11 new projects

April 2010

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M.A.H

elektor

www.elektor.com

Fireflies

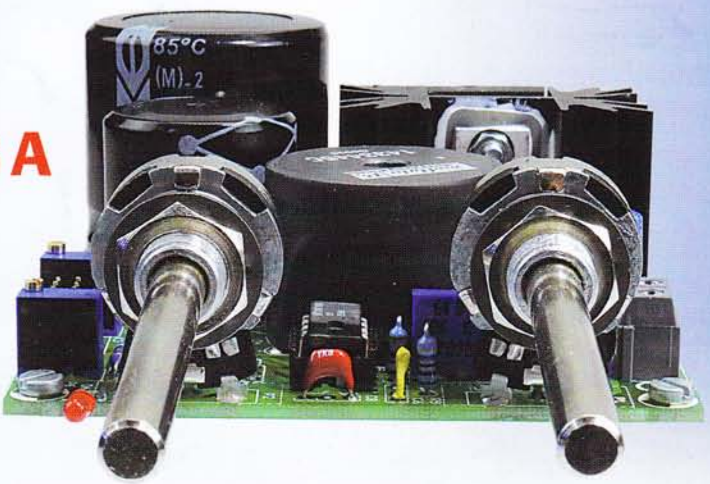
Easy experimenting with Artificial Intelligence

+ Super Robots
Myths, promises, threats

+ Sceptre
The software library

Unilab

A switch-mode 0–30 V / 3 A bench supply



+ OBD Analyser NG
gets Bluetoothed

Measuring Tweezers

Special tools for measuring SMD components

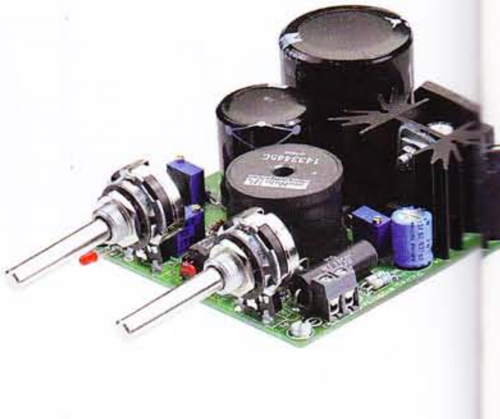
Pop it off the stack

Contrary to what some readers seem to think or even fear, assembling Elektor as a monthly journal is hardly ever a problem in terms of articles in stock. Indeed I've a small stack of articles worth 50 odd pages I can easily slot into any edition — no problem, it seems, but that's in terms of pages only. The trouble comes with the various factors exerting force on the content. Let me list a few, not necessarily in order of importance: the theme of the month, the enthusiasm of a lab worker about his XYZ widget, advertising pages sold and arriving at 11.59, announcements printed on the Coming Attractions page, Anglo-American electronics culture issues, embedded systems shows, cover design, competitors' coverage of the subject, author contracts, items sold in our web shop, articles to be supplied for translation to licence partners. Each of these factors (there are many more) can clash with just about any of the others, so the conflict matrix is potentially large, while the only dead certs I look at every month are: 88 pages to fill and the edition to arrive at subscribers on [date#1] sort of punctually and in bookshops on [date#2+5], punctually.

While this paints a grim situation, nothing untoward happened these past 399 editions and in fact it's the wide diversity of subjects and articles that brings relief rather than complication. The edition at hand is a fine example of variegated articles at many levels and covering the ever increasing areas and niches modern electronics seems to diverge into. We look at robotics both high brow (*Super Robots*, page 16) and down to earth (*Fun with Fireflies*, page 58) with the latter article a small gem by presenting a hands-on approach to the concepts of artificial intelligence and robot swarms.

Our efforts at removing widespread fears of working with SMD parts continues unabated with *Measuring Tweezers* (page 22) in which five of those nifty tools are examined to see if they are worth the investment. Another can of worms called microcontroller vs. conventional electronics can remain largely closed this month with both 'sides' served almost equally in terms of pages. Tell me if you think otherwise and I will put your message on the stack of things to do to keep everybody happy in 88 pages.

Jan Buiting
Editor, Elektor UK & US editions



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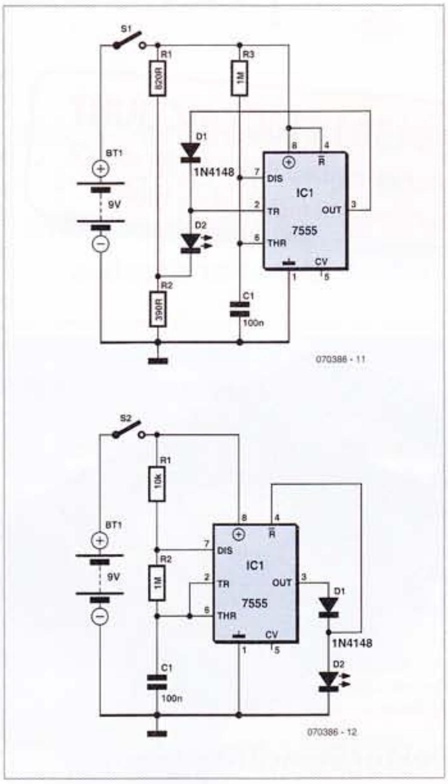


LEDs as photosensors — busted?

'LEDs double as photosensors', Analogue Design Tips, Elektor January 2010 (070386-I)

A number or readers responded to this Design Tip, some confirming its operation and happily experimenting, others suspecting that it was an early April Fools joke. Thomas Scherer one of our regular contributors put the circuit through its paces and reported on the results of his measurements as follows:

Dear Jan — I checked out a number of LEDs in my collection. The interesting conclusion is that some of them work, some don't, and some are excellent. In my tests, the blue LEDs gave the worst results. With the other colours, I measured anything from 0.5 V to nothing. Even some of the white LEDs generated around 120 mV. The best results were obtained with red, green or yellow LEDs with clear, colourless packages. They yielded an amazing 1.2 to 1.3 V. LEDs with clear coloured packages were also somewhat better than those with diffuse coloured packages. Otherwise I could not draw any systematic conclusions; it appears to depend on the manufacturer. Even a pair of LEDs that must be 30 years old still produced 60 mV. My test conditions were: illumination with a 20-W fluorescent lamp (daylight colour) at a distance of 50 cm.

Modern wireless technology

The 2.4 GHz Bandalyser, E

lektor February 2010 (090985-I)

Dear Editor — I am pleased to see that you are featuring more and more projects related to modern wireless technology (ISM, ZigBee, WLAN, etc.) in your magazine. You published an article in the February issue on a 2.4-GHz scanner. It's a bit of a pity that the wireless receiver module used in this project (type CYWM6935) has already been discontinued by the manufacturer. As you also designed the scanner described in this article around an Atmel AVR microcontroller as the main control unit (and you regularly use this microcontroller in other projects as well), I would like to suggest that you consider a project using the new (and thus highly current) Atmel ATmega128RFA1 microcontroller.

This device features a 2.4-GHz transceiver module integrated on the same chip as the microcontroller. As I personally use Atmel microcontrollers frequently and by preference, I look forward with great anticipation to an Elektor project featuring this new device, so that I can learn something about how to use it.

Rodrigo Supper

The problem with product discontinuation is unfortunately sometimes unavoidable because it cannot be foreseen. However, in most cases the components remain available from distributors and retailers for a relatively long time. The other side of the coin is that with new ICs you sometimes have to wait a long time after the product announcement before real products become available; the elapsed time between the first design samples and the actual availability of regular production devices is often several months. There have also been cases where fully developed projects could not be published because regular production of the devices concerned was simply cancelled in economically uncertain times. In such cases, all you're left with is a few prototypes and your expenses.

I agree that the ATmega microcontroller plus wireless transceiver combo could form the basis for an interesting project, Accordingly, I have forwarded your suggestion to my colleagues in the Elektor lab with my warm recommendation.

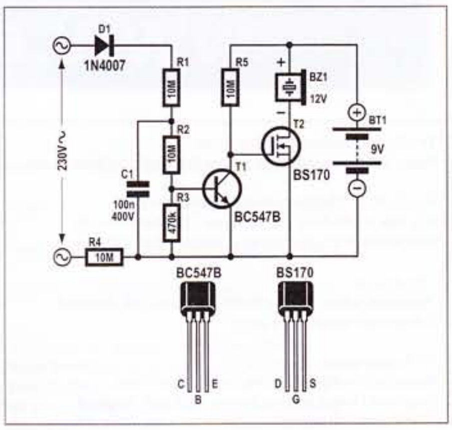
Hands off my loudspeakers

'Power Cut Alert', Christmas Holidays Circuits, Elektor December 2009

Dear Jan — I recently completed a project for converting my loudspeakers into an active loudspeaker system. It cost a lot of time, effort and money. As my loudspeakers were stolen once already, I also thought about how I could prevent this in the future.

The aim was to protect the loudspeakers reliably and unobtrusively without using an additional cable. As the loudspeaker system is driven by a balanced signal, it would be possible to use the 'phantom supply' principle to apply a DC voltage to the loudspeaker signal line and monitor this voltage. With this arrangement, an alarm will be generated if the XLR connector for the loudspeaker is disconnected. The drawback of this approach is that the loudspeakers and the amplifier outputs must be isolated from the phantom voltage. This would require using (large) capacitors to couple the audio signal in and out while blocking the DC voltage. This is not especially practical, and certainly not desirable.

Another option would be to use motion



sensors, but this would certainly create problems with our industrious house cleaner, who has no fear of dusting off the loudspeaker enclosures. In the December 2009 issue of Elektor, I found a circuit under the heading 'Power cut alert' that is designed to monitor the AC mains voltage. Even though my application is quite different, this circuit is also suitable for providing property protection, and I certainly regard my expensive loudspeakers as property worth protecting. Of course, the same technique could also be used with other valuable items.

I have now built and tested the circuit, and it works perfectly. As soon as the AC power cable of the active speakers is unplugged, the alarm goes off.

In order to disable the alarm if necessary, I mounted a Cinch socket in an inconspicuous location on the loudspeaker connector panel and connected it to the emitter and collector of the BC547 transistor. To disable the alarm, it's only necessary to plug in a shorted Cinch plug, but burglars won't know this (or at least I assume that burglars do not make a habit of reading Elektor!).

The only drawback of this circuit is that the battery needs to be replaced from time to time. However, the battery could be replaced by a small power supply with a transformer and rectifier that charge a large electrolytic capacitor and keep it charged as long as the mains voltage is available. If mains power is lost, the charge in the capacitor will allow the piezoelectric alarm to operate as long as necessary. Of course, the capacitor charge won't last for several hours, but it will last long enough to cause the burglars to flee.

G. Luyt (Netherlands)

Compensation method

'Two black boxes', Retronics, March 2010

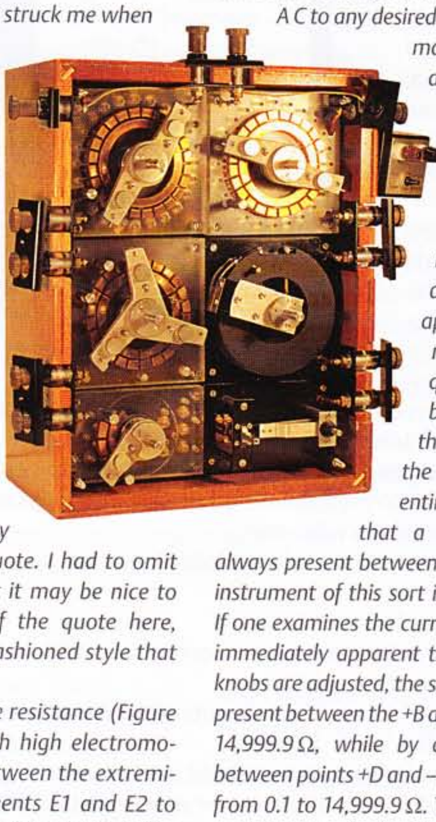
Hi Jan — I always find the Retronics articles fascinating. For the article in the March 2010 issue ('Two black boxes'), you actually didn't need to go so far back in time to find a description of the compensation method. It was described in the 1980 edition of the *Radio and Electronic Laboratory Handbook* by M.G. Scroggle, who was very well known at that time.

For more information, see:
http://phylab.nuaa.edu.cn/edit/UploadFile/200911517446235.pdf

C.J. Warners

Thank you very much for your response. The article in the PDF document does indeed describe the compensation method in detail. I wasn't able to find a modern description of this principle because I didn't think of using 'potentiometric' as a search term. This illustrates once again that you can't find everything on the Internet if you don't know the right search terms.

Incidentally, what especially struck me when I was in the attic of De Slegte (in Utrecht) with that book in my hands was that the schematic diagram (Figure 5 in my article) was virtually a construction drawing for my compensator. Perhaps the accompanying photo makes this more apparent. The circular selector switches are arranged differently, but you can probably imagine how excited I was with the similarity.



The original version of my article included a longer quote. I had to omit it due to lack of space, but it may be nice to present the full version of the quote here, which is written in an old-fashioned style that is always fun to read:

'Let A B be a wire with large resistance (Figure 4). A constant element with high electromotive force E is connected between the extremities A and B. The two elements E1 and E2 to be compared are connected (as shown in the schematic drawing) to point A and to a pin S, from which a lead proceeds further by means of a moveable contact. If one now determines the two points P1 and P2 at which no current flows through the galvanometer branch circuit with E1 and E2, respectively, the following expression holds true:

E1/E2 = resistance of AP1 / resistance of AP2

With an extended wire of uniform thickness, the ratio of the resistances can simply be taken to be the ratio of the lengths. If one imagines this extended wire to be replaced by a resistor substitution box, for each change in the resistance A C it will be necessary to relocate the contact C to a different point in the resistor substitution box, but in such case it will generally prove impossible to maintain the resistance of A B at a constant value. However, if A B is replaced by two identical resistor substitution boxes connected in series, and C is taken to be the point at which these two boxes are connected together, one can adjust resistance A C to any desired value less than A B while maintaining a fixed resistance between A and B. This only requires that the shorting plugs removed from the one box be plugged into the same positions in the other box, which although it may in itself appear simple, often gives rise to errors. Consequently, instruments have been devised in which the mutual changes to the resistances are effected entirely automatically, so that a constant resistance is always present between the two end points. An instrument of this sort is called a compensator. If one examines the current flow in Figure 5, it is immediately apparent that no matter how the knobs are adjusted, the same resistance is always present between the +B and –B terminals, namely 14,999.9 Ω, while by contrast the resistance between points +D and –D can be set to any value from 0.1 to 14,999.9 Ω. The numerical markings next to the knobs directly indicate the value of this resistance.'

I'm sure you'll agree with me that this text does full justice to the ingenuity of the automatic compensator.

Rolf Blijleven

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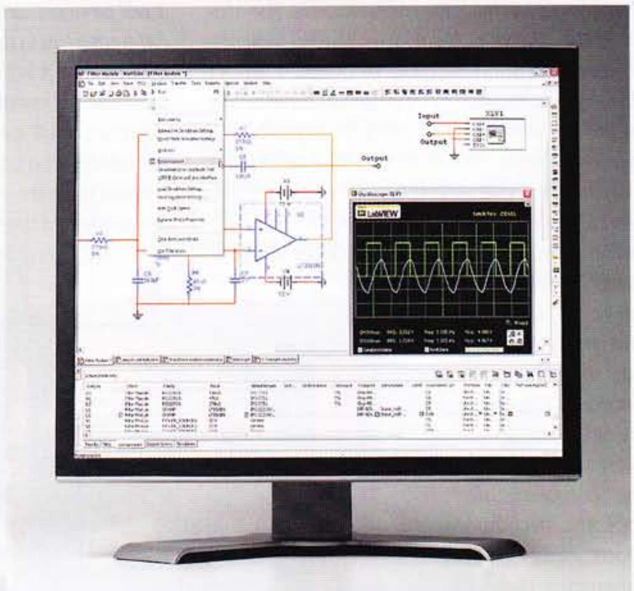
NI Multisim 11 simplifies circuit simulation for teaching and design

National Instruments introduces Multisim 11, the latest version of its circuit simulation software, with specialized editions for both hands-on learning and professional circuit design. The easy-to-use Multisim software delivers a graphical approach that abstracts the complexities of traditional circuit simulation, helping educators, students and engineers employ advanced circuit analysis technology.

The academic edition of Multisim 11 incorporates specialized teaching features and is complemented by circuits textbooks and courseware. This integrated system helps educators engage students and reinforce circuit theory with an interactive, hands-on approach to investigating circuit behavior. Widely implemented throughout academia, technical colleges and four-year universities choose Multisim for its interactive components, simulation-driven instruments and integration to real-world analog and digital measurements.



Multisim 11 Professional helps engineers optimize circuit designs, minimize errors and reduce prototype iterations. When combined with the new NI Ultiboard 11 layout and routing software, Multisim provides engineers a cost-effective, end-to-end prototyping platform. Its integration with NI LabVIEW measurement software also helps engineers define custom analyses to improve design validation.

Key benefits of Multisim 11 include the following:

Multisim 11 Academic

- Simplify digital circuits teaching by exporting raw VHDL from a programmable logic device (PLD) schematic
- Guide hands-on electronics experiments with new educator-requested AC single-frequency analysis
- Correlate simulated data with real-world measurements by integrating with the NI Electronic Laboratory Virtual Instrumentation Suite (NI ELVIS) educational prototyping platform

Multisim 11 Professional

- Simulate better with SPICE parser improvements, updated BSIM models, support for advanced parameters and enhanced digital simulation accuracy
- Prototype easier and ensure design synchronization and transparency with enhanced forward/backward annotation from the Multisim schematic to an Ultiboard layout
- Improve design communication with on-page connectors and a new WYSIWYG net naming system

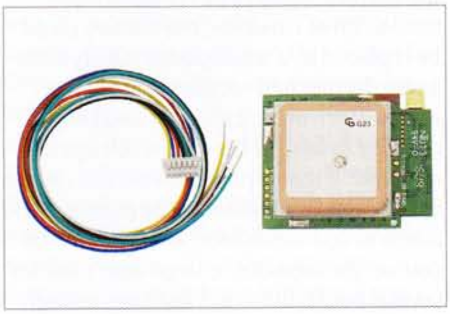
Readers can learn more and watch videos about Multisim 11 by visiting the web page below.

www.ni.com/multisim/upgrade (100106-I)

GPS receivers with or without antenna

The PMB-648 GPS module from Parallax provides high performance with a SiRFstar-III chipset and integrated patch antenna. See the Parallax GPS Comparison Chart to evaluate this model side-by-side with the very similar PMB-688 and the low cost PMB-248.

The PMB-648 GPS features 20 parallel satellite-tracking channels for fast acquisition of NMEA0183 v2.2 data for robotics navigation, telemetry, or experimentation. There is a built-in patch antenna; rechargeable battery for memory and RTC backup; cable for power, TTL and RS-232 connections.



Features:

- high sensitivity
- SiRFstarIII chipset
- 20 parallel satellite tracking channels for fast acquisition and reacquisition
- built-in rechargeable battery for memory and RTC backup
- supports NMEA0183 V2.2 data protocol
- includes cable for power, TTL and RS-232 connections

The new PMB-688 GPS module has a SiRFstarIII chipset and integrated patch antenna plus an MMCX connector for the company's external GPS antenna. The PMB-688 retails at $39.99.

www.Parallax.com (100106-II)

Haptic piezo controller

Maxim Integrated Products introduces the MAX11835 fully integrated, programmable HPC (haptic piezo controller) for single-layer and multilayer piezo actuators. The MAX11835 is a novel haptic solution that provides customers with an enhanced, true "touch" experience with touch screens.

Consumers are accustomed to 'feeling' the button press on keyboards, keypads, and many modern devices. Touch screens and capacitive sensors provide an interactive user interface, but the user cannot feel the touch because there is no mechanical button. The MAX11835 adds the feeling of mechanical feedback to touch screens and capacitive buttons. The product can be used with any touch-screen or touch-button controller. However, as part of its new TacTouch concept, Maxim provides design-in support and reference designs guaranteeing an optimal touch experience and simplified design-in when combined with the company's touch-screen controllers.

Target applications are any consumer or industrial equipment that has touch-screen displays or traditionally has mechanical buttons. Typical examples include cell phones, MIDs (mobile Internet devices), MP3 players, portable media players, digital photo frames, multifunction printers, digital still/video cameras, and POS (point-of-sale) terminals.

The MAX11835 drives both single-layer and multilayer piezo actuators over a wide 5V to 250V voltage range. The wide output voltage range not only lets designers choose between these two types of piezo actuators, but also guarantees a future-proof solution for alternative actuator technologies. By integrating a user-programmable haptic pattern generator, programmable boost converter, and high-voltage, high capacitive load driver, the MAX11835 generates a user-configurable, slew-rate-limited, boosted voltage output.

The MAX11835 has sufficient on-chip memory to simultaneously store multiple user-defined haptic waveforms, which are downloaded at power-up through the serial I2C interface. During operation, only a haptic trigger pulse is required from the system or application processor to play out the waveform. Unlike other driver ICs, no high-speed waveform pattern needs to be sent during operation. This simplifies code design on the system or application processor, reduces software load, and improves haptic response time. Obtaining low latency (from the instant of touch detection to haptic response) is crucial to effectively mimic the real-world feeling of a button press.

www.maxim-ic.com/MAX11835 (100106-IV)

Texas Instruments and Circuit Cellar launch DesignStellaris 2010 Design Contest

Texas Instruments and Circuit Cellar* invite you to compete against other top embedded engineers around the world in the Texas Instruments DesignStellaris 2010 Design Contest! The sky is the limit when you're designing with an ARM-based Texas Instruments Stellaris microcontroller featuring the SafeRTOS real-time kernel integrated into on-chip ROM. By entering a project you could win a share of $10,000 in cash prizes and recognition in Circuit Cellar magazine!

Texas Instruments has generously supplied everything you need to get started! The Stellaris EKK-LM3S9B96 Evaluation Kit includes: an evaluation board with an 80 MHz LM3S9B96 MCU featuring Ethernet MAC+PHY, CAN, USB OTG, and SafeRTOS in ROM; a time-limited copy of the Keil RealView Microcontroller Development Kit, cables, documentation, and StellarisWare software.

So how do you get started? Easy. First, to learn more, visit link # 1 below. Then request your complimentary sample kit using link # 2.

TI has generously provided all the essentials you need to get started!

Because Circuit Cellar's primary role is publishing a print magazine about hands-on embedded systems projects, every DesignStellaris 2010 contest entrant is viewed as a potential author. Industry leaders pay attention to these contests. Circuit Cellar magazine is proud to report that a considerable number of past contest entrants say that the publicity from their participation benefited both their careers and manufacturing ambitions.

* As of December 1, 2009, Circuit Cellar is an Elektor International Media publication.

1. www.circuitcellar.com/designstellaris2010/index.html
2. www.circuitcellar.com/designstellaris2010/kit.html

(100106-III)

Configure a custom power supply in under five minutes

ACAL Technology announce the immediate availability of the Excelsys powerKit which allows designers to use the world's smallest power supplies to configure a plug-and-play custom power module in under five minutes.

Each powerKit contains an application-specific Xgen powerPac chassis module, and seven different Xgen powerMod dc output modules which can be inserted, removed or exchanged to create a custom power-supply. These provide a range of output voltages, from 1.5V to 58V, with a maximum current of up to 50A. The kits are presented

in a rugged case and include two pairs of serial, and two pairs of parallel, links as well as power and signal connectors, documentation, screwdriver and a voltage adjustment tool.

The Xgen series of power sources provides additional flexibility with a number of user-configurable functions. These include local and remote adjustment, adjustable straight-line or foldback current limit and output inhibit/enable functions. powerMods can be configured in parallel for higher-current applications and in series for operation at higher voltages. High-efficiency conversion techniques allow Xgen series power sources to achieve minimal power losses, whilst advanced packaging reduces their size to create the industry's smallest power supplies.

The powerKit has been optimised for standard, medical, high-temperature and low-noise applications. The standard and medical versions are available with power ratings of 1340W or 750W, with 6 and 4 powerMod slots respectively; the powerKit for high-temperature applications has a 600W rating and six slots; whilst the low-noise powerKit is rated for 1200W and offers six slots.

www.acaltechnology.com/uk/excelsys1

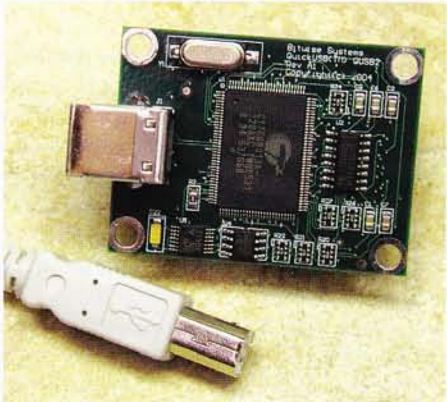
(100106-V)

Customizable high-speed USB2.0 module

QuickUSB from Saelig Company is a unique and customizable quick and easy USB2.0 connectivity solution. This compact 2"x1" circuit board implements a bus-powered Hi-speed USB 2.0 endpoint terminating in a single 80-pin target interface connector. With the companion QuickUSB Customizer software, you can tailor the QuickUSB Module to give your product a custom-developed look and feel with a user-defined 'My Product' string descriptor, a unique PID (Product ID), and a user- defined serial number to create uniquely identifiable products.

Today, any product that connects to a PC must have a Hi-Speed USB 2.0 connection, and a number of generic solutions are available. But when you finally have your USB interface working, USB device must be assigned product ID (PID) and a vendor ID (VID). VIDs are assigned by the USB Implementers Forum at approx. $2,000. None of these generic solutions allows you to easily make a product that enumerates on a PC with your company and product identification.

QuickUSB gives you the ability to include



a complex, high-performance computer interface into your product quickly and easily. No-one will even know it's QuickUSB inside. QuickUSB is a functional module that includes built-in firmware, a device driver and software that works on Windows 98SE, ME, 2K, XP, Vista and Windows 7. It includes drivers and software applications that work right out of the box. The QuickUSB Library supplied supports all the popular programming languages and works with any language that can call a DLL. QuickUSB is supported on Linux too (MacOS X support will be available soon).

QuickUSB module provides: an 8 or 16-bit High Speed Parallel Port for really fast data transfer, from DSPs or FPGA based circuits; up to three general- purpose 8-bit parallel I/O ports; two RS-232 ports; one I2C port, with multiplexer; one soft SPI port or FPGA configuration port. These interfaces give the designer the ability to convert existing products to USB 2.0 or create new designs from scratch. In both cases, the software supplied with the modules eliminates any need to understand the workings of USB 2.0, while making it really easy to access the different interfaces from the PC. This is a complete implementation of USB 2.0 that uses its full speed potential unlike other options that are "compatible" with USB 2.0 but use much slower USB 1.1 data transfer. With QuickUSB, 96 MBps bursts on parallel port and 20 MBps continuous data are possible.

These software libraries include the USB 2.0 drivers, application DLL and examples of using the software in most commonly used programming languages, including Visual Basic, C++ and Delphi. The DLL includes functions to read and write individual bytes or data blocks from each interface, and all the set up details needed to provide flexibility e.g. LSB or MSB first on SPI port, input or output on each I/O pin or baud rate on serial port.

QuickUSB modules are available now from Saelig Co. Inc. Pittsford NY, USA at $149 each.

www.saelig.com (100106-VI)

New high frequency LCR Meters

GW Instek presents two new high frequency LCR Meters, the LCR-8110G and the LCR-8105G. As the latest members of the GW Instek range, these high frequency LCR meters were developed to satisfy the growing need for high frequency component and module characterisation.

With the rapid development of telecommunication technology, the need for accurate high frequency component and module characterization is essential. The LCR-8000G Series provide accuracy, versatility and high resolution for a wide range of component measurements; including DC resistance measurements and voltage/current monitoring. Component characteristics can be verified using a number of circuit models and test frequencies to emulate real circuit operation; ensuring accurate verification and significantly reduced trial and error time. Customised program sequences can be created using the Multi-Step function.

Each program sequence supports up to 30 test steps set with separate parameters and test limits. This allows normally tedious test routines to be automatically stepped through with the press of a button. To easily verify components, the Graph Mode plots component response over a wide range of frequency or voltage sweeps. Both GPIB and RS-232C interfaces are standard to display test results on a PC or for remote control.

www.gwinstek.com (100106-VII)

Australia's youngest engineers to innovate using Altium Designer

Altium is adding a local element to its FIRST Robotics Competition (FRC) sponsorship, supporting the first Australian team to enter the worldwide competition.

The FRC is an annual robot design competition organized by FIRST, a not-for-profit organization dedicated to fostering a greater understanding and appreciation of science and technology. Designed to inspire young people to innovate, the FRC challenges teams of students to develop a robot in six-weeks using a standard kit of parts and a common set of rules. The competition attracts thousands of students and is televised by stations around the world.

This year Altium is sponsoring the Australian FRC team as well as providing all 1,800 FRC teams with a 12-month licence of its electronics design software, Altium Designer. This gives young engineers real-life experience with the same electronics design tool used by organisations that include NASA, Cessna, Cochlear and the Volkswagen Group of America.

Altium's extended support also sees engineers from Altium's research and development team mentor the students.

"The FIRST Robotics Competition provides a wonderful opportunity for young engineering minds to experience science and technology in a fun and competitive environment," said Matt Schwaiger, Senior Vice President of Global Customer Success. "We are proud to be fostering the talents of these students and providing them with all the tools and support they need to excel in the FIRST Robotics Competition."

The FRC Championship will be held April 15-17, 2010 in Atlanta's Georgia Dome.

"Australia doesn't produce enough of its own engineers and we can't afford to wait until kids are at HSC level before we start trying to get them interested," said Australian team coordinator, Associate Professor Mike Heimlich.

"This program is designed to get kids excited about engineering, science and technology by giving them the opportunity to see what a fun and creative process working in this field can be."

www.altium.com (100106-VIII)

Three C/V characterization capabilities in one chassis

Keithley Instruments' Model 4225-PMU Ultra Fast I-V Module is the latest addition to the growing range of instrumentation options for the Model 4200-SCS Semiconductor Characterization System. It integrates ultra-fast voltage waveform generation and current/voltage measurement capabilities into the Model 4200-SCS's already powerful test environment to deliver the industry's broadest dynamic range of voltage, current, and rise/fall/pulse times, expanding the system's materials, device, and process characterization potential dramatically. Just as important, the Model 4225-PMU makes ultra-fast I-V sourcing and measurement as easy as making DC measurements. Its wide programmable sourcing and measurement ranges, pulse widths, and rise times make it well-suited for applications that demand both ultra-fast voltage outputs and synchronized measurement—from nanometer CMOS to flash memory.

Unlike previous solutions, which required up to three different test stands to characterize a device, material, or process thoroughly, the Model 4225-PMU's broad dynamic range allows characterizing the full range of materials, devices, and processes with a single set of instrumentation. Now, labs can configure one flexible system to handle all three measurement types: precision DC I-V (Model 4200-SMU), AC impedance (Model 4210-CVU C-V Instrument), and ultra-fast I-V or transient I-V (Model 4225-PMU).

Each 4225-PMU module provides two channels of integrated sourcing and measurement but takes up only one slot in the nine-slot chassis. Each chassis can accommodate up to four modules for a maximum of eight ultra-fast source/measure channels. Each channel combines high speed voltage outputs (with pulse widths ranging from 60 nanoseconds to DC) with simultaneous current and voltage measurements. The module provides high speed voltage pulsing with simultaneous current and voltage measurement, at acquisition rates of up to 200 megasamples/second (MS/s) with 14-bit analog-to-digital converters (A/Ds), using two A/Ds per channel (four A/Ds per card). Users can choose from two voltage source ranges (±10 volts or ± 40 volts into 1 megohm) and four current measurement ranges (800 milliamps, 200 milliamps, 10

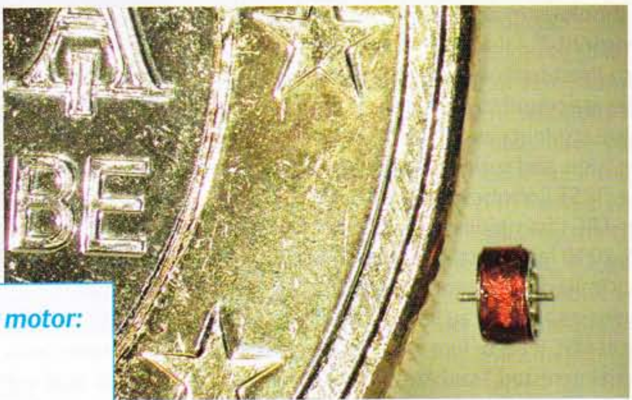
milliamps, 100 microamps).

Each Model 4225-PMU can be equipped with up to two optional Model 4225-RPM Remote Amplifier/Switches, which provide four additional low current ranges. They also reduce cable capacitance effects and support automatic switching between the Model 4225-PMU, the Model 4210-CVU, and other SMUs installed in the chassis. The Model 4220-PGU Pulse Generator Unit, which offers a voltage-sourcing-only alternative to the Model 4225-PMU, is also available.

http://keithley.acrobat.com/p77402742/

(100106-IX)

World's smallest motor now even smaller



Last year Elettor reported on the smallest hand-made miniature electric motor, with an E-weekly item in April 2009 editon and an article with a drive circuit in the November 2009 edition of Elektor. With this motor, Elektor reader Jos d'Haens booked a world record and managed to obtain an official certificate from Guinness World Records, naturally accompanied by a notice in the well-known Guinness book.

Features of the new motor:

- diameter 1.3 mm
- length 0.7 mm
- volume 0.9 mm3
- weight 3 mg
- speed 500–10,000 rpm

Now, thanks to improved and refined production methods and production tooling, Jos d'Haens has succeeded in further reducing the size of the motor, which was already good for a world record last year, so much that its volume could be reduced from 1.9 mm^3 to 0.9 mm^3 (or more precisely, 1.30 x 0.65 = 0.863 mm^3), which breaks the 'psychological barrier' of 1 mm^3. In order to achieve this, a small CNC machine tool was developed for drilling the holes in the motor end plates (hole diameters 0.3 mm and 0.1 mm). Thanks to improved polishing of the shaft and rhodium plating of the bearings, it was possible to increase the speed to the range of 10,000 to 12,000 rpm.

In the meantime, a new control circuit has also been developed as an alternative to the original combination of a 555 IC and a 4018 IC. Now a programmed ATtiny13 microcontroller handles this task. This makes driving the motor a good deal easier, but the original method is still preferable for high speeds because it allows the frequency to be ramped up more gradually.

This is an impressive achievement, which is bound to be rewarded by a new certificate from Guinness World Records. Here at Elektor we have no doubt that Jos has plans for even further miniaturisation.

The photo shows the motor next to a 50-eurocent coin for comparison.

(100106-X)

World's First 4 Channel / 30 GHz solution enables 56 Gb/s IQ Modulated QPSK analysis

LeCroy Corporation has extended the power of its WaveMaster® 830 Zi 30 GHz real-time oscilloscope by providing a simple and fast method to combine two oscilloscopes and provide 4 channels at 30 GHz. This solution is ideal for measurement and analysis of 28 to 56 Gb/s IQ modulated signals where ultra-high real-time bandwidth and four channels is required, or for capture and detailed analysis of other leading edge technologies. The solution is enabled with the Zi-8CH-SYNCH Oscilloscope Synchronization Kit, which is compatible with all WaveMaster 8 Zi models, so it may be used to create four channel data captures from 20 GHz to 30 GHz or eight channel data captures from 4 GHz to 16 GHz.

The oscilloscope synchronization kit is comprised of a small hardware module that plugs into one of the two oscilloscopes. Once attached, it identifies that oscilloscope as the 'Master' for display and control purposes. A variety of other cables for trigger synchronization, clock sharing, and data transfer are connected between the "Master" and a 'Slave' oscilloscope. Triggering of both oscilloscopes may be performed in a pseudo-auto trigger mode, or by application of a customer trigger signal. Upon successful trigger, all waveforms from both the

'Master' and the 'Slave' oscilloscope are displayed on the 'Master' oscilloscope grid for easy viewing, debug and analysis. The complete setup time is no less than 5 minutes prior to deskewing channels.

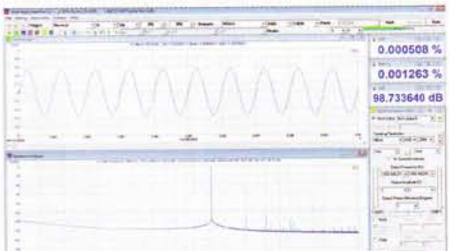
The LeCroy WaveMaster 830 Zi oscilloscope was launched on January 5, 2009 as the second product line developed from LeCroy's next-generation 'Apollo' chipset. The scope features a real-time bandwidth of 30 GHz and a sampling rate of 80 Gigasamples/second on two channels. The complete acquisition system used in the Alcatel-Lucent experiment used two WaveMaster 830 Zi oscilloscopes for a total of 4 channels at 30 GHz.

www.lecroy.co.uk (100106-XI)

Multi-Instrument 3.2 released

Virtins have realeased Multi-Instrument 3.2 and offer it for download at for 21 days' fully functional free trial. The free trial period is valid even if you have tried previous versions of the software on the same computer before.

If you are our existing customer, you are eligible for free upgrading to the same license level you own. Both softkey and hardkey upgrade links are available a the Virtins website.



New features in Version 3.2 include and added DDP Viewer, the ability to run the program as an ActiveX automation Server, the Hot Panel Setting Toolbar, added functions to Lock / Unlock Panel setting under Help submenu, functions to Hide / Show various Toolbars in Dislay Setting Dialog, "Start Frequency" option for X axis in Spectrum Analyzer and Spectrum 3D Plot, and more.

www.virtins.com (100106-XIV)

Speed, performance and low cost combined in spectrum analyzer

Anritsu has developed the MS2830A Spectrum Analyzer which is an addition to the expandable MS269xA product line and supports high measurement speeds and superior performance at a low cost. As a result this helps improve efficiency of R&D and production, cutting measurement time, improving yield, and reducing power consumption to cut CO2 emissions.

The new instrument supports frequency ranges from 3.6 to 13.5 GHz, providing superior RF specifications for average noise level of –153 dBm (1 GHz, without preamplifier), third-order inter-modulation distortion (TOI) of +15 dBm, and total level accuracy of ±0.3 dB (typical). Easily customized expandability from the minimum configuration to an all-in-one advanced TRx tester helps keep down costs to only what is needed, and is available from less than 10 K .

The measurement speeds for basic spectrum analyzer functions, such as sweeping, frequency switching, peak search, display and reading of measurements put the MS2830A at the top of its class, while the Vector Signal Analysis option supports even faster measurement of bandwidths up to 31.25 MHz. The instantaneous averaging of modulation signals and noise dispersion measurement significantly out perform all conventional sweep spectrum analyzers.

The MS2830A is caopable of measuring average noise levels of –153 dBm (1 GHz, without preamplifier), third-order intermodulation distortion (TOI) of +15 dBm, and has a total level accuracy of ±0.3 dB (typical), yet at a low cost of below 10K€.

The MS2830A can be customized from basic configuration to comprehensive all-in-one tester to meet customer's current needs at minimum cost or to minimize future expansion costs. This provides the convenience of a modular based system, but with the performance and convenience of a dedicated test instrument.

The MS2830A consumes 45% less power than current models, cutting electricity costs and saving CO_2 emissions.

The MS269xA and MS2830A measurement software are fully compatible. Using the MS269xA for R&D and the MS2830A for manufacturing reduces production start-up times and makes it easy to transfer control software from R&D to manufacturing.

www.anritsu.com (100106-XII)

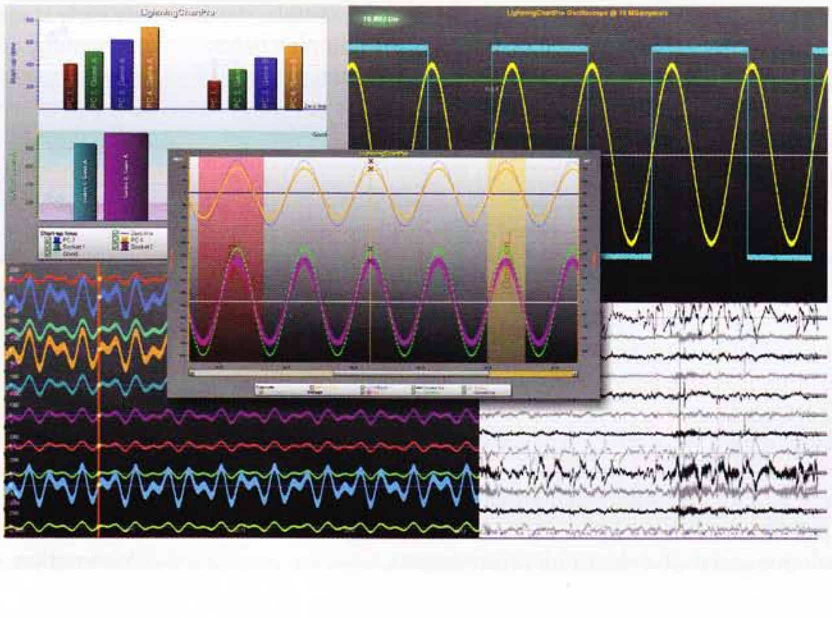
Fast signal plotting and chart creation under Windows

LightningChart Pro from the Finnish company Arction is especially designed for professional data acquisition software, PC-based oscilloscopes and signal analysers, scientific research, medical and other real-time measurement and signal monitoring applications. Optimized for high-speed sampled signal data handling with innovative CPU overhead saving techniques, it is able to handle huge point counts, where all other chart/graph controls get delayed, frozen or crashed.

By utilizing great power of modern display adapters, the screen resolution can be very high even with the most demanding real-time measurements. There are numerous horizontal scrolling modes available, providing an ideal and smooth scrolling effect for every scenario. The data handling capacity is up to hundreds of millions of new data points / sec.

LightningChart Pro allows using many different series types, signal tracking cursors and signal markers. Data handling capacity and performance is excellent also in signal review and analysis applications. For that purpose, it has also built-in customisable scroll bars, with 64-bit value range for direct usage as sample indexing in long high speed measurements. Appearance is fully customisable providing very modern user interface. For easy properties setup, chart has a built-in Chart editor window.

www.arction.com (100106-XIII)



Super Robots
Myths, promises, threats and the 'here and now'

By Andrew Eliasz (First Technology Transfer Ltd., United Kingdom)

Artificial Intelligence and 'Intelligent Robots' are topics that fire the imagination. Generally, imagination runs ahead of what can be achieved, yet, with time, things that were once considered phantastical quite often get to be 'realised'. How close are we to realising the kinds of robots and intelligent computer systems depicted in films such as HAL in Kubrick's *2001 A Space Odyssey*, or the lifelike child in *AI*, or the kinds of robots in *I Robot*?

A common theme in many science fiction books and films involving robots is based on the fear, that lies deep in many of us, that robots created 'to serve mankind' may turn on it and either destroy or enslave it. This may have something to do with the fact that we live in a culture where getting rich and acquiring power is seen by many as the only goal in life. The potential of achieving such things with the aid of powerful AI software and versatile 'smart' robots appeals to such people, but there is always the fear "what if they acquire our values and turn out to be better than us".
It is quite possible that one of the many current developments in Artificial Intelligence and Robotics whose significance has not yet been realized may turn out to be a key 21st Century technology. Maybe some of the topics covered here will inspire some of the next generation of Elektor projects, or be the start of an illustrious engineering career. Let's hope that these future developments serve a socially useful purpose.

Learn from nature

At the outset it is worth noting that simple mechanisms can sometimes give rise to very complex behaviour, as, for example, demonstrated by fractal and chaotic systems, or the complex behaviours demonstrated by social insects such as ants, termites or honey bees. Leaving aside deep philosophical discussions as to the nature of intelligence we may list pertinent questions like

- what kinds of intelligent systems can we build now or in the near future?
- what kinds of mechanisms can be constructed for moving around and manipulating the environment without direct (human) intervention?
- what can we learn from studying how biological systems have evolved and the strategies that have developed for allowing organisms and systems to flourish, and how might these insights be applied?

Food for thought! Back on earth, the 'ingredients' at our disposal are

- sensors
- transducers capable of providing motion or manipulation capabilities
- analogue and digital electronics components
- software (either compiled directly into silicon, or executed via a processor or processors)
- sources of computer inspiration from biology
- patterns for constructing artificial life models in hardware
- competitions and challenges designed to stimulate research and progress
- patterns and protocols for learning and communication

This is a multi-disciplinary brew that should attract not only specialists but also technophiles, interdisciplinarians and 'broad thinkers', and the results should by now surpass 'autonomous robots' of which there are plenty around already (**Figure 1**). A good starting point for those interested in the inspirational role of biology in computing is Nancy Forbes' book [1] on, among others, attempts to construct information processing systems that use biological systems.
Techniques based on this work and ideas that have been applied to various aspects of robotics such as path planning, image processing, locomotion control and data fusion include neural networks, genetic algorithms and artificial immune systems. Areas that are still in their very early stages include DNA computing, self-assembly and nanotechnology and amorphous computing (based on models of cell colonies or swarms of bees — systems that demonstrate self-organising capabilities). A fascinating and reasonably up to date collection of descriptions of actual robots and robot models inspired by examples from living organisms has been put together by Adamatzky and Komosinski [2]. Here can be found such marvels as

- the stiquito, a hexapod insectoid robot that uses heat activated nitinol wires for locomotion, and a description of attempts to construct and study a colony of such insectoids;
- using neural networks and delayed reward protocols to learn legged locomotion such as how to hop over rough terrain, or, how to run if you're a four legged robot
- a swimming and walking robotic salamander (the one described here uses PIC16 and PIC18 microcontrollers and I2C for interprocessor communication, although a CAN bus based version is planned.)
- a gorilla robot that can walk on two legs, or use all four limbs for locomotion, or climb ladders and swing from branch to branch

"How do you spot a 'rogue' robot?" (from the film "I Robot")

(a form of motion is called "brachiation")
- the use of genetic algorithms to optimise the design of the walking mechanisms of legged robots
- the use of FPGA devices to implement the perception, and navigation systems for roving robots by means of a reward based conditioning strategy (you might think of it as applying Pavlovian conditioning to the developing of robot behaviour)
- the use of microbial fuel cells to power robots
- using slime moulds as a mechanism for controlling robot behaviour by interfacing a slime mould 'chip' to a microcontroller

The approaches just described are still a long way from being widely applied but do demonstrate the potential and excitement associated with this area of robotics research. Currently it seems unlikely that robots will contain purely biological systems inspired software or make heavy use of biological sensors and biological control systems. Development of biological systems inspired software is computationally very intensive and time consuming, and hence can only be applied to fairly specific problems.

Kismet and the human(oid) factor

Learning and language capabilities are likely to become more and more important for a whole range of robot applications e.g. companion robots, exploratory robots, "smart" household appliances (think of e.g.a much improved ROOMBA that can be taught and instructed by voice).

Smartness should include the ability to communicate e.g. robot-human communication, robot-robot communication. Devising software endowing robots with language and learning capabilities (e.g. being able to tell a robot to perform some task or take note of some feature in its environment) is a very complex task, even if we are considering a language restricted to a fairly narrow domain.

Think how you might build and program a robot that could respond appropriately to an instruction such as "pick up those socks and put them in the laundry basket". If you don't believe me then dip into a copy of *Language and Learning for Robots* [3], an apparently introductory book till you try to implement the code it outlines. Yet , considerable progress has been made in realising such sociable machines. An impressive example of what could be achieved

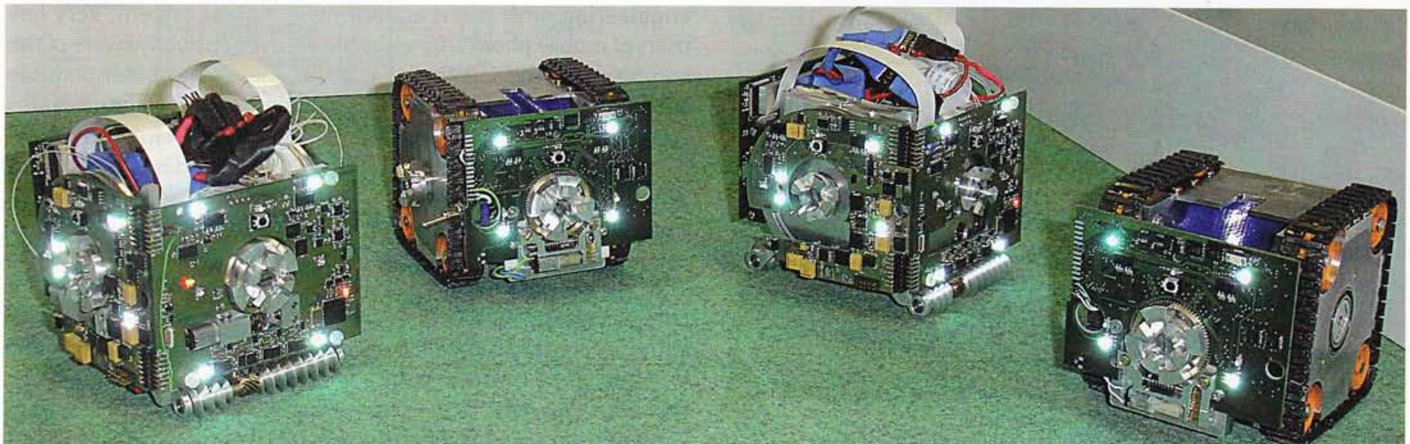


Figure 1. It's too easy to call a robot 'autonomous' if biological aspects are not, or insufficiently, included in the design.

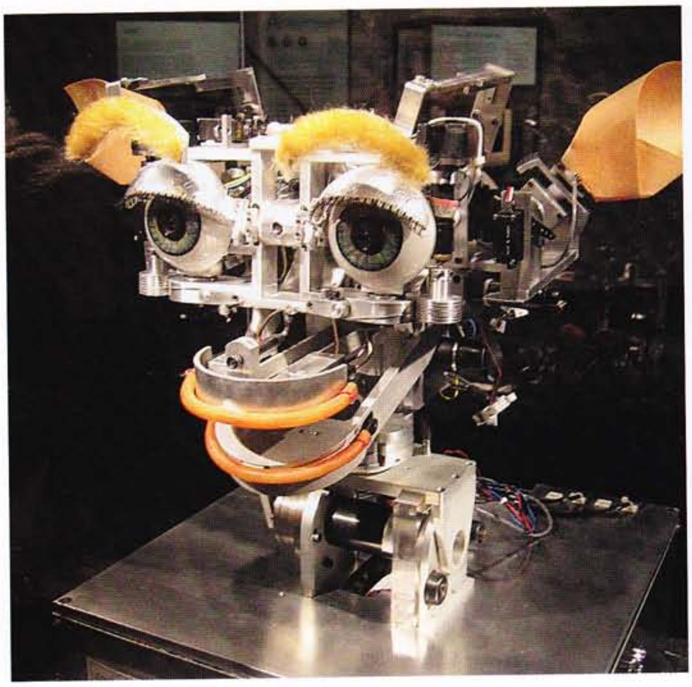


Figure 2. Kismet in action (stills do not do it justice).

using 1990's technology was MIT's Kismet [4], "an expressive robotic creature with perceptual and motor modalities tailored to natural human communication channels" (**Figure 2**). The computing power underlying Kismet is fairly substantial involving four Motorola 68322 embedded systems running a specialised variant of Lisp; nine networked workstations running QNX (a Unix like RTOS); networked Linux and Microsoft Windows machines.

The videos of Kismet interacting with real live humans are very impressive. The resources consumed in developing Kismet probably ran into several millions of dollars even allowing for the fact that bright MIT PhD students are a cheap source of labour (the hardware alone cost around $25K). Software maintenance costs would be huge if Kismet were to be deployed in the real world. It should not come as a surprise that the Kismet project is no longer being actively pursued.

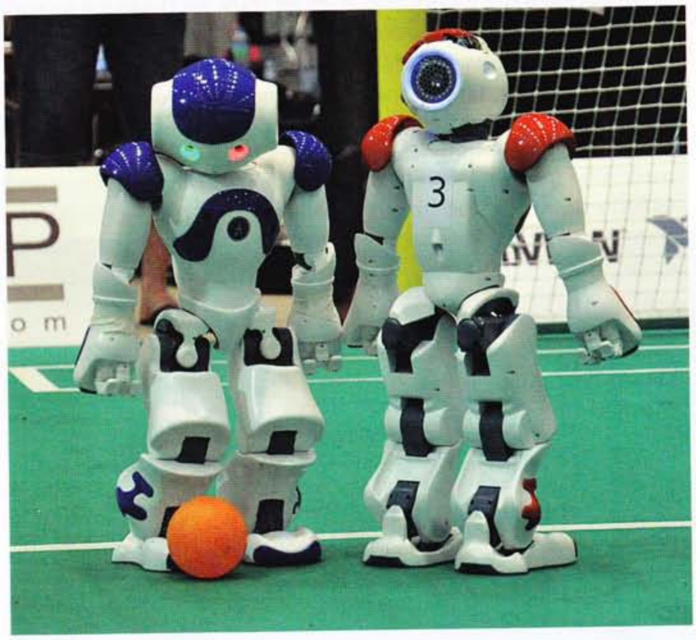


Figure 3. Nao footballers at the RoboCup 2009 Final. Fortunately Aldebaran has an IDE for "Choreographing" NAO robot movement.

Sociable robots

Progress in the practical realisation of sociable as well as team player robots requires the availability of standardised platforms with standardised application development frameworks at prices in the 10K-20K range. An example of one such robot is Nao [5], a humanoid robot that has been used in the development of Robot Soccer teams (**Figure 3**). Its underlying development environment is Gostai's URBI. For those with more limited budgets it is worth noting that URBI has also been ported to Lego Mindstorms NXT.

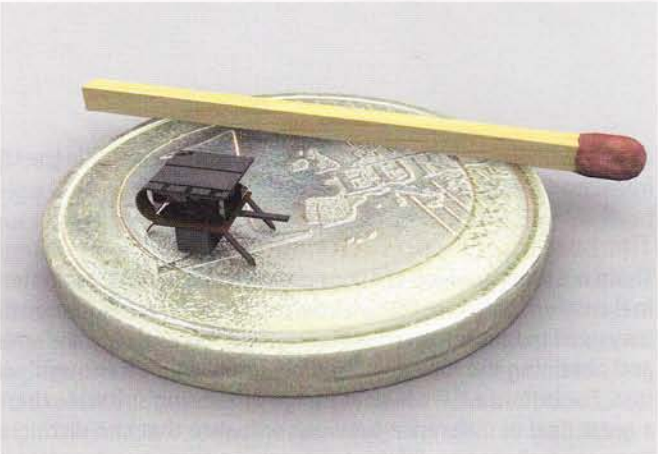
Socially capable robots can be found in helping children and adults with learning and social interaction difficulties, such as those suffering from autism. The robot dolls and faces developed for this work are far less complex and sophisticated than Kismet, for example, but have proven to be remarkably effective. These robot dolls and toys, because of their relative simplicity make possible less overwhelming social experiences and are very forgiving of social *faux pas*. One such cute simplified robot is called Keepon (**Figure 4**), and it has proven to be remarkably successful in helping children with communication disorders.

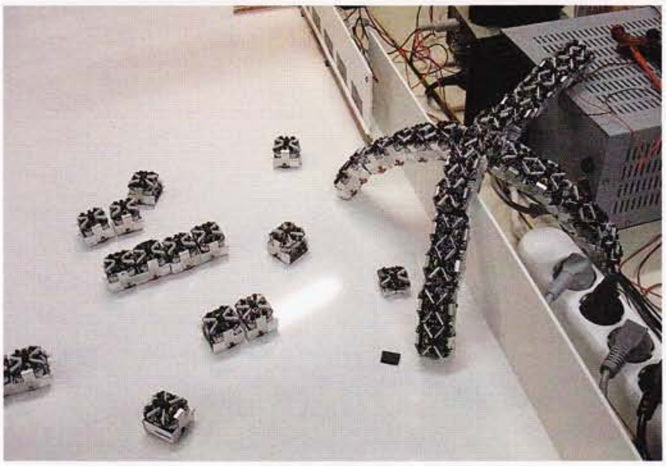
From concept to silicon

As with software engineering, so also with robotics and AI there is the dream of a "magic silver bullet" that will banish complexities and make building super robot systems almost effortless. Many people take software for granted and it is not all that uncommon to hear statements such as "it can't be that difficult it's only a piece of software", or "what do you mean by claiming that designing and writing software involves considerable creativity". Unlike powerful, well organised and politically well connected professions such as the legal or medical professions the engineering and software engineering professions are not held in great esteem. Very few users of mobile phones, for example are even remotely aware of the complexity of the software that makes these almost indispensible "gadgets" work, not only the image and voice processing, but also the underlying operating system and the need to make the software extremely reliable. The blue screen of death is not an option for mobile telephony software. Yet, the software for autonomous robots must be even more reliable, especially where robot malfunction may result in serious damage or injury.

The problem with software is that it "contains bugs", and the more complex the software the larger the number of bugs. It would be extremely rash to claim that any computer system was completely bug free. It must also be pointed out the processors too may contain bugs that may necessitate workarounds when implementing software that will run on these processors. For some, so called 'hard realtime' applications it is a bug if the software does not respond to certain events within a specified time of the event occurring, or if

Swarm robotics and Ad Hoc smart networks


An I-Swarm nome.


A "swarm" of Symbrion Robots.

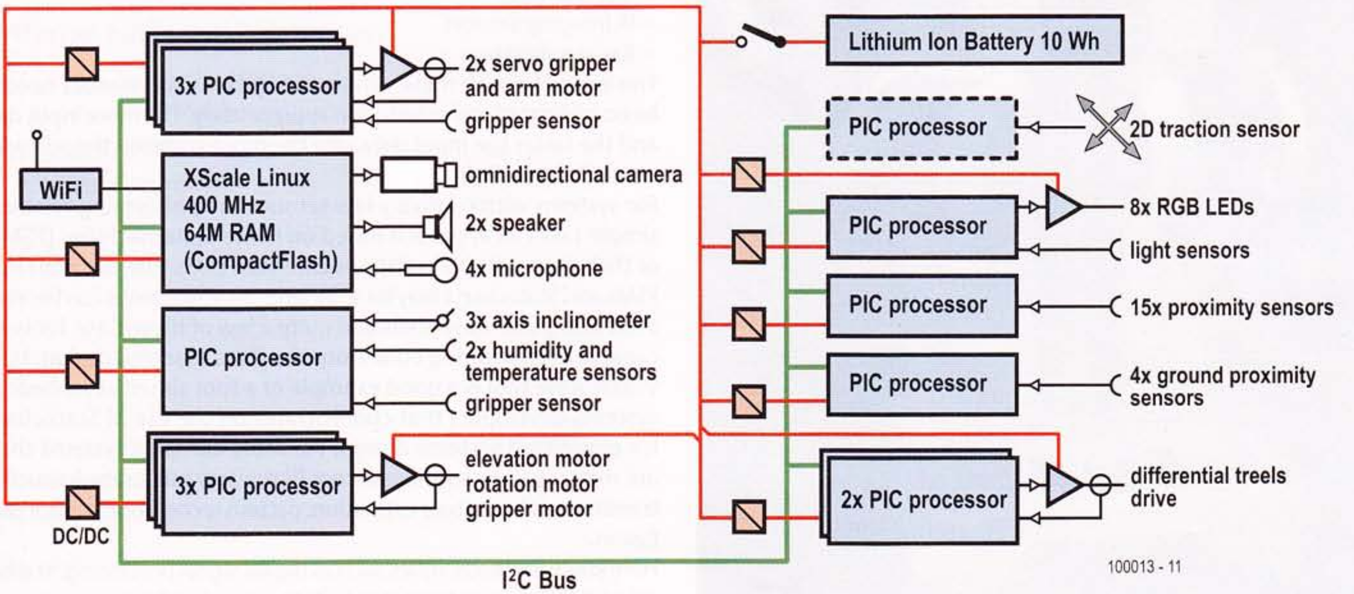
For robots to co-operate socially they need to communicate in some way. They can either all communicate via some central communications hub, or, they can make use of self-organising wireless networking technology of the kind used in Ad Hoc networks.

Quite a few of the robots being developed in this context have turned out to be surprisingly complex. Current swarms are relatively small in number (10's to 100's of robots). The I-SWARM project aims to deploy a swarm of a thousand or more tiny (they will fit into a 3 mm sided cube) robots [7]. Some fascinating projects on swarm behaviour include

- Symbrion-Replicator, which is also exploring the use of Artificial Immune System techniques for controlling swarm behaviour [8] and developed from the I-SWARM project and the open SWARM-ROBOT project [9]
- the S-Bot project developed at the EPFL in Lausanne (Switzerland) [10]

The Symbrion bots and the S-Bots contain quite powerful processor hardware needed to run the complex software that makes them work so well. The processors being researched for the various Symbrion bots include ARM7, ARM Cortex 11, XScale PXA270 (ARM 10) and Blackfin. The S-Bot has a 400 MHz XScale CPU, 64 MB Flash, 32 MB RAM and 12 distributed PIC microcontrollers for low level I/O and sensor handling.

Development of applications using these swarm robots requires use of simulators to explore various scenarios before trying them out on the real robots.



Block diagram of an S-Bot.

Figure 4. 'Keepon' can help children with communication disorders.

and it is partly in response to the annoyances of having to grapple with closed source frameworks that powerful open source frameworks are being developed. A good example is the ROS framework — which works with e.g. the PR2 robot (**Figure 5**), and an example of a framework that is moving from closed to open source in the URBI framework — which works with e.g. the NAO robot.

Figure 5. WillowGarage's PR2 Robot.

The best robot — no such thing

There are many tradeoffs to consider when building robot systems. In the case of software the selection of algorithms and frameworks may need to take into account issues such as scalability and speed, and obtaining the 'best' solution or simply a 'good enough' solution. For instance if we look at image processing software there is a great deal of difference between software that can distinguish between balloons of different colours, perform numberplate recognition, or recognise facial gestures. Similarly, with voice recognition there is a whole range of difficulty levels e.g. recognising a few dozen words, processing whole sentences, or being able to hold a rational and interesting conversation.

For autonomous mobile robots the locomotion and navigation platform is an essential subsystem. At the simplest level there are line following and maze traversing robots. At a higher level there are robots that need to be able to explore, learn about and navigate in their environment, like the robots entered into the Trinity College Fire Fighting Robot competition. At a still more advanced level there are robots such as NASA's Mars Explorer, or the robots that compete in the DARPA autonomous vehicle event.

Sensors and subsystems found in autonomous robots, typically include

- touch / contact / bump sensors
- sonar or laser-based ranging sensors
- digital compass and GPS
- LED / photodiode sensors for e.g. line following
- odometry subsystem (e.g, using optical encoders)
- CCD cameras
- IR imaging sensors
- Radar subsystem

The inputs from all these various subsystems and sensors need to be co-ordinated and acted upon appropriately. The more input data and the faster the input data rate the more complex the software needed to handle it.

For systems with relatively few sensors and performing relatively simple tasks an approach based on Finite Statemachines (FSMs), or their more complex relations Extended FSMs, Hierarchical Finite FSMs and Statecharts may be sufficient. State Machines can be modelled using UML Case Tools and quite a few of these Case Tools are capable of generating code from the state machine design. IAR's Visual State tool is a good example of a tool aimed at embedded systems developers that concentrates on the use of Statecharts for embedded systems design. For more complex systems there are many options to choose from [6] to carry out subtasks such as transformation, feature extraction, pattern recognition, sensor data fusion.

Here you'll find techniques such as digital signal processing, statistical and syntactic pattern recognition e.g. using Bayesian networks or Hidden Markov Models (HMM), discriminant functions, Classification And Regression Trees (CART), Neural Networks, Genetic Algorithms, Artificial Immune Systems (AIS) as well as various hybrid approaches based on combinations of the above techniques (e.g. using a Genetic Algorithm to evolve a Neural Network). These techniques can be deployed in an 'adaptive" or 'non adaptive' i.e. fixed manner.

Developing software for robotics systems has many interrelations with developing simulation, computer game, entertainment system and "electronic trading" system software. Simulation can be used to explore robot capabilities before the robot has been constructed, or to explore various deployment scenarios before robot deployment in the field. It is perfectly reasonable to devise robots that exist purely as software running on powerful computers, or a network of such computers connected via the web. Examples of such bots include chatterbots, game playing bots and e-trading bots.

By providing these bots with access to semantic web resources such as knowledge rich 'ontology' based repositories (e.g. by exposing these resources as web services) it is apparent how the capabilities of robot systems can be extended. Adding in smart sensor based Ad Hoc networks it is easy to envisage entire 'communities' of robots with varied self organising capabilities. If we further add in the possibility of interfacing robots with biological systems (e.g. arrays of electrodes implanted into e.g. animal brains, or arrays of surface electrodes picking up signals associated with neural activity) it is possible to envisage all kinds of applications of which prosthetic limbs and exoskeletons are but a starting point. Adding in the discoveries from stem cell research, molecular biology and genetic engineering suggest the development of e.g. computers with biological extensions. The ethical issues with developing and deploying such technologies are many and complex.

(100013)

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[10] http://lis.epfl.ch/research/projects/SwarmBots/index.php

Measuring Tweezers
Special tools for measuring SMD components

By Harry Baggen (Elektor Netherlands Editorial)

SMDs are nice and compact, but their small dimensions also have some drawbacks. You can hardly tell different types of passive components apart, and the markings are not especially clear. With special SMD measuring tweezers, you can quickly check what type of component you have and measure its value. We tried out five such devices in our lab.

SMDs have several advantages compared with conventional leaded components. For example, they take up much less space on the PCB, which allows the entire circuit to be made a good deal smaller. Thanks to the small component dimensions, the signal paths can also be shorter, which results in less interference and allows operation at higher frequencies or clock rates. However, there are also some disadvantages. Especially with relatively large ICs, manual PCB assembly is rather difficult. You quickly reach the point where you need an SMD oven if you want to do a good job of assembling boards with SMDs. Another disadvantage becomes apparent in prototype assembly or when you need to repair a board fitted with SMDs: component overlay markings are usually minimal due to the tiny dimensions. For this reason, SMD boards from the Elektor Shop often do not have any component overlay at all, and in such cases we print the board layout at somewhat larger scale in the magazine. The differences in the external appearance of resistors, inductors and capacitors are also often so small that you have to guess at what type of component you're looking at.

Manufacturers of measuring instruments have also recognised this problem, and they have developed special devices to deal with it. Now we can hear you thinking: things actually aren't all that bad; you can manage fairly well with a multimeter and suitable (small) probe tips. That's true, of course, but with special measuring equipment it's a whole lot easier to make measurements on passive SMD components.

For this review article, we surveyed the market to see what types of measuring tweezers are available. By this we mean RC and RLC meters equipped with special tweezers for use with SMDs. Some of these instruments have all of the circuitry and the display built into the base of the tweezers, resulting in a more or less convenient instrument (more about this later) that you can use to measure component values and (in some cases) determine what type of component you're measuring, all without having to direct your gaze somewhere else. There are also 'normal' multimeters where the meter (with the display) is a separate unit and SMD measurement capability is provide by special tweezers equipped with a cable that can be connected to the meter.

Five candidates

The instruments in this practical test differ considerably in their basic design and price. First we have two measuring tweezers, priced at less than £35 (€40), that are suitable for measuring resistors and capacitors. One of these instruments can also measure DC voltage. Our third example of 'pure' measuring tweezers is the Smart Tweezers instrument, a clever device for making R, L, C and voltage measurements that features a significantly higher price tag — nearly £260 (€300). This is the only instrument in the group that is also suitable for lefties, since it has a configurable display orientation. In addition, we have two meters with a fairly conventional design. The Peak

Brand / Second Source	Model	Price (approx. rrp)	Supplier(s)
Agilent www.agilent.com	U1732B U1782A SMD tweezers	around £200 (€230) excl. VAT tweezers around £25 (€30) excl. VAT	Agilent webshop or authorized distributors worldwide.
Siborg www.siborg.com/smarttweezers	Smart Tweezers	£260 (€295) and up, excl. VAT	Siborg webshop.
Peak Electronics www.peakelec.co.uk	LCR40 with PEAK-SMD03 accessory (SMD tweezers)	£79 incl. VAT (€81 excl. VAT) Tweezers £20 (€23)	Peak webshop or authorized distributors.
Voltcraft Extec	RC-100 SMD tester Extec Tweezers	£20 incl. VAT	Conrad Electronics: www1.uk.conrad.com, # 121434 - 89. Extec Tweezers
Voltcraft Tenna	SMD-200 RCD meter Tenna Component Tester	£30 (€35) (incl. VAT)	Conrad Electronics: www1.uk.conrad.com, # 123007 – 89. Tenna: Farnell # 1749431

Atlas LCR40 is a small, intelligent LCR meter priced at around £80 (€100), with a tweezers probe available as an accessory. The final member of the group is the Agilent U1732B, an RLC meter with a large display and priced at around £200 (€230). An accessory SMD tweezers probe is also available for this instrument.

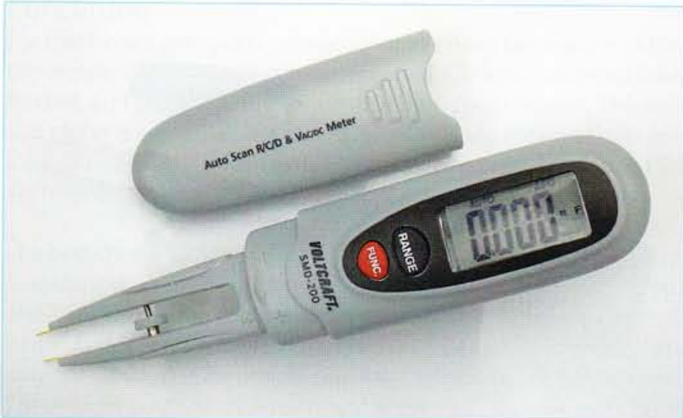
Voltcraft RC-100 / Extec SMD tester

This is a lightweight RC meter in tweezers form, powered by two LR44 button cells. The reasonably large $3^3/_4$-digit display is easy to read. The 'Function' button (which also acts as an on/off button) selects the measurement mode: resistance, capacitance, or diode. The meter has autoranging capability (which cannot be disabled) for resistance and capacitance measurements. The resistance ranges extend to 40 MΩ, while the capacitance ranges extend to 200 µF. The forward voltage of the diode is displayed in diode mode. Power is switched off automatically after 15 minutes of non-use.

The RC-100 is reasonably adequate for measuring SMDs. The tips of the tweezers are fairly wide and rounded off, which makes it difficult to make good contact with the contact surfaces of SMDs, especially if they are already soldered on a board. Although the autoranging function is handy, it takes several seconds for the instrument to find the right range. With high capacitance values, you have to wait quite a while before the right value appears. The instrument does not recognise the component type automatically, so you need to know whether you are dealing with a resistor or a capacitor. There is a 'Relative' button for making relative measurements (measuring the difference between one component value and another one).

Voltcraft SMD-200 / Tenna Component Tester

This meter has the same basic design as the RC-100, but with a somewhat different case design and a different colour (grey instead of dark yellow). It is also powered by two LR44 button cells, and it also has a $3^3/_4$-digit display. However, it differs in operation. After being switched on with the 'Function' button, the meter enters scan mode where it automatically determines what type of component it is connected to (resistor, inductor or capacitor) and then displays the component value (or the forward voltage if the component is a diode). You can manually select a component type by repeatedly pressing the 'Function' button, and you can use the separate 'Range' button to disable autoranging and select a particular range. The resistance ranges extend to 60 MΩ, while the capacitance ranges extend to 60 µF. Power is switched off automatically after 10 minutes of non-use.



As a special feature, the SMD-200 allows the tweezers portion to be unplugged and replaced by a cable (included) with an adapter and probe tips. In this configuration, the device can be used as a replace-

ment for a regular multimeter, and it enables you to measure DC and AC voltages up to 600 V.
The SMD-200 is somewhat more satisfactory than the RC-100 for measuring SMDs, thanks to its automatic component detection, which is certainly convenient. The tips of the tweezers are very similar to those of the RC-100, which means they aren't great. The autoranging function is reasonably fast and certainly usable in practice. According to the user guide, the auto-scan function does not work properly with capacitors larger than 6 µF. However, in practice we had no trouble measuring values exceeding 100 µF without needing to change to manual operation.

Siborg Smart Tweezers

This is the most luxurious SMD tester in the group, with prices starting at around £270 (€300). You may not see the difference right away, but the secret is in the details. The probe arms extending from the case, which has a good ergonomic design, are excellent; the tips are finished very precisely and mate well. You can even fit different types of tips (available as accessories). The meter body holds the circuitry and a graphic display (with 4-digit resolution for the main value) and three LR44 button cells; a version with a rechargeable battery and charging station is also available. The measuring tweezers are activated and operated by a sort of thumbwheel with a built-in pushbutton. There is a fairly extensive menu that can be used to select all sorts of manual modes and other settings, but by default the Smart Tweezers are configured for automatic LCR detection. You can also switch manually to diode measurement, voltage measurement, or even a trace mode in which the screen shows a sort of oscilloscope display for slowly changing voltages. The measuring ranges (manual or autoranging) extend to 10 MΩ, 5000 µF, and 1000 mH. The voltage range is limited to 8 V. A cap is included for protecting the probe tips. The meter switches off automatically after a user-configurable time (default: 30 seconds).
Making measurements with the Smart Tweezers is a piece of cake. The thumbwheel control takes a while to get used to, but once you have the knack it's pretty smooth. The probe tips make good contact and can be positioned precisely. With resistors, capacitors and inductors, the component is identified almost immediately and the measured value is displayed along with extra information at the top of the display, such as the measuring frequency and (with inductors and capacitors) either the internal resistance or the dissipation factor or *Q* (quality) factor (user selectable). This way you can immediately get an idea of the quality of the component. Four different measuring frequencies can be selected: 100 Hz, 120 Hz, 1 kHz and 10 kHz. When a diode is measured, a diode symbol is displayed if it is OK. The voltage trace mode is a nice extra feature, but it's not especially convenient because it must be selected separately in a submenu and you also have to change the setting of a small switch. However, that's the only shortcoming of what is otherwise a very handy little meter, which unfortunately is rather pricey.

Peak Atlas LCR40

The LCR40 is housed in a small enclosure with a two-line display that shows the value of the measured component with 4-digit resolution. It is powered by a 12-V alkaline battery. A short, permanently attached cable with two small probe tips provides the connection to the component to be measured. You can also connect an accessory cable with SMD tweezers (SMD03) in place of the clips. The meter switches off automatically around 15 seconds after a measurement is made.
This instrument automatically detects resistors, capacitors and inductors, and it has autoranging capability (which cannot be disabled). Operation is especially simple, with only two buttons available. The 'On/Test' button switches on the instrument and starts the measurement process. The value appears on the display five seconds later; this delay can be eliminated by pressing the button a second time. Only the component value is shown with resistors, but with capacitors and inductors you can also display the measuring frequency selected automatically by the instrument (1, 15 or 200 kHz, depending on the component value, or DC with relatively

Other options

If you don't want to right away buy a separate meter for measuring SMDs, you can always buy a tweezers accessory, which are available from mail order suppliers, including Mouser, Farnell and DigiKey. The accompanying cable and banana plugs typically allow the add-on to be connected to a normal multimeter. Many multimeters nowadays can also measure capacitance, so this arrangement at least enables you to measure resistors and capacitors.

It is also possible to put build your own SMD tweezers, for example from a few pieces of PCB material. You can find a detailed construction description for this on the Maxim Integrated Products website at www.maxim-ic.com/app-notes/index.mvp/id/4459

high-value electrolytic capacitors). The internal resistance of inductors is also measured, and you can use this to calculate the *Q* factor. The LCR40 is suitable for resistors up to 2 MΩ, capacitors up to 10,000 µF, and inductors up to 10,000 mH.
There's not much more to say about the LCR40. It is easy to use, produces accurate measurements, and automatically detects the component type. One drawback is the fact that you have to press the button each time you want to make a new measurement, which is clearly intended to achieve long battery life. The tweezers accessory is easy to use, and the right-angle metal tips provide a good grip on small SMD components.

Agilent U1732B

This is the only instrument in the group with a conventional form factor. It is approximately the same size as a typical multimeter. The meter has an especially large, clear display that shows the primary measured value ($4^1/_2$ digits) along with several other items, such as the selected component type, the measuring frequency, dissipation

factor, *Q* factor or phase angle (user selectable), and a few other settings. It also has backlighting, which can be switched on manually. This instrument does not automatically detect the component type; you must first press a button to select what you want to measure (inductance, capacitance or resistance). However, it does have autoranging (which can be disabled). The measuring ranges extend to 10 MΩ, 10,000 µF, and 1000 H. The basic accuracy is a respectable 0.5% in the resistance ranges and 0.7% in the inductance and capacitance ranges. It takes several seconds to make a measurement. There is a button for changing the standard measuring frequency (1 kHz) to 100 Hz, 120 Hz or 10 kHz. With capacitors and inductors, you can choose to have the dissipation factor, *Q* factor or phase angle shown in addition to the component value. The meter has an optical port for connection to a PC using an accessory cable. It has several built-in terminals for fast measurement of leaded components, and several short cables with alligator clips are included. Agilent can also supply a special SMD tweezers accessory for this meter, equipped with three connectors (+, – and shield).
Although this is a fairly large instrument, the U1732B is convenient in use. The connecting cable is fairly long, but the build-in shield makes it reasonably thick, with the result that it sometimes gets in the way. The measuring tweezers are solidly built and have nicely finished gold-plated tips, but they are certainly not petite. The tips are also fairly large, and they have such a smooth finish that the SMDs sometimes pop out. The meter works quite well, is very accurate, and provides a lot of information. There are a variety of extra features that we did not try out for this practical test, such as testing components within specific tolerance ranges and measuring components in series or parallel mode. This may not be the most suitable instrument for use as a special SMD meter, but it is otherwise an excellent instrument with such a low price that it should actually be standard equipment in every electronics lab.

Conclusion

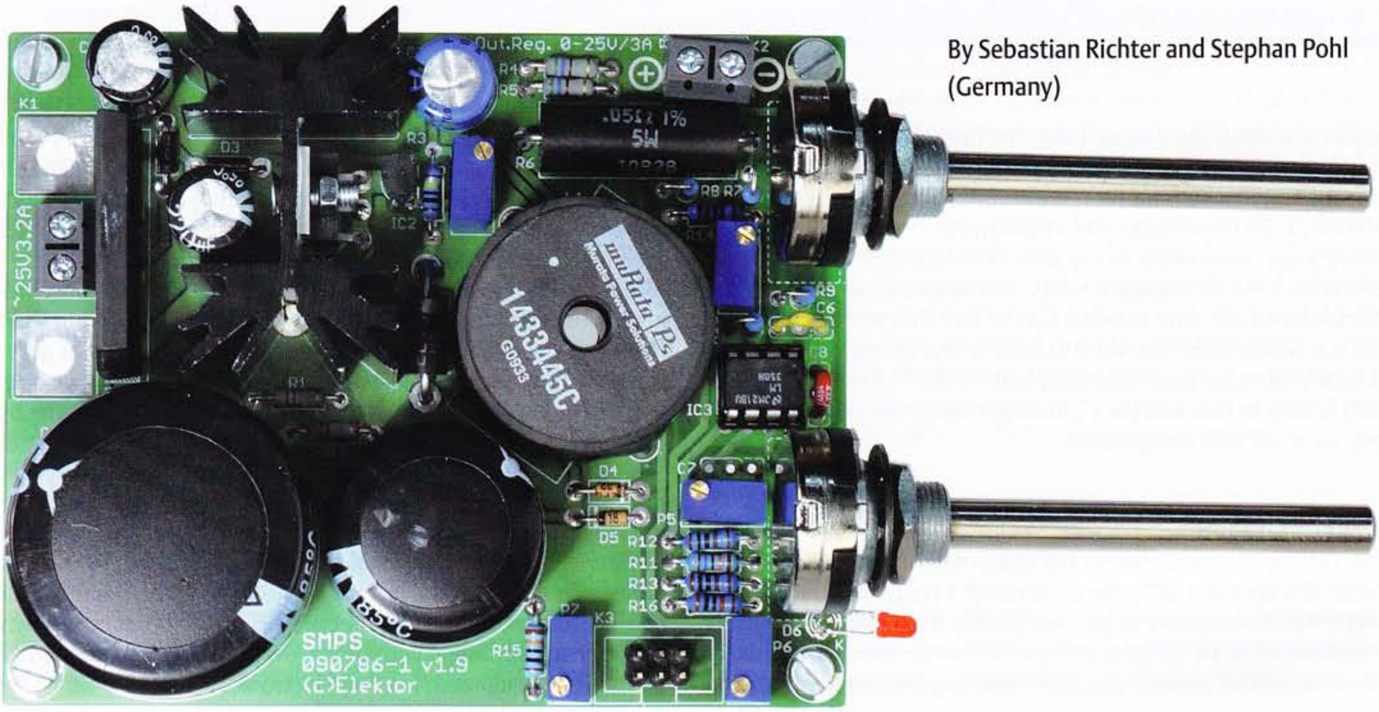
For electronics entusiasts who occasionally need to measure SMDs, the inexpensive measuring tweezers are doubtless usable but fairly limited, and their mechanical construction is not so great. The Peak LCR meter is a good deal better; it is fast and accurate and has serviceable tweezers. Unfortunately, you have to press the button for each measurement and the display switches off rather quickly.

The best choice for SMD measurements is unquestionably the Smart Tweezers; you only need to grasp a component with its pointed tips and it shows you the component type and value, including the dissipation factor or *Q* factor. However, it is rather expensive, so it is probably only attractive for people who work with SMDs on a daily basis. The Agilent U1732B is a robust and accurate LCR meter with quite a few features, and it is more than worth its price for electronics enthusiasts and professionals who need to make LCR measurements fairly often. Although the SMD tweezers accessory has very nice mechanical construction, it is not especially suitable for making measurements on such tiny components. In addition, the U1732B does not have automatic component detection, which makes it less suitable for quickly sorting out loose SMDs.
The main question is how you intend to use such an instrument. The Smart Tweezers are especially handy for working exclusively with SMDs, but the drawback of instruments of this sort is that they are poorly suited to measuring leaded components. If you are looking for a general-purpose solution, the relatively inexpensive Peak LCR40 or the somewhat more expensive but vastly more versatile Agilent U1732B is a much better choice.

(091038)

UniLab

A switch-mode 0–30 V / 3 A bench supply



By Sebastian Richter and Stephan Pohl (Germany)

A power supply with adjustable output voltage and current limiting is part of the basic equipment of every electronics lab. However, the increased complexity of a switch-mode design scares away many potential builders, even though it actually isn't all that complicated if you use a suitable combination of well-known technologies. The circuit described here is suitable for a building a single or dual power supply.

The idea of developing a switch-mode laboratory power supply arose in the electronics enthusiasts group [1] of the Institute for Power Electronics and Electrical Drives (ISEA) [2] at RWTH University in Aachen, Germany. Conceived as a starter project for novice electronics designers, it manages without a microcontroller and can be implemented at low expense.

This power supply is based on an integrated switching regulator to keep the component count within reasonable limits. The functional units of this IC include voltage regulation, switching signal generation, and integrated power switch. This means that only a few external components are necessary.

Thanks to the compact construction, it is easy to build a dual power supply in a single enclosure. A dual power supply is especially handy when you need more than one supply voltage. Naturally, both supplies are galvanically isolated, so they can also be connected in series to achieve higher voltages or used in parallel (connected via diodes) to provide more current.

Architectures

A conventional power supply architecture has a mains transformer followed by a rectifier and a linear regulator that controls the output voltage. At high power levels with a large difference between the input and output voltages, a linear regulator dissipates a lot of power as heat and needs a large heat sink. This high power dissipation makes the power supply inefficient, and it means that the transformer must provide the dissipated power as well as the useful power. This makes the transformer unnecessarily heavy and expensive.

Another option, which results in significantly lower power dissipation and thereby improved efficiency, is to use a switching regulator instead of a linear regulator. Although secondary-side switch-mode power supplies are somewhat more complicated than power supplies with linear regulators, they have only slightly higher component counts thanks to the availability of integrated circuits. The higher efficiency allows a more compact design, and in particular a distinctly smaller heat sink. Although the mains transformer cannot be eliminated, it is smaller than with a linear regulator because the higher efficiency means that transformer does not have to provide as much power that is dissipated as heat.

By contrast, a primary-side switch-mode power supply rectifies the mains voltage straight away without a mains transformer and filters the rectified voltage to obtain a high DC voltage (325 V). This is then converted into a low AC voltage by the combination of a suitable converter (such as a full-bridge circuit) operating at a high frequency (in the kilohertz range) and a small high-frequency transformer. This voltage is in turn rectified to obtain a low DC voltage. A galvanically isolated sensing circuit feeds this voltage back to the regulator section of the converter, which in turn maintains the desired output voltage. The major advantages of this technology are the very small transformer (depending on the switching frequency) and high efficiency (90% or better is possible). However, this form of low-voltage generation requires a very high component count and a complex design, and due to the high input voltage it can be hazardous in the construction and test phases. In addition, the inductive components in particular must often be custom-made.

Consequently, we decided to use the secondary-side switch mode option for this project, which is intended to be suitable for novices. It utilises a step-down (buck) converter topology [3].

Switching regulator

Many ICs are available to simplify the construction of buck converters. The National Semiconductor LM2576 used here is a member of the Simple Switcher family [4] and has already become almost a classic example of its type. Along with a power switch, it contains the functional units for generating the pulse-width modulated drive signal and regulating the output quantity. **Figure 1** shows a block diagram of the internal structure of the LM2576 as well as the standard configuration for output voltage regulation.

The regulator operates by comparing the voltage on pin 4 of IC1 with an internal 1.23-V reference voltage. The difference signal is amplified and compared with a sawtooth waveform. The sawtooth signal goes to zero at the start of each switching cycle, and the power switch is switched off at the same time. When the instantaneous value of the sawtooth signal exceeds the value of the amplified difference signal, the power switch is switched on and remains on until the start of the next switching cycle. As a result, the output voltage (V_{out} in the schematic diagram shown in **Figure 2**) is regulated such that the voltage on pin 4 of IC1, which is taken from the junction of voltage divider P1/R12, is 1.23 V. If P1 is adjusted to a higher resistance, the voltage on pin 4 drops. This causes the switch to remain on longer, and the output voltage increases to the point that the voltage on pin 4 is again 1.23 V. In the opposite direction, reducing the resistance of P1 causes the switch to remain off longer, which causes the output voltage to drop. However, it is not possible to reduce V_{out} below 1.23 V with the standard circuit. If P1 is set to 0 Ω, the output voltage is connected directly to pin 4 via R14. R14 is included in the circuit to prevent the output of IC3b from being connected directly to the power supply output when P1 is set to its minimum value (0 Ω).

A negative auxiliary voltage is generated to allow V_{out} to be adjusted down to 0 V. On the positive half-cycles of the input AC voltage, D2 conducts and charges C2. On the negative half-cycles, D2 is cut off and D3 conducts whenever C2 is charged to a higher voltage than C3. Capacitor C2 discharges into C3, causing C3 to be charged to a voltage that is negative relative to ground. This voltage is stabilised by an LM377 linear regulator (IC2), and it can be adjusted with P3 so that the reference ground potential (PGND) for IC1 is negative relative to the power supply ground by the amount of the reference voltage. This means that the voltage on pin 3 of IC1 is −1.23 V. This offset only affects the regulator circuit in IC1, while the output voltage V_{out} remains referenced to GND. This trick makes it possible to adjust V_{out} down to 0 V.

With this buck converter topology, output capacitor C5 can be 'actively' charged by switching on the power switch, with the result that V_{out} rises. However, C5 can only be discharged 'passively' by the connected load while the power switch is off. It is there-

Features

- Adjustable secondary-side switch-mode power supply (buck converter)
- Output voltage 0–30 V (typical) (25 V minimum)
- Adjustable current limiting up to 3 A
- Maximum output power 90 W
- Compact PCB layout
- Switching frequency 52 kHz
- Parts kit available from the Elektor Shop

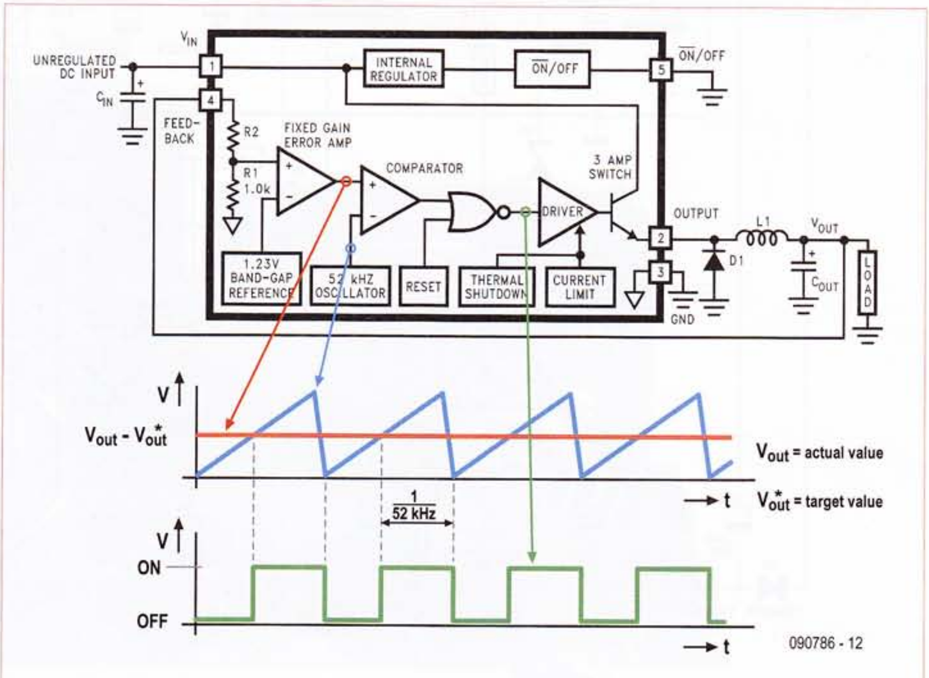


Figure 1. Block diagram and basic circuit of the switching regulator.

fore a good idea to provide a minimum load, here consisting of R4 and R5, to allow the output voltage to quickly reach the set level even when no external load is connected.

Current limiting

Adjustable current limiting is often very helpful in a lab environment in order to protect the connected circuitry. For this purpose, the circuit detects the voltage across sense resistor R8, which is proportional to the output current. IC3a amplifies this signal by a factor of approximately 4, and C6 attenuates high-frequency noise. P4 is used to compensate for the offset of the current sensing circuit (including the offset of IC3a). IC3b is wired as an adjustable non-inverting amplifier, with D6 and D7 at the output allowing only positive output currents. As a result, IC3b can increase the voltage on R12 but not reduce it. If IC3b increases the voltage on pin 4 of IC1 above the value resulting from the setting of P1, the current limiter causes the power switch to switch off earlier. This reduces the value of V_{out} and thus limits the output current to the maximum level set by P2.

If the current is less than the set maximum value, the anode of D6 (and D7 as well) is negative relative to the cathode, which causes the diodes to be cut off. In this state, the switch-off point of the power switch is determined solely by the voltage regulator. D6 is connected in series with D7 to prevent reverse-voltage breakdown of the LED, since the maximum allowable reverse voltage of the LED is only around 5 V.

The upper limit of the adjustable current range can be preset with P5. The lower limit is determined by the maximum gain of IC3b. The desired current limit level (maximum current) can be set within these limits by adjusting P2. As an LED, D7 provide a visual indication when current limiting is active.

Construction and initial use

The transformer should be rated for at least 1.2 times the nominal output power of the power supply, which means at least 90 watts or so for a single power supply. The secondary voltage should not be higher than 25 V, since the maximum voltage that IC1 and IC2 can handle is 42 V. With a 25-V transformer, you still have some safety margin even with 10% overvoltage on the AC mains. If you want to build a dual power supply, you can use a toroidal transformer with twice the power rating and two secondary windings as an alternative to two separate transformers. For sense resistor R6, you can use a length of inexpensive resistance wire instead of a 'real' sense resistor. With the specified resistance wire, a length

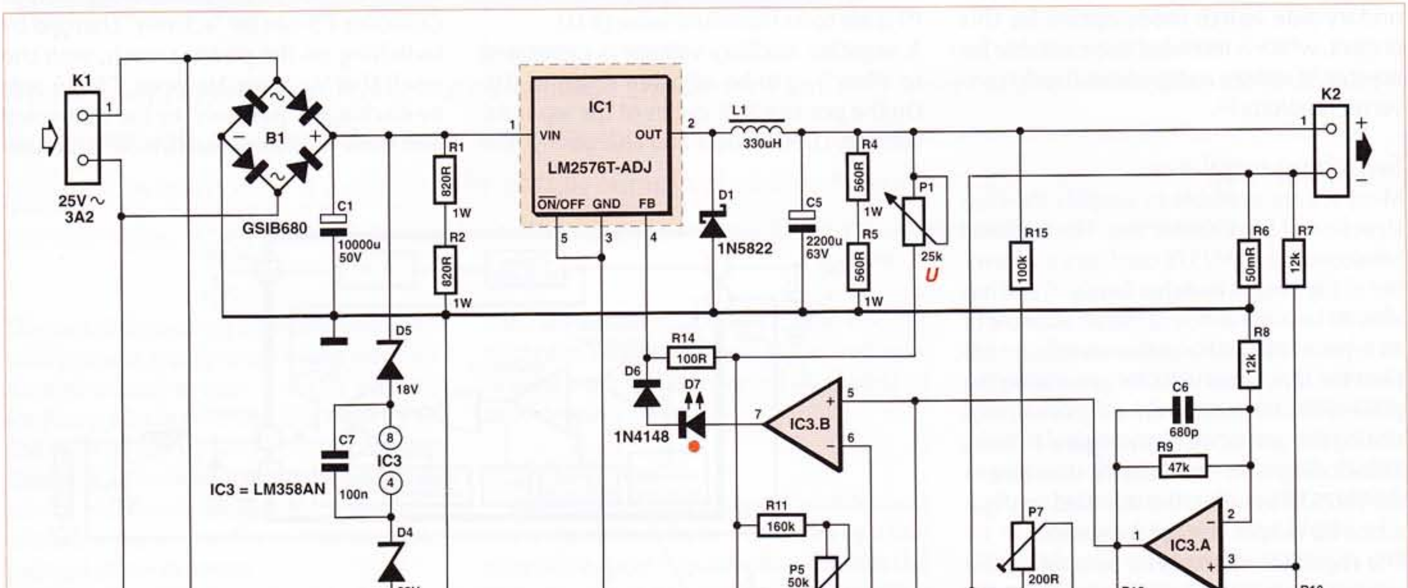


Figure 2. Power supply schematic diagram. A negative auxiliary voltage allows the output voltage to be adjusted down to 0 V.

COMPONENT LIST

Resistors

(default: 250 mW 1%)

R1,R2 = 820Ω
R3 = 240Ω
R4,R5 = 560Ω 1W
R6 = 0.05Ω 5W (Vishay Dale type LVR-05R0500FE73 or 1.73Ω/m resistance wire, see text)
R7,R8 = 12kΩ
R9 = 47kΩ
R10 = 39kΩ
R11 = 160kΩ
R12,R13 = 1kΩ
R14 = 100Ω
R15 = 100kΩ
R16 = 10kΩ
P1 = 25kΩ potentiometer, linear
P2 = 250kΩ potentiometer, linear
P3 = 50Ω trimpot, multiturn, vertical
P4 = 10kΩ trimpot, multiturn, vertical
P5 = 50kΩ trimpot, multiturn, vertical
P6 = 1kΩ trimpot, multiturn, vertical
P7 = 200Ω trimpot, multiturn, vertical

Capacitors

C1 = 10,000µF 50V radial
C2,C3 = 220µF 63V radial
C4 = 100µF 63V radial
C5 = 2200µF 63V, radial
C6 = 680pF ceramic
C7 = 100nF ceramic

Inductors

L1 = 330µH 4.5A (muRata Power Solution type 1433445C) or 330 µH 3A (Würth type 744137)

Semiconductors

B1 = 800V 6A bridge rectifier (e.g. Vishay type GSIB680)
D1 = 1N5822 (Schottky diode, 40V 3A)
D2,D3 = 1N4007
D4 = zener diode 22V 1W
D5 = zener diode 18V 1W
D6 = 1N4148
D7 = LED, 3mm, red, low current (2mA)
IC1 = LM2576T-ADJ (National Semiconductor) (see text)
IC2 = LM337LZ
IC3 = LM358AN

Miscellaneous

TR1 = power transformer, secondary 25V 3.2 A (see text)
Heatsink for IC1 (T0-220 <9.9K/W, e.g. Fischer Elektronik type SK129 25,4 STS)
K1,K2 = 2-pin PCB terminal block, lead pitch 5mm
K3 = 6-pin DIL pinheader, lead pitch 2.54mm (0.1")
PCB, order code 090786-1
Kit of parts, contains all components except power transformer. Order code 090786-71, see Elektor Shop section or www.elektor.com/090786.

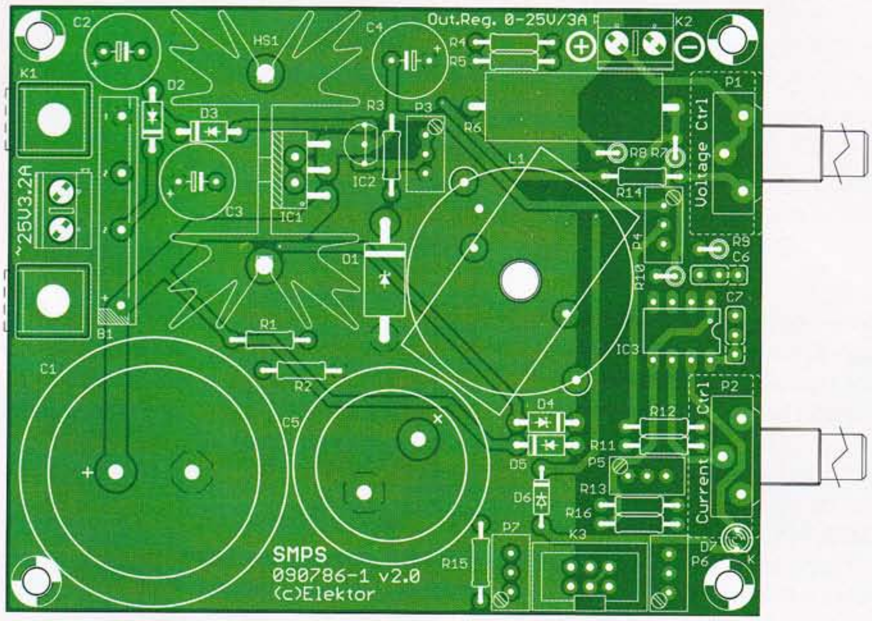
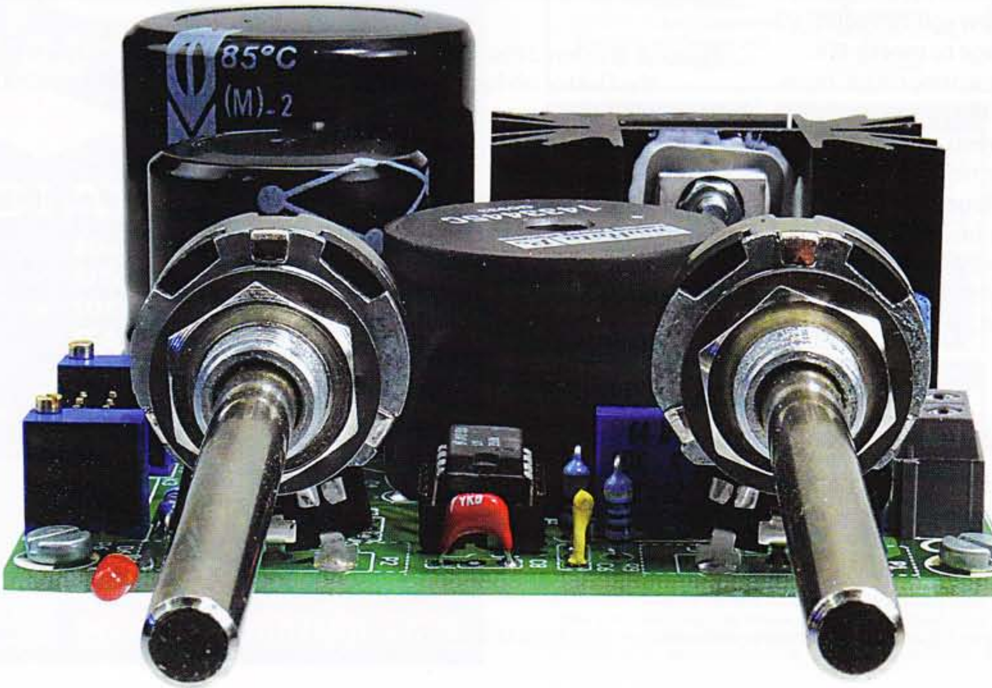


Figure 3. The double-sided circuit board allows very compact power supply construction.



About the authors

Sebastian Richter completed his studies in Electrical Engineering at RWTH Aachen University in 2005 and was awarded the degree of Diplom-Ingenieur (equivalent to an MSc). Since then he has been working as a research assistant at ISEA in the field of power electronics. He is also actively involved in teaching and is one of the co-founders of the Institute's electronics enthusiasts group.

Stephan Pohl completed his studies in Electrical Engineering at RWTH Aachen University in 2008 and was awarded the degree of Diplom-Ingenieur. Since then he has been working as a hardware designer at PicoLAS GmbH, where he is involved in the development of current sources for laser diodes. During his studies, he served as an advisor for the electronics enthusiasts group at ISEA, in which role he was primarily involved in teaching students analogue circuit technology.

of wire equal to the distance between the through-plated lead holes will have a resistance of approximately 50 mΩ. Any small difference can be compensated by adjusting P5.

With regard to parts selection, it is important to use a genuine National Semiconductor LM2576-ADJ, since problems may arise with 'type-equivalent' components from unknown manufacturers.

Before assembling the circuit board (**Figure 3**), you should preset multi-turn trimpots P3 and P4 for minimum resistance (for this purpose, connect the wiper to the appropriate potentiometer terminal as indicated by the PCB layout). After assembling the board, you should again check the polarisation of the electrolytic capacitors (C1, C2, C3 and C5) and setting P1 and P2 to mid travel before switching the circuit on for the first time.

If the circuit is working properly, it should be possible to adjust the output voltage from approximately 0 V to around 25 V after it is switched on. To precisely adjust the zero point, rotate P1 (preferably a multiturn potentiometer) to its minimum resistance and connect a load. Now you can adjust P3 to set the output voltage to exactly 0 V.

To calibrate the current sensing circuit, measure the voltage across the series connection of R15 and P6 (between (IC3a pin 1 and K3 pin 6) with no external load connected. Adjust P4 until this voltage is set to zero.

If you now connect a low-resistance load to the output and turn P2 to its upper limit, you can adjust P5 to set the upper limit of the adjustable current limit range (do not exceed 3 A).

A proper lab power supply also has voltage and current displays. Voltage dividers R15/P7 (voltage) and R16/P6 (current) are provided for this purpose. Potentiometers P3 and P4 are used to set the zero points for the output voltage and current, while P6 and P7 are used to calibrate the built-in instruments. For this purpose, set the power supply output to a point near the upper end of its voltage or current range and calibrate the built-in instruments by comparing the displayed values with reference values measured using a multimeters.

If you want to build a dual lab power supply with two UniLab boards, a tailor-made display unit with a backlit four-line LCD module is being developed in the Elektor lab. It continuously shows the voltage and current of the two outputs. Along with this display unit, Elektor provisionally plans to publish an article on a suitable enclosure and a front panel design in a future edition.

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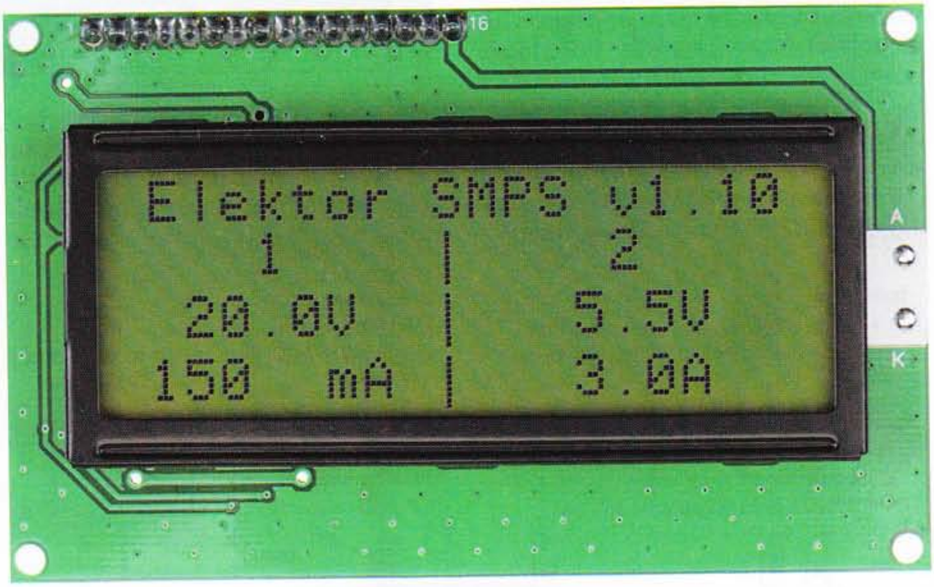

Figure 4. A tailored display unit with a backlit four-line LCD module is being developed in the Elektor lab for building a dual lab power supply with two UniLab boards.

Links and Reference Documents

[1] Bragard, Michael and Richter, Sebastian: 'LED Top with Special Effects', Elektor December 2008 (download from www.elektor.com/080678)

[2] www.isea.rwth-aachen.de/en

[3] Sánchez Moreno, Sergio: 'Cool Power', Elektor June 2008 (download from www.elektor.com/080198)

[4] LM2576 data sheet (download from www.national.com/ds/LM/LM2576.pdf)


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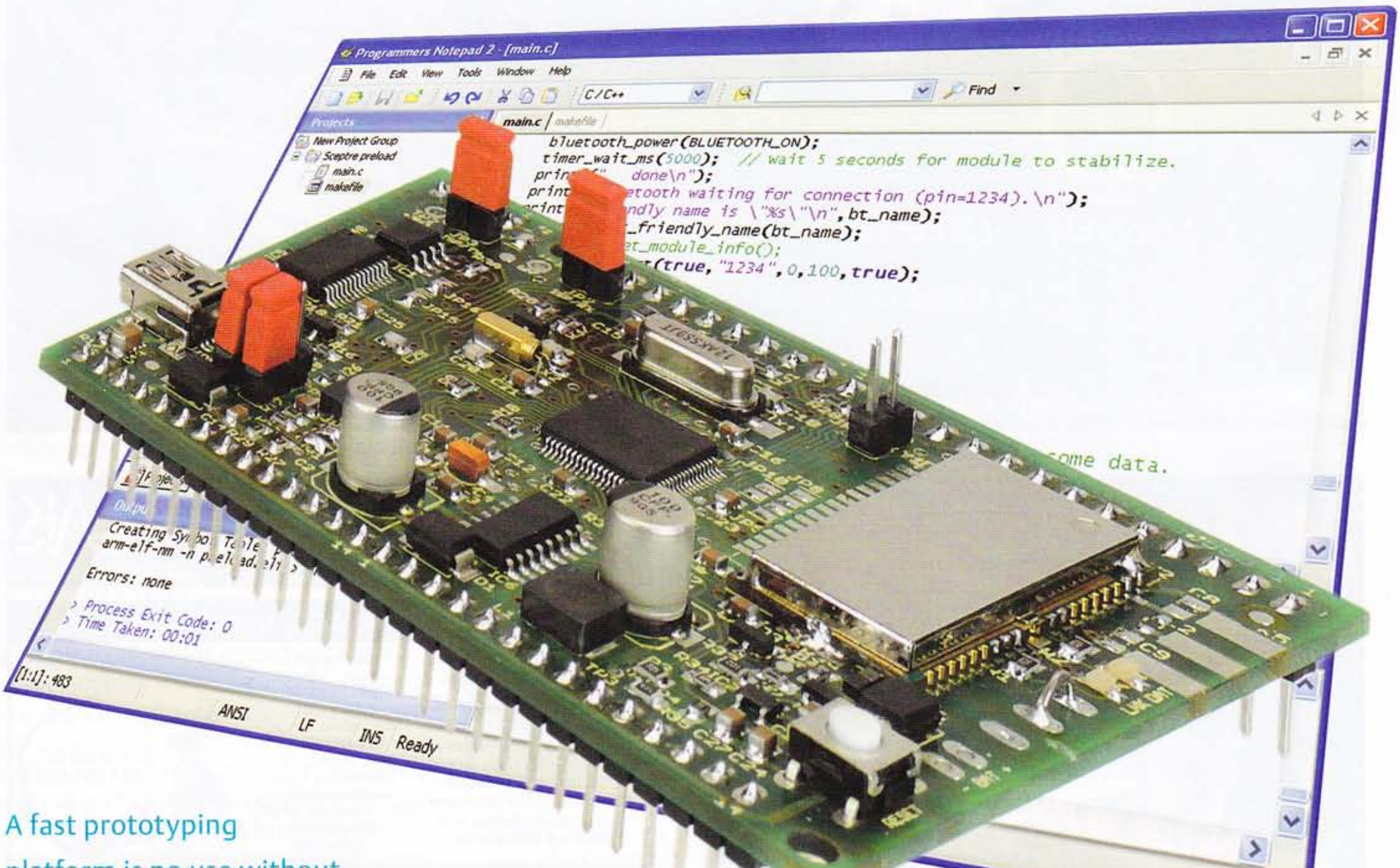
Grasping the Sceptre

Software library for easy programming

By Clemens Valens (Elektor France Editor)



A fast prototyping platform is no use without technical support. However well-designed the hardware, however comprehensive the software, if no-one explains how to actually use it all, it won't be as easy to use as you'd like. So having described the hardware last month, here now are the explanations and details of the Sceptre software. Let your reign begin!

Before getting into the details of programming the Sceptre, let's start by reminding ourselves of a few of the basic principles of programming in C. Oh yes, most of the Sceptre is programmed in C — for the time being, at least, as there are plans afoot for a C++ layer. We're not aiming here to go into detail about C itself, but rather, about the mechanism for converting a program written in C into executable code for the microcontroller. It's important to understand how all this works so as to be better able to program any microcontroller-based system, including the Sceptre, of course.

Figure 1 gives a flow diagram that shows which tool is used at which moment and with what type of data. At the top, we find the application in C, which may be made up of several files. At the bottom, the executable to be programmed into the microcontroller. So what goes on in between?

First of all, the compiler 'translates' (compiles) the source code in C to turn it into source code in assembler language. The

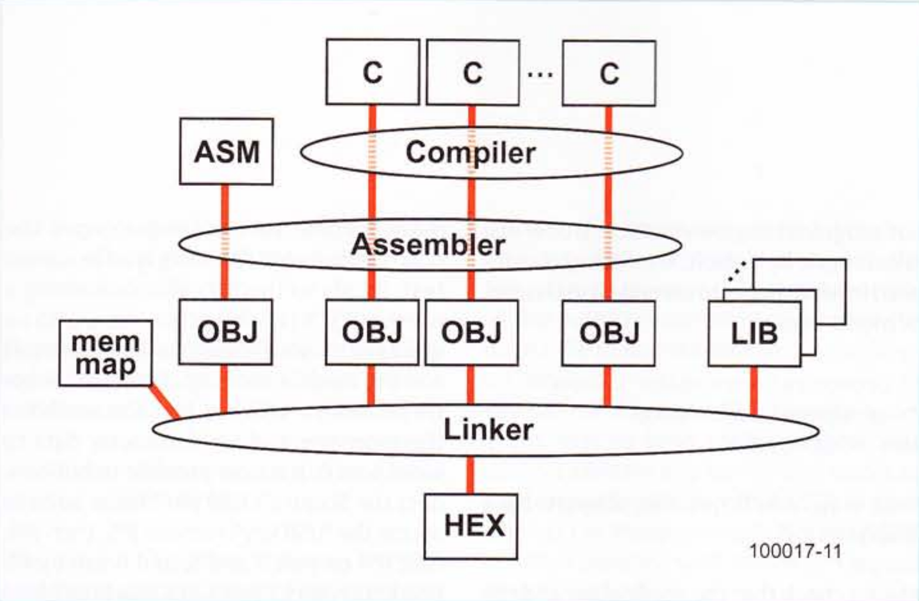


Figure 1. Flow diagram for the compilation chain.

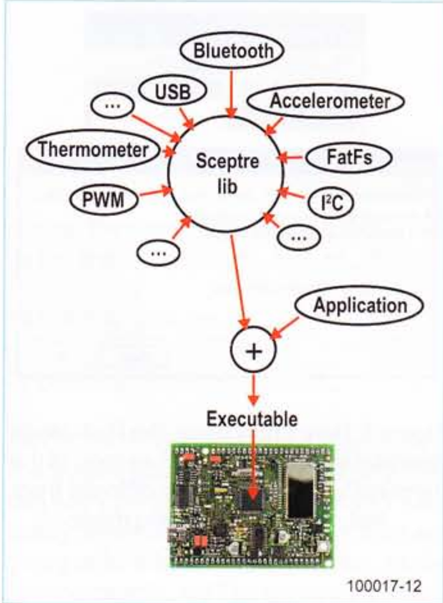


Figure 2. The Sceptre library, its contents, and its place in a project.

compiler can issue warnings and flag up errors. Always take care to resolve any warnings, if you possibly can. Errors are of the 'typo' or 'undefined object' variety, and must be corrected, or else you won't be able to go on.

It's the assembler that converts the source code into assembler language, creating from it what are called 'objects'. At this point, it's possible to add other functions written directly in assembler. This will often be the case for a special file commonly named **CRT** (from C Runtime) or **Startup**, which contains the very low level system initialization. In this file, the interrupt and reset vectors and stack are initialized, along with the memory and the pre-initialized variables. It's also from this file that we call the **main** function of a program in C.
The linker incorporates all the objects produced by the assembler into the executable. It also adds the objects archived in libraries that the application is going to need. The libraries contain functions that don't change very often, like **printf**, but which can be re-used over and over again. If this tool fails to find certain objects, it will return 'unresolved external'-style errors.
The linker requires a map of the memory in order to organize the objects and create links between them. With the help of this map (or table), it determines the function addresses and writes them into the various calls and jumps in the program. That's why it's called a 'linker'.
It's up to the user to provide this memory map (also called a 'linker script'), since it depends of course on the hardware.
The end product of the linker is an executable file that can be programmed into the microcontroller.

What we've just been describing is the 'compilation chain'. The previous instalment [1] explained that we've opted for WinARM [2] as our compilation chain. You can refer back to part 1 for details on installing WinARM. Apart from the functions for controlling the board, the Sceptre's software distribution [3] contains the elements needed for the compilation chain, such as a Startup file and a memory table (.LD file).

The compilation chain is launched using the **make** command, a very powerful program (included in WinARM, of course); make runs a script usually named **makefile**. A makefile contains all the commands and options for producing an executable from the source files and libraries. Make is so powerful that a makefile can be extremely complex and incomprehensible. So the best thing to do it to take a makefile that works and adapt it to your own project. Naturally, the Sceptre distribution also contains a makefile.

The Sceptre library

Since the Sceptre offers a certain number of on-board peripherals, it's only logical to bring all their drivers together into one library to make them easier to use and save a little compiling time, since they don't have to be re-compiled every time. At the time of writing, the library already contains the drivers for the USB, the SD memory card reader, the Bluetooth module, the UARTs, the counters, the real-time clock (RTC), ADC, DACs, PWM, the thermometer, and the accelerometer (**Figure 2**). Certain functions for initializing the micro are also included in the library, along with part of the newlib interface (see box about newlib). Not surprisingly, the library is called **sceptre** (.a). In order to use it, you need to include the file **sceptre.h** in your project and tell the linker where it can find the library.

The Sceptre library offers functions that make it easier to use a peripheral. For example, to set up a Bluetooth connection, all you have to do is call the `bluetooth_connect` function after the module has been initialized. To read the accelerometer, there is the `accelerometer_read` function, while `thermometer_read` lets you read the thermometer. It's easy, too, to turn the Sceptre into a USB key thanks to `usb_mass_storage_init` and `usb_mass_storage_tick`. Files on the SD card are manipulated using `f_open`, `f_close`, `f_read` and `f_write` (similar to `fopen`, `fclose`, `fread` and `fwrite` in libc) and to write to serial port 0, there is `printf`. You see, a lot of the work has already been done – and it's not finished yet! Take a look at the documentation in the **doc\html** folder, starting from the **index.html** file.

Figure 3. Here's how to run the Flash Magic terminal and configure it. The speed of the terminal's serial port can be different from that of the programming mode.

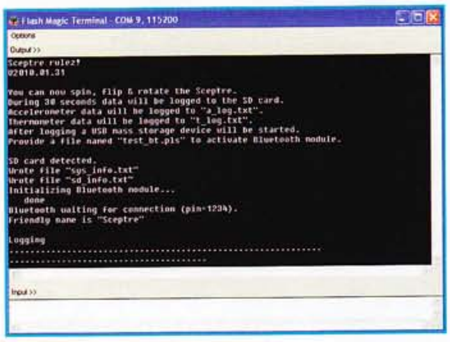


Figure 4. It works! The Sceptre start-up messages on an RS-232 terminal.

You can extend, modify, and correct the library, as you have access to everything. Each time you modify something in this library, you'll need to re-compile it. This can be done at a command-line prompt by running the make command in the distribution's **core** directory (perform a 'clean' first so as to be sure you are starting out from zero):

```
C:\sceptre\core>make clean
C:\sceptre\core>make
```

For ARM7 experts, here's an interesting bit of information: the library can be compiled in **ARM mode** or in **thumb interworks (iw) mode**. In ARM mode, the Sceptre is a true 32-bit system, but the executables are larger. In thumb-iw mode, the executables are smaller, but also slower, as the processor works in a 16-bit-compatible mode. With 512 kB of program memory, there's plenty of room to store a program in ARM mode, but programming the microcontroller will take longer. By default, the library is compiled in ARM mode; to compile it in thumb-iw mode, use:

```
C:\sceptre\core>make clean
C:\sceptre\core>make
ARM_MODE=thumb
```

That way, you'll get the **sceptre-iw.a** library.

Always check that the application and the library are using the same mode!

The Sceptre library includes other libraries found on the Internet, in particular **lpcusb** [4] and **fatfs** [5]. The former provides the USB driver, the latter is a FAT file system making it possible to read and write Windows, Linux, or MAC-compatible SD cards. When you compile the Sceptre library, you may see a number of warnings during compilation of files from the external libraries. Ignore them, there's nothing terribly serious, these libraries work perfectly. Given that these libraries are maintained independently of Sceptre, we avoid modifying them.

Getting stuck in...

The Sceptre distribution contains a test application named **app_preload**. This program is pre-loaded on the Sceptre boards available from our website [1] and lets you check easily that the whole board is working properly. To use it, you need to connect the Sceptre's USB port (JP4 and JP5 on pins 1 and 2) to a computer with the FTDI drivers installed (see previous article [1]). Run an RS-232 terminal program on the computer — for example, Flash Magic [1] — and configure the correct serial port for a speed of 115,200 baud, eight data bits, no parity, and one stop bit (see **Figure 3**). Disable the hardware flow control Press the board's Reset button. Now you should see a screen similar to the one in **Figure 4**.

After a few seconds, the application attempts to open an SD card to write a few little files with information about the system to it, then, for 30 seconds or so, it saves in two other files the data read from the thermometer and accelerometer (wave the board about a bit!) By writing a file named **test_bt.pls** to the SD card, containing a name in ASCII (16 characters max., with no spaces or '_', you request the Bluetooth test and the module starts up. Lastly, the Sceptre becomes a 'USB key' that also sends the thermometer and accelerometer data to serial port 0. It is now possible to hot-connect the Sceptre's USB pin header so as to access the 'USB key': remove JP5, then JP4, refit JP4 on pins 2 and 3, and finish by fitting JP5 on pins 2 and 3. It's also possible to change the USB key mode into serial port mode, but nine times out of ten, this will entail re-booting the board.

If you connect an LED with its anode to pin 1 of K7 and its cathode to GND via a 330 Ω (or so) resistor, it will flash at a frequency of 1 Hz.

With the Bluetooth module enabled, it ought to be possible to connect to a computer and send data. The Sceptre sends everything it receives on UART0 to the Bluetooth module and vice-versa.

The test application is compiled via a command-line prompt in the app_preload directory:

```
C:\sceptre\app_preload>make
clean
C:\sceptre\app_preload>make
```

The test application's makefile compiles the application and if necessary the Sceptre library too.

If everything works properly, make will end without any errors and creates a **preload.hex** file. This is the file you'll have to program into the microcontroller, using for example lpc21isp (included in WinARM) or Flash Magic (see previous article [1]). The latter detects automatically if the HEX file it's supposed to use has been modified (what's more, it displays the date and time the file was last saved), so all you have to do is click on the *Start* button to begin the flashing. The flashing will take longer or less time, depending on the file size. Unless you're keeping an eye on the programming, you may not spot the Flash Magic success message, as it goes off about 30 seconds after the end of flashing.

Flashing the microcontroller using lpc21isp is done using the command (if you're using COM4):

```
lpc21isp -control preload.hex
com4 38400 12000
```

The `-control` option indicates that it's lpc21isp that puts the board into programming mode and will restart it once programming is over.

Two indicators alongside the USB socket show if a data transfer has in fact taken place.

We recommend taking the test application as a starting point for your own project. Thanks to its makefile, you don't need to compile the library separately. Create a directory for your project alongside the app_preload directory so as to ensure that all the paths remain correct. Consult the main.c file to find out how to use the Sceptre library.

You can use any text editor to write a program, just so long as the source code doesn't contain any formatting codes or page formatting (nothing but ASCII, in other words!) The **Programmer's Notepad** (PN) [6] editor supplied with WinARM is a good choice (see box).

Add your C files into your project's makefile (not into the library one!) below the line 'SRC = main.c', like this (note the '+='!):

```
SRC = main.c
SRC += my_file.c
...
```

You can add as many files as you like. To change the name of your executable, modify the line:

```
TARGET = preload
```

by entering the name you want.

To be continued...

The Sceptre library is still not complete. Certain parts are almost finished, others have barely been started, and new functions are going to be added as you go along. In the coming months, we'll be presenting extensions and applications for the Sceptre which will all offer new possibilities. Updates will be announced on [7].

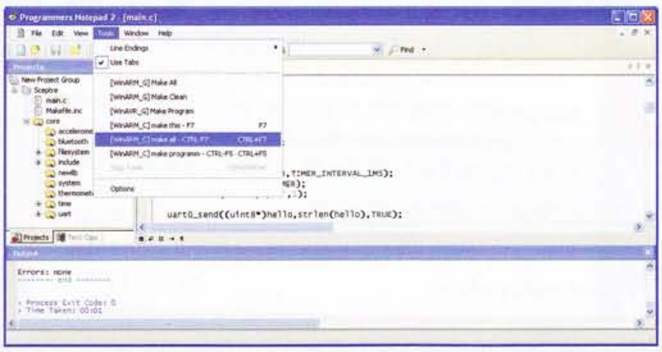
(100017-I)

Programmer's Notepad 2

The WinARM distribution also includes Programmer's Notepad 2, a special text editor for programmers. This tool can be found in the WinARM\pn directory and is initially configured for WinARM. There is now a more recent version [7]. All you need do to install this version is to delete everything in the WinARM\pn directory *except for* the tools sub-directory containing the macros for WinARM. Next, download the Portable Edition and unzip it into the WinARM\pn directory.

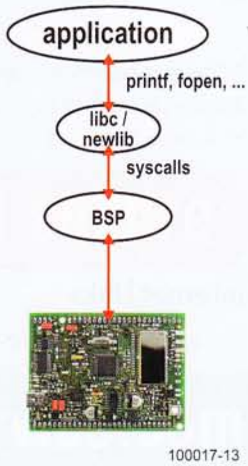
Use the command **Tools-> [WinARM_C] make all – CTRL-F7** to compile your program.

PN picks up the messages issued by the tools called by make and displays them in the Output window. Do look at the messages carefully, as there may be warnings or errors to be corrected. Sometimes a tool stops because of an error that's nothing to do with your program, but which indicates a Windows problem (noticed in particular with Windows Vista). If this happens to you, it's better to call make manually from the command line prompt.



libc, newlib, syscalls, and BSP

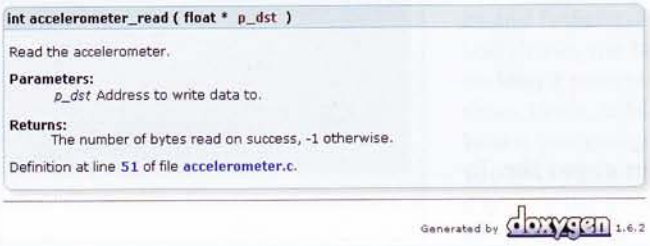
GNU C includes the **libc** library containing a very large number of functions that make programming in C easier. Certain of these functions depend on the hardware, particularly the functions that manipulate files and data streams. Normally, it's the operating system (OS) that makes the link between the hardware and libc, but where the OS doesn't do it, it's up to you the user to do it yourself (only if you want to make use of these functions, of course). This is why a version of libc for embedded systems has been introduced, with the name of **newlib**. This new library offers an interface named **syscalls** which lets you graft a board support package (**BSP**) onto the library in order to adapt it to the hardware. If now you are only using standard C functions in your application, all you have to do is modify the BSP to make it all work on another platform.



For the Sceptre, we've incorporated some of the syscalls in order to allow use of printf, fopen, etc. Among others, printf is a very handy function for debugging and lets you send character strings to Sceptre's serial port 0.

Documenting using Doxygen

It's important to document software, but this is not always easy and one soon forgets to update the documentation following a modification. Tools exist that let you automatically extract the comments (REMs) from a piece of software so they can be presented in a usable form. **Doxygen** is one of these tools, and by no means the least. What's more, Doxygen is free and open-source, and so ideally suited for our project.



To make the most of Doxygen's capacities, you need to respect certain layout rules for source files. Like any self-respecting software, Doxygen offers a plethora of options that you'll probably never use, but already with just a handful of commands, it's possible to do some good things. So remember to format your comments like this:

```
/**
* @file
* Description of file.
*/
```

A Doxygen comment starts with /** and ends with */ — the other asterisks are optional. It's also possible to enter a Doxygen comment on a single line using ///.

An "@file" block is obligatory, in order for Doxygen to take account of the file. Use the block below for commenting on a function.

```
/**
* Short function description.
*
* @param <parameter name> <parameter
description>
* @return <description of value returned>
*/
```

Doxygen extracts all these blocks of comments and creates from them a collection of HTML pages (among others) with the links to the definitions, sources, types, etc. — it's very impressive. Take a look, for example, at the Sceptre documentation included in the distribution.

And here's another very handy Doxygen command: @todo

Doxygen creates a special page with each todo found. With a function like that, you'll never forget anything again!

sysint.h

In the world of microcontrollers, it's very important to use variable types that correspond to the hardware. The size of the types depends on the hardware, and the fact that a character uses eight bits on platform A by no means implies that it will use as many on platform B. So to avoid such difficulties, you define clear types like uint8_t (unsigned 8-bit integer) or int32_t (signed 32-bit integer). Unfortunately, everyone does this a bit after their own fashion, and the result, when you glean your code a bit from everywhere, is that you often find yourself with several definitions of the same type (and not necessarily identical) like BYTE, BOOL, or DWORD, which the compiler doesn't like one bit. So we strongly recommend you to only use the types defined in **sysint.h**, supplied with the GNU tools. This file contains type definitions specially designed for programming microcontrollers. Do this, and everyone will be grateful to you for it.

Internet Links

[1] www.elektor.com/090559

[2] www.siwawi.arubi.uni-kl.de/avr_projects/arm_projects/#winarm

[3] www.elektor.com/100017

[4] sourceforge.net/projects/lpcusb

[5] elm-chan.org/fsw/ff/00index_e.html

[6] www.pnotepad.org

[7] elektorembedded.blogspot.com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A Fast Charger

Turn a low-cost SMPS into a battery charger

By Uwe Hofmann, Günter Gerold and Dr. Thomas Scherer (Germany)

Here's how three ElektorWheelie fans came up with an idea for a fully automatic fast charger to keep the batteries in prime condition. This low-cost design uses an off-the-shelf switch-mode power supply coupled to an intelligent controller and can be easily adapted to charge other types of cell.

In 2009 we published the complete construction details of the ElektorWheelie [1], a single-axle, self balancing, electric powered personal transporter. It was through the German forum that the three authors made contact. Before long they had agreed that a fast charger for the ElektorWheelie's two lead acid batteries would make a useful addition to the project. The idea was to add an external controller to an existing low-cost industry standard 12 V 60 W switch-mode power supply (SMPS) shown in **Figure 1**. It needed a little more investigation to make sure it was up to the job. The SMPS must supply a voltage of 14.4 to 14.8 V for the

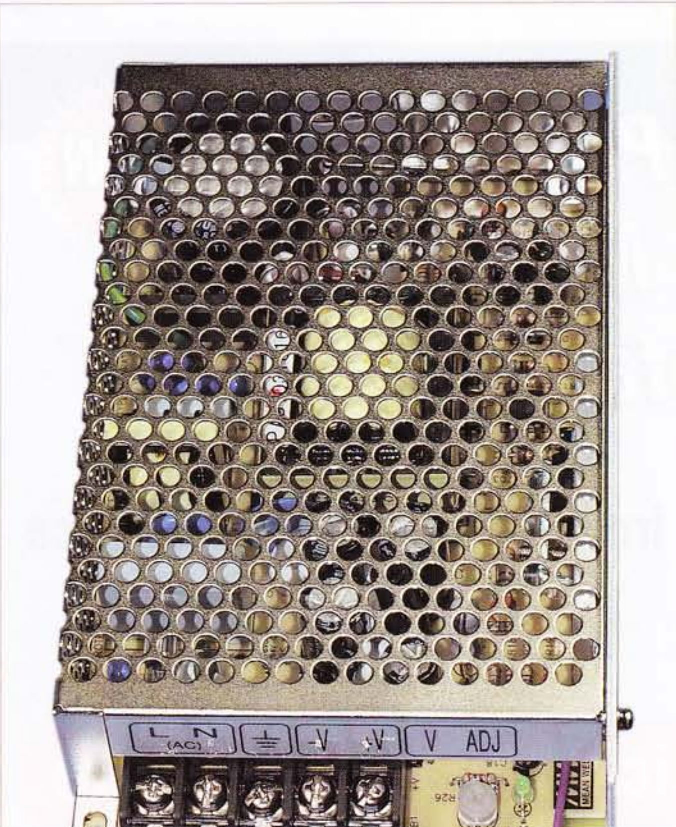


Figure 1. The SMPS used here. These types of power supplies are now widely available and are quite cheap.

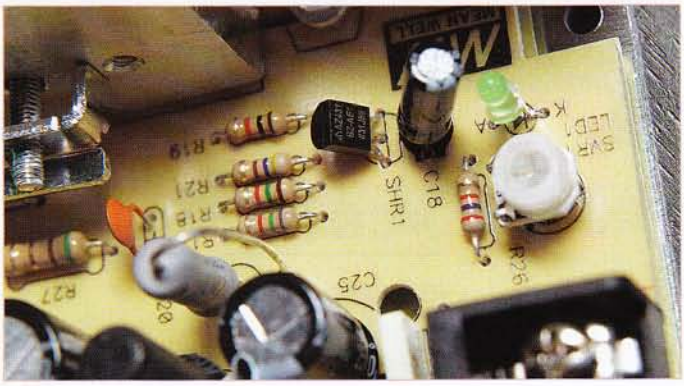


Figure 2. The SMPS output voltage is sensed by a TL431 (SHR1) shunt regulator.

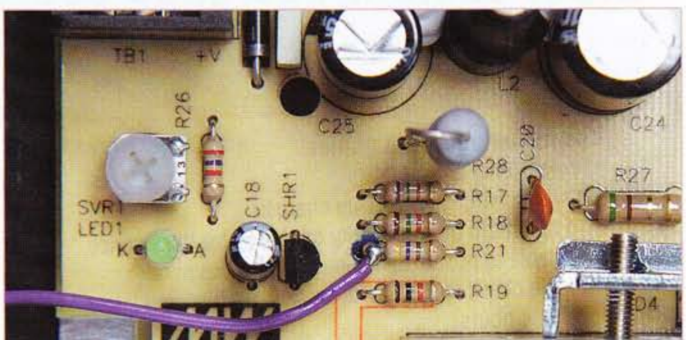


Figure 2a. A flying lead is soldered to R21 in the SMPS so that its output voltage can be controlled by the external add-on board.

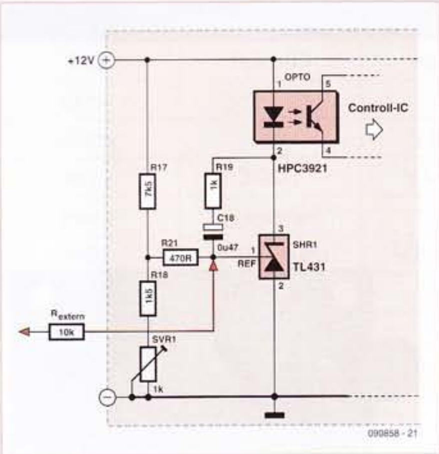


Figure 3.
The circuit diagram.

Features

- For fast chargeable 12 V lead acid batteries.
- 3.5 hour fast charge.
- Protected against short-circuit and reverse polarity connection.
- Optimised charging curve.
- Based on a modified low-cost industry standard SMPS.
- High efficiency from 76 %.
- Dead battery detection.
- The firmware supports 9 Ah cells, other cell capacities can be accommodated.
- Suitable for lead-acid and LiPo rechargeable cells.

final charging phase and must also remain stable with an output of less than 10 V.

Lifting the lid revealed a fairly typical layout using a switched primary winding. The secondary voltage level is sensed by a TL431 [4] three pin adjustable shunt regulator (SHR1 in **Figure 2**). This type of regulator is also known as an 'adjustable zener diode'; the zener voltage is defined by a simple voltage divider network (see **Figure 3**). The regulator senses the secondary voltage and adjusts the switching controller on the primary side via an optocoupler. The output voltage adjustment preset can be seen in **Figures 2** and **3**. This basic operating configuration is standard and used in hundreds of other SMPS designs so you are not restricted to the model specified here.

In order to convert this basic SMPS into an 'intelligent' battery charger we need to add a microcontroller to measure current (via a series 'sense' resistor) and control the voltage using the TL431 fitted in the SMPS.

Tweaking the supply

As shown in **Figure 3** a connection to the TL431's reference pin is necessary so that an external voltage can control the SMPS's output voltage. From the resistor values used in the SMPS it was calculated that a control voltage of 0 to 5 V connected via a 10 KΩ resistor would produce an output voltage range from 9.5 V to 15.5 V.
Resistor R21 on the SMPS circuit board has one end connected to pin 1 of the TL431. This is a convenient point to solder the wire which will feed in our external control voltage (see **Figure 2a**). A test with a 10 k resistor connected to 5 V gave an output voltage from the SMPS of 9.5 V. The upper voltage level however hit a wall at 14.7 V even with the 10 kΩ resistor grounded. This is not going to be quite enough to fully charge a 12 V lead acid battery. It seems as though there is some additional voltage limiting measure built into the circuit for safety.
A closer look revealed the culprit: underneath the transformer is a 13 V Zener diode wired in series with the input LED of an optocoupler. Its output is connected to the switch-mode controller IC to limit the output voltage. The solution was to add a silicon diode type 1N4148 in series with the zener to lift the threshold, the maximum output voltage increased to 15.4 V (see **Figure 4**).

The circuit

With the aid of a microcontroller and a few additional components we can build a fully automatic charging station (**Figure 5**). For processing power you can use an ATtiny24, it has everything required already built-in: an ADC input to measure levels of current and voltage, a PWM output with 16-bit resolution to generate the 0 to 5 V control voltage and some digital outputs to switch the charging supply and control an RGB LED to display one of seven distinct colours to indicate the charger's status. A crystal is not needed if the internal 8 MHz oscillator is used. A low reference voltage (1.1 V) allows the use of a low impedance current sense resistor and reduces energy dissipation.

A 5 V voltage regulator supplies power to the controller and LED. The power MOSFET T2 disconnects the output when an error is detected. Power Schottky diode D1 prevents a potentially destructive current flowing through the parasitic diode of T2 if a battery is connected in reverse to the charger. The two paralleled Schottky diodes connected to the port pins PA1 and 2 likewise protect these inputs against accidental battery reversal.
IC1 calculates the charge current by measuring the voltage drop across R9. A 2 W resistor will suffice for current up to 3.6 A. The 10-bit A/D converter and 1.1 V reference voltage allow a measurement resolution of around 10 mA.
The output voltage is measured by R10, R12 and P1. The maximum voltage drop across

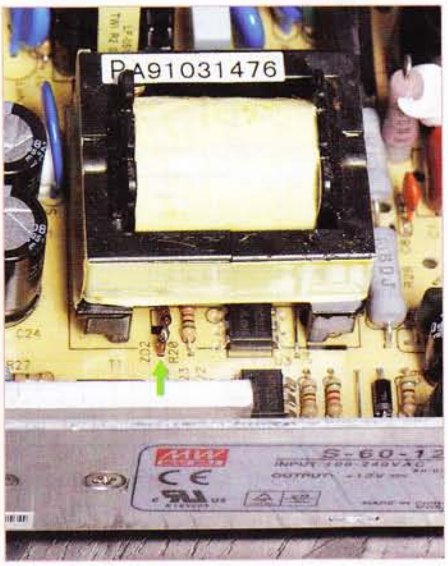


Figure 4. Hidden under the transformer is an over-voltage protection zener diode and optocoupler. An additional silicon diode in series with the zener diode raises the maximum output voltage by 0.7 V.

Table 1. Operating modes

Mode	Description	Voltage	Current	LED
1	No Battery	< 1 V	-	white
2	Deep discharge	1 to 10 V	-	yellow
3	Pre-charge	10 to 12 V	1/20 C	cyan
4	Start fast charge	>12 V	increasing	violet
5	Fast charge	12 to 14.6 V	max. 3/10 C	blue
6	Float charge	13.8 V	max. 1/50 C	green
7	Error	-	-	red
8	TO (time-out)	-	-	blink

Table 3. Using standard components

Component	Description
IC1	ATtiny24, DIL14
IC2	78L05
D1	SB540
D2	1N4148
D4,D5	SB140
T1	BC547
T2	IRF540

Table 2. Error modes

Mode	Description	when...	LED
A	Over voltage	> 15 V	red
B	TO pre-charge	Mode 3 >1 h	blink cyan
C	TO start charge	Mode 4 > 10 s	blink violet
D	TO fast charge	Mode 5 > 4 h	blink blue

R9 is 0.36 V which leaves 0.74 V of the of the 1.1 V reference voltage to measure the voltage. This means that the measuring resolution of a 15.5 V level (at maximum current) is not 15 mV but more like 22 mV. Correction for the scaling change is performed in firmware.

The controller produces a 10-bit PWM signal of a few kilohertz filtered by the low pass filter formed by R3 and C2. The resulting smoothed DC level in the range from 0 to 5 V is connected to the reference pin of the TL431 in the SMPS via resistor R2. R3 and R2 together make 9.5 kΩ in total. The SMPS now outputs a controllable voltage level in the range from 9.5 V to 15.4 V. R2 can be changed to alter the voltage range if necessary.

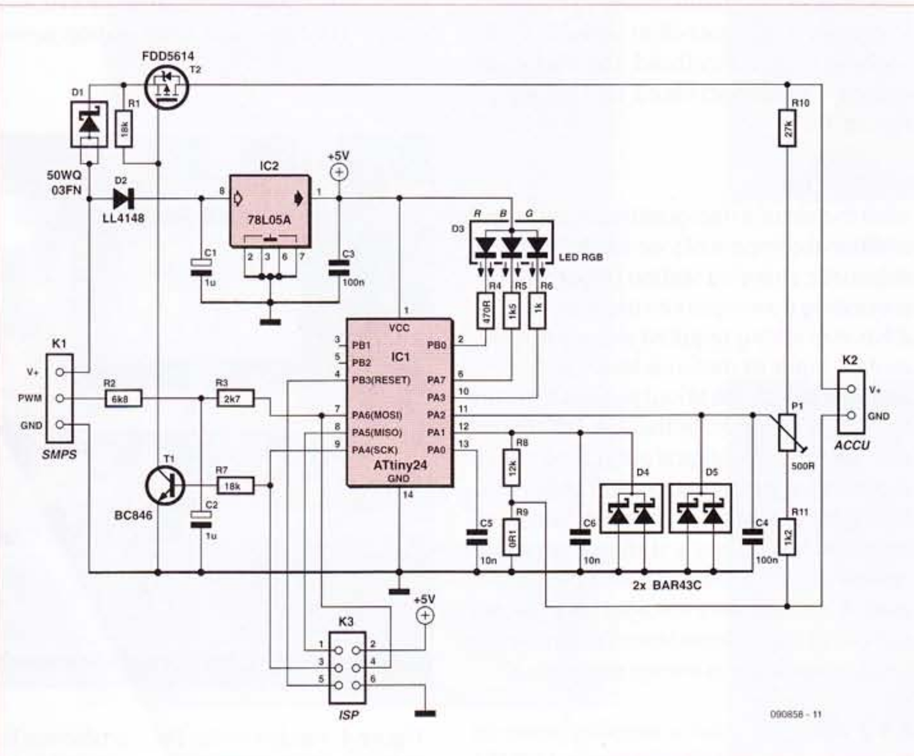


Figure 5. Two ICs plus a few discrete components converts the SMPS into an efficient battery charger.

Operational Modes

The following describes charging a 12 V 9 Ah (1C = 9 A) lead acid battery. The operating and failure modes are listed in **Tables 1** and **2**.

- After switch on the controller measures the voltage on the output and switches to mode 1 if no battery is connected. The SMPS output voltage will be set to less than 10 V.
- With a battery connected the controller measures its voltage. A value of less than 10 V indicates the battery is either in deep discharge or one of its cells is defective. The charger switches to mode 2.
- A battery voltage in the range from 10 V to 12 V, will initiate a pre-charge phase supplying a charge current of 1/20 C (= 450 mA). After one hour if the battery is still 'bad' the controller indicates failure mode C.
- Should the battery voltage rise above a 12 V threshold the controller initiates mode 4 where the current ramps up to reach 3/10 C (= 2.7 A) in a few seconds.
- This charge level is maintained in mode 5 for a maximum of four hours. When the battery voltage reaches 14.6 V a constant-voltage charge phase begins which gradually reduces the charge current with rising cell voltage.
- When the charge current falls to 1/50 C = 180 mA it enters float charge mode, supplying a maximum current of 1/50 C and a maximum voltage of 13.8 V until the battery is removed.

Construction

Thanks to the miniaturisation expertise of Uwe Hofmann we have managed to cram

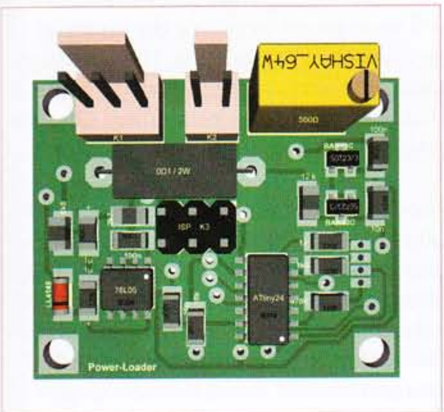


Figure 6. 3D simulation of the mini PCB topside rendered using Target 3001. The double-sided board is not through-hole plated.

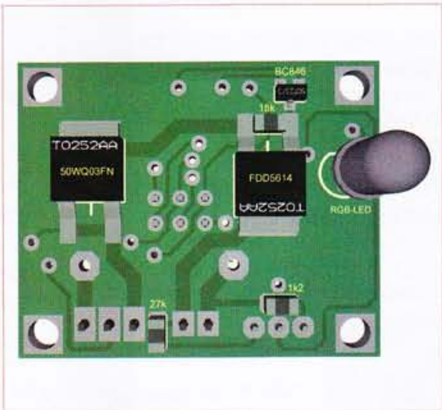


Figure 7. 3D simulation of the mini PCB underside rendered using Target 3001. Ensure that the diode and MOSFET are correctly fitted.

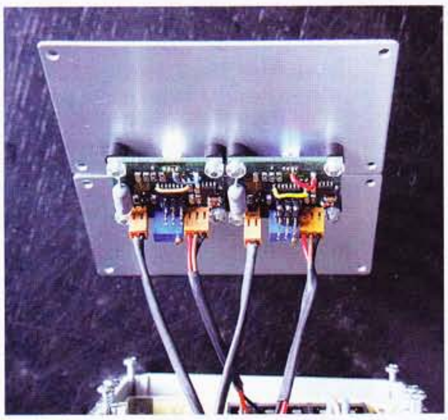


Figure 8. Prototype of the twin fast chargers laid bare (rough draught) for the ElektorWheelie with 2x12 V outputs.

everything onto a PCB measuring just 3 x 3.7 cm (**Figure 6**), the circuit could almost be fitted in the SMPS case. The disadvantage is that SMD components are used but all of the components specified can be easily hand soldered if necessary. All the PCB files are available so those of you with the facilities can make the board yourself. The PCB requires some through-contacts to be soldered by hand to connect between the two layers. The PCB and the circuit diagram in Target-3001 format, the PCB layout in EPS format and the firmware source code (also the hex file) can be freely downloaded from the article's web page [5].

When soldering the components to the PCB by hand first start on the underside with T2 and D5 (**Figure 7**) these are quite bulky and the board becomes hot when they are soldered in place. Afterwards solder the topside components. When a soldering oven is used bake the top side components, leaving the few remaining underside components to be hand soldered. Finally solder the connector and preset carefully into place, the plastic on these components cannot withstand high temperatures for too long. The board is double sided but not through-hole plated so there are a few pads which require a small length of wire soldered through to make connections between the two layers.

The RGB LED must be a common anode type with four pins. Diffuse 5 mm LEDs manufactured by A-BRIGHT are suitable [6].

Although a neat job is produced it is not absolutely necessary to use the PCB. The circuit is quite straightforward and can be built using conventional leaded components on a small square of prototyping perfboard. **Table 3** lists the necessary leaded components.

Adaptations

The circuit as it stands has been designed to fast charge a 12 V lead acid battery with a capacity of up to 12 Ah. The firmware assumes that a 9 Ah (as specified for the ElektorWheelie) will be charged. The ElektorWheelie uses two batteries so two separate fast chargers connected in series (**Figure 8**)

COMPONENT LIST

Resistors
(SMD 1206)
R1,R7 = 18kΩ
R2 = 6.8kΩ
R3 = 2.7kΩ
R4 = 470Ω
R5 = 1.5kΩ
R6 = 1kΩ
R8 = 12kΩ
R9 = 0.1Ω 2W
R10 = 27kΩ
R11 = 1.2kΩ
P1 = 500Ω, multiturn preset

Capacitors
(SMD 1206)
C1,C2 = 1µF 25V, electrolytic or multilayer
C3,C4 = 100nF
C5,C6 = 10nF

Semiconductors
D1 = 50WQ03FN, Schottky, SMD TO252AA
D2 = LL4148, SMD MINIMELF
D3 = 4-pin RGB LED, 5mm, common anode*
T1 = BC846, SMD SOT23
T2 = FDD5614, SMD TO252AA
IC1 = ATtiny24, SMD SO14
IC2 = LM78L05A, SMD SO8

Miscellaneous
K1 = 3-pin PCB plug, lead pitch 2.54mm (0.1")
K2 = 2-pin PCB plug, lead pitch 2.54mm (0.1")
K3 = 6-pin double row pinheader
SMPS 12V, 5A *
Silicon diode for SMPS, e.g. 1N4148*
PCB *
Firmware* for IC1
* see text

Test and calibration

Once the add-on controller board is fully populated connect a bench top power supply (minimum voltage range: 8 to 14 V @ 1A) to pins 1 and 3 of connector K1. Now carry out the following calibration procedure:

- Mode 1: First set the bench power supply output to 8 V and then switch it on. The add-on board LED showing white indicates that the circuit is functioning correctly.
- Mode 2: Link V+ from K1 with V+ from K2. This effectively bypasses T2 and D1. The output on K2 will be 8 V and the LED will show yellow.
- Mode 3: Set the bench supply output to exactly 10 V. P1 can now be adjusted to the point at which the LED switches from yellow to cyan.
- Mode 4 & B: Increase the voltage slowly, when the voltage gets to 12 V the LED turns to violet, 10 s later the LED will begins blinking violet indicating that the current ramp up to 3/10 C was not achieved in 10 s.
- Mode 5: Set the bench top supply to 13.5 V and connect a load to pass a current of 0.2 to 0.3 A (e.g. two 100 Ω/4W resistors connected in parallel). Switch the bench supply quickly off and then on, the LED will show blue.
- Mode 6: Reduce the output loading so that 100 to 150 mA current flows (remove one of the 100 Ω load resistors). This is now the end of the fast charge phase and the charger switches to float charge. The LED changes to green. Remove the wire linking V+ on connectors K1 and K2 and then remove the load resistor, load current now falls below the minimum threshold for a connected battery and the controller switches to mode 1.

Now with the calibration almost complete we can dispense with the bench top supply and connect the SMPS plus and minus to connector K1. The flying lead from the SMPS connects to the 'PWM' position on K1. At switch on the LED should show white.

Turn the output voltage adjust preset on the SMPS until a value of 9.5 to 9.9 V is reached. Ensure that the LED on the SMPS does not start flickering. The charger is now ready for use. The voltage drop across R9 gives the charging current.

Table 4. values for LiPo cells

Mode	Description	3 cell	4 cell	Current
1	No battery	< 1 V	< 1 V	-
2	Deep discharge	< 9 V	< 12 V	-
3	Pre-charge	9 to 11 V	12 to 14.3 V	1/10 C
4	Start fast charge	> 11 V	> 14.3 V	Increasing
5	Fast charge	12.6 V	16.8 V	1 C
6	Float charge	12 V	16 V	1/50 C
A	Over voltage	>13 V	>17.2 V	-
-	SMPS rating	12 V	15 V	4 A
-	R10	27 kΩ	36 kΩ	-

The Authors

Uwe Hofmann is a technician working at Miniatur-Wunderland in Hamburg, Germany [8].

Günter Gerold is a self-employed radio and TV technician [9].

Dr. Thomas Scherer works as a technical author and designs laboratory equipment.

will be required to enable the batteries to be charged independently. The pin assignments of the charger plug are the same as that used in the previous 'Power Charger' article [7].

The circuit can easily be adapted to cater for other rechargeable batteries. It is however important to choose a SMPS capable of supplying sufficient current. The supply's nominal output voltage should correspond with the battery's nominal voltage. The SMPS we used here exhibited a certain degree of 'hunting' if we tried to adjust the output to less than 9.5 V. This condition is not dangerous but caused the LED to pulse. The add-on controller board described here is suitable for use with SMPSs with outputs in the range from 8 V to 20 V.

To use the fast charger for any voltage other than 12 V it will be necessary to change the value of the voltage divider formed by R10 and R11. In addition some constants defined in the firmware need changing. This last part is easy; the source code is well documented and written in BASCOM. Thanks to the program size it is possible to recompile the software using the size-restricted free demo version of the BASCOM environment.

The fast charger is also suitable for use with 4 Ah LiPo cells popular with model builders. With a charge current of 4 A = 1 C the LiPo cells will be fully charged in a little over an hour. **Table 4** gives values for each mode of the charging process.

(090858)

Internet Links

[1] www.elektor.com/090248

[2] www.elektor.de/wheelie-forum

[4] www.fairchildsemi.com/ds/TL%2FTL431.pdf

[5] www.elektor.com/090858

[6] www.a-bright.com.tw/fullclamp/AL-513RGBW-A-004.pdf

[7] www.elektor.com/090582

[8] www.miniatur-wunderland.de

[9] www.gerold-online.de/cms

Latest from the Elektor Lab

Corrosion fighter spray

by Jens Nickel

Last month we took a look at the problem of dusty pots and wafer switches. This provoked an email from a long time Elektor reader (from issue 1!) praising the article he went on to outline a problem he had himself. A telephone socket fitted in the wall of an outdoor enclosure often had a layer of condensation on the plastic faceplate. Despite a good level of ventilation, over the years the humidity has resulted in leakage currents and oxidation of the plug contacts, corrosion of the conducting tracks, terminal block and to some extent the incoming telephone wire pair.

His question is how can he rectify the problem? Should the telephone outlet and plug assembly be covered with a layer of non-conducting silicon grease or petroleum jelly? Or would a dose of 'Kontakt 61' contact coating do the trick?

We hesitate to recommend either of these options; besides the mess there is a very real chance that the plug contacts will get smeared with grease when the phone is unplugged and poor/intermittent contact will add to the problem.

A fairly recent development of a spray coating is ideally suited to this situation. The company at www.wet-protect.com advertises a range of sprays which claim to protect electrical circuits from the effects of water ingress and condensation. The spray leaves a permanent water repellent protective film over the surface. A promotional video shows a treated hair dryer operating under water! (Don't try this one at home). Similar products may be available from other suppliers, let us know which ones you've found to actually work — highest odds among products for model building and ship repair. In the meantime Graupner distribute rebadged cans of WET.PROTECT. Graupner products are stocked by model shops throughout the world.

Guests in the lab

February was chilly but we were pleased to extend a warm welcome to some visitors who dropped by to see us. Remco Krul of National Instruments brought the latest release of Multisim with him (see News; www.ni.com/multisim). Our February article 'Blinded by the Light' also prompted a visit from Gerard Grashof of Fluke (www.fluke.com). Armed with a '434 Power Quality Analyzer' he was able to give us more insights into power factor measurement of LED lamps. More on this in our next edition!

Rob Staals (photo) of JTAG Technologies (www.jtag.com) was spreading the word of 'boundary scan' for PCB assembly testing. In the old days an assembled PCB was tested in a fixture using a bed of spring loaded pins to contact test points. The complexity of today's multi-layer boards using high-density LGA and BGA chip outlines means that some signals cannot be probed. This is a real headache for board testers. The answer is boundary scanning. In essence each signal pin of each chip has a dual function; In test mode they are configured as a cell in a 'boundary scan' shift register passing through every chip on the PCB. Test patterns can be shifted into place and latched into the chips to generate outputs. Individual PCB tracks can be tested and shorted/open circuits pads identified. After testing, all the chips revert to normal mode and the test circuitry effectively becomes invisible. In addition to the register cells the manufacturers need four extra pins on each IC for control and passage of the serial data. Most manufacturers (but not all) now offer JTAG interface capability option for their chips. Rob's Company supplies the fixtures and software for boundary scan board testing. With the circuit net list the software automatically tests all connections. Memory modules can be tested by simulating the signals of a boundary-scan enabled microcontroller.

ELabsInside@Elektor

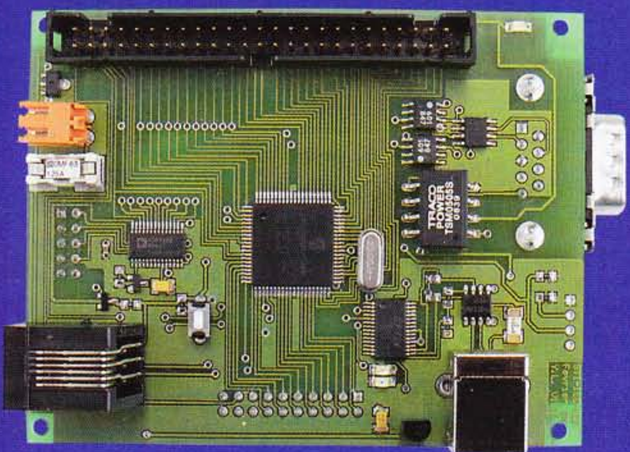
- Got a question for the designer of an Elektor circuit?
- Any contributions or comments on the E-Labs Inside stories?
- Suggestions of boards or electronic software that you think would be interesting to review?
- Discovered anything new that you want to tell us about?

Don't hesitate; we look forward to your feedback sent to elabsinside@elektor.com, please include [e-labs] in the subject line.

The making of the dsPIC board

By Jens Nickel

We usually receive many more projects than we have space to print. So first we make a preliminary selection at an editorial meeting, bringing together both editors and lab technicians. This whittles the total down to about ten high-quality projects every month. These go on the 'waiting list' of interesting circuits, which forms the basis on which the individual editions of Elektor are planned, taking into account the Publishing Plan. The editorial meeting takes place about four months ahead of the planned publication date for the magazine, and projects that make it this far then go off to the labs.

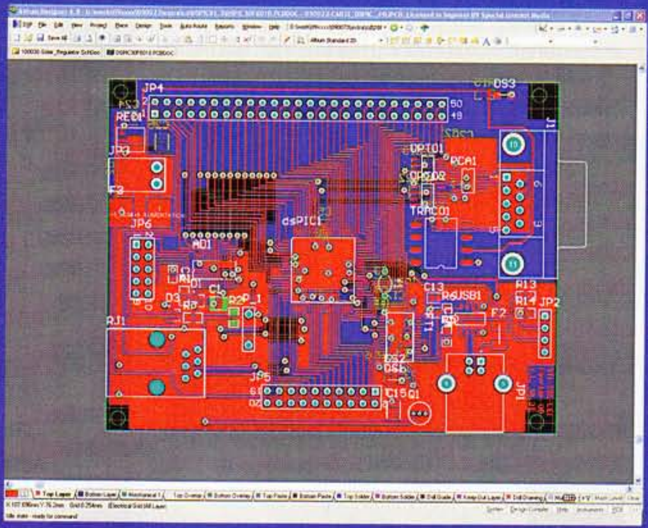


The 'dsPIC board', a processor board with a range of interfaces, was originally conceived by two authors from the French-speaking part of Switzerland, and so communications were handled by the staff of Elektor's French edition. We had not previously used the dsPIC30, a powerful PIC-family microcontroller with DSP functions. The authors had already designed a printed circuit board, developed a few working example applications, and produced comprehensive documentation. The editorial meeting approved the project without hesitation.

A few months passed before publication plans crystallised for this compact board. During that time the authors, working at the celebrated École Polytechnique in Lausanne, sent us updates and extensions to his project, including an elegant expansion board for controlling a solar heating installation. This made the project a perfect fit for the May 2010 issue, whose theme was to be 'green electronics' (see Publishing Plan at www.elektor.com). At the planning meeting for that issue, at the beginning of January, the team quickly came to the conclusion that we should publish the two circuit boards as two separate articles, since the processor board might be interesting to readers as a project in its own right. Elektor developer Daniel Rodrigues got down to work on the project.

It starts with a prototype

A printed circuit board is not essential for a project, but does make it much more attractive. An assembled and functioning printed circuit board from the author gives us confidence that the project can be made to work, but nevertheless we reroute all boards in our labs in order to comply with our house style and to generate component mounting plans. Usually our in-house developer will ask the author(s) to send in his prototype, and in this case it was not long before Daniel had a



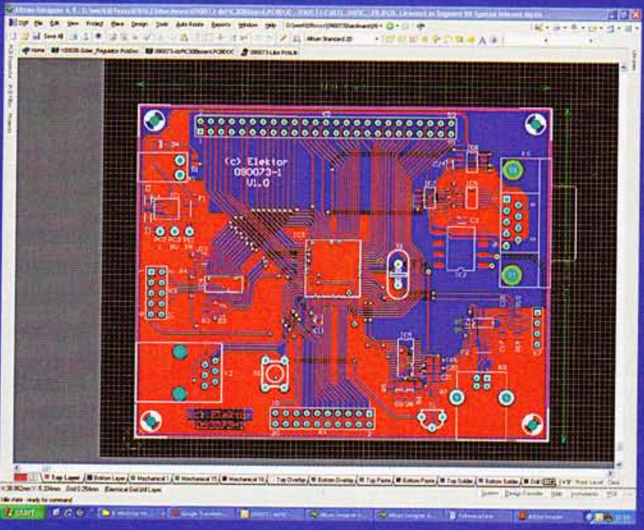
rather impressive processor board on his bench (see photo). The authors also sent in their CAD files, by good fortune prepared using Altium Designer, the same package as we use in our labs. We can also accept Eagle PCB and schematic files, as well as Ultiboard or Multisim files.

After a quick scan of the circuit diagram Daniel started to check the availability of the components used. If a component seems hard to obtain we will try to find a more readily-available substitute, although this is not always possible in the case of some special-purpose devices. In the case of the dsPIC board Daniel had little cause for concern: "I changed the fuses," he reports, "'because holders for the fuses the author had used were not easy to find." To bring the design into line with our standards, SMDs in an 0603 package were replaced by 0805 types. This makes the project a little easier for constructors. "In some circuits we have to replace everything: voltage regulator, microcontroller, display, the lot," says Daniel. When substituting components, there are often also corresponding changes to be made to firmware as well.

Once Daniel has put together the parts list for the board, he passes it to Jan Visser in the next-door office. Jan knows the catalogues of mail order giants such as Farnell, Conrad Electronics and DigiKey backwards: "it usually takes three days to a week to get all the parts in," he explains. Of course our lab also boasts an extensive stock of standard SMD and in particular leaded components. We also keep about forty different types of microcontroller, and the Elektor Shop sells a wide range of pre-programmed devices.

The Elektor PCB

Meanwhile, Daniel has been working on the printed circuit board. Since Altium CAD files had already been prepared, the work was quicker than usual. First the components are positioned on the blank board, using the footprints provided by the author. "I've tried to keep roughly to the component placements



the author used,"' Daniel says. For our double-sided board layout we made sure all connectors were mounted on the same side of the board. As can be seen from the screenshots (author's layout on the left, ours on the right) we have also removed all the 90 ° corners from the tracks, replacing them with 45 ° turns. For the original layout the author had made vias using the leads of components — common practice for prototypes but not suitable for professional manufacture. So these were changed, and then finally the dimensions of the board (already a little larger than the original) were rounded up to a whole number of centimetres. We don't often work to standard sizes such as the Eurocard format unless the requirements of a particular enclosure dictate otherwise.

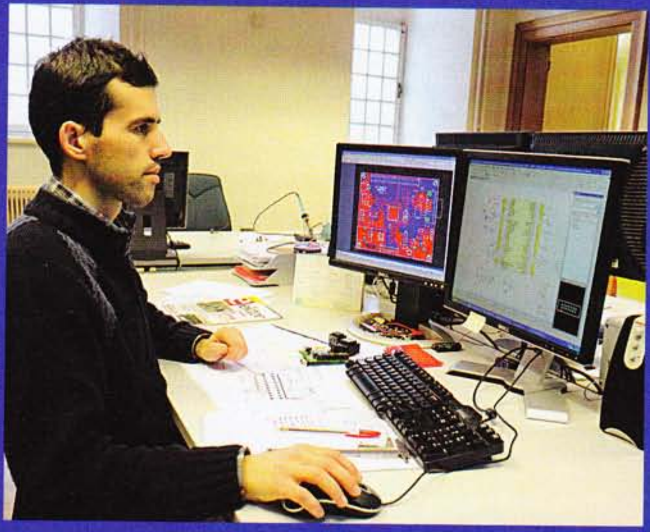
The finished board design is then sent for manufacture to our partners Eurocircuits, just across the border in Mechelen, Belgium. This gives a little time for our engineers to work on other projects before components and circuit board come together in the lab. By the middle of February there are a good dozen circuits in the pipeline for the summer double issue.

Daniel is making progress with the second board, and has some questions for the authors. In particular he is concerned about the type of flow sensor the author is using in his solar installation. He has also noticed an oddball connector used to supply power to the temperature sensors.

To the author for testing

As soon as the two boards have been made and populated they undergo a range of tests. "'For this project we just checked for shorts and other obvious problems," Daniel explains. For functional testing the board is sent to the authors, who can try it out in conjunction with the other expansion boards they made. They can also replace the boards in their solar installation with our versions for a practical test.

"Doing those tests here would have been difficult," Daniel remarks, "because we don't have the necessary sensors and



magnetic valves to hand." He also notes that authors will often have much more experience and skill in using special-purpose devices like the dsPIC microcontroller, pointing out that it would take a long time just to write suitable test routines to exercise all the pins and interfaces on the microcontroller.

What if the authors find that Elektor board doesn't work? Daniel grins. "Then we just have to work quickly." Like time and tide, publication deadlines wait for no man. Find out what happens in the next instalment!

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We receive a steady stream of questions from readers who have designed interesting circuits. How do we decide which projects make it into the magazine? What do we require from the author? How is the work divided between author and the Elektor labs? Here we complement our 'Author Guidelines' (which can be found tucked away on our website under 'Service') with our 'Making of' E-Labs Inside pages.

CO_2 Meter under test




By Jens Nickel

Back in January we mentioned that we were working on the design of a new CO_2 meter. This one is specifically designed for use in cars where the confined space can quickly lead to a build up of CO_2 concentration in the air. Its effects are well known: headache, sickness and poor concentration.

We chose a CO_2 sensor which uses the principle of infrared absorption. The alternative is a laboratory-grade cell but these are not so practical; they require a couple of hours before producing an offset-corrected measurement. The sensor used for this design is ready to go within one minute, true to the plug'n'play philosophy we can just plug the CO_2 meter in (to the vehicles cigarette lighter socket) and drive!

Prototype ...

The sensor is produced by ZyAura of Taiwan. It features a high level of integration including an SPI interface. This allowed us to get the first prototype up and running relatively quickly. The module repeatedly sends data packets over this interface indicating the CO_2 concentration and air temperature. All that's necessary is a microcontroller (e.g. an ATmega) to extract and display the data. A small alphanumeric display using HD44780 compatible commands is all that's necessary for display purposes. Chris Vossen was able to produce the necessary firmware relatively quickly using pre-programmed software building blocks (in the form of C functions). From the hardware point of view the prototype only needed a small square of prototyping board, a couple of chips for the power supply and a suitable enclosure (not forgetting ventilation holes to allow for air circulation).

... and test

Once we had the prototype sorted it was clear that we would need to devise a rigorous and punishing series of trials to fully test the design (would you expect any less?).

We had previously made preliminary lab tests on the circuit and our chief designer Antoine Authier had already tested the meter in his own car. The time was now right to make a more systematic trial using a real-world test environment; I went in search for some willing lab rats...

By the end of the day I had assembled our team; Chris volunteered to shout out the readings from the passenger seat, Antoine would make notes and our graphic designer Mart Schroijen would be responsible for taking some photos.

It's a tough job...

One cold February morning we assembled in the car park, we would be using my (aging) VW Golf to put the CO_2 meter through its paces. The plan was a short journey through the countryside and then around 20 miles of motorway driving. Before starting we calibrated the meter using some local fresh air to give a reading of 400 ppm.

In the first few miles we switched the car ventilation system to recycle so that no fresh air would be drawn in. As expected the meter reading began to rise, after just five minutes it had already exceeded 1000 ppm and was still rising steeply. At eight minutes we had reached 1740 ppm but the rise was now less steep (we guessed this was probably due to air leakage around the door seals). At this level you don't need a meter to tell you that the CO_2 concentration is high, you are increasingly aware of the stuffy, fuggy atmosphere and feel a growing urge to open a window. After another ten minutes the CO_2 level had plateaued at around 1900 ppm, again we guessed that leakage around the doors had achieved equilibrium with the expelled CO_2. 1900 ppm is a surprisingly high reading after just 15 minutes driving.

...but someone has to do it

We were all feeling uncomfortable so everyone was in agreement with the next stage of the test... we needed air. We switched the ventilation controls to draw in fresh air and turned the fan on. Depending on the fan setting we recorded readings between 1100 and a more bearable 800 ppm.

For the last part of the test we would really be stretching our powers of endurance to the limit; travelling at 70 mph with an outside temperature hovering around zero centigrade we switched the ventilation fan to maximum and wound down the windows. The CO_2 concentration quickly dropped to just over 600 ppm.

Result: The sensor has a really fast reaction time and its good resolution means that you quickly get an indication whether CO_2 concentration is stable, decreasing or increasing. This information can be critical when several people are gathered together in a confined space. The head of our lab Antoine Authier had also discovered that you don't need a full car to get high levels of CO_2; he had recorded in-car levels of 1300 ppm and above during his daily 50 minute commute through rush hour traffic. This little box of tricks is going to be very useful, if all goes well we will reveal all in the May 2010 edition of Elektor.

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Computer controlled 8-channel relay board. 5A mains rated relay outputs. 4 isolated digital inputs. Useful in a variety of control and sensing applications. Controlled via serial port for programming (using our new Windows interface, terminal emulator or batch files). Includes plastic case 130x100x30mm. Power Supply: 12Vdc/500mA.
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Assembled Order Code: AS3180 - **£59.95**

DTMF Telephone Relay Switcher

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Assembled Order Code: AS3140 - **£89.95**

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4 channel computer serial port temperature monitor and relay controller with four inputs for Dallas DS18S20 or DS18B20 digital thermometer sensors (£3.95 each). Four 5A rated relay channels provide output control. Relays are independent of sensor channels, allowing flexibility to setup the linkage in any way you choose. Commands for reading temperature and relay control sent via the RS232 interface using simple text strings. Control using a simple terminal / comms program (Windows HyperTerminal) or our free Windows application software.
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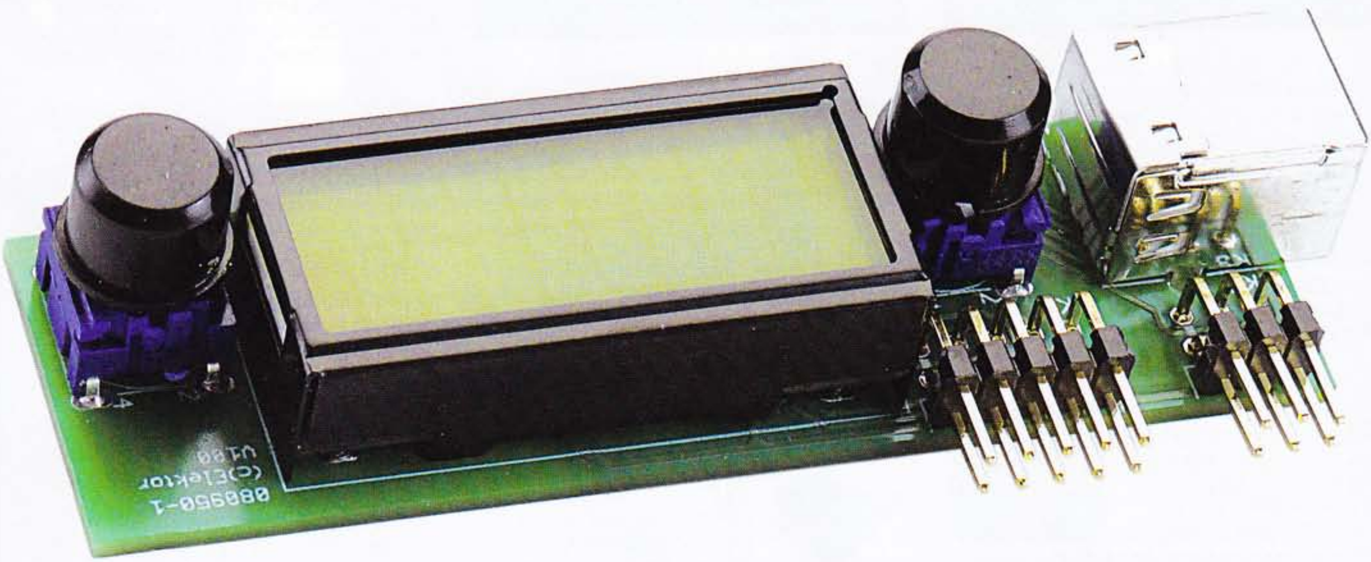
Small is Beautiful: Minimod18

A new microcontroller board for Elektor ATmega projects



By Wolfgang Rudolph and Dr Detlev Tietje (Germany)

Minimod18 is a very compact general-purpose microcontroller module. It includes frequently required peripheral components, such as pushbuttons and an LC display, as well as several interfaces (USB, I²C and ISP/SPI). You only have to assemble the peripheral circuitry necessary for your specific application and connect it to the Minimod18. This way you can build a complete device with entry and display capability in almost no time.

This tiny microprocessor module immediately invites comparison. The KIM-1 computer [1] was a sensation when it was launched in 1976. For US$245, you got a real computer with a 6502 microprocessor running at a 1-MHz clock rate. Of course, the KIM was supplied 'naked': no case, no power supply, and no interfaces (see **Figure 1**). Nevertheless, the first boards cost around £150 at that time and were hard to come by almost everywhere outside of the USA.

In terms of processing power, the Minimod18 is leagues ahead of the KIM. Although the Minimod18 lacks some of the features of the distant ancestor of today's PCs, such as the system monitor program and an abundance of I/O ports, it offers many excellent technical features and is distinctly more compact than the KIM-1. The inset provides a brief summary of the integrated features, including pushbuttons, an LC display, a 64-KB EEPROM, and three interfaces: USB, I²C and ISP/SPI.

Integrated boot loader

The Minimod18 board measures 80 by 25 millimetres (**Figure 2**), which makes it only half as large as the already pleasantly small ATM18 board. It is fitted with an ATmega328P-AU microcontroller in a TQFP32 package [2]. The only essential difference between this microcontroller and the ATmega88 is its considerably more generous memory capacity, so it is fully compatible with our ATM18 projects. This also allows us to sacrifice a bit of the flash memory space for an integrated boot loader.

A boot loader is a small program located at the top of flash memory. If the microcontroller is configured appropriately, it starts this program first. After starting up, the boot loader can establish a link to an external device, receive data, and store the data in flash memory or EEPROM. This eliminates the need for accessory hardware in the form of a programmer. The Minimod18, which can be ordered from the Elektor Shop, comes pre-programmed with an adapted version of USBaspLoader. This means that newcomers no longer have to procure additional programming hardware.

USBaspLoader emulates the very popular and widely used USBasp programmer [3] and is thus compatible with a large number of PC programs, including the widely used program AVR-Dude, which is conveniently included with the GCC compiler (WinAVR). All you need is a USB cable, since the Minimod18 has a built-in USB port. The USB port is connected to the same pins as the 'Passepartout' project featured in Elektor March 2010. Just like it, the Minimod18 board is powered directly from the USB port.

If you hold the left button pressed while applying power to the board (plugging in the USB cable), the Minimod18 enters programming mode and can write data to the flash memory and internal EEPROM. You have to launch AVR-Dude for this purpose. For example: to copy the contents of the file 'hello.hex' to flash memory, enter 'avrdude –c usbasp –p m328p –U flash:w:hello.hex' in the command line (see Figure 3). Press the right button to exit programming mode and

Features

Microcontroller:

- Atmel ATmega328P-AU AVR RISC microcontroller
- 32 KB flash memory
- 1 KB EEPROM
- 2 KB RAM
- 8 ADC inputs
- 3 timers and 6 PWM channels
- 20 MHz clock
- I²C, SPI, and USART interfaces
- Supply voltage 1.8–5.5 V

Board:

- USB socket
- Power supply over USB possible
- 16 MHz crystal
- 64 KB EEPROM with I²C interface
- EADIPS082-HNLED LCD module (2×8 alphanumeric with LED backlight)
- Contrast adjustment trimpot
- 2 buttons
- Connector for SPI/ISP
- Connector for I²C and ADC

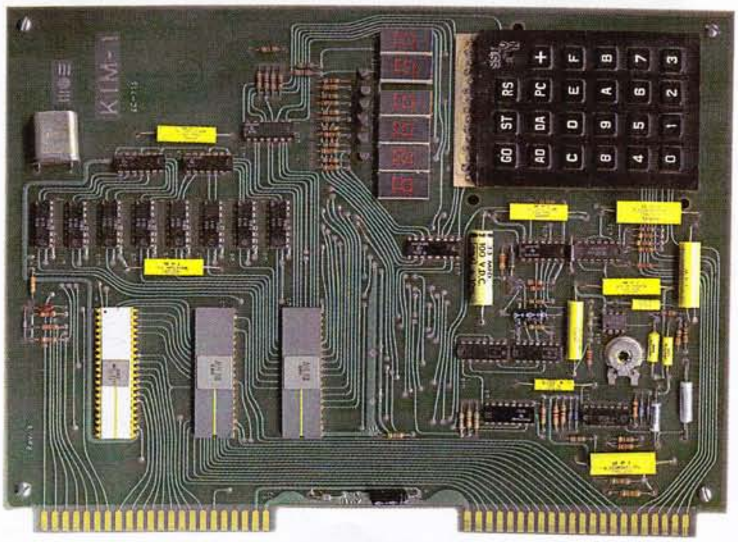


Figure 1. KIM-1 was one of the first hobby computers that did not require any soldering by the user (photo: University of Stuttgart [7]).

COMPONENT LIST

Resistors

R1,R2,R5 = 2.2kΩ (0603)
R3,R4 = 68Ω (0603)
R6 = 10kΩ (0603)
P1 = 10kΩ Trimmer (TC33)

Capacitors (0603)

C1,C2 = 22pF
C3–C6 = 100nF

Inductors

L1 = 10 μH (0603)

Semiconductors

D1,D2 = 3.6V (SOT23)
IC1 = AT24C512 (SO-08M)
IC2 = ATmega328-AU (TQFP32-08), programmed, Elektor order # 090773-41

Miscellaneous

LCD = EADIPS082-HNLED
K1 = 1-pin pinheader, right angled
K2 = USB-B socket
K3 = 6-pin pinheader, angled
S1,S2 = PCB mount pushbutton
X1 = 16MHz quartz crystal (ABM3)
PCB, order # 080950-1 from Elektor Shop
or
ready populated and tested module with preinstalled bootloader, Elektor Shop order # 090773-91

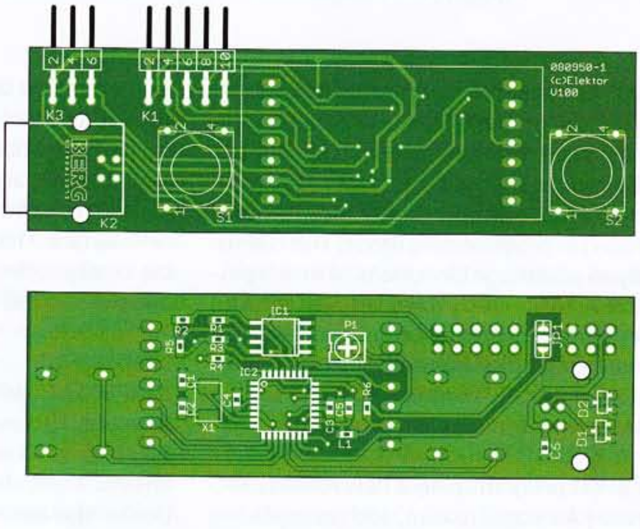


Figure 2. The compact PCB can easily be fitted in your own equipment.

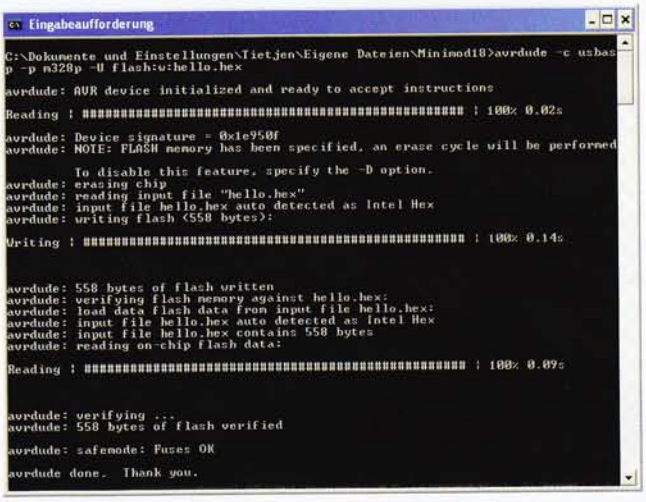


Figure 3. The microcontroller can be programmed in practically no time with the free AVR-Dude PC program.

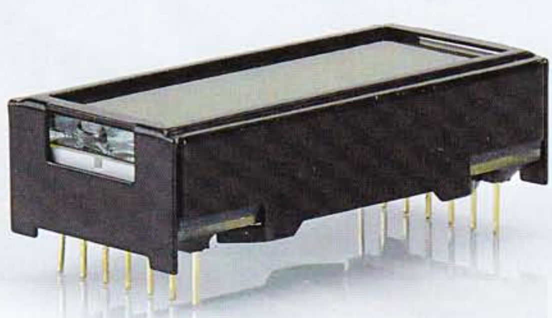


Figure 4. The alphanumeric display module has LED backlighting.

start the application program (the downloaded program). This is all you need in most cases. However, the system does not allow you to change the fuse settings (which control the basic operation of the microcontroller) in programming mode. This is actually an advantage for novices, since it's possible to make costly mistakes with the fuse settings. Under certain conditions, you can even render the Minimod18 totally unprogrammable. By contrast, nothing can go wrong when you use the boot loader.

If direct programming is nevertheless necessary for some reason, such as replacing the boot loader with a new version, you will have to use an external programmer. It can be connected to six-way connector K3. Before you do this, you must alter the configuration of the solder bridge on the back of the board to make the Reset pin available in place of the Slave Select (SS) pin and transform the SPI interface into an ISP interface. This gives you full control over the configuration and programming of the microcontroller.

Display

A DIPS082-HNLED module from Electronic Assembly [4] is used for the display. This is a very high-contrast, backlit module with two lines of eight characters each (**Figure 4**). Unlike the two-wire LCD module of the ATM18 board, it is connected in the conventional manner with a 4-bit bus, which allows the optimised library functions of BASCOM or corresponding modules for other compilers can be used. This only requires adjusting the pin assignments. The same holds true for programs written for the ATM18 board if you want to run them on the Minimod18 board. On the Minimod18 board, PD4–PD7 and PC1–PC3 are used for the Enable, R/W and RS signals (see the schematic diagram in **Figure 5**). The display contrast can be adjusted using trimpot P1.

USB interface

As already mentioned, the USB-B port can also be used to power the Minimod18 board. The port circuitry follows the recommendations of the V-USB project [5] in order to allows USB driver 'USB.Treiber' to be used. This driver is also used for the boot loader. The Minimod18 board is also very suitable for implementing many other applications that simulate a USB device in software, such as a PC keyboard or other device.

The module can be powered either via the USB port or via pin 2 of SPI/ISP connector K3. The module draws around 60 mA, most of which us used to backlight the LC display. If you use the Minimod18 board without a PC, it can be powered from a 5-V AC mains adapter with a USB connector. These AC adapters are available at very reasonable prices.

Other interfaces

A standard SPI interface, which is supported by the Atmel hardware, is provided for driving external peripherals. You can alter the configuration of solder jumper J1 to convert it to a programming interface (ISP port). The pins can also be used individually for digital I/O signals. Pins PB3, PB4 and PB5 are connected to pins 4, 1 and 3 of connector K3.

The three A/D converter inputs (ADC6, ADC7 and ADC0/PC0) are available on pins 3, 4 and 5 of connector K1. This gives the Minimod18 access to the world of analogue electronics. A PWM output of the microcontroller (PD3) is also available on pin 6 of connector K1. It can alternatively be used as an interrupt input (INT1).

The connectors can be used independently (one 6-way and one 10-way) for connect-

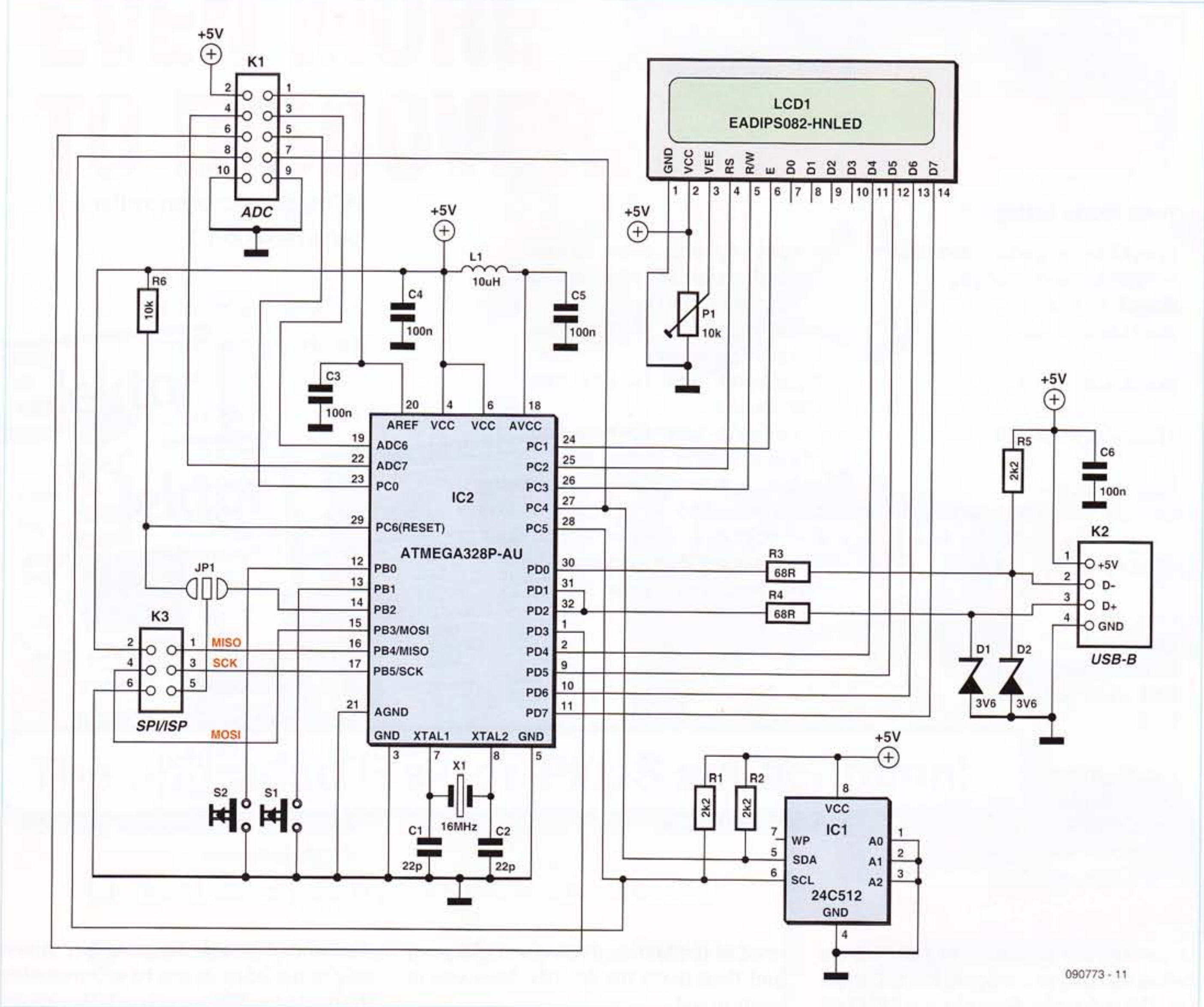


Figure 5. Various ATmega microcontroller signals are available via connectors.

ing your own peripheral circuitry using flat cables. However, it is also possible to fit the additional hardware on a single PCB with a 2-row by 10-way socket header, which can be mated directly with the Minimod18 board.

The AREF input, which supports the use of an external voltage reference, is also fed out to pin 1 of connector K1. There is no jumper for connecting the reference voltage line to V_{CC} as on the ATM18 board, since the ATmega has internal capability for using the supply voltage (AVCC) as the reference voltage.

The Minimod18 board has two pushbutton switches (S1 and S2) that use the internal pull-up resistors of the ATmega microcontroller. S1 (left) is connected to PB1, while S2 (right) is connected to PB0.

The 64-KB onboard EEPROM (IC1) provides sufficient storage space for using the Minimod18 as a data logger, among other possibilities. The 24C512 EEPROM is connected over an I²C bus and can be accessed directly from BASCOM. With GCC, you can simply use the included I²C library.

The entire circuit design corresponds to Atmel's recommendations. An external 16-MHz crystal is provided for clock generation, a 10-kΩ pull-up resistor is connected to the Reset input, and a 100-nF film capacitor is provided for supply decoupling. The AREF input also has an external 100-nF film capacitor, and AVCC is decoupled from the V_{CC} rail by a 10-μH inductor and a film capacitor.

The first program

The controller in the LCD module is compatible with the widely used HD44780 controller. The Internet offers C programmers a variety of libraries for driving LCD modules, which only require configuring the right pin assignments. For maximum compatibility, the R/W input of the LCD module is connected to PC3. This allows polling of the controller's Busy flag, which many libraries in fact do. However, BASCOM does not make any use of this input; instead, it assumes that this pin is tied to ground. Con-

'Hello World' listing

```
$regfile = „m328pdef.dat"       ' specify the used micro
$crystal = 16000000             ' used crystal frequency
$baud = 19200                   ' use baud rate
$hwstack = 32                   ' default use 32 for the
                                'hardware stack
$swstack = 10                   ' default use 10 for the
                                'SW stack
$framesize = 40                 ' default use 40 for the
                                'frame space
$initmicro                      ' run subroutine _init_micro
Config Lcdpin = Pin , Db4 = Portd.4 , Db5 = Portd.5 , Db6 =
   Portd.6 , Db7 = Portd.7 , E = Portc.1 , Rs = Portc.2
Config Lcd = 16 * 2             'configure lcd screen,
                                '8*2 not available
Cls
Lcd „Hello"
Lowerline
Lcd „World"
End                             'end program

_init_micro:
Ddrc.3 = 1
Portc.3 = 0                     'LCD: R/W low
Return
```

ATmega microcontroller pin utilisation

PB0 & PB1:	Buttons 1 & 2
PB2–PB5:	ISP/SPI interface
PC0:	ADC0 / digital I/O
PC1:	LCD E
PC2:	LCD RS
PC3:	LCD RW
PC4 & PC5:	I²C interface (external EEPROM)
PC6:	Reset
PD0–PD2:	USB/RS232 interface
PD3:	PWM/INT1/digital I/O
PD4–PD7:	LCD D4-D7

AVCC, AREF, ADC6, and ACD7 are used for A/D conversion

sequently, it is necessary to pull PC3 low before starting to configure the LCD module. This is done by '$initmicro' in BASCOM. The example program shown in the 'Hello World' listing illustrates how to access the LC display with BASCOM. This program can be downloaded from the project page for this article [6].

What's next?

This general-purpose miniature module is a perfect starting point for developing your own applications. All you have to do is assemble your own circuit on a bit of prototyping board, download your program code to the Minimod18 via the USB port, and then mate the boards. Now you're ready to go!

However, we aren't leaving you entirely on your own. Two applications for the Minimod18 are already under development, and they should be published in Elektor the near future. One is a general-purpose battery charger that only requires assembling the power circuitry on another PCB. The other is a weather station with a data logger and wireless sensors. Here the Minimod18 can also show the acquired data on the display. On top of this, you can run most of the previously published ATM18 projects on the Minimod18 board. This usually requires only minor adaptations to accommodate the hardware differences (available pins and LCD module drive).

Incidentally, we don't plan to toss the ATM18 board on the scrap heap. We will continue to use it in future projects.

(090773-I)

Internet Links

[1] http://en.wikipedia.org/wiki/KIM-1

[2] www.atmel.com/dyn/resources/prod_documents/8161S.pdf

[3] www.obdev.at/products/vusb/usbasploader.html

[4] http://www.lcd-module.com/eng/pdf/doma/dips082e.pdf

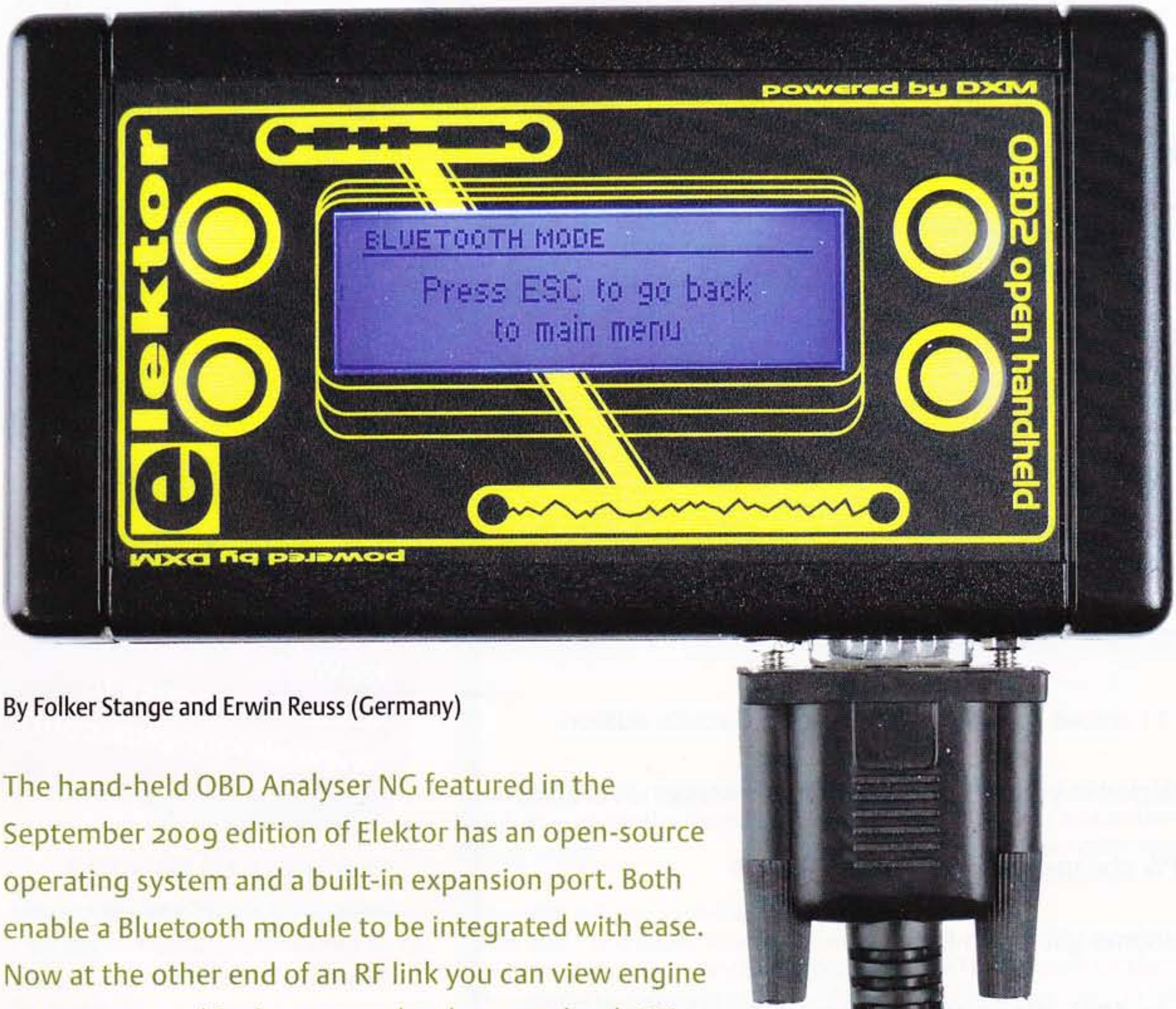
[5] http://vusb.wikidot.com

[6] http://www.elektor.com/090773

[7] http://computermuseum.informatik.uni-stuttgart.de

Bluetooth for OBD-2

OBD Analyser NG goes wireless



By Folker Stange and Erwin Reuss (Germany)

The hand-held OBD Analyser NG featured in the September 2009 edition of Elektor has an open-source operating system and a built-in expansion port. Both enable a Bluetooth module to be integrated with ease. Now at the other end of an RF link you can view engine parameters and faults on a netbook or notebook PC!

The OBD Analyser NG [1] diagnostics tool uses an AT90CAN128 controller with 128 KB flash memory. This is more than enough for hand-held use but if you were planning to implement a trouble-code database you would soon start to feel that memory space was becoming a little cramped. Likewise its simple display is ideal for quick diagnosis of simple problems but does not allow more complex graphical representations of sensor readings. Nowadays the majority of netbook or notebook computers come equipped with a Bluetooth interface and if yours does not have one a low-cost Bluetooth dongle can easily be added. With this in mind, what's to stop us from adding a Bluetooth interface to the popular OBD analyser NG and (with the right software) turning it into a far more useful and sophisticated engine data analyser?

The Bluetooth module

The BTM-222 module is the central player in the expansion of the OBD analyser NG. Regular readers will recognise it from the role it played as an add-on to our ATM18 microcontroller board described in the December 2009 edition of Elektor. In its application here the Bluetooth module and decoupling capacitors are mounted onto a small carrier board soldered to the analyser's expansion port using pinheader strips. Printing the quarter-wave antenna directly on to the PCB simplifies construction and assembly of the expansion board into the case of the OBD analyser.

The BTM-222 is a class 1 type of mod-

Features

- Bluetooth Class 1 (range up to 100 m)
- Antenna printed on the PCB
- RF data rate of 19200 Baud
- Low cost Bluetooth module
- 28 mm x 38 mm PCB.

ule which specifies a maximum transmitter power of 100 mW (20 dBm), giving a range of around 100 m (300 ft). In order to achieve an RF link over this distance it is necessary for the Bluetooth transceiver in the notebook or netbook to also be Class 1. A Class 2 or 3 module will result in a reduced operating range (see **Table 1**). If your PC has low-power or no Bluetooth capability then a Bluetooth USB stick (make sure it's Class 1) can be added at very little cost.

The circuit and construction

The circuit (**Figure 1**) consists of just a Bluetooth RF module (IC1), a voltage regulator (IC2) and two rows of pinheaders (J1 and J2). IC2 converts the 5 V supply to 3.3 V required by the Bluetooth module. The pinheaders carry the 5 V supply and three control signals. Port pin PF5 from the analyser's microcontroller is used here to switch the power regulator on the BTM-222 under software control. PF6 and PF7 carry the serial data communication between the BTM222 and a software UART in the OBD analyser.

Assembling the expansion board and fitting it to the analyser is relatively simple. The PCB (**Figure 2**) is supplied with the voltage regulator and supply decoupling capacitors already fitted so it is only necessary to mount the BTM-222. Do this in the same way that you would solder a large SMD IC but just solder the Rx, Tx, antenna, supply voltage and ground pins to their PCB pads. Just five pins of the OBD analyser's expansion port are required by the expansion module (see photos). All of the 20 pins however pass through the expansion board (**Figure 3**) to facilitate any future developments.

Get your motor running

Before we can begin communications with the Bluetooth module we need to check that the OBD analyser NG is running the latest firmware version (available from the Elektor website [2]). The firmware supporting Bluetooth operation is the file named HandheldOpen_121 in the zipped folder 090918-11. This latest firmware version has been shipped with the OBD analyser NG kit since January 2010. Those of you who took delivery before this date will need an ISP programmer (e.g. either [3] or [4]). See the 'Firmware update' text box for details of how to transfer the latest firmware version to the controller.

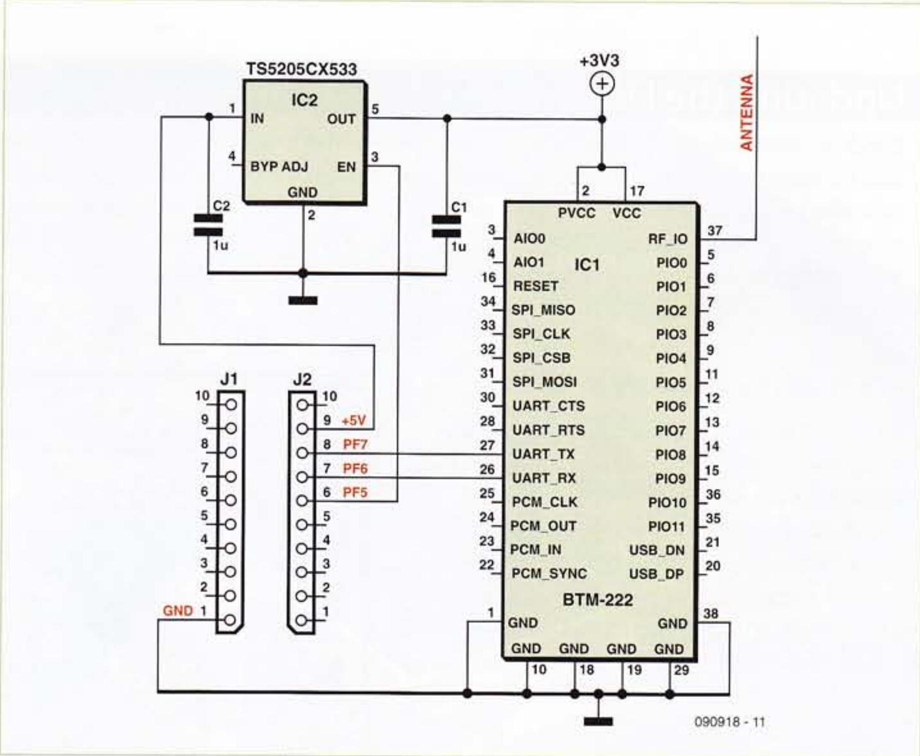


Figure 1. The complete Bluetooth expansion circuit requires little more than the BTM-222 Bluetooth module and a voltage regulator.

Table 1. Bluetooth Class vs. range			
Class	Max. Power [mW]	Max. Power [dBm]	Range (unobstructed) [m]
Class 1	100	20	approx. 100
Class 2	2.5	4	approx. 50
Class 3	1	0	approx. 10

COMPONENT LIST

Capacitors
C1,C2 = 1µF SMD

Semiconductors
IC1 = BTM-222 Bluetooth radio module
IC2 = TS5205CX533 (SMD SOT23)

Miscellaneous
J1,J2 = 10-pin pinheader
Kit of parts, contains partly populated PCB and all components. Elektor Shop # 090918-71, see www.elektor.com/090918

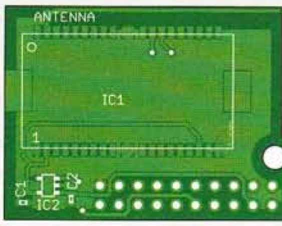
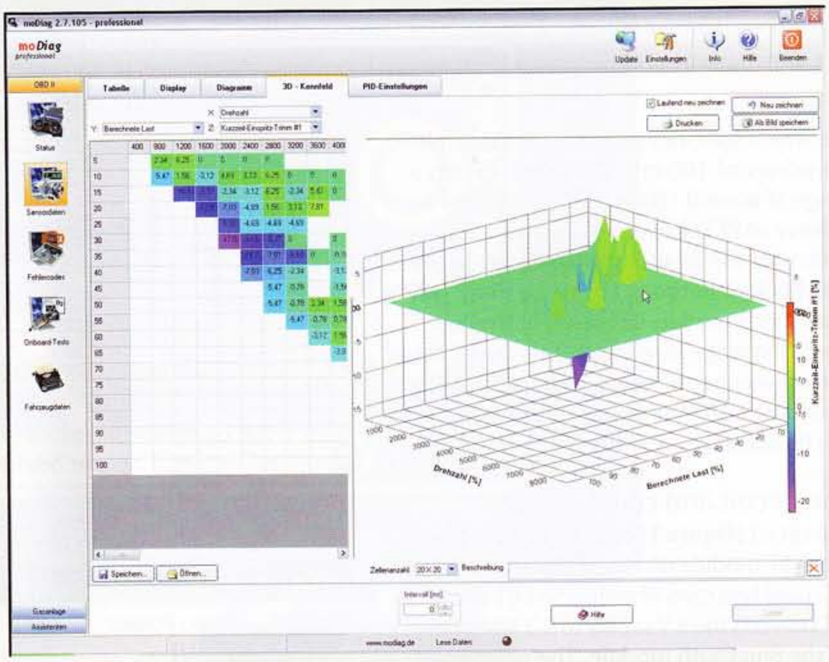


Figure 2. The Bluetooth PCB uses a length of PCB track as a 'printed' antenna.

Updating the Firmware

Check the OBD analyser NG main menu options, if the Bluetooth mode is not available (all versions below build 121) then you need to download the latest firmware version from the Elektor Website [2]. You will require an ISP programmer with a 10-pin connector to fit the Atmel AVR controller family of devices (see [3] or [4] for example). This is connected to programmer socket SV1 on the component side of the PCB. If the programmer provides a supply voltage on pin 2 of SV1 the analyser should be unplugged from the vehicle's OBD connector for programming. In this case fit jumper J3 (behind pin 2 on SV1). The downloaded software ZIP folder can now be unpacked to a directory and the software run. Firmware update will take just a few seconds.

PC software for the OBD Analyser NG



So far we have dealt with the OBD analyser NG's hardware expansion. The only thing missing is diagnostic software running on the laptop to interpret and display engine data. The moDiag program [5] performs this function and is available as three different versions offering increased levels of sophistication. MoDiag is optimised for OBD interfaces using AGV and DIAMEX chip sets and therefore ideally suited for the Elektor OBD analyser NG which uses a DXM module.

The program stores sensor readings during transit in files with a *.csv extension for later analysis using spread sheet programs such as MS Excel. Bluetooth communication removes the need for any in-car cabling which could potentially distract the driver. Also interesting is the graphical representation of the lambda readings which can be used to identify a worn-out sensor. The ability to combine several sensor readings on the display gives the laptop a big advantage. In contrast the hand held OBD analyser on its own does not allow this flexibility. Similarly a database containing the meanings of all the possible diagnostic trouble codes greatly speeds up fault identification whereas the hand held unit does not have memory space to accommodate this feature. The moDiag 'professional' version can also map a 3D representation of a combination of sensor data.

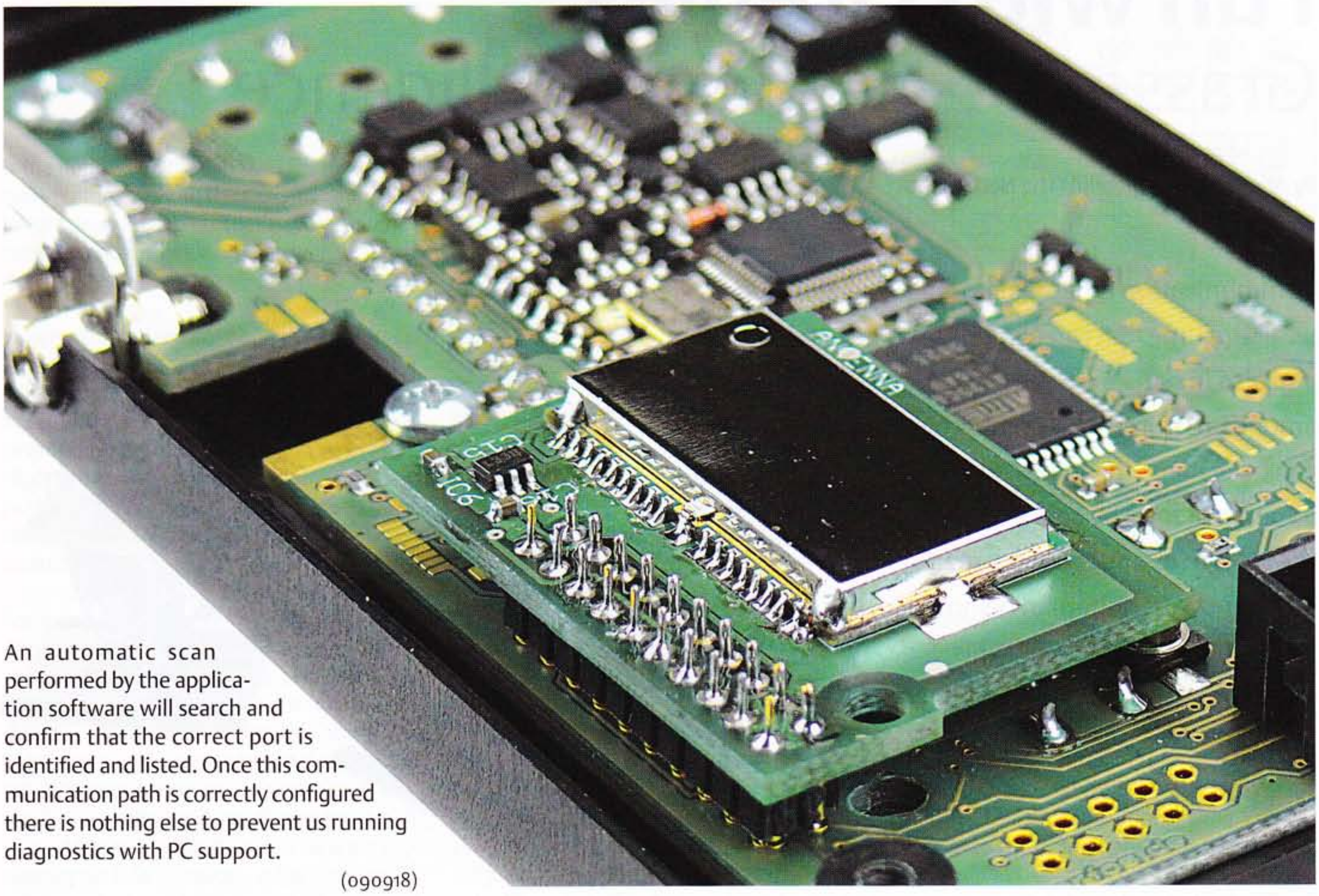
Using either the moDiag 'expert' or 'professional' version allows continuous measurements of engine power and torque to be displayed as a graph. The current instantaneous value is also shown on the display. The professional version also includes a special LPG adjustment mode to optimise an engine set up for LPG operation and includes a large library of trouble code meanings. The 'professional' version is useful for vehicle workshops and includes functions to optimise LPG engine conversion settings and also has an extensive data base to store documentation, diagnostic reports, data readings and gas conversion details of every customer's vehicle.

The Bluetooth set up procedure described in the text can be simplified by the use of a small assistant in the moDiag program which independently searches for the interface and in most cases avoids the need to use the Windows device manager.

moDiag is suitable for PCs running Windows 2000, XP, Vista or Windows 7. The standard version of the program is free and available for download from the Elektor website [2].

Matthias Tieben

For operation you will require a Bluetooth-capable Windows notebook or netbook (as described above). The first step is to plug the OBD analyser NG into the vehicle's OBD connecter. Now select the Bluetooth option (**Figure 4**) from the menu on the OBD analyser. When activated the blue backlight lights up. On the notebook Windows will indicate that a new Bluetooth device is available. A serial port should have been found, click on this and then 'next'. Now enter a passkey, in our case we simply use the sequence '1234' and then press Enter. Windows now activates the newly found Bluetooth device and displays some COM ports. The first 'detailed' COM-Port is the one which needs to be entered into the application software (OBD software running on the notebook) as the communication port. The application software can be the 'moDIAG' [5] software, or similar.



An automatic scan performed by the application software will search and confirm that the correct port is identified and listed. Once this communication path is correctly configured there is nothing else to prevent us running diagnostics with PC support.

(090918)

[1] www.elektor.com/090451

[2] www.elektor.com/090918

[3] www.elektor.com/080161

[4] www.stange-distribution.de (click on the Union Flag)

[5] www.modiag.de/english/mobydiag_pro.htm

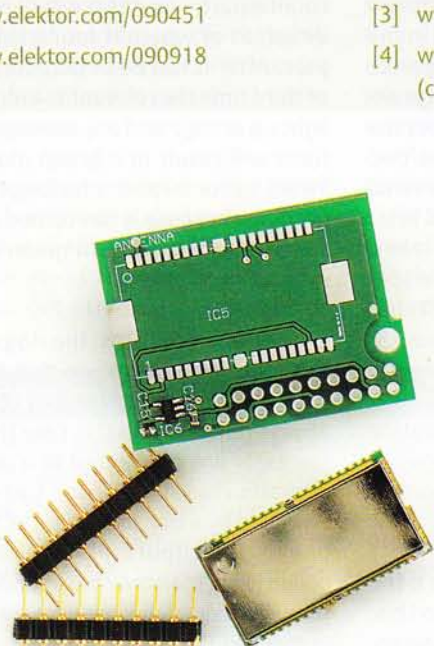


Figure 3. The PCB comes with the supply decoupling capacitors and voltage regulator already mounted.

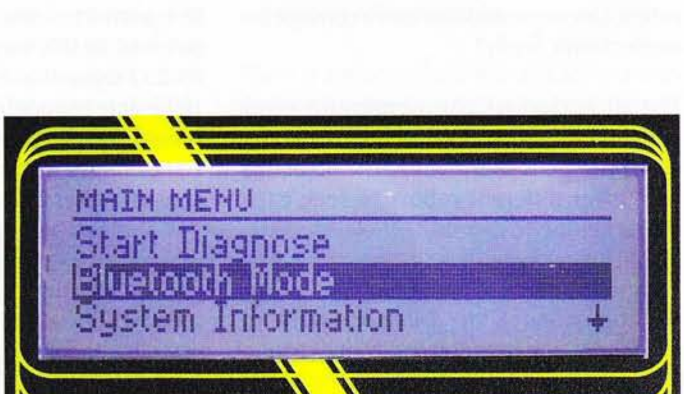


Figure 4. The latest firmware now has a Bluetooth option.

Fun with Fireflies
Grass-roots artificial intelligence

By Abraham Vreugdenhil (The Netherlands)

Communication is happening everywhere around us all the time. Between people, computers and also in nature we see communication among creatures. This communication can have many meanings, like indicating a source of food by ants and bees, the search for a suitable partner by other animals, or human beings simply being sociable. It is this communication, between 'fireflies' in particular, that's being explored here in a fun way and on a shoestring budget.

Fireflies flash their lower abdomens in an attempt to attract members of the opposite sex. In the dark these flashing fireflies form a fascinating spectacle. Searching, finding and communicating, that is the object in this case. This has strong similarities with all kinds of electronic applications. But to what extent can we mould this into a concept for an electronic firefly?

The direction of the communication between different, small robotics circuits forms the basis of this idea. The objective here is for different robots to seek each other out and to recognise their response. For the sensors we use an infrared transmitter and receiver. A ring of eight bi-colour LEDs functions as the visible 'memory' of our 'Firefly' and indicates in which direction it has recognised a counterpart. The Firefly looks around with the aid of the servo on which it sits. All this is driven by a simple-to-program microcontroller type ATmega88.

Operation

The main objectives of the Firefly are orientation and communication. To do this you have the ability to communicate using an infrared (IR) signal. This is done with the circuit shown in **Figure 1**. You use the serial output of the microcontroller, so that you can simply use the *print x* command in the software program. You then take a separate output of the processor and use it to generate a 36-kHz square wave. You connect the IR transmitter diode between these two outputs. In this way you generate a serial RS-232 signal that is modulated at 36 kHz. To be able to receive this signal you take a special IR-receiver, type SFH 5110. The special attribute of this receiver is that it has a 36-kHz filter built in, creating a nice RS-232 signal that you can connect directly to the serial input of our microcontroller. If you use a somewhat slow communication speed (2400 baud in our case), then you can establish some very effective communications between multiple robots.

You can accomplish the orientation if the Firefly is able to look around. To do this, the robot is mounted on a modified servo. A normal servo rotates through an angle of only 270 degrees, but in this circuit a continuously rotating servo is used (see sidebar 'Servo modification'). In this way the Firefly can scan its surroundings with the IR-receiver. The first time it recognises a counterpart, a red LED will light up in the direction of where it found this counterpart. After it has been detected a second or third time the relevant bi-colour LED will light up orange and any subsequent detections will result in a green glowing LED. When a counterpart is no longer detected (perhaps because it has turned away), the series reverses, so from green to red and eventually off.

When the robot turns, the ring of LEDs on the robot also 'turns', so that those LEDs pointing in the direction of its counterparts always remain lit. In this case the 8 bi-colour LEDs are connected in a matrix configuration to save I/O pins. Each column is switched by a transistor type BC547. When one of the outputs (PD4 through PD7) is pulled High, then the corresponding transistor will conduct and one or more of the four outputs PC0 through PC3 are pulled High, so that the corresponding LEDs will light up. A short time later another transistor is turned on allowing 4 other LEDs to come on also. Since this happens quite quickly there is the impression that all 16 LEDs are turned on simultaneously. In the program, a slightly longer delay is used in order to obtain somewhat of a slowly blinking effect, just as with real fireflies.

When starting up there is the option of entering the calibration procedure for the servo. Pushbutton S1 is used for this. A 22-kΩ pull-up resistor ensures that the corresponding input of the microcontroller is High and only goes Low when the button is pushed. The calibration procedure is started when the signal at the input of the microcontroller (PB1) is Low.

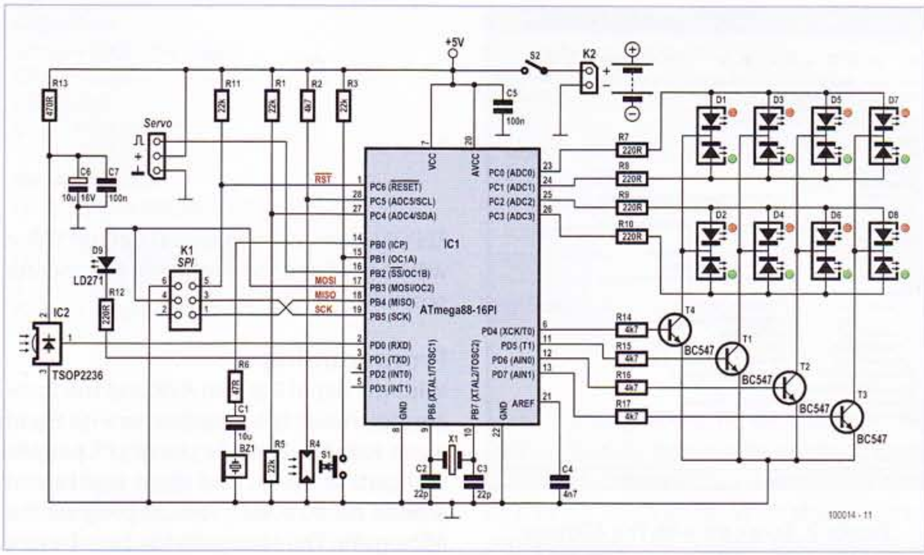


Figure 1. The schematic for the Firefly is quite minimal. There is nevertheless a type of intelligent communication.

For peripheral devices there are a light dependent resistor (LDR), a piezo transducer and a voltage divider available. The LDR in our design is used to simulate randomness, to determine whether the servo is to turn to the left or to the right. A 10-bit ADC measurement is performed and the value of the least significant bit (bit 0) is used for certain decisions. The least significant bit (LSB) changes value frequently, particularly since this was made dependent on the ambient light. Very small changes in light level that are almost impossible to detect will result in a very rapidly changing value of the least significant bit. This creates a primitive but effective pseudo-random number generator.

To drive the piezo-transducer a resistor of about 47 Ω is required and a small electrolytic capacitor of 10 µF, 16 volts w.v. When you buy the piezo transducer, do make sure that you get a transducer mounted in a housing. Without the housing you won't be able to hear much.

Software

The 'brains' of our Firefly is of course the software that runs in the ATmega88. The program, *FireFly_v1.bas*, is a free download from the project web page [1]. It basically consists of a main loop, which repeatedly sends the number '1' by using the *print 1* command. Subsequently, the Firefly will turn 45 degrees in a random direction depending on the *servo_dir* variables and a check is made whether a character has arrived at the serial input using the command *A = Ischarwaiting()*. If this is the case then the variable *Target* is set.

The 16-bit variable with the name *Long_Led* contains information about the state of the eight bi-colour LEDs. The lowest bit is the green LED1, the second bit is the red LED1, the third bit the is green LED2, the fourth bit is the red LED2, etc. With the call to *L_led_bew(servo_dir_2 , Target)* this variable is continually updated, based on the turning direction of the servo (*servo_dir_2*) and if something has been seen (*Target*). The interrupt service routine that runs in the background, continually jumps to the label *Display_led*. Each time in that subroutine the next four bits of the variable *Long_Led* are copied to the correct positions of the eight bi-colour LEDs.

In the main loop, based on the measurement of the LDR, a decision is made as to which direction the servo will turn. If the lowest bit is a '1' then the servo will turn to the left, if it is a '0' then it will turn to the right instead. All this will give the appearance that the Firefly-circuit lives a life of its own.

There is a routine built into the software to deal with servo specific tasks. Each type of servo requires a different amount of time to turn a specific amount. This is deter-

Programming language

The software for the Firefly is written in BASCOM AVR. This basic-compiler has been especially written for the Atmel AVR series of processors to which the ATmega88 also belongs. Programming microcontrollers with BASCOM AVR represents a nice introduction to microcontrollers and robots. The compiler is well supported, has clear documentation with many examples and the demo version can compile a program of up to 4K. That's more than enough for many projects, including this one. The registered version has no limits in program size and is fully supported. In previous issues of Elektor (September 2008 through January 2009, among others) more detail is provided on BASCOM and you are kindly referred to those pages.

The ATmega88 is also very suitable for use with a so-called bootloader. That's a piece of software allowing the software to be programmed without using the ISP cable, but by using the IR-connection instead. For this purpose you obtain a bootloader from the internet [3] and add the routine that generates the 36-kHz carrier signal. So now you can reprogram the Firefly with a new program using a USB-IR module, without needing a cable between the Firefly and the computer. Reprogram the Firefly on the fly, so to speak.

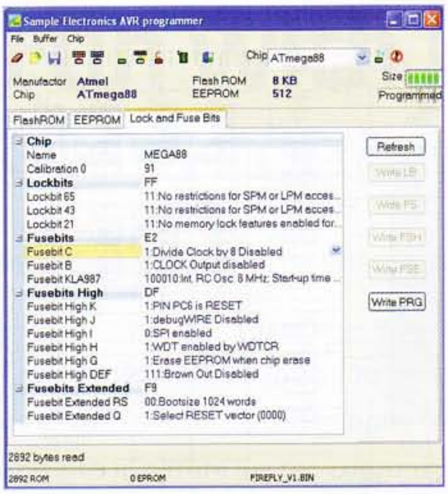


Figure 2. Take care with the ATmega fuse bit settings! If you accidentally use the wrong settings it is possible that the controller cannot be programmed any more using ISP.

mined by the subroutine *Ijken:* This routine is called when S1 is pressed while the Firefly is switched on. At the end of the routine the values are stored in the EEPROM of the microcontroller. If you start the Firefly without pushing then S1 the microcontroller retrieves this information from its EEPROM. If there are no values stored in the EEPOM then an (erroneous) default value will be used and the Firefly will not operate properly.

The prototype may look somewhat 'unfinished', but that is why it is called a prototype.

Programming

With the aid of Bascom AVR and the Sample Electronics ISP-programmer [2] (easy to make with the use of a cheap LPT peripheral card in the PC and three resistors of around 300 to 500 Ω) you can program the ATmega88. The Atmega88 has been factory preset to use the built in 8-MHz oscillator and the divide-by-8 internal divider for the clock speed. These settings cause (timing) problems with the servo controller, so you have to change a Fuse-bit. The relevant Fuse-bit is *C* (see **Figure 2**). This is by default enabled and in your case it has to be changed to Disabled. Afterwards the program will run at 8 MHz instead of the default 1 MHz.

By the way: When you're looking at the Fuse-bits you will notice that there are many different settings for all kinds of things. Different clock speeds, internal clock, external clock, bootloader enable, far too many to mention. But be careful! If you accidentally select the bit for external clock, for example, then the circuit will no longer work and you will not be able to get it going again with the ISP programmer. You will then require a 'real' programmer capable of pulling the reset pin to 12 V, which allows the processor to be brought back to life. Alternatively you will need to connect an external clock from another, working processor. All annoying and a hassle, so take care!

When the software is programmed via the ISP into the controller, the EEPROM is also overwritten. Consequently the servo calibration procedure needs to be repeated every time the ATmega is reprogrammed via ISP.

Getting started

A printed circuit board was designed for this project, which is available from the Elektor Shop as item # 100014-1. The board contains a few eye-catching features: the ring of eight bi-colour LEDs, the IR receiver, the IR transmitter, the connectors for the servo and the ISP programmer, the two contact pins for the ping-pong ball bracket and, of course, the microprocessor. Because the IR receiver can also sense the IR light that is transmitted by the IR LED on the board, you need to make a metal screen of 15 x 15 x 15 mm. Any 'light leaks' can be plugged with correction fluid (like Tipp-ex) or similar. This is easy to use and once it has dried it blocks all light. Using 18 to 20 cm of spring steel wire (piano wire, 0.3 mm diameter), make a bracket to suspend the ping-pong ball. In this ping-pong ball you melt two small holes to capture the spring steel wire. At both ends solder a push-on connector so that the ping-pong ball can be easily attached and removed. The ball is mounted directly above the IR LED, so that it becomes a diffused beacon, visible from all directions.

The PCB is attached to the servo. For the four cells you could use, for example, a 1x4 or 2x2 AAA battery holder. Either can be attached with a cable tie, Velcro or double-sided tape to the servo. The optional piezo transducer may be mounted to the side of the servo with some double-sided tape.

The servo is attached to a base with its driving wheel. This base consists of an old 3.5" floppy disk, to emphasize that it is a true foundation in more ways than one. Drill a 2 to 3 mm hole and screw the disk directly to the servo wheel. Four rubber furniture felt pads can help to prevent the floppy disk from sliding around.

Calibration

Each type and brand of servo is slightly different. As a consequence you have to calibrate the servo. This is what the servo calibration program is about. When switching the Firefly on (with S2), the controller checks whether S1 is pressed. When S1 is pressed, the servo will turn increasingly slower. When it stops you have to release S1. Press S1 again. The servo will start to turn again and slowly reduce its speed until it reaches standstill. Release S1 again. The first time round is a coarse calibration, the second, a fine calibration. In this way the controller has 'learned' when the servo stops. Now you have to teach it how fast the servo turns around. Press S1 again, the motor will turn again and now release S1 after two full revolutions are completed. Repeat this once more (the motor will now

COMPONENT LIST

Resistors
R1,R3,R5,R11 = 22kΩ
R2,R14,R15,R16,R17 = 4.7kΩ
R4 = LDR, e.g. type A9060, Conrad Electronics #. 145475
R6 = 47Ω
R7,R8,R9,R10,R12 = 220Ω
R13 = 470Ω

Capacitors
C1,C6 = 10µF 16V radial
C2,C3 = 22pF
C4 = 4.7nF
C5,C7 = 100nF

Semiconductors
D1,D2,D3,D4,D5,D6,D7,D8 = bicolour LED, 5mm
D9 = IR LED, 5 mm
T1,T2,T3,T4 = BC547
IC1 = ATmega88, programmed

Miscellaneous
X1 = 12MHz quartz crystal
BZ1 = AC buzzer
S1 = SPNO pushbutton, Tyco Electronics type FSM4JH
S2 = SPDT miniature switch, C&K type ET01MD1CBE
K1 = 6-pin (2x3) pinheader
PCB, order # 100014-1, see www.elektor.com/100014
Servo motor
Ping-Pong ball

turn the other way) and the controller is able to calculate the amount of time required for a 45 degree turn.

Current consumption

The Firefly uses four AAA (LR03) batteries as its power source because of their versatility. The eight bi-colour LEDs together with the IR transmitter, IR transceiver, the controller and not forgetting the servo use about 100 mA. The capacity of good alkaline AAA batteries is typically 900–1150 mAh. This allows the Firefly to operate for about ten hours on a set of fresh batteries. Rechargeable AAA cells can also be used, but when using these make very sure that there are no short circuits anywhere. With an alkaline battery the voltage drops quickly when the current is too high, but with a rechargeable batter the voltage remains high, which can lead to charred, defective components.

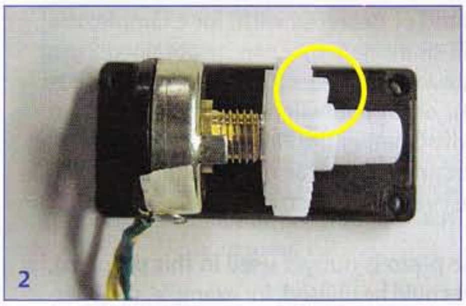
Experimenting

The IR communication takes place via the 36-kHz modulation of the RS-232 signal at 2400 baud. This signal can easily be generated or detected with, for example, the USB-IR module that can be obtained from Conrad Electronics (part number 993137-89), or an equivalent. With this you can verify whether the Firefly is transmitting IR ight and you can also send light, to which the Firefly will react.

The piezo is not yet used in this program, but could be utilised, for example, to generate a certain sound depending on how many 'counterparts' the Firefly has detected.
The resistive divider, comprising two 22-kΩ

Servo modification

1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3

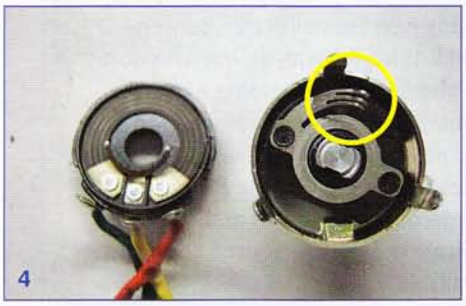
A servo operates with an input signal of 1 to 2 ms that is repeated every 20 ms. A signal of 1 ms means that the servo is rotated completely in one direction, 1.5 ms means the centre position and at 2 ms the servo rotates completely to the other direction. Servos normally rotate through an angle of about 270 degrees, but here we want to it to turn all the way around. We therefore have to modify the servo.

The modification in principle comprises three things: removing the end-stop so that the mechanics can rotate through a full 360 degrees, taking out the potentiometer and replacing it with two fixed resistors so that the electronics in the servo thinks that the potentiometer is always in the centre position.

First we disassemble the servo (**Photo 1**) and with a sharp knife remove the end-stop from the final gear (**Photos 2** and **3**). Now we will (partially) remove the potentiometer. There are two types of potentiometer. With cheaper servos, such as the Hitec-300 that we used here, the shaft of the potentiometer is the same as the shaft of the final gear in the servo. When we want to remove the potentiometer we will have a problem with the attachment of the final gear of the servo. If the servo has a separate bearing for the final gear, then we can simply take out the potentiometer. In the first case we have to modify the potentiometer instead of removing it. Open the potentiometer (**Photo 4**) and remove the wiper and that part that rotates inside the potentiometer and hits against the internal ridge with a small drill and a hobby knife (**Photo 5**). You don't need the 'lid' of the potentiometer (with the carbon track), so leave that out.

In place of the potentiometer you need to connect two resistors on the servo PCB. First check the resistance value of the potentiometer (usually 5kΩ) and take two resistors that together also have about this same value. Two resistors of 2.2kΩ or 2.7kΩ each are suitable in our case. Connect them to the servo PCB instead of the potentiometer (**Photo 6**). Make sure that you connect the resistors in such a way that it appears to the electronics that a potentiometer is connected and that it is always in the centre position.

Before putting the servo back together, check that that all the parts of the servo are able to rotate around completely. Now you're ready to reassemble the servo (**Photo 7**) and check once more that the servo can rotate 360 degrees. The servo is now ready for use.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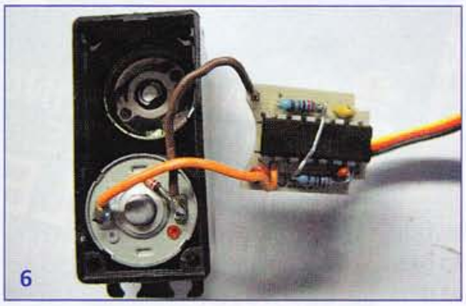

6

resistors, is not yet used either. At the node between these two resistors you should be able to measure half the power supply voltage, with a resolution of 10 bits (1024 steps from 0 to 5 volts). You could use this to measure the condition of the batteries quite accurately. In theory, the operation of the servo changes when the battery voltage decreases. This changing characteristic could be compensated for, based on the measured voltage.

The Firefly circuits are all identical. They all send the same message and all look for the same information. Whenever 'something' arrives, they recognise that and respond to it. They could also each have their own identity or number. In this case each Firefly transmits a different message. The program could then be adapted so the Fireflies will recognise only certain counterparts before reacting. You are free to experiment with this circuit and there is no maximum number of Fireflies that can communicate with each other. The more the merrier...

(100014-I)

Internet Links

[1] www.elektor.com/100014

[2] http://8051help.mcselec.com/index.html?sampleelectronicsispprogrammer.htm

[3] http://mcselec.com

Burn or Turn?

1- and 4-cilinder motors from trashed hard drives

By G. van Zeijts (The Netherlands)

Has your hard drive crashed? Don't throw it away! You can still use it in many interesting projects. As an example, the author has used the read/write arm to make an alternative motor that is controlled via the PC.

No doubt some readers will have experienced this at some time: the hard drive in the PC has given up the ghost. This is very irritating, and even more so when you haven't made a backup of your data. The silver lining of this cloud is that inside every hard drive is an interesting part, which we'll make use of in this article. The online encyclopaedia Wikipedia refers to this part as an 'actuator' [1].
The actuator moves the read/write arm of the hard drive, on which the magnetic read and write heads are mounted, to the correct position. The actuator is controlled via a clever bit of electronics, which is found inside every hard drive. The actuator itself is nothing more than a coil inside a very strong magnetic field.

The nice thing is that the arm has quite a long throw and is comparatively powerful. This article should motivate the real do-it-yourselfers amongst us to start experimenting with these actuators. It shouldn't be the end of the world if you don't have a broken hard drive to hand. Since a fair number of hard drives crash you'll find that every computer repair shop will have a few in their bin. If you ask nicely you may even get them free of charge.

Actuator

What exactly does one of these actuators look like? Once you've removed the cover and electronics from the old hard drive you're left with an aluminium plate with two motors: one to rotate the platters and one to position the read/write arm. The latter is the actuator that we're after.
To make it easier to work with, we first remove some of the aluminium plate so that just the actuator remains (see **Figure 1**). Be careful that you don't cut through any of the steel parts, since the steel filings will immediately fly to the magnets. They'll be very difficult to remove again, since those magnets are really powerful!

At the end of the actuator arm are the read/write heads, but we have no use for these here. The interesting part for us is the coil that turns between the magnets. The two connections for this coil are made with two very thin wires that usually go to a multi-pole connector. We have to find these two connections and provide them with a separate connector. One possibility is to use a terminal block, as can be seen on the right in Figure 1.

The resistance of the coil is usually somewhere between 8 and 12 ohms, which makes it perfect for use with a 5 volt supply. The motor will obviously provide more power if you put 12 volt across it, but this can only be done for short periods! Otherwise the coil turns into a small heater (with a very limited lifespan)! Reversing the + and – causes the actuator to provide a force in the opposite direc-

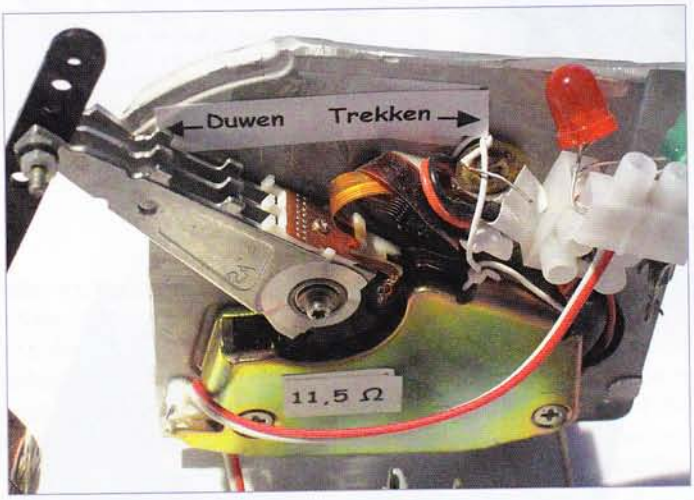


Figure 1. It makes it easier if we remove part of the aluminium plate (left) and connect the actuator coil to a terminal block (right).

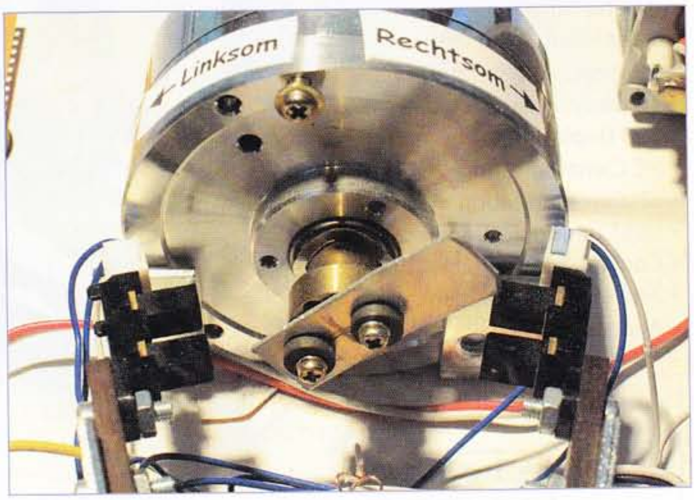


Figure 2. The metal plate that moves through the two photointerrupters tells the PC what the position of the crankshaft is.

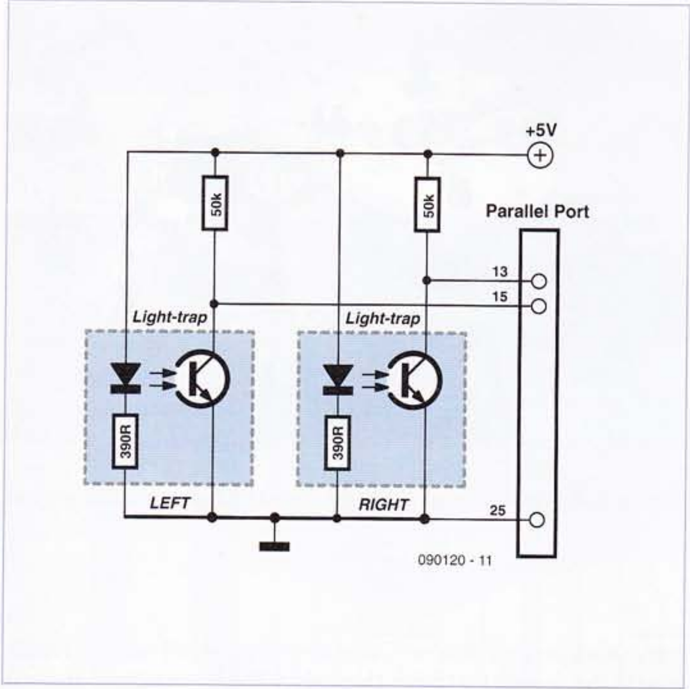


Figure 3. The outputs of the photointerrupters are connected to the parallel port of the PC.

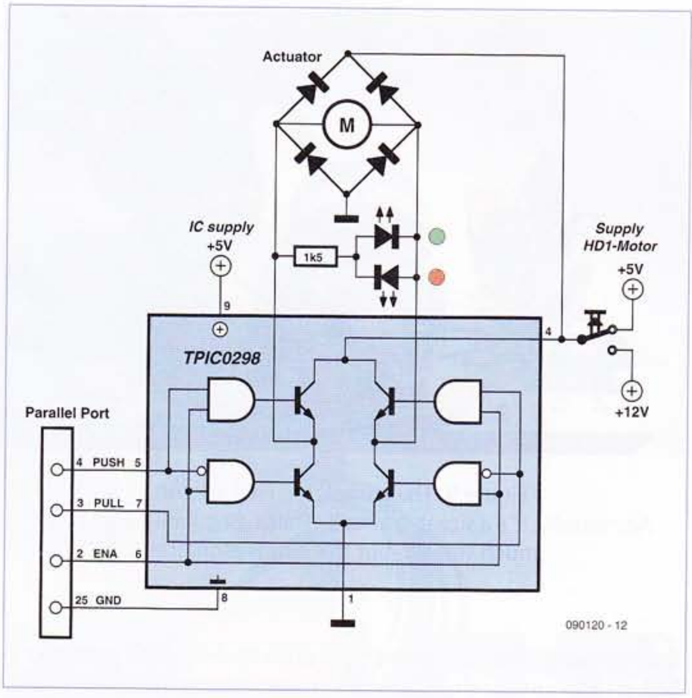


Figure 4. Three outputs from the parallel port (and a ground connection) are required to drive the HD1 motor.

tion. When a computer is used to control the actuator any real DIYer should be able to come up with various ideas to try out

What can I do with it?

An actuator normally doesn't get much attention, but it should be ideal to drive 'something', considering the relatively large force it can provide. As an example, you should be able to make a rotating motor, which works using the same principle as that used in a car engine. The back and forth motion of the actuator is converted into a rotary motion by the crankshaft. Since an actuator is used as the driving element, our project was given a suitable name: the HD motor, (HardDisc motor)
In this article we look at two types:

- a single-cylinder motor, driven by 1 actuator (the HD1 motor)
- a four-cylinder motor, driven by four actuators (the HD4 motor)
-

Since the HD1 motor is more interesting as far as the control is concerned we'll look at this in more detail.

The HD1 motor

The arm of the actuator has to be connected to a crankshaft. For this a read/write head from a broken video recorder was used. This part has very smoothly running bearings and it even has a small flywheel, which reduces the shocks in the rotating movement.

The actuator is capable of pushing or pulling, depending on the polarity of the supply voltage applied to the coil. Since there is often a need to reverse the rotation of DC motors in various devices, dedicated ICs have been developed for this purpose. This IC also has a function built in for the control of the speed of the motor. The paragraph on 'The driver chip' explains the workings of this IC in more detail.

In order to determine when the actuator has to push or pull, a piece of metal has been mounted on the crankshaft, which rotates through two photointerrupters (see **Figure 2**). From these the computer can determine the position of the crankshaft and hence output the correct signal for the actuator to push or pull. The speed of the HD1 motor can be controlled via the computer (see the paragraph 'The driver chip'). To see if the actuator is pushing or pulling, a red and green LED have been connected in parallel with the actuator.

Connections to the PC

The connections from the photointerrupters to the computer are shown in the circuit in **Figure 3**. All connections are made via the parallel port. Two inputs are used: one to indicate that the crankshaft is in the left position and one for when it is on the right. The type of photointerrupter used isn't important. Just about anything should be suitable. A photointerrupter from an old printer or out of a mouse can easily be used here, for example.
Three outputs from the parallel port are used to drive the actuator. One to make the actuator push, one to make it pull and the last one is for speed control (enable) (see **Figure 4**).

The driver chip

The driver chip for controlling the actuator sits between the parallel port and the motor. For this we've chosen an IC with the part number TPIC0298 (other numbers such as TLP298 or L298N are also used for this IC). This is a so-called 'Dual full H-Driver', obtainable from various sources. Further details on H-Drivers (also called an H-Bridge) can be found on the Internet, for example on [2] and [3]. This IC was originally designed to control a bi-directional stepper-motor, but it can also be used to drive two DC motors independently and make them turn in either direction.
The circuit in **Figure 4** shows the IC and the connections between

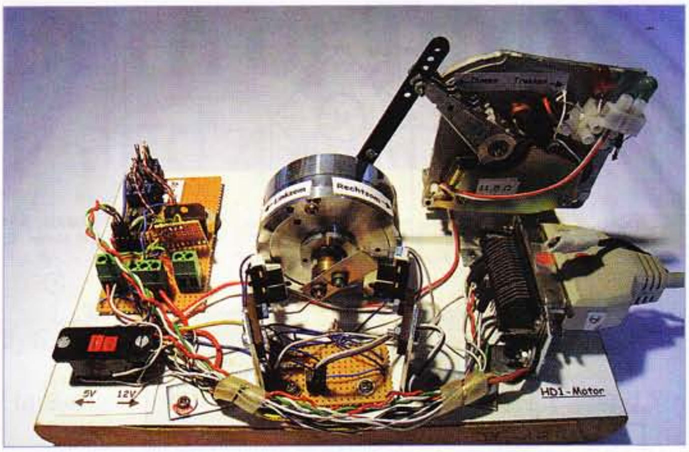


Figure 5. The completed HD1 motor.
Admittedly, it's a sizeable circuit. These days it could be made much smaller, but this way is more fun.

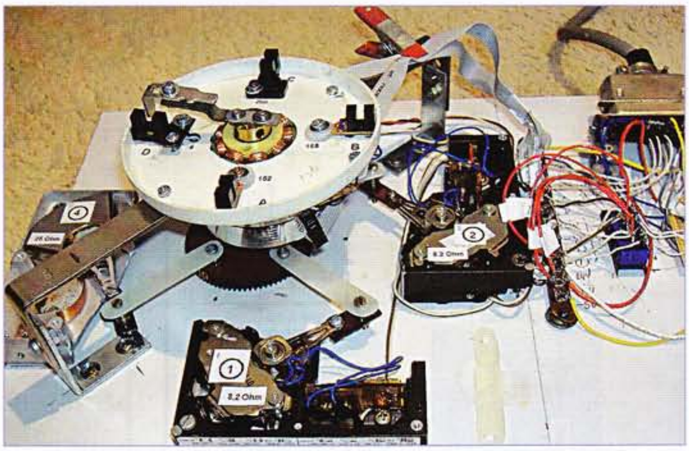


Figure 6. A 'four-cylinder' version is constructed as a radial engine.

the HD-motor and the computer. To drive the HD motor we use only half of the IC. Inside the IC are four electronic switches that are controlled by the logic AND gates in such a way that the actuator pulls in one state (pin 2 high and pin 3 low) and pushes in the other state (pin 2 low and pin 3 high).
One computer output is connected to the Enable input of the IC and is used to control the speed of the HD motor using PWM (Pulse Width Modulation). The PWM works in both directions of the actuator and provides a smooth speed control. Four protection diodes have been added to the circuit to prevent damage to the IC from back EMF surges.

Software

The program that drives the motor is written in Visual Basic under Windows XP and can be freely downloaded from the web page for this project [4] under number 090120-11.

The program is quite simple and provides the following functions:

- Determine the position of the crankshaft and control the actuator accordingly: 'push' or 'pull'
- Select clockwise or counter clockwise rotation
- Control the speed using PWM
- Measure and display the revs in rpm.
- Where necessary, the program includes comments and it can of course be written in any computer language. It can however be possible that Windows throws a spanner in the works:
- With Windows Vista Microsoft only permits you to access the USB ports; the program can therefore not be used under Vista
- With Windows XP it is still possible to access the parallel port directly (using the dll 'inpout32.dll')
- With Windows 98, 95 and older you can still play to your heart's content with all ports (parallel, serial, game and sound, using the dll 'ports.dll').

The program available for download will therefore work under Windows versions up to XP, but not under Vista of Windows 7!

The results

The completed HD1 motor (**Figure 5**) turns at a maximum rate of about 1000 rpm using a 5 volt supply and about 1800 rpm using 12 volt. As already mentioned, the latter should only be tried for very short periods of time. Otherwise the coil will heat up rapidly due to the current that flows through it. The lowest speed at which the HD1 motor can run is about 200 rpm.
As an aside: the efficiency of the complete system surrounding the HD1 motor is about 1%..., considering

- estimated power consumption of the PC: 200 W, actuator: 12 W.
- estimated mechanical power output: 2 W

More cylinders?

If you feel that a single cylinder is a bit frugal, by all means add some more! Once the single cylinder motor worked well the author thought that it should also be possible to build 4, 6 or 8 cylinder versions. It ended up as a four-cylinder version, which was christened the HD4.
Since it is very complicated to make a crankshaft for a four-cylinder motor the actuators have been placed in such a way that we end up with a radial motor (see **Figure 6** and [5]). The four cylinders in a radial motor all drive the crankshaft on the same plane. They've been mounted on a square so they each take care of 90 degrees. This made it possible to mount everything on a single flat wooden board, as can be seen from the photo.

To determine the position of the crankshaft four photointerrupters have been added. From these the computer can determine which actuator should be turned on. One thing that differs from the HD1 motor is that the actuators are no longer driven by an (expensive) IC. Instead, a simple Darlington transistor is used per actuator. Because of this, each actuator can no longer push but only pull. However the four-cylinder motor can still rotate either clockwise or counter clockwise.

(090120)

Internet Links

[1] http://en.wikipedia.org/wiki/Actuator

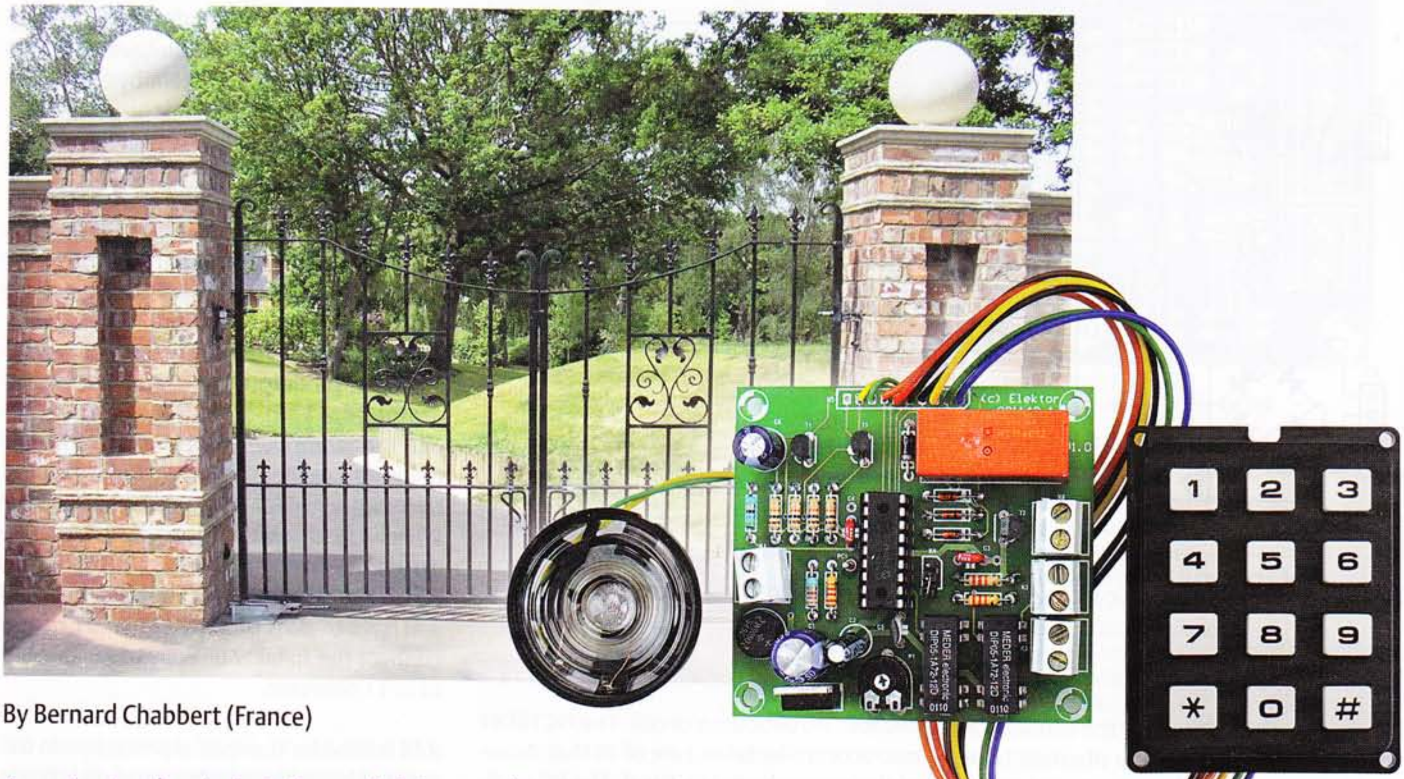
[2] http://en.wikipedia.org/wiki/H-bridge

[3] www.discovercircuits.com/H/hbridge.htm

[4] http://www.elektor.com/090120

[5] http://en.wikipedia.org/wiki/Radial_engine

Beep, beep... Sesame
A musical electronic lock



By Bernard Chabbert (France)

A motorised gate is jolly useful, just so long as you don't forget the remote control or the key. Normally, the control system for this type of gate makes provision to connect a push-button for opening or closing it without needing a remote control or key. This button must not be accessible from outside, whence the need for a more complex system. The code lock suggested here lets you control up to three such gates using push-buttons after entering a valid secret code

Technical specifications

- digital keypad with sound effects
- four codes with up to 15 digits
- three individually-driven floating contact outputs
- plays the March of the French Foreign Legion
- PIC16F84 microcontroller
- no critical components

There's a digital keypad for entering the secret code. The device can store up to four different codes, each with a maximum of 15 digits, since each member of the family will find it easier to remember a code they've chosen themselves than one that's imposed upon them. The holder of code #1 is the only person who can modify all four codes.

For the security of the system, it's going to be constructed in two parts, since if everything is in a single external unit, all you'd need to do to open the gate would be to break open the case and short a contact. So the external part will only contain the keypad and a little speaker to give a sound when you press a key. Of course, this part will have to be protected from the rain, with a little roof or a door. The electronic part will be installed somewhere inaccessible from outside — inside the house, for example.

There is a beep every time you press a key, regardless of whether it's the right one or not. If you make a mistake, there is nothing to tell you this until you get to the end of the code. The code (which mustn't start with an *) must end with a #. Then you choose the function: operate one of the three relays, or go into administration mode (see **Table 1**). When an incorrect code is entered, it counts as an error. After four errors, the keypad stops working for two minutes. There is another security feature: there must be less than two seconds between keystrokes, otherwise the current procedure is abandoned. The end or abandon of a procedure is indicated by three high-pitched beeps.

If a code is forgotten, only the administra-

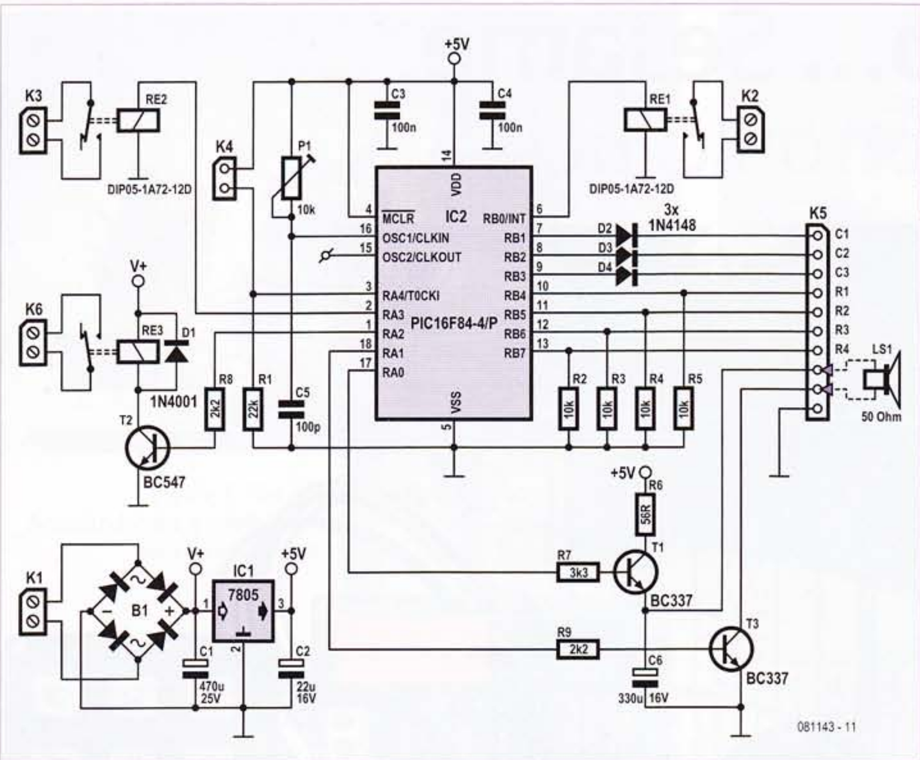


Figure 1. A musical electronic lock doesn't need many components if the microcontroller is powerful enough.

tor can enter a fresh code. If the administrator's code ever gets lost — a situation to be avoided, naturally — there's a special procedure, which involves opening up the electronics unit.

Circuit

The circuit of the project (**Figure 1**) is remarkably simple: there's no keyboard decoder, no debounce circuit. The PIC16F84 microcontroller takes care of all that. None of the components is critical. The RC oscillator formed by P1 and C5 is set to around 1 MHz, which means 250,000 instructions per second. RB1 to 3 output a voltage to scan the keypad in a matrix of three columns and four rows. This voltage is input to RB4 to 7. For example, if we press the 5 key, RB5 receives a pulse. Touching any key wakes up the microcontroller, which is normally in standby. In this standby condition, the oscillator is stopped and the power consumption is practically zero.

Following entry of a valid code, key 1 operates RE1 for 2 s via output RB0, key 2 operates RE2 via output RA3, and key 3 operates RE3 via output RA2, R8, and T2. This output is designed for a low-voltage electric strike, powered from its own transformer.

RA0 and RA1 output the beeps. This device produces a kind of 'twang' (a bit like a plucked string), which is kinder on the ear than the usual basic 'beep'. Before giving the 'twang', capacitor C6 is charged for 80 ms via RA0 (via R7, T1, and R6). RA1 then drives the speaker (via R9 and T3) for an 80 ms beep. If you prefer the basic beep, all you have to do is omit R7, T1, and C6, and connect the speaker directly to R6, instead of to T1 collector.

RA4 is used for the special procedure in the event of losing the administrator code (code #1): fit a jumper to K4 and press * and # at the same time, then remove the jumper. Turn off the power when fitting and removing the jumper. Code #1 is now just #, like the very first time you use it after programming the microcontroller.

March of the French Foreign Legion

The program generates four beeps at different pitches that can follow each other at intervals of 80 ms. If the oscillator is adjusted correctly, these will be the four notes G_5 (784 Hz) C_6 (1047 Hz), E_6 (1319 Hz), and G_6 (1568 Hz). These are the same four notes a bugle makes, and are all you need to play the bugle part of a military march. So why not do just that? We've included this in the program, since there was some room to spare in the program memory. If you press 7 after entering a code, the speaker plays the 'March of the French Foreign Legion' for about a minute. This can be used to set the oscillator using an oscilloscope, for those who have one. Set P1 to obtain a 250 kHz squarewave on test point PC1 while the tune's playing. Without a scope, the oscillator can be set by comparing the

Table 1.
After entering a valid code followed by #, eight functions are possible: To activate a relay, enter a code, then #, then 1, 2, 3, or 8. This table summarises all the functions available.

Function	Description
1	Activate relay RE1 for 2 s
2	Activate relay RE2 for 2 s
3	Activate relay RE3 for 2 s
4	Modify one of the four codes: enter code 1 without pausing for more than 2 s, then # 4, then the new code, then # followed by the number of the code (1–4). The new code is only stored if the procedure is completed without errors, and you'll hear beeps if it has worked correctly.
5	Disable beeps
6	Enable beeps
7	Set oscillator frequency
8	Activate relay RE3 for 5 s

beeps with a tuning fork or a musical instrument playing C, or just so the tune sounds nice, neither too fast nor too slow. Without the music playing, the microcontroller is in standby, the oscillator is stopped, and there's nothing to see on the scope.
The beeps can be disabled by pressing 5 after entering a valid code, or enabled by pressing 6. The beeps are enabled by default when power is applied.

Powering

No provision has been made for a transformer. There are plenty of them available commercially or in second-hand shops (plug-top power adaptor, which obviates introducing 230 V mains into your project), just so long as they provide around 12 volts and 150 mA , either AC (bridge rectifier B1 will take care of rectifying it) or DC (B1 means you don't have to worry about the connection polarity).

Relay # 3

The contacts of the little 8-pin DIL relays RE1 and RE2 (0.2 A) are not intended for the current needed to operate an electric strike for a door, which often requires 2 A @ 15 V AC. This needs a heavier-duty relay, RE3, which is a 12 V relay powered from 12–15 V (V+ tapped off before the regulator IC1). As the microcontroller can't drive this sort of relay directly, it is operated via T2.

Warning: under no circumstances is this circuit able to supply the power for an electric strike! The contacts of RE3 are simply used to feed the electric strike from the power provided by its own transformer. If you're not using an electric strike, you can omit R8, D1, RE3, and T2.

Software

The program is written in Microchip PIC assembler language. It's not very difficult, as there are only 35 possible instructions. But the program does use over 600 of them, with copious comments. It's assembled using MPASMWIN (included with MPLAB [1]) which converts it to a hex file that can be loaded directly into the PIC using a suitable program and a programming device. The PCB doesn't make any provision for in-situ programming (ICSP).

COMPONENT LIST

Resistors
R1 = 22kΩ
R2–R5 = 10kΩ
R6 = 56Ω
R7 = 3.3kΩ
R8, R9 = 2.2kΩ

Capacitors
C1 = 470µF 25V, radial
C2 = 22µF 16V, radial
C3, C4 = 100nF
C5 = 100pF
C6 = 330µF 16 V, radial

Semiconductors
B1 = W06M bridge rectifier, 800mA
D1 = 1N4001
D2,D3,D4 = 1N4148
IC1 = 7805
IC2 = PIC16F84-4/P, programmed, Elektor # 081143-41
T1,T3 = BC337
T2 = BC547

Miscellaneous
P1 = 10kΩ horizontal multiturn trimpot
RE1,RE2 = 5V SPNO relay, 500Ω coil, Meder type DIP05-1A72-12D
RE3 = 12V DPDT relay, Tyco type V23057-B002-A201
K1,K2,K3,K6 = 2-pin PCB screw terminal block, lead pitch 0.2 inch (5.08 mm)
K4 = 2-pin pinheader, lead pitch 0.1 inch (2.54 mm), with jumper
K5 = 10-pin pinheader, 10 contacts, lead pitch 0.1 inch (2.54 mm)
Loudspeaker, 50Ω impedance
Numerical keypad, 4x3
PCB, order code 081143-1, see Elektor Shop section or www.elektor.com/081143

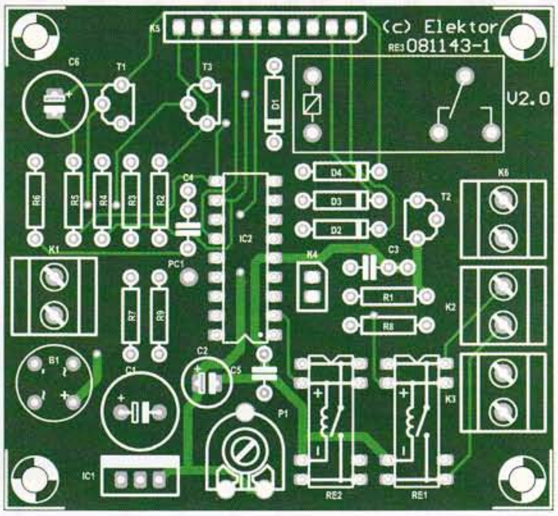


Figure 2. How to wire up the PCB.

You can download the source program, its flow diagram, and the hex file free from [2].

Construction and testing

You shouldn't encounter any difficulties building this project (**Figure 2**). Relays RE1 and RE2 look symmetrical but in reality they aren't, due to the integrated diode; for RE3, follow the holes on the PCB. Where there are no holes, you'll need to cut off the pins that aren't required. Take care to get the microcontroller the right way round, as a wrongly-fitted PIC will be ruined for good!
Connect up the keypad and speaker using a 10-core cable (including one for the ground link). This may not be used if the case is plastic, but it must be there — it is connected to the negative power rail and to the cable screen.
Once you have finished construction and wiring up, apply power to the circuit. You'll hear three high-pitched beeps to tell you that the system is initialising. If you don't hear them, the circuit isn't working properly! Turn off the power at once and investigate the cause.
If you did hear the three beeps, press the key sequence # 1. Each press is followed by a beep and relay RE1 is activated for 2 s (easy enough to check with an ohmmeter). You'll also hear a beep indicating a correct code, a little 5-beep jingle that indicates the process has ended correctly, and to end, the three high-pitched beeps that indicate the initialization of the microcontroller, after which it goes into standby.

Next, try out all the procedures in **Table 1** before your final installation.
Go on, have fun, you've earned it — press # 7.

Don't forget to store at least secret code #1.

(081143)

Internet Links

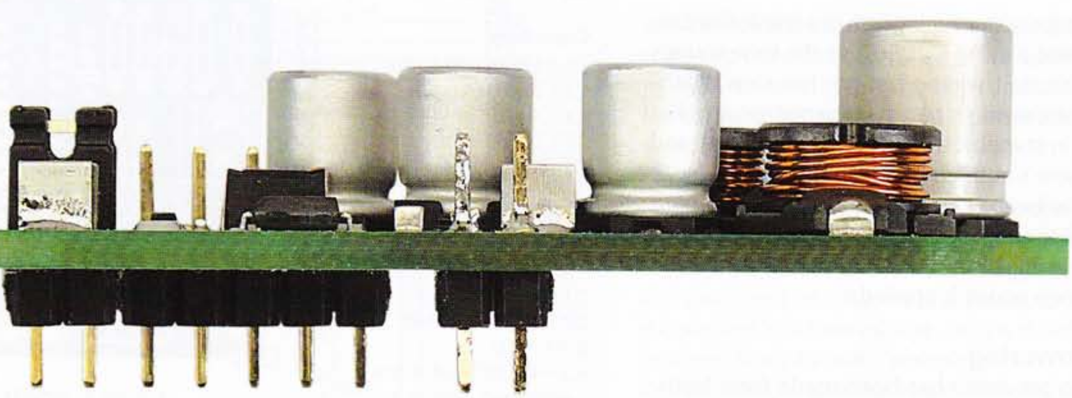
[1] www.microchip.com/mplab

[2] www.elektor.com/081143

[3] http://pagesperso-orange.fr/bernard.chabbert/

5 V Power Controller
Battery operation from 2 V to 8 V

By Daniel Goss (Germany)



These days many components and microcontrollers are designed for low-voltage operation and can be powered directly from a battery. For various reasons, however, it is often necessary to power them from a 5 V supply. Designing a high-efficiency supply is time-consuming, and so he we present a universal solution in the form of our 5 V power controller.

Features

- Input voltage range 2 V to 8 V (for example from two AA cells or two lithium-ion or lithium-polymer cells)
- Power a 5 V circuit drawing up to 150 mA using two AA cells
- Especially designed for 5 V microcontroller circuits
- Efficiency: 75 % at 2 V and >76 % from 3 V to 8 V input voltage
- Standard, readily available components
- All connections on 2.54 mm pitch headers
- Soft-off function under processor control
- Power on button can also be used as general input button
- Low current consumption in soft-off standby

If a circuit can run on a wide range of power supply voltages it is easy to power it directly from a (rechargeable) battery. However, if we want to use components like LCD panels or sensors, it is often the case that a tight-tolerance supply is required. Many microcontroller application circuits still use a 5 V supply, and so there is a clear need for this versatile supply, capable of producing a stable 5 V at its output with an input voltage anywhere from 2 V to 8 V.

This means that the circuit can be powered from two AA cells (2 V to 2.4 V), two lithium-ion or lithium-polymer cells (about 7.2 V), or anything in between. The maximum output current of 150 mA should be enough for most battery-operated circuits. Logic level control inputs allow the circuit to be started up, as well as to enter and exit a standby mode.

The idea

In view of its voltage range and easy availability we selected the Linear Technology LT1302, normally used as a boost-type switching converter. Here, however, we use it in a SEPIC (single-ended primary inductor converter) topology [1], effectively turning the device into a buck-boost converter [2]. This gives a wider input voltage range, as the converter operates in either step-up mode (with an input voltage below 5 V) or step-down mode (with an input voltage above 5 V) as appropriate. As a bonus we also get DC isolation between input and output when the circuit is disabled.

The circuit (**Figure 1**) is constructed on a small printed circuit board using surface-mount components (**Figure 2**). The pins on the board are on a 2.54 mm pitch (**Figure 3**) and so it can easily be mounted on prototyping board for experimentation. The battery is connected at K1, and the output is present on K3. K2 is a test jumper. The minimum allowable input voltage of 2 V at K1 means that in practice two AA cells can be discharged to 1 V each before the circuit fails to operate.

Pin 1 on K3 carries the regulated 5 V output. The other pins are BattSense, PowerOn, PowerHold and ground. BattSense allows a microcontroller with an analogue-to-digital converter to monitor the battery voltage. The other pins function as follows.

If PowerOn is taken to ground the switching converter starts up and delivers 5 V at the output. The microcontroller can now take PowerHold to 5 V to keep the converter running. If PowerOn is now released the circuit will continue to run as T1 remains turned on. The microcontroller can power itself down by taking PowerHold low. We will look at how to connect the circuit to a microcontroller, as well as other applications, in the last part of this article.

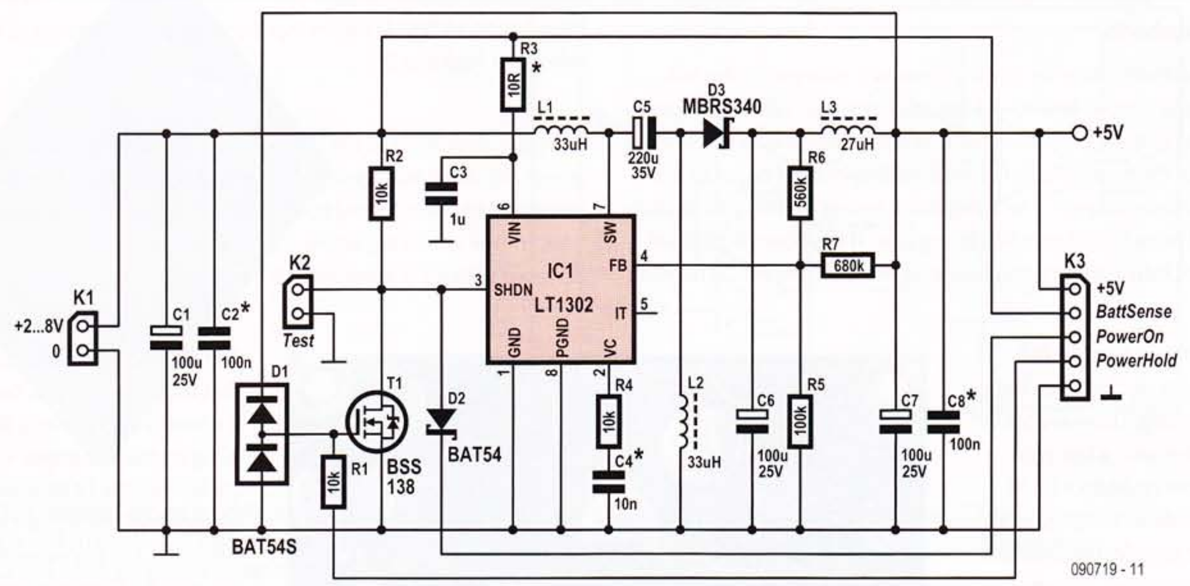


Figure 1. Circuit diagram of the 5 V power controller using the Linear Technology LT1302.

Function

Figure 4 shows a block diagram of the LT1302, which is essential to understanding how the circuit works. Readers who would like to analyse the circuit in more detail are recommended to look at the free LTSpice [3] simulation program.

The free download accompanying this article [4] includes a few illustrative oscilloscope traces from the simulator.

In boost mode (step-up) operation a boost cycle starts with the switching transistor integrated into IC1 (Q4 in Figure 2) conducting to ground, causing a current to flow in L1. C5 then discharges via L2, and the current in L2 increases. **Figure 5** shows the current flows in L1 and L2 when the transistor is conducting. The currents are in opposite directions but of approximately the same magnitude. Now IC1 turns the transistor off. C5 is no longer connected to ground via Q4, but to the input supply voltage further offset by the back e.m.f. of L1. L2 also tries to maintain its current flow. In conjunction with C5, this causes a positive voltage to appear on D3 that is greater than the supply voltage to IC1 (which is the input voltage to the circuit). **Figure 6** shows the current flows when the transistor is not conducting.

C5 and L2 thus together charge reservoir capacitor C6. This continues for around

COMPONENT LIST

Resistors

(all SMD 0805, 1%)
R1,R2,R4 = 10kΩ
R3 = 10Ω (see text)
R5 = 100kΩ
R6 = 560kΩ
R7 = 680kΩ

Capacitors

C1,C6,C7 = 100µF 25V SMD (e.g. Farnell # 1735335)
C2,C8 = 100nF 100V SMD (e.g. Reichelt.de # SMD-1812 100N, see text)
C3 = 1µF 25V SMD tantalum 0805 (e.g. Farnell # 1135280)
C4 = 10nF 100V SMD (e.g. Reichelt.de # SMD-1812 10N, see text)
C5 = 220µF 35V SMD (e.g. Farnell # 9695877)

Inductors

L1,L2 = 33µH, 2A, 0.12Ω SMD (e.g. Farnell # 1612699, Reichelt.de # L-PISM 33µ)
L3 = 27µH, 0.8A, 0.26Ω, SMD (e.g. Farnell # 1539570)

Semiconductors

(all SMD)
D1,D2 = BAT54S (SOT-23, STMicroelectronics)
D3 = MBRS340 (SMC, ON Semiconductor)
T1 = BSS138N (SOT-23, Infineon)
IC1 = LT1302 (SO-8, Linear Technology)

Miscellaneous

K1,K2 = 2-pin pinheader
K3 = 5-pin pinheader
PCB # 090719, see Elektor Shop or www.elektor.com/090719
PCB artwork download from www.elektor.com/090719

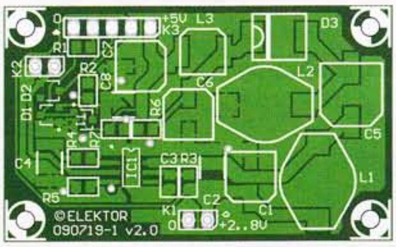


Figure 2. The printed circuit board is entirely populated with surface-mount devices. Because of the high temperatures used in reflow soldering with lead-free solder C2, C4, C8 and the headers are fitted manually.

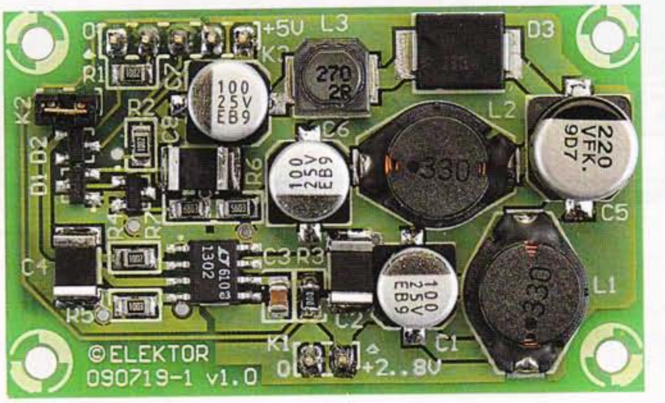
Lab Notes

By Ton Giesberts

Here in the Elektor labs we made a few minor changes to the author's original circuit. Resistor R1 and dual diode D1 were added to protect the gate of T1, and we felt that it would be a good idea to use pins on the board with a 0.1-inch pitch to make it easier to use the circuit in prototypes. The fixing holes are not on this grid to allow the board to be slightly smaller. In any case, if the board is plugged or soldered into a prototyping board no fixing screws will be needed.

from 3.5 V to 6.5 V. At higher input voltages the efficiency gradually falls off to 76.2 % at 8 V.

The main advantage of the buck-boost principle is the wide range of acceptable input voltages. The disadvantage is the lower efficiency compared to the standard configuration of the LT1302 as a pure boost mode converter, where a maximum efficiency of 87 % can be achieved with a 3 V input and a 5 V output.



Three of the surface-mount components are 1812-outline film capacitors. These are MKT-type devices with a low equivalent series resistance (ESR) and better dielectric properties than, for example, 0805-outline ceramic capacitors. However, it is doubtful whether the film capacitors can withstand reflow soldering with lead-free solder paste: Wima's 1812 film capacitors are rated up to 220 °C, and the datasheet gives 210 °C as the maximum temperature for the core of the capacitor. The melting point of polyester is around 245 °C.

The LT1302 data sheet suggests that for input voltages over 5 V it is worth adding extra decoupling on the IC's power supply consisting of a 10 Ω resistor (minimum 2 Ω) and a 1 µF tantalum capacitor. For our experiments we used a 0 Ω resistor for R3 and a 100 nF 0805-outline capacitor for C3. At input voltages in the 2 V range the voltage drop across R3 can mean that the supply voltage to the LT1302 falls too low. If, for example, the circuit is powered from two AA cells, R3 can be bridged and a tantalum electrolytic used for C3.

For our prototype we soldered all the components except for the headers and capacitors C2, C4 and C8 in the Elektor SMD oven using lead-free solder, with the temperature reaching 260 °C. C2, C4, C8 and the headers were soldered by hand.

We measured the efficiency of the circuit with an output current of a little over 150 mA, using a 33 Ω load resistor and fitting the test jumper at K2. The efficiency depends on the input voltage, from a minimum of 74.8 % at 2 V to a maximum of nearly 77 % at input voltages

When the SHDN signal is low the quiescent current varies from around 0.4 mA to 1 mA with input voltages from 2 V to 8 V. The IC itself draws just 0.2 mA, and the rest is down to the current through pull-up resistor R2 when SHDN is low. The minimum shutdown voltage is 1.8 V and the minimum bias current for the pin is 20 µA, and for this reason a value of 10 kΩ was chosen for R2. In practice a rather higher value will work perfectly well, which will improve the efficiency of the circuit at higher input voltages. When T1 is off (gate taken to ground) the circuit draws just 10 µA.

4.5 µs, at which point IC1 turns Q4 on again. C5 is discharged again via L2 and a current again begins to flow in L1. This alternating pattern continues until the voltage on FB (pin 4 of IC1) reaches 1.245 V. When this happens, the LT1302 switches off its internal 220 kHz oscillator. Since current can no longer flow into C5, the output voltage starts to fall. When the voltage on FB falls below 1.24 V the oscillator starts up again. After four cycles or so the threshold voltage is again reached and the oscillator stops once more.

In buck mode (step-down) operation, at higher input voltages, one switching cycle is typically enough to bring the voltage on FB over the 1.245 V threshold, and so the oscillator stops immediately. As the input is isolated from the output via C5, no further current can flow and the output voltage starts to fall. As soon as the voltage on FB falls below 1.24 V another cycle starts.

As a result of the way the converter works, the output voltage has rather a lot of ripple. To smooth out this ripple, C6 is followed by a filter comprising L3, C7 and C8. To ensure accurate regulation, the voltage divider used to generate the voltage on FB (R5, R6 and R7) is rather complex. R6 is responsible for 55 % of the feedback voltage and ensures a rapid response, while R7 helps compensate for the voltage drop across L3.

A low level on the shutdown input (SHDN, pin 3) activates the LT1302; if the pin is pulled high (via R2) the device will remain in a standby state. T1 pulls SHDN low if the connected microcontroller drives its input high.
R3 and C3 together provide a supply to the LT1302 relatively free of voltage variation and spikes.

Use with a microcontroller

The example circuit in **Figure 7** shows how the circuit can be connected to an ATtiny24

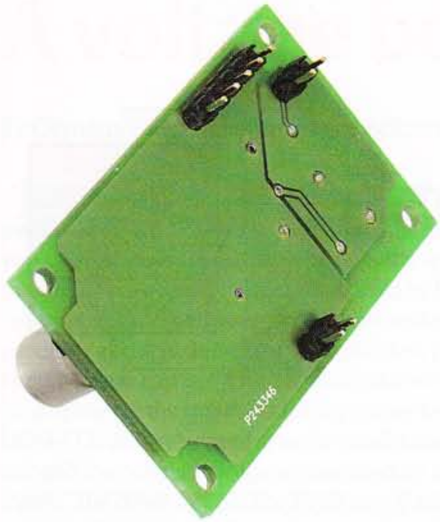


Figure 3. The headers are on a 2.54 mm (.1 inch) pitch and so the board can easily be mounted on an ordinary prototyping board.

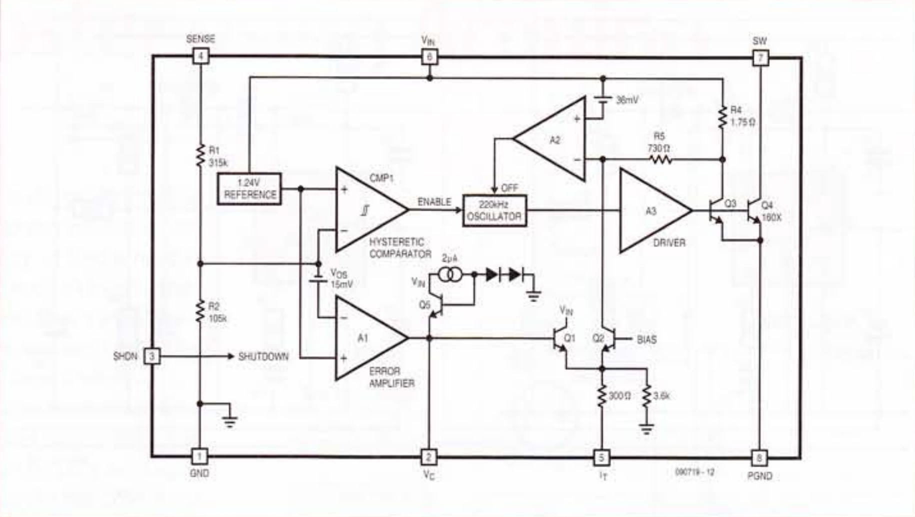


Figure 4. Block diagram of the LT1302. Q4 switches the current through external inductors.

microcontroller. The PowerOn and PowerHold pins on K3 of the 5 V power controller board are connected to the microcontroller. It is important not to leave PowerHold open circuit, as then T1 will not turn completely off and the overall current consumption of the circuit will increase unnecessarily. Pushbutton S1 can be read by the microcontroller as an ordinary input, using R1 as

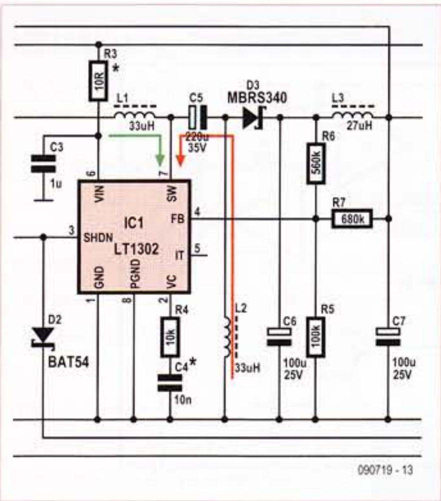


Figure 5. The pattern of current flow in L1 and L2 when the transistor is conducting.

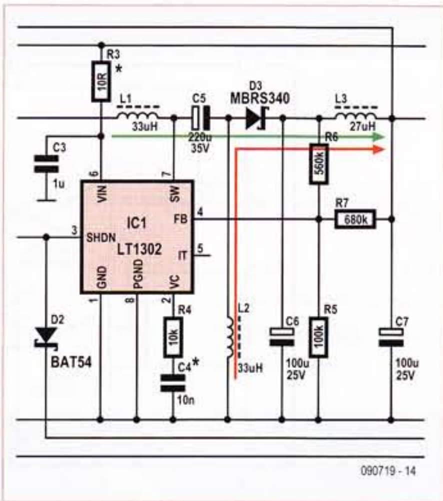


Figure 6. Pattern of current flow when the transistor is not conducting.

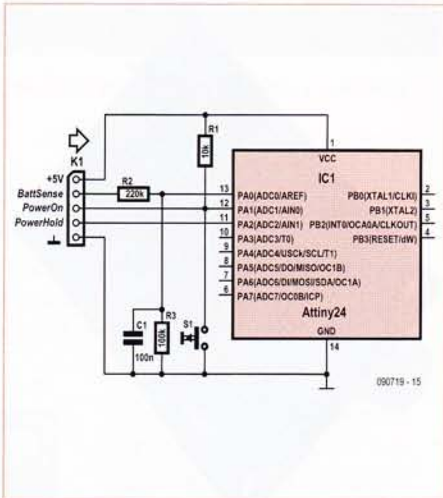


Figure 7. Example connection to a microcontroller.

a pull-up resistor. Schottky diode D2 in the power supply circuit isolates it from the pull-up, and so the button can be used as a 'power on' button for the supply. When the button is pressed the supply starts up and delivers 5 V to the microcontroller. The microcontroller starts running its program, which can then take PowerHold high. FET T1 in the supply circuit now conducts and keeps the circuit active even if the button is released. The microcontroller can subsequently switch off the power supply, for example after the user selects a certain menu item or after a certain period of inactivity, by taking PowerHold low. The whole circuit, including R1 and hence also the PowerHold signal, goes to ground potential, T1 turns off fully, and the current consumption of the power supply circuit drops to less than 20 μA.

The circuit can of course be used just to power individual parts of a larger circuit. In this case again the PowerHold signal is driven by the microcontroller in order to enable and disable the 5 V supply.

Since the microcontroller will not be able to drive the PowerHold signal high while it is being programmed, we have provided an option to enable the supply permanently by fitting a jumper to K2. This allows for programming, debugging and testing of the system, including the supply itself, without needing to make any software modifications.

If the BattSense pin is to be connected to an analogue-to-digital converter in the microcontroller, the input used should be as high impedance as possible. This pin is never isolated from the battery, even in standby mode, and this means that attention must be paid to the current flowing through the voltage divider. Since the voltage is present when the supply is off, it can be used to power a wake-up circuit or as a back-up supply to retain memory contents, although it is important to note that the voltage is neither regulated nor filtered. To make an accurate measurement of battery voltage, a 100 nF smoothing capacitor can be added to the voltage divider: this will buffer the divider from glitches arising from the sample-and-hold capacitor at the input to the analogue-to-digital converter, allowing higher resistances to be used in the voltage divider. Observe also that the battery voltage will be present on the microcontroller input even if the rest of the circuit is unpowered. Normally this will not cause any difficulty because of the high impedance of the voltage divider.

(090719)

About the author

Daniel Goss is a qualified information technology and systems integration specialist. He works as an IT consultant designing technical and security solutions with the largest IT services supplier in Germany. In his spare time he designs electronic circuits, mostly based around AVR microcontrollers, and writes Windows programs in C++ and in C#.

E-mail address: flashback@flashsystems.de

Home page with software and more projects: http://www.flashsystems.de (in German)

Internet Links

[1] http://en.wikipedia.org/wiki/SEPIC_converter (description of the SEPIC principle)

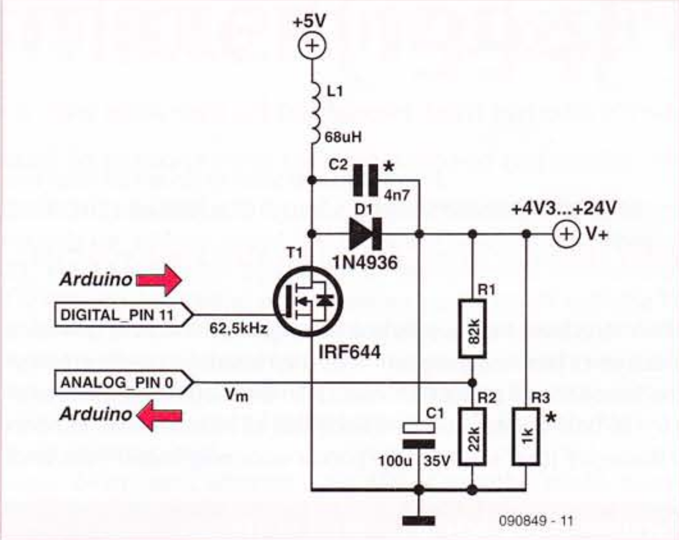
[2] www.maxim-ic.com/app-notes/index.mvp/id/1051 (application note)

[3] www.linear.com/designtools/software/ (free download of LTSpice)

[4] www.elektor.com/090719 (project pages with free downloads)

A voltage booster using Arduino

By Clemens Valens (Elektor France Editorial)



If your project needs a higher voltage rail than is already available in the circuit, you can use an off-the-shelf step-up device. But when you want a variable output voltage, it's less easy to find a ready-made IC. However, it's not complicated to build such a circuit yourself, especially if you have a microcontroller board that's as easy to program as the Arduino. And this also lets you experiment with the circuit so you can get a better understanding of how it works.

No surprises in the circuit — a largely conventional boost convertor. The MOSFET is driven by a pulse width modulated (PWM) signal from the µC, and the output voltage is measured by one of the µC's analogue inputs. The driver adjusts the PWM signal according to the difference between the output voltage measured and the voltage wanted.

We don't have enough space here to go into details about how this circuit works, but it's worth mentioning a few points of special interest. The small capacitor across the diode improves the efficiency of the circuit. The load is represented by R3. The components used make it possible to supply over 1 A (current limited by the MSS1260T 683MLB inductor from Coilcraft), but maximum efficiency (89%) is at around 95 mA (at an output voltage of 10 V). To avoid damaging the controller's analogue input (≤5 V), the output voltage may not exceed 24 V. For higher voltages, the values of resistors R1 and R2 would need to be changed.

The MOSFET is driven by the µC, which is nothing but a little Arduino board. The Arduino's default PWM signal frequency is around 500 Hz — too low for this application, which needs a frequency at least 100 times higher. So we can't use the PWM functions offered by Arduino. But that's no problem, as the Arduino can also be programmed in assembler, allowing a maximum frequency of 62.5 kHz (the µC runs at 16 MHz). To sample the output voltage, a frequency of 100 Hz is acceptable, which means we can use Arduino's standard timers and analogue functions. The Arduino serial port is very handy — we can use it for sending the output voltage set point (5–24 V) and for collecting certain information about the operation.

Thanks to the Arduino environment, it only took about half an hour to program. You can download the software from [1].

(090894-I)

[1] www.elektor.com/090894

UV light box

By Gert Baars (The Netherlands)

Fabricating printed circuit boards is not something that every electronics hobbyist does for themselves. It is, however, not really that difficult. The most important necessities are a PCB layout, a printer (or perhaps a copier), a light box, photo-sensitive PCB material, chemicals and an etching tray. It is often the light box that presents the most difficulties.

The PCB layout can be copied (using a copier) from an existing design or you can design it yourself using a computer and suitable software. The layout needs to be printed onto a transparency (make sure that the transparency is suitable for use in laser or inkjet printers). The necessary chemicals (sodium hydroxide for the developing and iron(III)-chloride or copper-chloride for the etching) are not difficult to obtain. It is not necessary either to etch using a foam-etching box, but this does etch much quicker. Etching can simply be done in a plastic tray, and etching with iron(III)-chloride will be a little faster if the etchant is at about 40 °C.

As already mentioned, exposing the PCB is often the most difficult part. In the past, the PCB with the layout in an exposing frame would sometimes be placed in the bright sun and it is also possible to expose the PCB using UV lamps. To make a 'real' light box yourself is not nearly as difficult as most people assume.

The required items are a housing with a sheet of glass, UV fluorescent tubes and perhaps a timer. The latter is not really necessary when a clock or watch is available. It therefore comes down to obtaining the UV fluorescent tubes with starters and ballast and a housing with a sheet of glass.

There is a cheap solution for this. For the housing you can use a discarded sheet scanner with all the innards removed. The fluorescent tubes could come from a face tanning machine, for example. In the 'prototype' made by the author the frame complete with the fluorescent tubes was cut out. This could then be placed in its entirety into the housing for the scanner. The accompanying starters and ballast fitted elsewhere in the old scanner housing and after connecting all the wires everything immediately worked as it should.

Because the layout has to be in good contact with the PCB to prevent shadowing, a sturdy piece of cardboard the same size as the glass was attached to the inside of the lid of the scanner. It is necessary to apply some pressure on the lid during the exposure, but a few books or fat catalogues on top of the lid is already sufficient. The exposure time for the best results with this construction appears to be about 2-3 minutes.

(090088)

Hexadoku

Puzzle with an electronics touch

Here's another fresh Hexadoku for everyone with a soft spot for puzzle solving. Our records indicate that Hexadoku has become popular with spouses of Elektor readers, too, and that's a good sign. The more correct entries, the better! Send the hexadecimal numbers in the grey boxes to us and you automatically enter the prize draw for four Elektor Shop vouchers. Have fun!

The instructions for this puzzle are straightforward. Fully geared to electronics fans and programmers, the Hexadoku puzzle employs the hexadecimal range 0 through F. In the diagram composed of 16 × 16 boxes, enter numbers such that **all** hexadecimal numbers 0 through F (that's 0-9 and A-F) occur once only in each row, once in each column and in each of the 4×4 boxes (marked by the thicker black lines). A number of clues are given in the puzzle and these determine the start situation. Correct entries received enter a draw for a main prize and three lesser prizes. All you need to do is send us the numbers in the grey boxes.

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Before May 1, 2010, send your solution (the numbers in the grey boxes) by email, fax or post to

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Prize winners

The solution of the February 2010 Hexadoku is: **95CD4**.

The £80.00 voucher has been awarded to: Alex Murphy (USA).

The £40.00 vouchers have been awarded to: Edwin Velner (The Netherlands), Kaz Tchorzewski (UK) and Ludwing Sanchez Carrillo (Colombia).

Congratulations everybody!

5		B		D	A		C			2			3	0	1
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1	2	G	C	D	3	B	8	E	4	5	9	7	A	6	F
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7	G	1	3	F	C	D	4	5	6	8	B	9	2	A	E
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9	8	E	7	G	A	F	C	2	3	1	D	B	6	4	5
B	A	2	D	6	5	8	3	4	9	G	E	C	F	7	1
C	5	6	G	4	9	7	1	B	A	F	8	E	D	3	2

G4WIM 24cm ATV Transmitter (1994)

By Jan Buiting, PE1CSI (Elektor UK/US Editorial)

In the early 1990s, activity in the 23 cm amateur radio band (1250-1300 MHz) soared due to the arrival on the market of wideband RF power amplifier modules that allowed easy generation of transmitter power levels in the watts range. Most of these units were Motorola and Mitsubishi made and originally designed as drop-in power amps in base stations of 800/900 MHz cellphone networks which were rolled out at a terrific pace at that time. In the years before the modular RF power amp, hams on 23 cm had a choice of (1) being happy with a few milliwatts, (2) juggling with expensive transistors, or (3) going through immense trouble to build a high power amplifier using tubes (usually 2C39s).

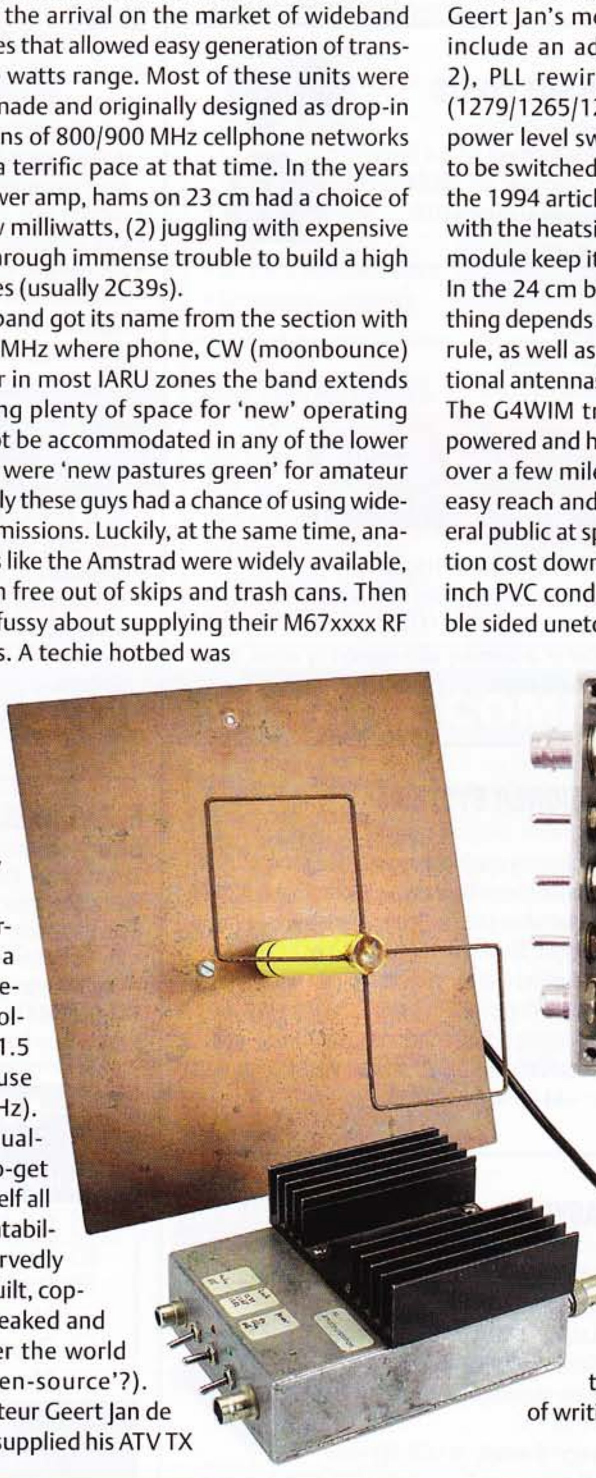
The 23 cm radio amateur band got its name from the section with most activity: 1296-1298 MHz where phone, CW (moonbounce) and SSB reigned. However in most IARU zones the band extends down to 1250 MHz offering plenty of space for 'new' operating modes so wide they cannot be accommodated in any of the lower bands like 70 cms. 24 cms were 'new pastures green' for amateur television (ATV) users. Finally these guys had a chance of using wideband FM for their TV transmissions. Luckily, at the same time, analogue satellite TV receivers like the Amstrad were widely available, first at low prices and then free out of skips and trash cans. Then Mitsubishi stopped being fussy about supplying their M67xxxx RF power modules as one offs. A techie hotbed was created and the popularity of FM ATV of 24 cms was boosted further by many repeater stations installed at elevated positions, all built, operated, maintained and paid for by kind souls.

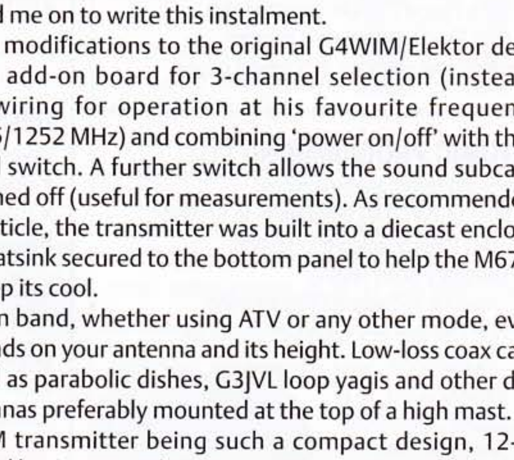
In February 1994 Tim Forrester G4WIM published a classic in the history of Elektor: a compact PLL controlled ATV transmitter with 1.5 watts output power for use at 24 cms (1250-1270 MHz). The double sided high-quality board and kit of hard-to-get parts supplied by Tim himself all added to an excellent repeatability factor. The project deservedly became popular and got built, copied, extended, bashed, tweaked and improved by hams all over the world (what do you *mean* 'open-source'?). Including Dutch radio amateur Geert Jan de Groot PE1HZG who kindly supplied his ATV TX and spurred me on to write this instalment.

Geert Jan's modifications to the original G4WIM/Elektor design include an add-on board for 3-channel selection (instead of 2), PLL rewiring for operation at his favourite frequencies (1279/1265/1252 MHz) and combining 'power on/off' with the TX power level switch. A further switch allows the sound subcarrier to be switched off (useful for measurements). As recommended in the 1994 article, the transmitter was built into a diecast enclosure with the heatsink secured to the bottom panel to help the M67715 module keep its cool.

In the 24 cm band, whether using ATV or any other mode, everything depends on your antenna and its height. Low-loss coax cables rule, as well as parabolic dishes, G3JVL loop yagis and other directional antennas preferably mounted at the top of a high mast.

The G4WIM transmitter being such a compact design, 12-volt powered and having enough output power to carry camera signals over a few miles to a base station, portable operation was within easy reach and 'portacam ATV' was often used to amuse the general public at special events. With this in mind, and to keep the station cost down, Geert Jan built a double-quad antenna from 5/8-inch PVC conduit and a matching T junction box. A piece of double sided unetched circuit board acts as the reflector and a length of stiff copper-plated wire was bent into the well-known 'quad' shape mounted at the front of the conduit. The yellow conduit can slide in the T piece — note the black marking to indicate the optimum distance between the quad and the reflector.





Tim Forrester G4WIM also published an NBFM transceiver in Elektor September 1992. At the time of writing he is still active as a radio amateur.

(090882)

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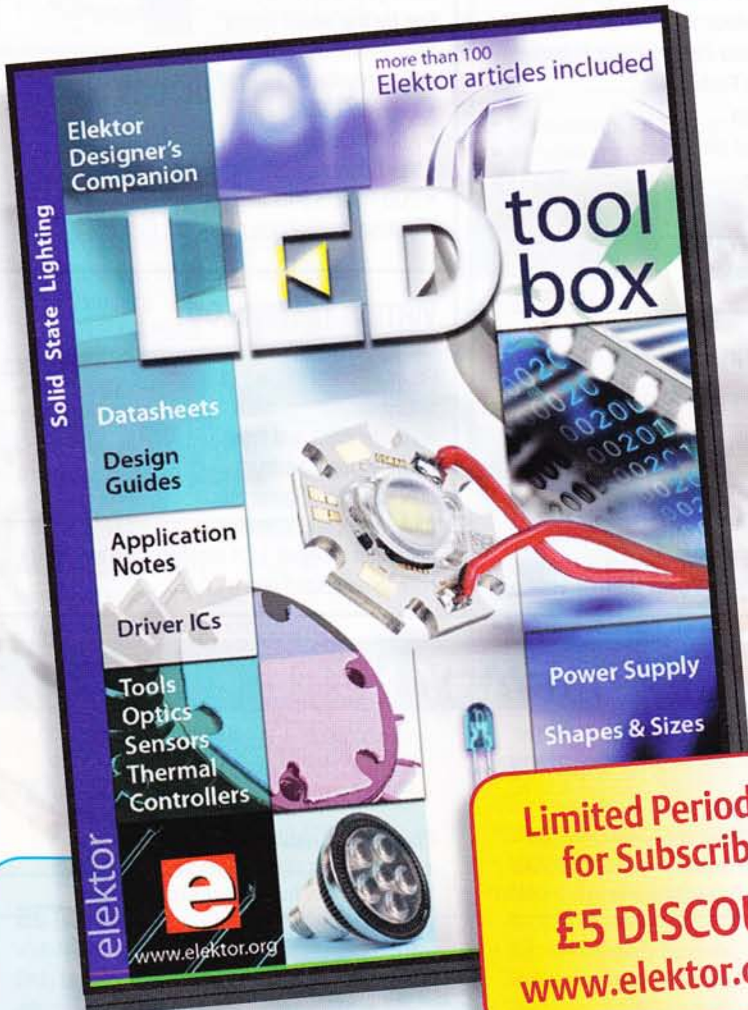

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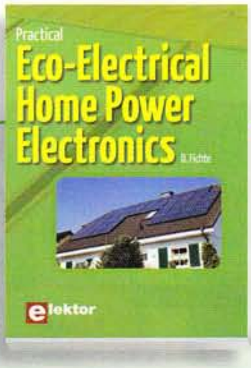

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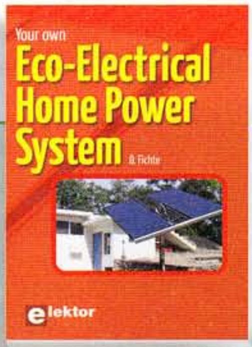

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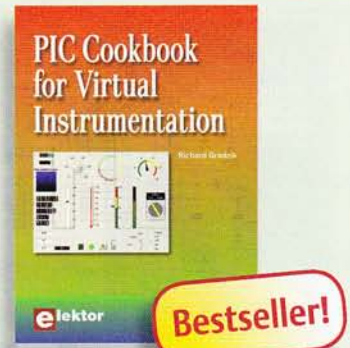

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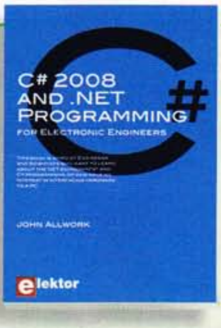

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This book is aimed at Engineers and Scientists who want to learn about the .NET environment and C# programming or who have an interest in interfacing hardware to a PC. The book covers the Visual Studio 2008 development environment, the .NET framework and C# programming language from data types and program flow to more advanced concepts including object oriented programming.

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Complete practical measurement systems using a PC

This book covers both hardware and software aspects of designing typical embedded systems based on personal computers running the Windows operating system. It's use of modern techniques in detailed, numerous examples has been designed to show clearly how straightforward it can be to create the interfaces between digital and analog electronics, programming and Web-design. Readers are encouraged by examples to program with ease; the book provides clear guidelines as to the appropriate programming techniques "on the fly".

292 pages • ISBN 978-0-905705-79-8
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New!

Modulo D

(March 2010)

The external appearance of this small module with an LC display almost belies what it has inside: a complete stereo preamplifier and final amplifier with IR remote control, adjustable tone, volume and signal levels, and an output power of 2 × 20 W (Class D), all with a single 12-V supply voltage. This makes it perfect for use in a car, boat or motor home.

PCBs, SMD-populated, and all other components

Art.# 090563-71 • £69.90 • US $112.80

WinAmp Controller

(February 2010)

A variety of remote control devices for Winamp and other PC-based media players have been available for a good while. All of these systems have one thing in common, which is that they are limited to buttons or keys or use virtual progress bars on the computer monitor. If you want to have a complete hardware interface unit with the same level of sophistication as the virtual Winamp design, you need a physical progress bar. In this project a small ATmega microcontroller uses the USB interface to provide a bidirectional link between the Winamp software and a hardware studio fader, which acts as a combined indicator and entry device.

Kit of parts, including PCB

Art.# 090531-71 • £85.00 • US $143.60

Bestseller!

Preselector for Elektor SDR

(December 2009)

Elektor's Software Defined Radio (SDR) is deservedly popular. The performance of a receiver depends to a large extent on its input filters. A selective input circuit improves antenna matching and immunity to interference from other strong signals. This preselector allows the use of up to four filters, tuned under software control using varicap diodes. A tuned loop antenna is also described that lets you use our SDR without an outdoor antenna.

Kit of parts, contains partly populated board, coil formers, ferrite rod with coils

Art.# 090615-71 • £47.00 • US $75.90

OBD Analyser NG

(September 2009)

The compact OBD2 Analyser in the June 2007 issue was an enormous success – not surprising for an affordable handheld onboard diagnostics device with automatic protocol recognition and error codes explained in plain language. Now enhanced with a graphical display, Cortex M3 processor and an Open Source user interface, the next generation of Elektor's standalone analyser sets new standards for a DIY OBD2 project. The key advantage of this OBD2 Analyser NG is that it's self-contained and can plug into any OBD diagnostic port.

Kit of parts including DXM Module, PCB SMD-prefitted, case, mounting materials and cable

Art.# 090451-71 • £84.00 • US $135.50

Kits & Modules

Product Shortlist

		£	US $
April 2010 (No. 400)			
UniLab			
090786-1	Printed circuit board	16.00	26.00
090786-71	PCB and all components, less power transformer	www.elektor.com	
Small is Beautiful: Minimod18			
090773-41	Programmed controller with Bootloader pre-programmed	21.80	36.00
090773-91	PCB, populated and tested with Bootloader pre-programmed	56.00	90.00
Bluetooth for OBD-2			
090918-71	PCB with SMDs fitted, BTM222 Bluetooth module	26.70	43.00
Fun with Fireflies			
100014-1	Printed circuit board	11.00	18.00
100014-41	Programmed controller	11.00	18.00
Beep, beep... Sesame			
081143-41	Programmed controller	15.50	25.00
5 V Power Controller			
090719-1	Printed circuit board	8.90	14.50
March 2010 (No. 399)			
Reign with the Sceptre			
090559-91	PCB, populated and tested, test software loaded	www.elektor.com	
Modulo D			
090563-71	PCB, SMD-populated, and all other components	69.90	112.80
February 2010 (No. 398)			
Battery Checker			
071131-41	ATmega32-16PU, programmed	17.80	28.80
071131-71	Kit of parts, excl. enclosure	124.00	200.00
Winamp Controller			
090531-71	Kit of parts	89.00	143.60
The ATM18 Radio Computer			
090740-71	PCB with Si4734/35 radio IC ready mounted and tested	27.50	44.40
January 2010 (No. 397)			
USB Magic Eye			
090788-1	Printed circuit board	9.90	16.00
090788-41	ATtiny2313-20PU, programmed	9.90	16.00
MIAC for Home Automation			
090278-91	Populated PCB in enclosure	154.00	248.40
Dimmer with a Micro			
090315-41	PIC12F629A, programmed	7.60	12.30
December 2009 (No. 396)			
Preselector for Elektor SDR			
090615-71	Kit of parts, contains partly populated board, coil formers, ferrite rod with coils	47.00	75.90
Top-of-the-Bill Lights Sequencer			
090125-1	PCB, bare (master module)	10.80	17.50
090125-2	PCB, bare (lamp module)	2.30	3.80
090125-41	Controller (PIC18F2550) for main PCB, programmed	14.50	23.40
090125-42	Controller (PIC12F508-I/SN) for lamp unit, programmed	2.30	3.80
The Vikings Are Coming!			
080948-71	Kit of parts: bare PCB and bluetooth module BTM222	23.70	38.30
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090823-41	PIC12F683-I/SN, programmed	6.50	10.50
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Solder Station 'Plus'			
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081101-1	Printed circuit board	12.90	20.90
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081101-71	Kit of parts incl. PCB, programmed controller and components	29.90	48.30

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dsPIC Development Board

This powerful control board with a 16-bit dsPIC30F6010 offers plenty of application scope including motor control. The base board has interfaces for USB, RS232, CAN, I²C and ICD2. There are also four DACs and all essential signals are bonded out to expansion connectors. The expansion board described in the same edition has even more connectivity to offer.

Fast Responding CO_2 Meter

A new CO_2 meter was specially developed by Elektor Labs for use in confined spaces like cars. Thanks to the use of a sensor based on CO_2 level detection by infrared light the meter has hardly any warm up time and should be ready to take measurements a minute or so after switch-on. Measured data are processed by an ATmega MCU that also takes care of driving a two-line LCD.

Auto Balancer for LiPo Battery Packs

With lithium-polymer battery packs it's essential to keep a close watch on the charge distribution between cells to prevent one of these from being overcharged or deep discharged. Typically, special ICs are used for this purpose but this project shows that standard components can do the job equally well. A single LM324 and some power Darlington transistors are sufficient for a battery pack with up to five cells.

Article titles and magazine contents subject to change; please check the Magazine tab on www.elektor.com
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