F		4	1			M	A
	1	I	6		8	A			E		H	F	L		2	K		4			5	9	3	
		2	L		9	J	P		3	8			K		7		B		5		C			N
9			K		1	C	L	M	6	5	B	N		4	D		G			F		8		2
		H			B	G	I		2	J	P				N		1		E		7			
4	6	9	8	3			I	J		N		K	G	A	M	O			C			7		
	O			F	P				D				A		1			B	M	E				H
M		E	P	N		4			H	C				B	J			F	I	D				O
H	B	J	A				2		L					E								N		F
7				D	G				O		F	M			B	I	P	L	K	8			3	9
6	7			I	J	E	H			A	C	N	F			B	D	G		9	5	1		8
		P	O		I				D	J		5				4		7			G		K	
G	H	N			A			8	P	M						3			O	J	L			
A	K		M	J			1	N	E		9							L	H	O	D	P		C
1	8	5		2	F		M	C		P		D		I		H	K	E		3		6	4	
2	3	1	5	6		D			G	H	J		K	M	C		E	7		O	8	4		
C	P	G	J	A	O	3			M	B	4		L	2		I		N			F	K		
L		H		N		5		F	A	1		E	O		P	D	J	B						
		O	N					K	8		6	C			D	L	I		A	P				
8	4			9					L	I		M	G		F		B	6		2		1		
5	E	A			4		K	L	1	6	C			2	3	G	O			9				
K		8	2	M	7		F	G	9	1	E		D	3		I			P	C	H	J		
		B	O	6	N	E	A	8	7			5	1		J	C	9		F		I	M		
	9			1	3	P		B		4		G	I	8	5		A		O	7	K			6
F	D		3	7	C		J	H	5	9	M		P		N			4					L

Solution grid (grey boxes)

D	A	5	C	0	2	9	8	7	3	E	F	1	4	6	B
1	4	9	3	F	B	A	D	5	6	0	2	C	8	E	7
B	7	E	F	3	6	5	4	8	9	C	1	D	2	0	A
8	6	2	0	E	1	7	C	4	D	B	A	5	F	3	9
3	1	F	B	A	E	D	9	2	0	8	7	4	6	C	5
7	2	8	D	C	0	6	5	1	4	F	3	A	9	B	E
9	E	4	A	8	7	1	B	D	C	5	6	3	0	F	2
5	C	0	6	4	3	F	2	B	A	9	E	7	D	1	8
4	F	B	E	7	C	2	3	A	1	D	0	9	5	8	6
2	3	6	8	1	5	E	0	C	F	4	9	B	7	A	D
A	5	D	1	9	F	B	6	3	2	7	8	0	E	4	C
C	0	7	9	D	4	8	A	E	B	6	5	F	3	2	1
F	9	3	5	B	D	4	1	6	8	2	C	E	A	7	0
6	8	A	7	5	9	C	F	0	E	3	B	2	1	D	4
E	D	C	2	6	A	0	7	F	5	1	4	8	B	9	3
0	B	1	4	2	8	3	E	9	7	A	D	6	C	5	F

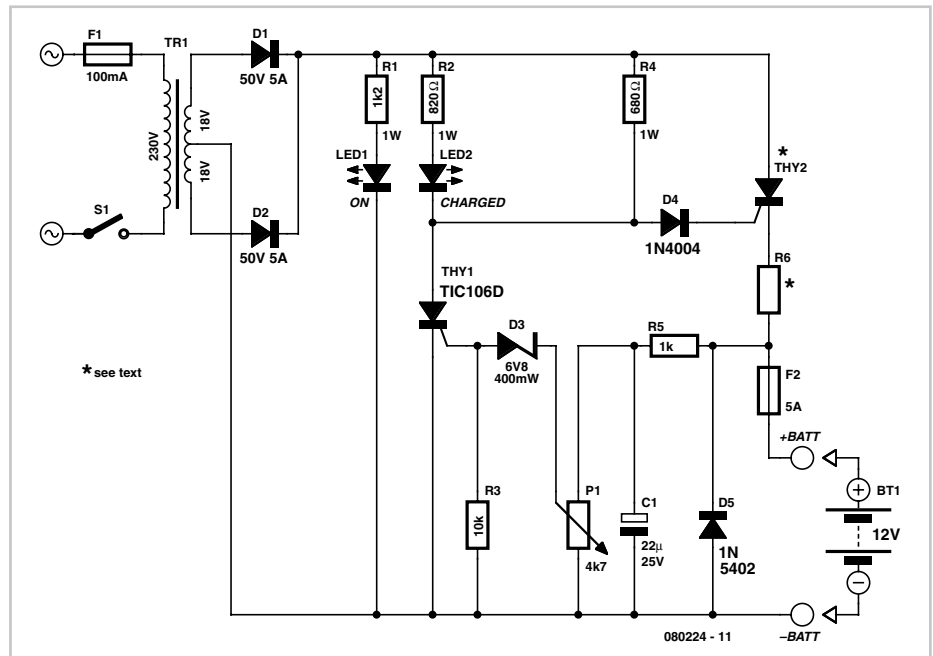# Automatic Car Battery Charger

C. Tavernier

A Summer Circuits edition on 'all things outdoors' — good, but what of all the battery-powered circuits that remains indoors? Once the fine weather starts, the family car tends to remain increasingly in the garage – which is as beneficial to the owner, his/her bank account and the air that we breathe as it helps — to an extent to — reduce CO_2 emissions. However, when we come to want to use the trusty vehicle again, it often happens that the battery shows serious, deeply worrying signs of being flat, sometimes to the point of preventing the engine from starting altogether. Push-starting is no longer recommended or even possible with modern cars, so a topped up battery is highly appreciated.

The solution of leaving an off-the-shelf charger permanently connected is not generally satisfactory, unless you're lucky enough to have an 'electronic' one. The majority of dirt cheap ordinary chargers don't include any regulation circuitry and so will over-charge a vehicle battery if you're unwise enough to leave it permanently connected.

So our proposed project is to build a charger that can act as both a standard charger, and a float charger that you can leave permanently connected without the slightest risk to your battery or fear of over-charging. What's more, it doesn't use any 'exotic' components and is ridiculously cheap.

Let's have a look at the circuit diagram. The voltage supplied by our charger's transformer is rectified by diodes D1 and D2 but is not smoothed. Strange as it may seem, this is vital for it to work properly, because as a result the rectified voltage consists of a succession of sinewave half-cycles, and hence falls to zero 100 times per second.

When thyristor THY2 is conducting, the battery is effectively charged, the charging current being limited only by resistor R6, which has to be calculated as shown below. This thyristor is triggered via resistor R4 for each half-cycle of the mains, except when thyristor THY1 is itself triggered. In that event, THY2 turns off the first time its supply voltage drops to zero, and no further current can reach the battery.

The voltage at the battery terminals is sampled by R5 and smoothed by C1 before turning on THY1 or not via P1 and D3. As long as this voltage is lower than a certain threshold, determined by the setting of P1 and corresponding to a battery that is not yet fully charged, THY1 is not triggered and so leaves THY2 conducting for all the mains half-cycles.

When the voltage at the battery terminals is high enough, THY1 is triggered and thus prevents THY2 from being triggered. This phenomenon is not in fact quite as clear-cut as we have just described, but takes place very progressively, so as it approaches full charge, the battery's average charging current gradually reduces automatically, eventually stopping completely once the fully-charged voltage has been reached.

LED1 acts as a charging indicator, while LED2 lights more when THY1 is being triggered frequently, thereby acting as a fully charged indicator.

Three components of the circuit proposed here need to be selected according to the characteristics you want your charger to have; these are R6, THY2, and TR1. R6 needs to be calculated according to the maximum charging current you want, from: R6 = 16 / I where I is the current expressed in amps. Warning! Given the value of the other elements in the circuit (D1, D2, TR1, and the fuse), do not exceed 5 A. The power dissipated in R6 can be calculated from $P_{R6} =$

36 / R6 with *P* expressed in watts and R6 in ohms, of course.

Thyristor THY2 should be a 100-V type (or more) rated at 1½ to 2 times the desired maximum charging current.

And lastly the transformer, which should have a power in VA given by: $P = 18 \times 1.2 \times I$ where *I* is the maximum desired charging current, expressed in amps.

The only adjustment to be made concerns pot P1 and will require access to a well-charged battery. Connect it to the charger output and replace the 5-A fuse with an ammeter – preferably an old analogue type, better able to respond to average currents than certain modern digital types. Then adjust potentiometer P1 to obtain a current of around 100 mA.

Later on, when you have the opportunity to charge a very flat battery, you will be able to fine-tune this adjustment by tweaking P1 to obtain a charging current close to the maximum you have set by means of R6. You'll need to find a compromise setting between the float charging current, which mustn't exceed around 100 mA, and this maximum current.

Whatever the accuracy of your adjustment, you can be reassured that your battery will be treated better by this project than by many of its non-electronic counterparts to be found in the shops.

(www.tavernier-c.com) (080224-I)

Auto-off for Audio Gear

Joseph Zamnit

A good way to spend a relaxing afternoon is to be in a quiet place with just the right amount of sun or shade, drinks within reach and listening to your favourite songs on MP3 or CD. You doze off and by the time you wake up again the audio equipment has dropped silent due to flat batteries. What a pity!

The simple circuit shown can prevent this embarrassing situation by de-actuating a relay when no audio signal is detected for about two seconds.

The circuit consists of a sensitive LM358 based comparator, IC1A, which keeps monostable IC2A (a 4538) triggered as long as an audio signal is detected at the input. Via coupling capacitor C1 the circuit takes its input signal from the 'hot' side of the loudspeaker or headphones in your audio gear. The monostable will time out 2 s after being triggered, the delay being determined by R6 and C3.
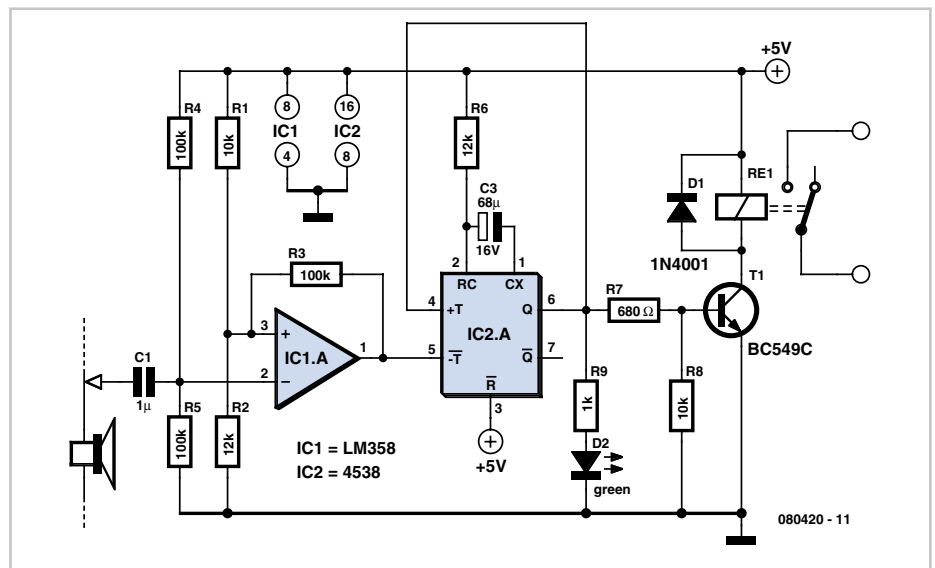
IC1 = LM358
IC2 = 4538

080420 - 11

(080420-I)

LED Switching Regulator

Jean Claude Feltes

On the author's bench lay two ICs, waiting to be tried out: an LM3404 switching regulator (only available in a surface mount package, unfortunately), and a U2352 PWM IC. Together they could be used to make a small dimmer for LEDs. As in the case of the 'Dimmable LED lamp' elsewhere in this issue we use a 6 V lead-acid battery as our source of energy, and a Luxeon 3 W LED as our light source. V_{CC} therefore lies between a minimum of around 5.4 V and a maximum of around 7.2 V.

The right-hand part of the circuit shows the switching regulator, which reduces the voltage from the 6 V lead-acid battery to the 4 V required by the high-power LED. As the voltage is reduced the current must increase, and so less current flows through the input power connections than does through the LED.

The LM3404 includes all the necessary control electronics along with a MOSFET switch. The voltage across resistor R_{sns} (CS, pin 5 of IC2) is proportional to the LED current and is compared against an internal reference of 200 mV. If the voltage falls below 200 mV the MOSFET is turned on for a fixed time t_{ON}. During this period the current through the inductor and the LED rises in an essentially linear fashion.

Time t_{ON} is determined by R_{ON} and the input voltage V_{IN}:

$$t_{ON} = 0.134\ (R_{ON}/V_{IN})\ \mu s = 1.83\ \mu s$$
(where R_{ON} is in kΩ and V_{IN} in V).

After this time period has expired the MOS-FET is turned off and an approximately linearly-falling current flows through the flyback diode and the LED until U_{sns}, the voltage across R_{sns}, reaches 200 mV, where-upon a new cycle begins. While the MOS-FET is off no current flows in the supply to the regulator. The minimum off time is 0.3 µs.

Ripple current is inversely proportional to the inductance and to the switching frequency. During t_{ON} the current rises line-arly and the voltage across the coil is
$U_L = U_{IN} - U_{LED} - U_{SNS} = 1.8$ V.
Hence
$U_L = L(\Delta I_{LED}/\Delta t)$.
With $\Delta t = t_{ON}$ we obtain a ripple current of 66 mA.
When the current reaches its lowest value the voltage across R_{sns} is 200 mV. The aver-age value of the current is one half of the ripple current greater.
With $R_{sns} = 0.3\ \Omega$ the average current is given by
$I_{avg} = 200\ \text{mV}/300\ \text{m}\Omega + 66\ \text{mA}/2 = 700$ mA.
This is around the maximum permitted value for a 3 W LED.
The LED current can be adjusted by chang-ing R_{sns}, for which we can use a twisted length of resistance wire. More elegantly, we can use the PWM IC to drive the DIM input of the switching regulator.
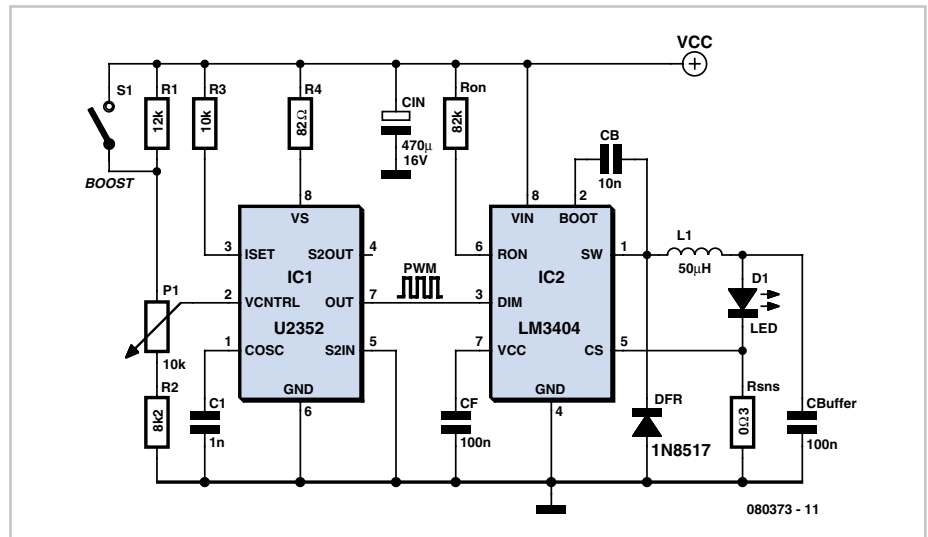
The U2352 can generate a PWM signal adjustable from 0 % to 100 % using a min-imum of external components. The basic frequency of the internal triangle wave oscillator is set by C1 to around 10 kHz:
$f_{osc} = 55/(C_{osc} \cdot V_s)$
(where f_{osc} is in kHz, C_{osc} in nF and V_s in V). The triangle wave voltage is compared against a reference voltage set by P1, and at the output of the comparator we have our PWM signal.

The signal passes through some internal control logic before reaching the output of the device to protect the output from overload. Since we do not require this function it is disabled by taking pin 5 to ground and pin 3 to V_{CC} via R3. It is not clear from the datasheet whether resistor R4 is strictly necessary for internal voltage stabilisation.

The PWM signal is taken from the output of the U2352 to the DIM input of the LM3404 and imposes a 10 kHz pulse-width modu-lation on the light produced. The 'Boost' switch (or pushbutton) forces the PWM output high and thus the LED to maximum brightness.

Lighting Governor

Peter Jansen

This circuit is very handy as a timer circuit for a lamp, for lighting a staircase, for exam-ple, but can also be used as indicator for the front doorbell. A significant advantage of this circuit is that the circuit draws almost no current when in the inactive state.

The circuit is activated with push button (S1), after which IC5 (a 555 timer IC) starts to count down the set time. During this time the triac continues to conduct and the lamp is turned on. The 'on' time of the lamp is on is determined by the combina-tion of R1 and C2 and can be changed as required by your application or personal preference.
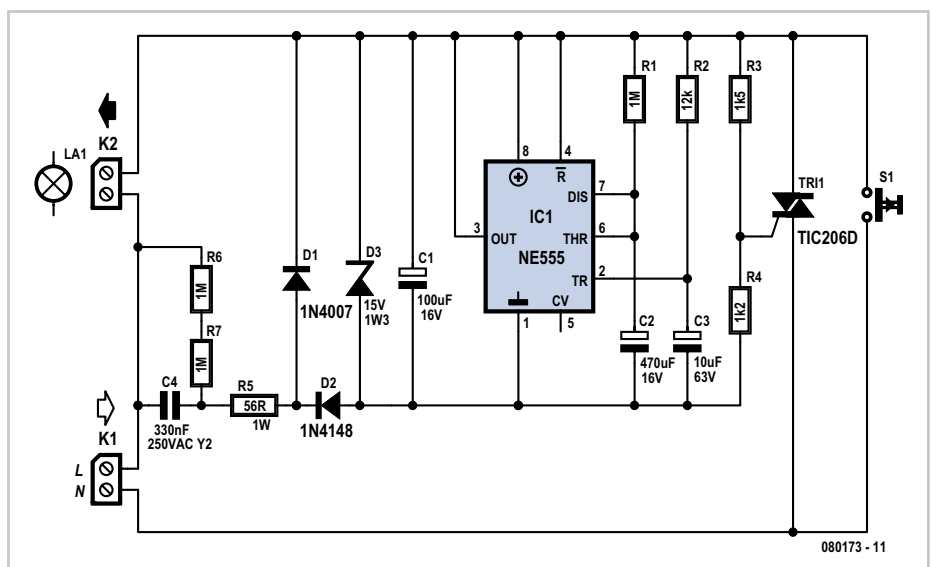
R2 and C3 have been added because the 555 expects a 'negative' pulse at its trigger input. When the power supply is turned on, C3 holds the TR input of the 555 Low for a

short time, which triggers the timer IC. Depending on the exact type (brand) of 555, the value of C4 (330 nF) may have to be changed to ensure a high enough power supply voltage when in the active state. Note also that you shouldn't use a 'too heavy' version of the triac. The circuit will drive at the most just a little more than 5 mA into the gate of the triac. The circuit worked properly when tested with a TIC206

and the slightly bigger TIC216.

When selecting push button S1, take into account the switching current of the lamp. The switch must be able to handle that safely.

In the event of a defective part, a 15-V zener diode is connected across the power supply for protection (D3). R6 and R7 have been added so that C4 will be dis-

charged. In this way no dangerous voltage can remain when the circuit is unplugged. When large values for C2 are used, such as the 470 µF shown here, a good quality capacitor is required for C4. Any potential leakage resistance will then have no influence on the set time. Because of an inferior capacitor in our prototype the time was considerably longer than expected...

(080173-I)

Solar Lamp using the PR4403

Burkhard Kainka

The PR4403 is an enhanced cousin of the PR4402 40 mA LED driver. It has an extra input called LS which can be taken low to turn the LED on. This makes it very easy to build an automatic LED lamp using a rechargeable battery and a solar module.

The LS input is connected directly to the solar cell, which allows the module to be used as a light sensor at the same time as it charges the battery via a diode. When darkness falls so does the voltage across the solar module: when it is below a threshold value the PR4403 switches on. During the day the battery is charged and, with the LED off, the driver only draws 100 µA.

071112 - 11

At night the energy stored in the battery is released into the LED. In contrast to similar designs, here we can make do with a single 1.2 V cell.
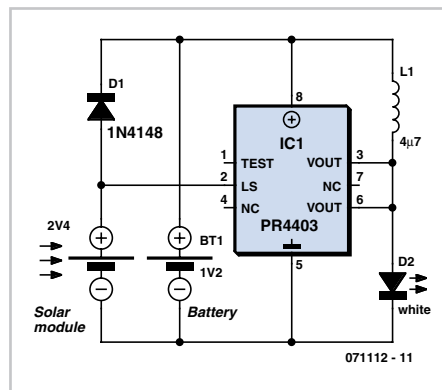
The PR4403 is available in an SO-8 package with a lead pitch of 1.27 mm. The other components are a 1N4148 diode (or a Schottky 1N5819) and a 4.7 µH choke.

Pin 2 is the LS enable input, connected directly to the solar module. According to the datasheet, it is possible to connect a series resistor at this point (typ. 1.2 M) to increase the effective threshold voltage. The LED will then turn on slightly earlier in the evening before it is not completely dark.

Pins 3 and 6 of the device must be connected together and together form the output of the circuit.

(071112-I)

12V Fan Directly on 230 V

Ton Giesberts

This circuit idea is certainly not new, but when it comes to making a trade-off between using a small, short-circuit proof transformer or a capacitive voltage divider (directly from 230 V mains voltage) as the power supply for a fan, it can come in very handy. If forced cooling is an afterthought and the available options are limited then perhaps there is no other choice. At low currents a capacitive divider requires less space than a small, short-circuit proof transformer.

R1 and R2 are added to limit the inrush current into power supply capacitor C2 when switching on. Because the maximum rated

080507 - 11
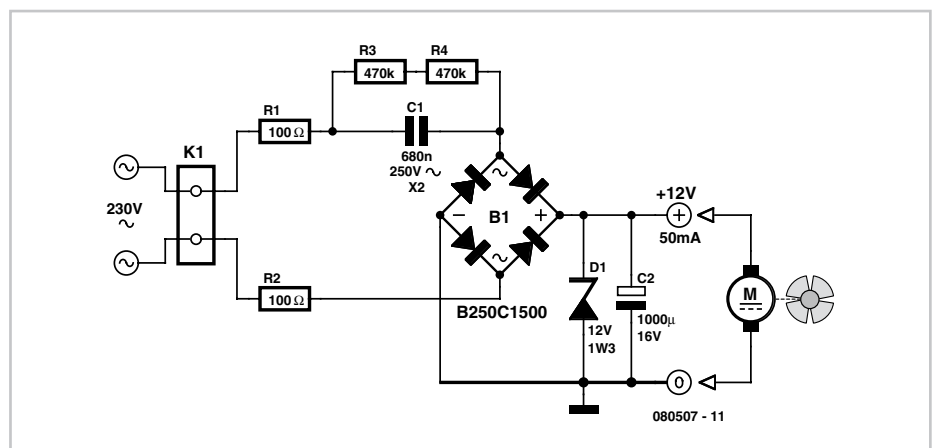
operating voltage of resistors on hand is often not known, we choose to have two

resistors for the current limit. The same is true for the discharge resistors R3 and R4

for C1. If the circuit is connected to a mains plug then it is not allowed that a dangerous voltage remains on the plug, hence R3 and R4.

Capacitor C1 determines the maximum current that can be supplied. Above that maximum the power supply acts as a current source. If the current is less then zener diode D1 limits the maximum voltage and dissipates the remainder of the power.
It is best to choose the value of C1 based in the maximum expected current. As a rule of thumb, start with the mains voltage when calculating C1. The 12 V output voltage, the diode forward voltage drops in B1 and the voltage drop across R1 and R2 can be neglected for simplicity. The calculated value is then rounded to the nearest E-12 value.

The impedance of the capacitor at 50 Hz is $1 / (2\pi 50C)$. If, for example, we want to be able to supply 50 mA, then the required impedance is 4600 Ω (230 V/50 mA). The value for the capacitor is then 692 nF. This then becomes 680 nF when rounded. To compensate for mains voltage variations and the neglected voltage drops you could potentially choose the next higher E-12 value. You could also create the required capacitance with two smaller capacitors. This could also be necessary depending on the shape of the available space. It is best to choose for C1 a type of capacitor that has been designed for mains voltage applications (an X2 type, for example).

Outside Light Controller

080258 - 11
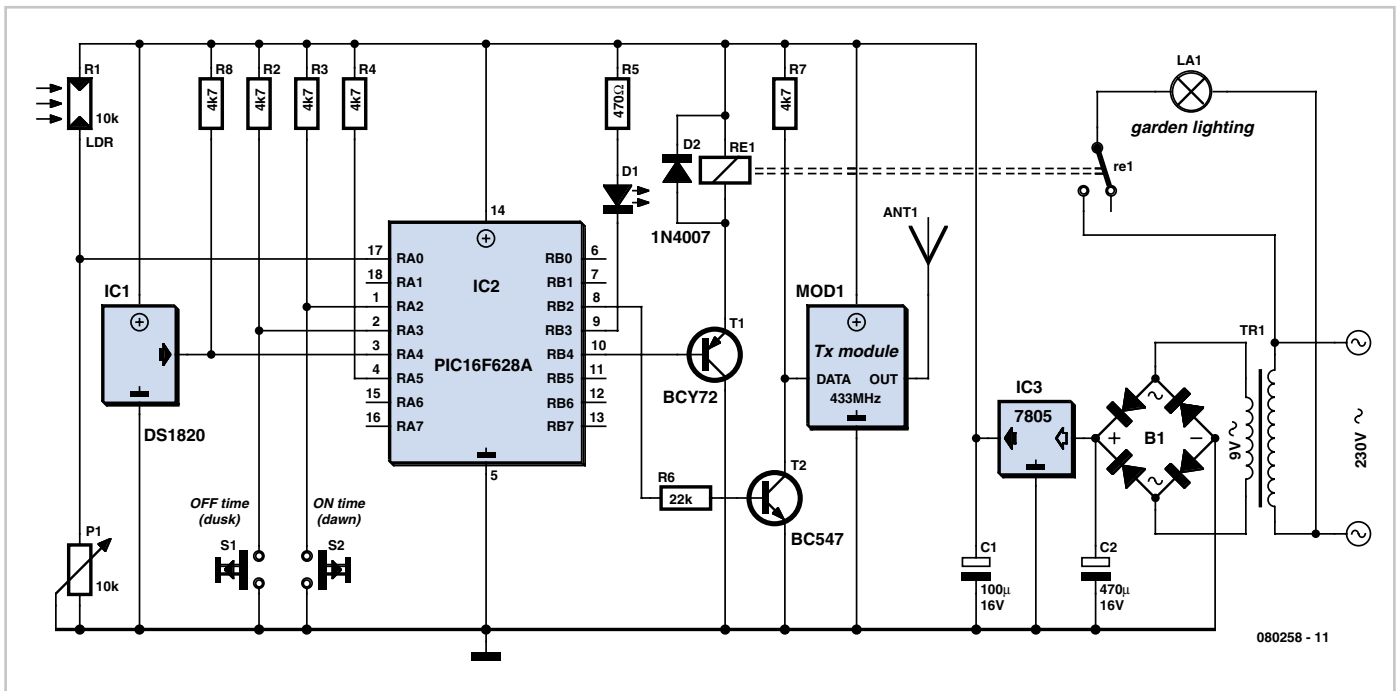
Wim de Jong

This controller turns on the outside lights as soon as it becomes dark and then turns the lighting off at a set time, so that the lights are not burning needlessly all night long.
It is also possible to automatically turn the lights on again in the morning at another preset time. Then once it is light enough outside they turn off again.

You could obtain this functionality with an LDR and a switching time clock. The LDR senses when it is dark enough and the clock can turn the lights off again at a preset time, and the other way around.
To keep the design simple and cheap, a different solution was chosen for this switching clock. A normal clock needs to be set initially and perhaps again periodically as the clock drifts after a while. In addition, a display is required to set this clock, plus a few push buttons.
Here a different approach is taken. Starting with the fact that an LDR can detect the sunrise and sunset and that the sun 'loops' around in 24 hours, we can use this knowledge as an alternative method for determining the time. This clock does not need to be set. The solar clock is born.
The controller is built around a PIC16F628A, which runs from its internal RC oscillator at 4 MHz.
When sunrise is detected, a counter is started, this counter keeps running until the following sunrise (reset).
At sunset, the current value of the counter is stored in the variable 'zontot'. So after sunset the time can be determined with the formula:

time = counter - zontot/2

This design has two pushbuttons to set the switching times; 'Evening off' (S1) and 'Morning on' (S2). The push buttons can only be operated after sunset and before sunrise. If in the evening (after sunset, the garden light are on) button S1 is pushed, the lights will from now on go off at this particular time. When button S2 is pressed in the morning before sunrise, the lights, from now on, will turn on at this time and continue to be on until sunrise.

These times are stored in the EEPROM inside the PIC so that they are not lost when the supply voltage is removed.

The DS1820 temperature sensor shown in the schematic and the 433-MHz transmitter (a cheap transmit/receive module from Conrad Electronics) are optional. These can be used to measure the outside temperature and send it to a receiver in the house. This outside temperature is sent as a byte once every minute and at a baud rate of 1200 bits/s (8 bits, no parity) with a reso-lution of half a degree. –2=–1°, 0=0°, 2=1° etc.

Sensor and transmitter can be omitted without any problems if this functionality is not required.

The adjustment procedure is as follows. Set the potentiometer so that the LED is on when it is dark and off when it is light. Leave the circuit alone for a 24-hour period so that the controller can synchronise with the daily sun cycle.

After that you can use the two pushbuttons to set the switching times.

(080258-I)

Downloads

The source and hex code files for this project are available as a free download from www.elektor.com; file # 080258-11.zip.

ISO Standard for Car Radios
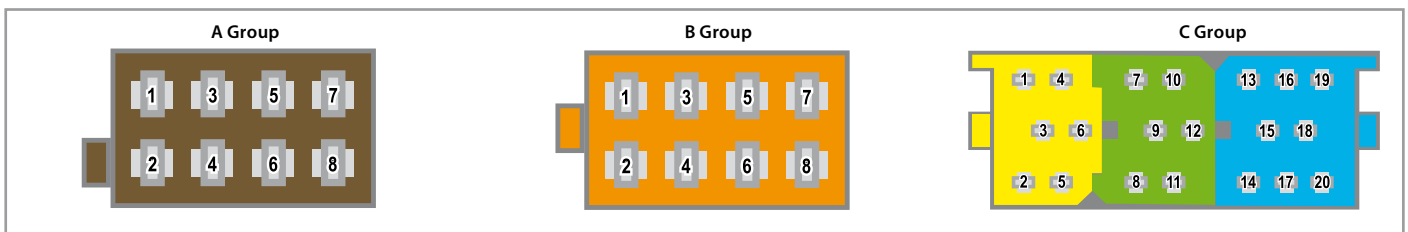
A Group	Power Supply	
1	RPM pulse	A pulsed RPM signal is used to maintain a constant volume level or to operate a navigation system. This is also known as SCV (Speed Controlled Volume) or GALA (Geschwindigkeits-Abhängige Lautstärke-Anpassung).
2	Remote control / ground / telephone mute	Mutes the audio output of the radio. This requires a hands-free kit that pulls pin 2 to ground during a telephone call.
3	Remote control	Strongly brand-dependent.
4	Constant 12 V in; orange (yellow)	Constantly connected to the +12-V terminal of the battery. Memory settings (stations, tone and time) are thus retained when the radio is switched off.
5	Switched 12 V out / antenna remote, blue	The motor-driven antenna is extended when 12 V is present on this pin. It can also be used to switch accessories such as amplifiers or sound processors.
6	Lighting, yellow/black	12 V must be present on this pin to illuminate the buttons of the radio and allow the display to be dimmed.
7	Switched 12 V in, red	The radio can be switched on if 12 V is present on pin 7 (via the ignition switch).
8	Ground, black (brown)	Connection to the chassis and thus to the negative terminal of the battery.

The assignments of pins 1 to 3 may be swapped, depending on the make or brand. Pin 3 is sometimes used for a brand-specific bus signal.
The assignments of pins 4 and 7 are often swapped (for example, by VW, Audi and Opel).
In recent VW models, pin 5 is used as a supplementary connection for constant +12 V. This means that if you install a different radio, you must disable this connection, as otherwise the new radio will have a short life.

B Group	Loudspeakers
1	Right rear + , blue
2	Right rear – , blue/black
3	Right front + , grey
4	Right front – , grey/black
5	Left front + , green
6	Left front –, green/black
7	Left rear + , brown
8	Left rear – , brown/black

C Group	Extensions
1	Line out, left rear
2	Line out, ground
3	Line out, right rear
4	Line out, left front
5	Antenna/remote 12 V out
6	Line out, right front
7... 10	Brand/make dependent
11	Phone in
12	Phone in, ground
13	CD ID
14	Brand/make dependent
15	Ground
16	Constant +12 V
17	Switched +12 V
18	CD changer line-in ground
19	CD changer line in, left
20	CD changer line in, right

The assignments of pins 1–6 are always as described here. However, recent Becker radios use pin 6 for the subwoofer output. Manufacturers can use the remaining pins as they see fit.

Giel Dols

A standard for the audio connections of car radios has been generated in order to avoid having every car manufacturer devise its own solution to this common and recurrent issue. This standard has now been adopted by the International Organization for Standardization (ISO). The mechanical construction, dimensions and shape are clearly specified, at least in principle. Here we have to say 'in principle' because some manufacturers cannot resist the temptation to arrange the signals on the connectors according to their own ideas.

The classic examples of this are Audi, Opel and VW, which practically make a tradition of exchanging the terminals for the constant supply voltage and switched voltage. As a result, if you connect a new radio it will behave in a very irritating manner: every time you switch off the ignition and remove the key, all your settings will be lost. As a result, most car radio manufacturers provide a simple way to swap these connections in the cabling.

The tables clearly show which signals are assigned to the various pins of the connectors (or how they should be assigned).

It is thus very much recommended to use a multimeter to check whether everything is

connected as it should be, especially for the connections in the 'A' group.

(080471-1)

PR4401/02 off the Beaten Track

Ernst Krempelsauer & Burkhard Kainka

The well-known PR4401 and PR4402 LED drivers from PREMA have enjoyed great popularity as a result of their low cost, tiny physical size, and ready availability. The device is a switching regulator that is specifically designed for driving white LEDs from a single dry or rechargeable cell. The only external component required is a small inductor (see **Figure 1**). For maximum output power a 10 µH inductor is needed in the case of the PR4401, and 4.7 µH in the case of the PR4402. With an input voltage of between 0.9 V and 1.5 V the PR4401 can then deliver a current of up to 23 mA into the white LED connected to its output; the PR4402 can manage currents as high as 40 mA. Other current-delivery applications besides driving LEDs are also possible, of course. For example, the LED can be replaced by a string of between one and ten NiMH cells in series plus a series diode (see **Figure 2**). The cells will then be charged at a current of up to 23 mA (PR4401) or up to 40 mA (PR4402).

The output of the switching regulator behaves as a kind of constant power source, always delivering (with the coil values suggested above) around 70 mW (PR4401) or 140 mW (PR4402) into the connected load. When charging NiMH cells the current will be at its maximum value given above when up to three cells are connected (3.6 V), and with more cells (that is, with a higher total battery voltage) the current will fall. With ten cells (12 V) the current flow to the battery is just 6 mA (PR4401) or 12 mA (PR4402).

The ICs are less suitable for applications where the load characteristics are not constant. The lower the load, the higher the output voltage, and with an open-circuit output an internal zener diode limits the output voltage to approximately 18 V. This diode therefore effectively replaces the missing load and dissipates the power output by the regulator. If the output voltage is limited to a lower value using an external zener diode then the regulator will deliver all the output power not taken by the load into the diode. The upshot of all this is that the lower the load, the poorer the efficiency of the circuit.

1

2

3

4
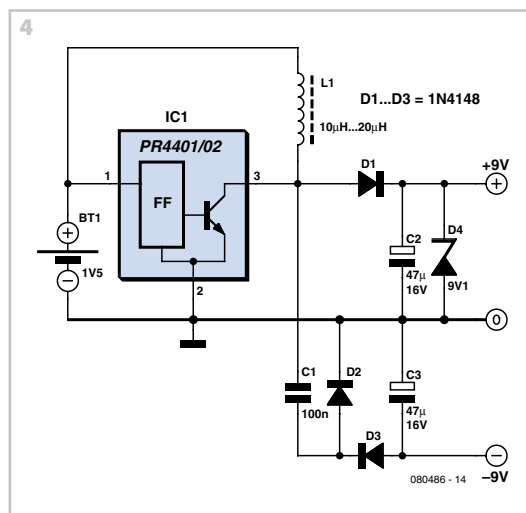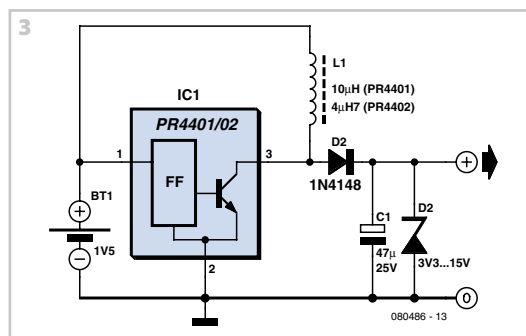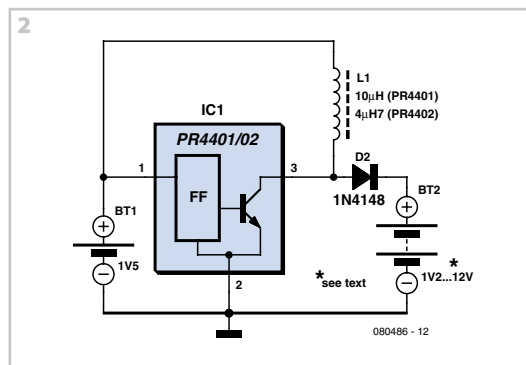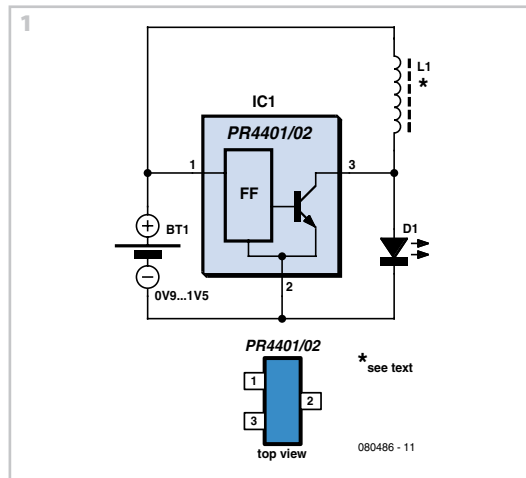
Applications of this attractive device as a voltage source are also worth a quick look. For example, you might be looking for an application for the printed circuit board, with PR4401 IC and coil ready fitted, that came free with the September 2007 issue of *Elektor*.

Figure 3 shows the circuit of a simple voltage regulator using a PR4401 or PR4402. The zener diode voltage is chosen according to the wanted output voltage, between 3 V and 15 V. These voltages can be generated from a single NiMH or alkaline cell (1.2 V or 1.5 V), which, for example, allows you to replace the expensive 12 V batteries found in some instruments and in remote controls for garage door openers. The maximum output current from the voltage regulator can be calculated as follows:

$$I_{max} = P_{max}/U_Z$$

P_{max} is 70 mW (PR4401) or 140 mW (PR4402) and U_Z is the zener voltage, which is equal to the output voltage. The circuit is most efficient when the output current is near to I_{max}. If necessary, I_{max} can be reduced by using a higher-valued inductor to match it better to the required output load. To a reasonable approximation, doubling the inductance will halve the maximum output current.

We can also use a LED driver to generate a symmetrical supply from a single NiMH or alkaline cell. **Figure 4** shows a practical example generating +9 V and –9 V. Because of the additional diode in the negative arm of the circuit, the negative output is about 0.7 V lower in magnitude than the positive. In our prototype, where we used a 15 µH inductor and a 1.5 V cell voltage, we obtained the measured output voltages of +9 V and –8.3 V (with no load), and +8.6 V and –7.9 V (with a 2.2 kΩ load, simulating the 4 mA current draw of a typical opamp circuit).

The current drawn from the 1.5 V cell was 50 mA in the no-load case and 80 mA in the 2.2 kΩ load case.

(080486-I)

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June 2008 (No. 378)

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May 2008 (No. 377)

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Display Computer
070827-91 .... Populated PCB in enclosure .... 78.80 ...... 157.60

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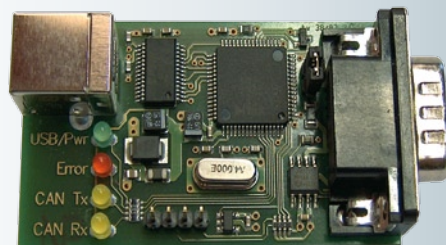
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Digital Command Control (DCC) is an increasingly popular open standard for model railway systems. In the September 2008 issue we describe a home-built DCC control based on the Elektor ARMee board (March & April 2005 issues) extended with a dedicated I/O board. The project is compatible with different DCC train control programs and the combination of software and hardware allows an extensive model train layout to be controlled.
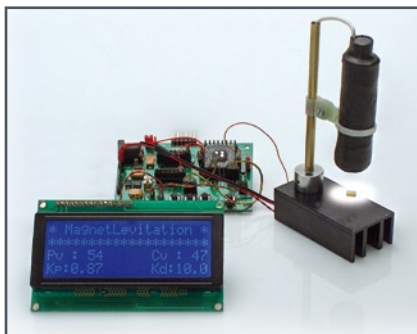
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