elektor electronics

leading the way

NOVEMBER 2006
£3.80
www.elektor.com

R8C Design Contest: the winners!

Hotheads

14 solder stations compared

USB stick for microcontrollers

- Smartcard reading & programming
- All wireless with ZigBee & XBee
- Spot-welding with capacitors

R46
11
9 770268 451128

BitScope

Pocket Analyzer

USB Oscilloscope & Logic Analyzer

The new generation Scope for the age of microelectronics.

8 Channel 40MS/s Logic Analyzer
✓ Capture digital signals down to 25nS with arbitrary trigger patterns.

3 Input 100MHz Analog DSO
✓ Classic Analog Scope using a standard x1/x10 BNC probe. Additional inputs on the POD for dual channel operation.

8 + 1 Mixed Signal Scope
✓ True MSO to capture an analog waveform time-synchronized with an 8 channel logic pattern triggered from any source.

Real-Time Spectrum Analyzer
✓ See the spectrum and waveform of analog signals simultaneously and in real-time

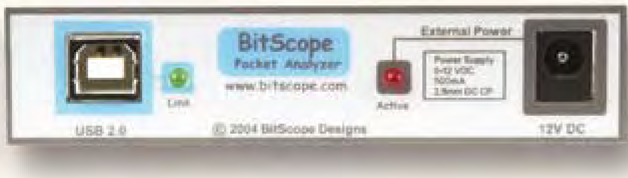
Waveform Generator
✓ Load up to 32K arbitrary waveform and replay via the onboard DAC (10MS/s) or a digital pattern from the POD (40MS/s)

Turn your PC or NoteBook into a powerful Scope and Logic Analyzer!

See inside your circuit in the analog and digital domains at the same time to make tracking down those elusive real-time bugs much easier.

Pocket Analyzer combines a high speed sample-synchronized storage scope and logic analyzer with a programmable waveform and logic pattern generator. Also included is an integrated real-time spectrum analyzer and powered "Smart POD" expansion interface so you've got all bases covered!

About the same size and weight as a Pocket PC, this USB powered BitScope needs no bulky accessories. It's the perfect low cost "go anywhere" test and debug solution.



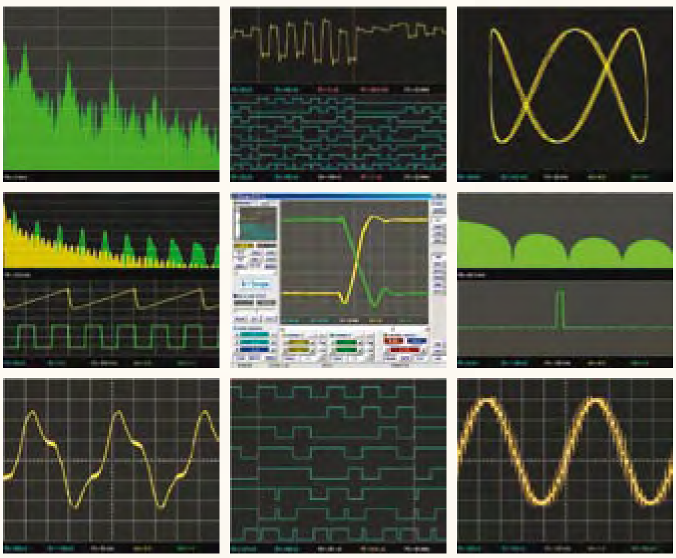
Standard 1M/20pF BNC Input
200uV-20V/div with x10 probe
S/W select AC/DC coupling
S/W select 50ohm termination
Arbitrary Waveform Generator

BitScope "Smart POD" Connector
8 logic channels, 2 analog channels
Dual channel capture from POD A/B
Async serial I/O for external control
Logic Pattern generator 32K 40MS/s

BUS Powered USB 2.0 Device
Single USB cable to your PC
Compressed data transmission
Simple ASCII control protocol
BitScope Scripting Language

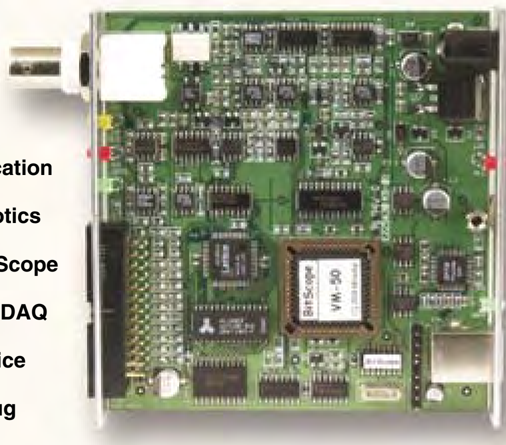
External/Passthru Power Supply
Auto senses an external supply - removes power load from USB for use with unpowered hubs.
Supplies up to 500mA via POD

BitScope and your PC provide an array of Virtual Instruments



BitScope DSO 1.2 software for Windows and Linux

- **R&D**
- **Education**
- **Robotics**
- **Lab Scope**
- **Fast DAQ**
- **Service**
- **Debug**



BitScope Pocket Analyzer uses highly integrated Surface Mount technology to provide functionality you would expect from scopes many times the size and price. Its programmable Virtual Machine architecture means new functionality can be added via software. For custom Data Acquisition, export directly to your spreadsheet.

www.bitscope.com

elektor electronics
leading the way

Balancing act

I answer about 250 readers' queries per month. In your correspondence, many of you first tell me that you like our magazine for its 'wide range of interesting subjects' (as it's often described) and then go on to ask questions of a technical nature. When replying with the information desperately needed at the other end of the post, telephone line or email server, I am always curious to know my correspondent's preferences in electronics as well as his or her interpretation of 'wide'. The few readers having taken the trouble to inform me typically wish to have a magazine that covers simple as well as complex, theory as well as practice, expensive as well as cheap, SMD as well as leaded, kit as well as DIY, PIC as well as AVR, and so on.

In this respect, I think Elektor Electronics is doing a reasonable job. As an example, last month we were criticised for our ready-made GBECG module by a few readers complaining that there was little fun in getting a fully assembled and working PCB in the post. Well, kindly note that a completely home-spun alternative is printed a few pages on in the same issue. "Just want to use it"': go to page xx — "Want to do it all by myself": page xx+10. You decide how you wish to experience electronics and we do our best to cater for your needs. The same with last September's articles covering RFID, we describe a ready-built Reader unit cheerfully alongside an experimental design that can be built cheaply and programmed to your heart's content.

The same balancing act is applied, to an extent, in this November 2006 issue: Smartcard theory (page 28) duly followed by a hands-on construction project (page 34). Also, a professionally designed and finished USB stick interface for microcontrollers (page 42) balanced by Brainiac-like electronics from the junkbox (pages 60). To run smoothly, an engine needs proper balancing in various places.

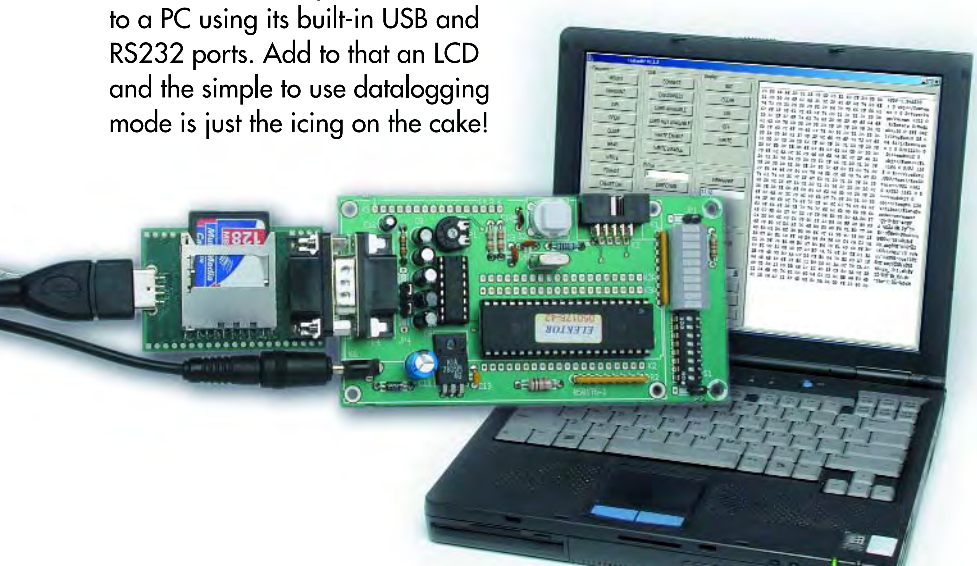
Jan Buiting, Editor

CONTENTS

Volume 32
November 2006
no. 359

42 USB Stick with ARM and RS232

This neat stand-alone memory stick can store or transfer data from a microcontroller system in the field to a PC using its built-in USB and RS232 ports. Add to that an LCD and the simple to use datalogging mode is just the icing on the cake!



know-how

hands-on

technology

info & market

infotainment

elektor electronics

leading the way

Volume 32, Number 359, November 2006 ISSN 0268/4519

Elektor Electronics aims at inspiring people to master electronics at any personal level by presenting construction projects and spotting developments in electronics and information technology.

Publishers: Elektor Electronics (Publishing), Regus Brentford, 1000 Great West Road, Brentford TW8 9HH, England. Tel. (+44) (0) 208 261 4509, fax: (+44) (0) 208 261 4447 www.elektor-electronics.co.uk.

The magazine is available from newsagents, bookshops and electronics retail outlets, or on subscription. *Elektor Electronics* is published 11 times a year with a double issue for July & August.

Under the name *Elektor* and *Elektuur,* the magazine is also published in French, German and Dutch. Together with franchised editions the magazine is on circulation in more than 50 countries.

International Editor: Mat Heffels (m.heffels@segment.nl)

Editor: Jan Buiting (editor@elektor-electronics.co.uk)

International editorial staff: Harry Baggen, Thijs Beckers, Ernst Krempelsauer, Jens Nickel, Guy Raedersdorf.

Design staff: Ton Giesberts, Paul Goossens, Luc Lemmens, Christiaan Vossen

Editorial secretariat: Hedwig Hennekens (secretariaat@segment.nl)

Graphic design / DTP: Giel Dols

Managing Director / Publisher: Paul Snakkers

Marketing: Carlo van Nistelrooy

Customer Services: Margriet Debeij (m.debeij@segment.nl)

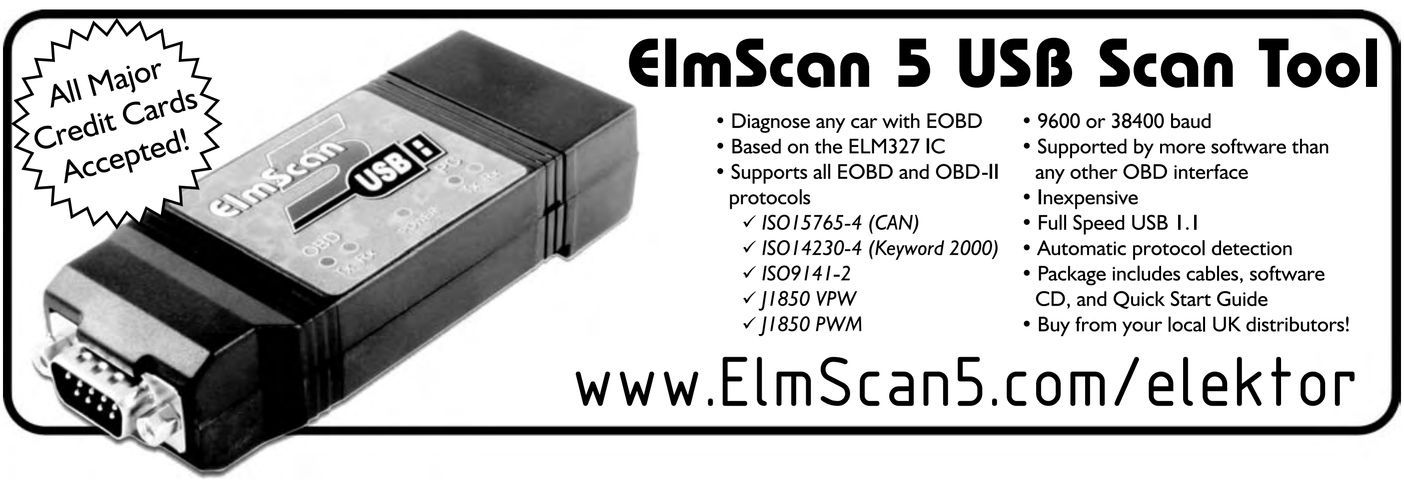
Subscriptions: Elektor Electronics (Publishing),
Regus Brentford, 1000 Great West Road, Brentford TW8 9HH, England.
Tel. (+44) (0) 208 261 4509, fax: (+44) (0) 208 261 4447
Internet: www.elektor-electronics.co.uk
Email: subscriptions@elektor-electronics.co.uk
Rates and terms are given on the Subscription Order Form

Head Office: Segment b.v. P.O. Box 75 NL-6190-AB Beek The Netherlands
Telephone: (+31) 46 4389444, Fax: (+31) 46 4370161

Distribution: Seymour, 2 East Poultry Street, London EC1A, England
Telephone:+44 (0)207 429 4073

UK Advertising: Huson International Media, Cambridge House, Gogmore Lane, Chertsey, Surrey KT16 9AP, England.
Telephone: +44 (0)1932 564999, Fax: +44 (0)1932 564998
Email: r.elgar@husonmedia.com
Internet: www.husonmedia.com
Advertising rates and terms available on request.

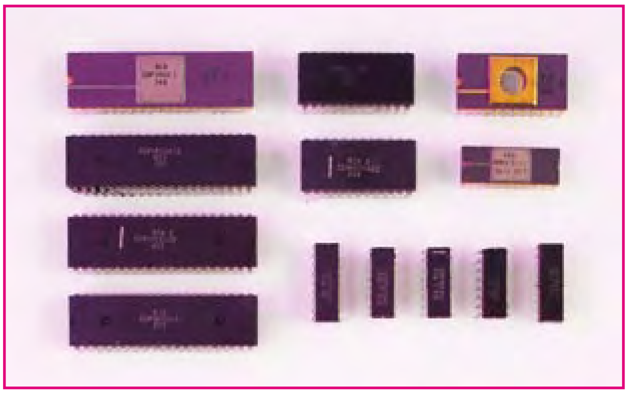
International Advertising: Klaas Caldenhoven, address as Head Office
Email: advertenties@elektuur.nl
Advertising rates and terms available on request.

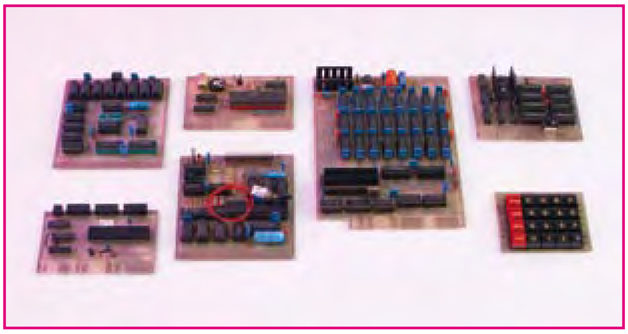



PEAK
electronic design ltd
tel. 01298 70012
fax. 01298 70046
www.peakelec.co.uk
sales@peakelec.co.uk
Handheld Test Gear - Cool, Smart.
Atlas DCA Semiconductor Analyser £55
Atlas LCR Passive Component Analyser £79
Atlas ESR Capacitance and ESR Meter £89
Atlas SCR Triac/Thyristor Analyser £109
Prices include UK delivery and VAT
atlas DCA
Enhancement mode
N-Ch MOSFET
semiconductor
component
analyser
on - test
scroll - off
PEAK electronic design ltd

Cool, that CDP1802

Our Retronics piece on the history of the CDP1802 'Cosmac' processor triggered warm response from a number of readers having suddenly realised that 30 years have passed since this oddball CMOS processor first appeared on the market. We congratulate not only the Cosmac ELF computer on its 30th birthday but also Nuts & Volts magazine for putting a remake of Joe Weisbecker's DIY computer on the front cover of their August 2006 issue. It is fair to say that it was the ELF computer that brought fame and glory to the 1802, in other wards, hobbyists gave the manufacturer, RCA, a free ride towards product acceptance by the industry. That rarely happens today, with the industry more usually dictating what crumbs are left for hobbyists to feed on.
The photos printed here show a number of rare and less rare members of the Cosmac CDP series of integrated circuits, as well as a collection of extension cards for the Cosmicos computer discussed in the October 2006 issue. The cards include pixel graphics for Chip-8 games, PPI (I/O), 48 k dynamic RAM, SD/DD floppy disk interface and a hex keyboard.
An active group of ELF/Cosmac followers may be found on the internet at http://www.cosmacelf.com/





Hybrid headphone amp

Dear Jan — Many thanks for publishing Jeff Macaulay's Headphone amplifier (July/August 2006, Ed.) which has been well incorporated as part of my stereo Hi-Fi system. I have made some minor improvements to it which some of your readers might be interested to know as well as a double-sided PCB layout, which if anyone is interested can contact me for. I am really impressed with the quality of the sound on my Sennheiser HD555, Cambridge Audio Azer CD player, utilizing only the preamp part of my main Rega Mira power Amp. The low voltage PSU and low-V, low noise ECC82 front end really set this Headphone Amp apart from a lot of such circuits I have seen, not to mention that I have built the unit for less than the cost of two CDs!

During my recent visit to Germany, I have recently upgraded to the high end Austrian made AKG model K601 which has a 120 ohm impedance. Unfortunately on returning home I found that the impedance mismatch caused a significant loss of dynamic range which degraded the higher quality of my new headphones. I am still working on a solution at this stage, perhaps Jeff might like to comment.
Thanks to Jeff especially and may more low-V hybrids be born into this world!
Tuck Choy (UK)

Old PCB numbers (2)

Dear Editor — I noticed the response to Tanglung (Singapore) on page 8, (Mailbox, September 2006), concerning the 'Peak Programme Meter'. This reminded me of all the fun I had in the 1970s building projects from the Elektor magazine. In fact, my first audio recording suite was built largely from projects in Elektor.
Audio mixers, peak LED meters, audio compressors, and amplifiers all graced my room. I let my subscription lapse in the mid 80's due to work changes, but since coming back to Elektor I still get excited when the magazine shows up each month.
Fred Vobbe (USA)

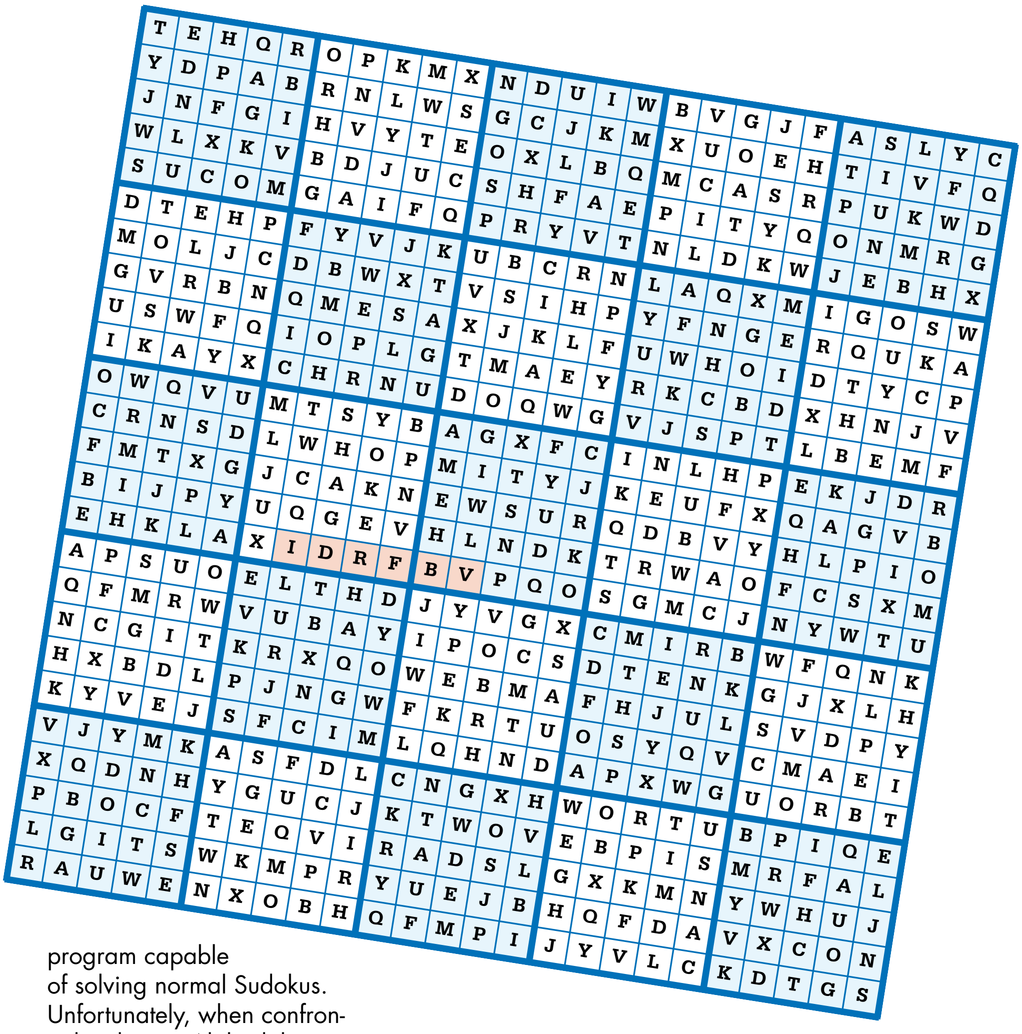
Thanks Fred, we sincerely hope the magazine continues to be a pleasure to read as well as a source of inspiration.

Fiendish Alphadoku

Dear Editor — I'd like to enter the competition with the answer "it is impossible to solve a 25x25 Alphadoku within two months" as I suspect the competition is a cruel joke ;)
Renne (Finland)

Dear Jan — just to say that the Alphadoku puzzle you ran in the July/August 2006 issue is proving a hard nut to crack. After weeks of attempting to find the solution I can only say: this one cannot be solved! I get stuck over and over again despite several serious attempts and even used Excel to record my 'proceedings' — in vain.
If this Alphadoku monster can be solved at all, I would claim that it has several correct solutions.
Today I cheated using a program supposed to be able to crack the puzzle but unfortunately it tells me there is no solution.
Michael Hanly (UK)

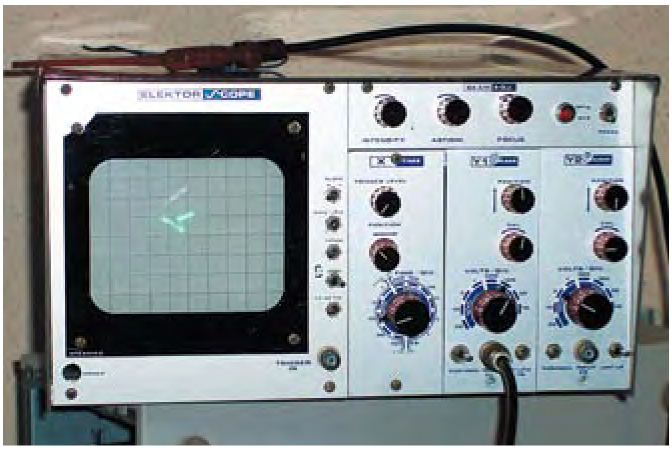
Dear Jan — the Alphadoku in the Summer Circuits issue was announced as incredibly difficult, so I was triggered to write an Excel program to solve it. I ended up with a



program capable of solving normal Sudokus. Unfortunately, when confronted with your Alphadoku, my program hangs after a while because no solution can be found. Is it possible that several correct solutions exist?
Frank Travally (UK)

Renne, Michael, Frank and everyone else who wrote in on the mighty Alphadoku, we can confirm that this puzzle was quite a challenge. Nonetheless, lots of readers gave it a try, some the old fashioned way using pencil and rubber, others writing programs hoping their PC would find the solution.
We cannot quite rule out that our puzzle has several correct solutions, which may be the reason the PC programs to crash, hang or fail to exit properly. However, none of the participants sent us a copy of a completed Alphadoku with a solution different from ours. Consequently we only accept 'IDRFBV' as the correct solution.

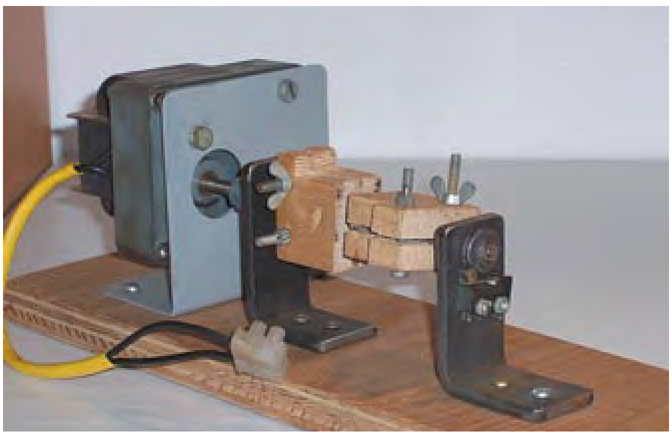
The total number of correct solutions received was 75, including entries from readers having successfully cracked the puzzle with homemade computer programs. Our compliments!



Elektorscope

Hi Jan — many thanks for your 'Retronics' page on the Elektorscope in the June 2006 issue. It reminded me that I still have that wonderful piece of test equipment in my loft. After rummaging around and opening a few boxes it not only greeted me but also proved fully functional (see photograph). I should add that that I have been out of touch with electronics for quite some time. I bought this scope as a second hand item in 1983 or 1984 (can't remember). It had a faulty transformer but I solved that with a home-made coil winding aid (second picture). The tensioned coil slowly turned on two wood blocks, with a motor and a microswitch on one of the sides supplying pulses to a counter. In this way I was able to count the number of turns of the stripped transformer as well as on the refurbished one.
I used the scope for a number of years until electronics disappeared in the background. Now I am picking up the hobby again and may be tempted to use the Elektorscope again. I will cherish it in any case.
Jan Huijs (The Netherlands)

To which we can only say: welcome back to a great hobby!



Top Brass

New Zealand based DIY amplifier component specialist, Design Build Listen has released a range of solid brass knobs to help DIY enthusiasts give the ultimate finish to their amplifier projects.

The knobs are machined from solid brass and are available in 30 mm (~1”1/8) or 50 mm (~2”) diameters. The 50-mm knob weighs in at a hefty 320 g or nearly _ lbs in old money!

Both knobs are available with central inserts in either black or stainless steel. These knobs are designed to complement Design Build Listens ezChassis® prepunched cabinets.

www.designbuildlisten.com

(067193-1)

Close-proximity wireless technology set to improve the management of diabetes

Cambridge Consultants today recently revealed an innovative medical device concept for managing diabetes that uses NFC, the close-proximity wireless communications standard, to integrate glucometers and insulin pumps. The prototype device, developed in conjunction with Philips, demonstrates how NFC can be exploited to simplify treatment for millions of diabetics worldwide, and could be the first of a new generation of medical devices that use close-proximity wireless communications.
According to the World Health Organisation (WHO), diabetes is officially classified as a worldwide epidemic with the number of people with the disease to double to 366m by 2030.

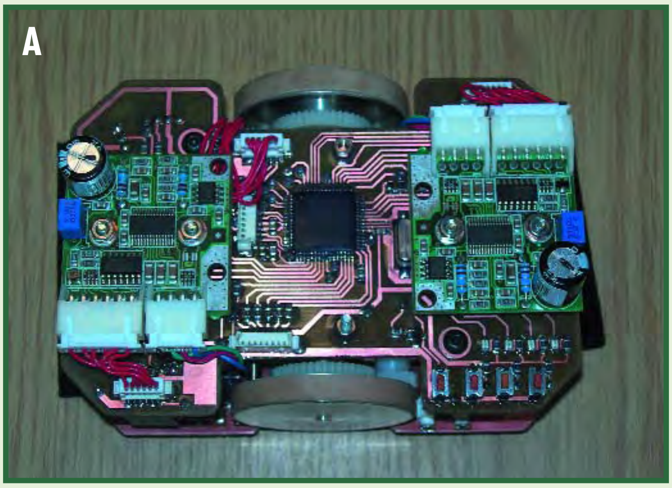
To tackle this growing global problem, the Cambridge Consultants concept device uses the unique characteristics of NFC to streamline treatment, by wirelessly linking a glucometer with an insulin pump. The glucometer records the blood sugar reading and then recommends a bolus dose of insulin. If the patient accepts the dose, then they simply swipe the glucometer against the insulin pump, which could be located beneath clothing, and the drug is delivered. This confirmation feature, which Cambridge Consultants dubs ‘patient-in-the-loop dosing’, enhances confidence and security, and allows the user to modify dosage calculations for lifestyle reasons. Cambridge Consultants believes that NFC adds genuine user-friendly characteristics that would inspire confidence in medical applications like this. These include a more ergonomic process with a simple user interaction, improved accuracy of dosing, data logging for compliance monitoring, and the ability to make devices much more discreet — with a major reduction in the need to handle or disturb the device. Such features benefit patients and health professionals alike, enhancing the reliability and integrity of treatment.
Cambridge Consultants selected Philips’ NFC technology as an ideal platform for improving the efficiency and security of human interaction with frequently-used medical equipment. These two important attributes stem from the intrinsic nature of NFC, which has a working range of just 10 cm, differentiating it from most other wireless technologies which typically operate over distances measured in metres. Unlike Bluetooth for example, a user must intentionally bring NFC devices into close proximity to make a connection, transfer information and then trigger the process.
A further advantage for medical device OEMs is the low cost of adding NFC wireless technology to products. One half of the wireless system can be designed to operate passively, drawing its power ‘over the air’ from the active terminal and avoiding bulky and costly batteries — and battery charging. This means that equipment may be wireless-enabled using an extremely low bill of materials, and with little or no impact on size.

www.CambridgeConsultants.com
www.westtechresearch.com

(067193-3)

All revved up — and somewhere to go

If you are looking for a new project that combines the elements of electronics design, programming and building then the annual **ROBOtic Event** at the University of Central England could be worth a visit. This annual event is aimed at robot and electronics enthusiasts who are interested in getting involved in robot building and maze solving. The event, held on 25th November 2006, is a relaxed opportunity to find out about **Micromouse competitions** and – if you already have a Micromouse – to test your designs on one of the standard mazes. There are a variety of events including maze solvers, wall followers and a Drag Race: that's a robot speed event, it does not mean you have to wear ladies clothes, unless you want to (although we do welcome anyone). Bring the kids for a day out – its free!


A

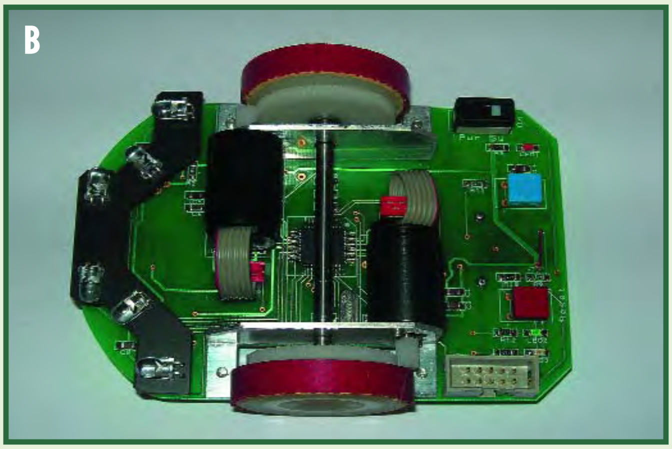
Here we show some of the mice built by competitors in the June 2006 event. There is a great variety of robots at these events which are more about encouraging people to get involved than competing. A few examples: **Photo A** shows a prototype total maze solver, by Mark Lumb. It uses a dsPICmicro and stepper motors as a main controller. Processing power and flexibility are the keys to this design and Mark hopes to test the robot for the first time in a maze at ROBOtic06.

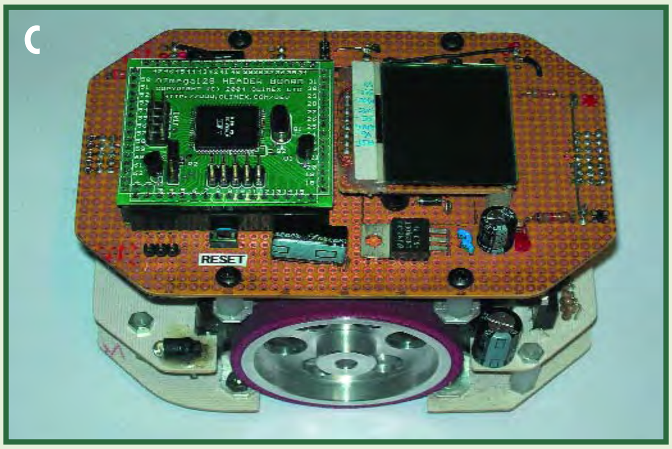
Photo B shows Ken Hewitt's latest design – ultra light, dsPIC controlled, with Lithium batteries on the underside of the PCB for optimum centre of gravity, and breathtakingly expensive DC motors incorporating precision distance encoders.

The assembly shown in **Photo C** is a very clever robot designed by Peter Harriaon, who built it around an ATmega device and stepper motors. It employs a hacked LCD display from a mobile phone to show a graphic of the maze as the robot finds its way around – this looks a little like a PACman game. At Micromouse 06 this was not the fastest mouse – but the LCD is a really neat feature showing the maze solving algorithm in action.

For further details see:
www.tic.ac.uk/micromouse/

(067216-I)


B


C

Vinculum Evaluation Modules & Application Areas

The **VDIP1** module is an MCU to USB Host Controller development module for the VNC1L device and is ideal for rapid prototyping and development of VNC1L designs.

- Jumper selectable UART, SPI or FIFO MCU Interfaces
- USB "A" type socket to interface with USB peripherals
- 2nd USB Interface available via module pins if required
- Single 5V supply input
- Auxiliary 3.3V/200mA power output to power external logic
- Traffic Indicator LEDs

VDRIVE1 is possibly the easiest solution for adding a USB Flash Drive interface to existing products. Only four signal lines plus 5V/GND are required to be connected.

- One USB "A" socket to connect to USB Flash Drive
- Link Selectable UART or SPI interface
- Only 4 signals to connect excluding PWR/GND
- Single 5V supply required
- Easy to implement command set

VMUSIC1 is a product that not only lets you add USB Flash Drive interfacing to your product but allows you to play back MP3 and other popular digital music formats direct from a USB Flash Drive.

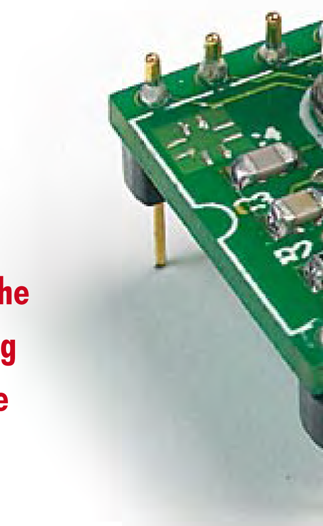
- One USB "A" socket to connect to USB Flash Drive
- Stereo 3.5mm headphone jack socket and audio line-out connector for audio playback.
- Link Selectable UART or SPI interface
- Only 4 signals to connect excluding PWR/GND
- Single 5V supply required
- Easy to implement command set

VINCULUM - IMAGINE WHAT YOU COULD DESIGN WITH IT...

Grand Prix R8C

Here are the winners of our Design Co

You decide who wins first prize!



Jens Nickel

In the last few months we've received four dozen entries from seven countries, putting the international jury in quite a sweat. The quality of the contributions was amazing, making the decision a truly tough choice. We're at the final stage now — deciding the first prize — and we need your help!

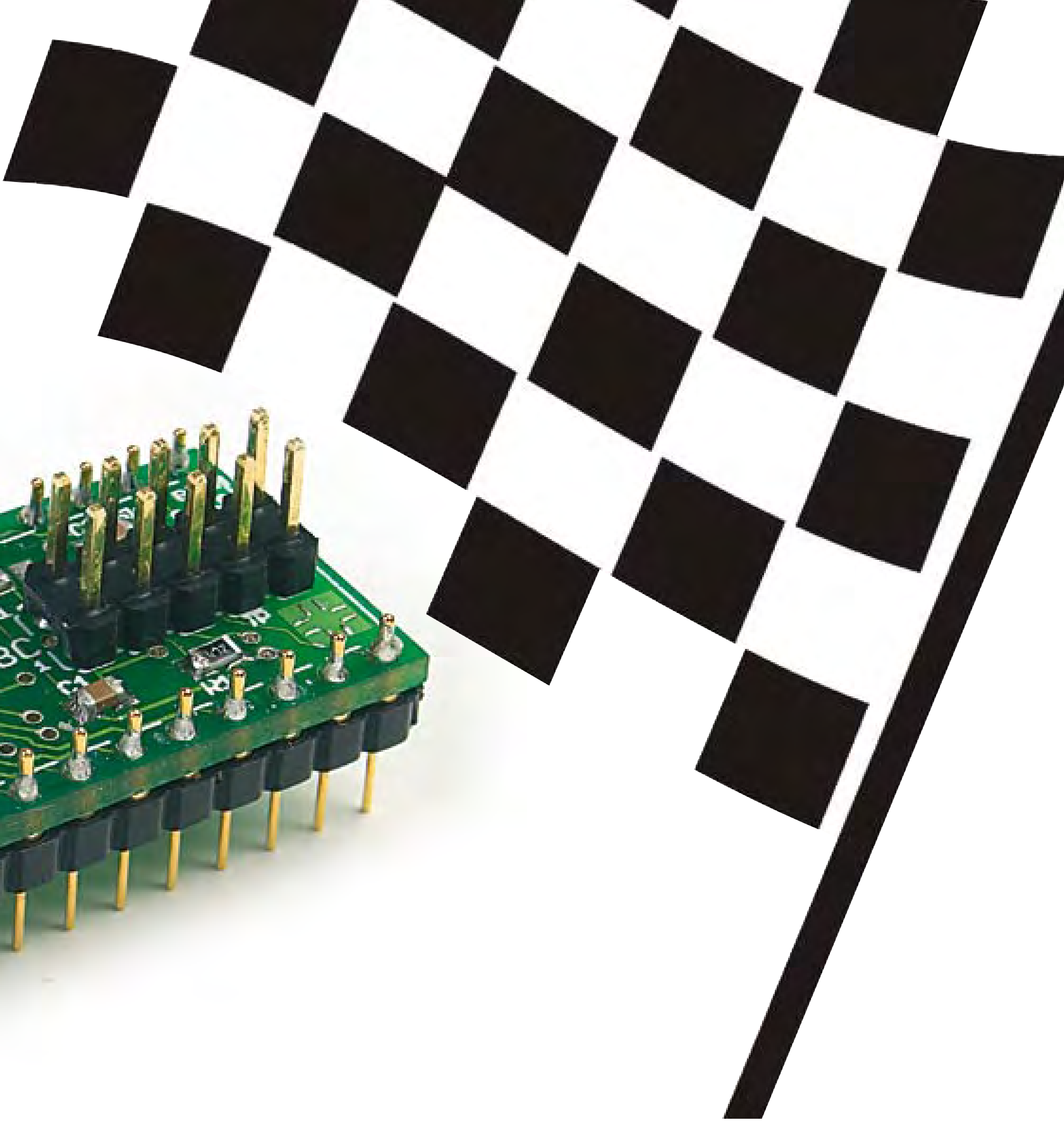
When we announced our **International R8C Design Competition** in the May 2006 issue [1], the response was initially quite modest. The number of entries rose significantly in July and August, however, and in the week before the deadline a good dozen contributions arrived in our German office alone. Evidently a lot of R8C fans had been working on their projects right up to the last minute.

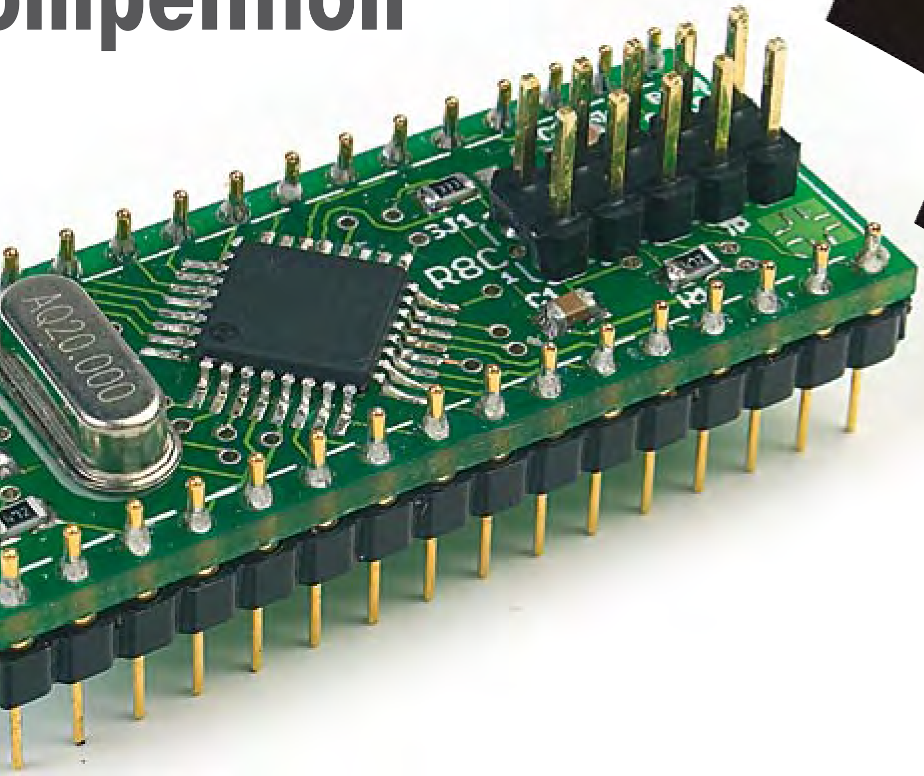
At *Elektor Electronics* HQ it was All Systems Go. For a start, many developers had supplied not only circuits, software and a brief description but also comprehensive documentation worthy of a diploma effort, wallets of photos and even short videos of their creations. Everything was examined, translated as necessary and sorted carefully. Guy Raedersdorf of the French *Elektor* explained for instance what a 'Cardiotachymétre' was. And our Dutch colleague Harry Baggen had first of all to point out that the entry called 'Butter, Cheese and Eggs' had nothing to do with his country's best-known agricultural products.
Now it was the turn of our jury experts. The Glyn distribution company's applications engineers Gunter Ewald and Alexander Pokorny — the two developers of the R8C Starter Board renowned across Europe — checked out the entries and put them through their paces. So did the well-known microcontroller expert and book author Burkhard Kainka and professional developer Jörg Schneide; the latter is familiar with the Renesas Controllers M16C and R8C down to the very last bit and byte. Joining the throng was microcontroller specialist Luc Lemmens from the *Elektor Electronics* labs, and naturally all of us editors had guidance (to an extent) from *Elektor Electronics'* international co-ordinating editor (ICE) Mat Heffels. And so it came to pass one Monday in September that all these worthies retired to the *Elektor Electronics* library with notebook PCs, data projectors and plenty of coffee to begin some serious discussion. The ICE — doyen of many multilingual editorial conferences — soon had a brainwave: "Let's make this as simple as the Eurovision Song Contest." No sooner said than done. It didn't take long to audition the first entry and hear the verdicts: "Burkhard Kainka: eight points…"

Tough decisions

Several pots of coffee later it was clear which were the top favourites. For mechanical ingenuity alone the developers of the mobile robot 'aNT' and the 'M & M Sorting Machine' earned our unanimous admiration. The entries 'Speed and Direction Controller', 'Speedmaster' and 'MicroPLC' impressed us in the way their conception had been thought through and with the well-rounded development of their hardware and software. 'MusicTree' stood out on account of the sheer number of functions and lines of code in its software, not to mention its high entertainment value. 'Isolation Transformer' enthused us too; this project may well appear in *Elektor Electronics* later this year, far removed from traditional hardware thinking and complete with stored functions in its R8C code! In the 'Transrapid' maglev project the jury was particularly taken with the polished degree of control achieved by the little microcontroller. And 'Digiclock' raised the pulse rate of everyone present by its designer's devotion to crafting 512 LEDs into a giant matrix!
It didn't take much discussion for the jurors to agree on the special prize for

ompetition





creativity. They say before you can make something you've got to invent it first and there's plenty of inventiveness about the 'TiltRocket' that won this prize (in this project a mobile phone display becomes the control panel of a space rocket gaming device).
Each one of these projects is featured in insets appearing on this and the following pages. Comprehensive info is available on our website too [2].

Also praiseworthy — and prizeworthy

This is not to say that the designs that didn't make it into the Top-10 were without merit — far from it in fact. Here's a brief rundown of the other prize winners.
Markus Schmidt developed a 'Pendulum Display', using strips of LEDs that spell out letters when swung to and fro. The jurors remarked on his programming skills and awarded him 11th prize. The tricky timing involved would not make it simple to use but a short film supplied proved that the design worked and could produce amazing results!
Behind the title 'Embedded Datalogger Interface' lies a cunning idea. The designer Michael Gaus cleverly recycled a cheap off-the-shelf USB card reader into a universal data logger, which earned him the jury's 12th prize.
Frank Schiller's 'Speech Analyser' scored by taking maximum advantage of the R8C's capabilities. Speech signals are analysed by Fast Fourier Transformation into their frequency components that the little microcontroller then compares by signature with samples stored in flash memory. The whole affair can also be displayed on a PC (13th prize).
The 'Universal Graphic Display' by Josef Schneider is a miniature digital storage oscilloscope (DSO). The display used is from a Nokia 3310 mobile phone; the data is stored in a MMC/SD card and transferred to the PC by USB cable. Tiny keys allow flexible configuration of the measurement parameters. The word 'universal' in the title is no exaggeration, making this well worthy of the 14th prize.
'Contrôles températures en 3 tiers' (three-channel temperature control) is the title of Michel Charrin's contribution. A solar control system employs a DS1921 i-button as temperature sensor, a single-wire bus connection to the R8C and a Linux-based fileserver — highly trendy and a worthy 15th prize winner!
Anastasios Kanakis' 'Colour Detector' determines the colour of a surface and given that the device is also provided with a speech output, his design could provide valuable assistance to the colourblind and people with visual or other impairments (16th prize).
The 17th prize went to Christian Koch and his contribution 'Clip SMS'. SMS texts — which can now be sent over fixed line telephone networks as well — can be sent and deciphered any place in the home where there's a phone socket. These text messages can then be used to control all manner of devices. The jurors awarded plenty of points here for the idea and the expertise used to decode the signals. There were, however, doubts that the system would only work on the German telephone systems.
As its name suggests, Olaf Kaluza's 'SD Logger' uses an SD Card for data storage, providing several gigabytes of memory for the microcontroller! In recognition of its technological progress over the data loggers of the good old days of the last century, the jury awarded it 18th prize.

2nd Prize: Robot Runner aNT

(Heiko Ott and Bernhard Schloss)

In this project an ultrasound sensor provides autonomous motion control and collision avoidance for a hexapod (six-legged) robot platform. Two standard hobby model servos provide the drive for each of the legs. The software separates motion control into individual phases, in which the servos are coordinated from one position to the next, at a rate that is either fixed (autonomous mode) or variable (slave mode under radio remote control). A special point is that the servos can operate at differing speeds and zero adjustment of the servos is a built-in software routine.

The entire electronics hardware consists of just the R8C board (using a MAX232) plus two voltage regulators/converters. All mechanical components of the platform and legs were constructed using CAD, with drawings and milling data provided. Two variants of the robots were built. The first or standard version has an ultrasound sensor module and the second has an arm that can be raised under servo control to carry a wireless camera. Two additional servos allow this to be moved left and right, also up and down.

The 'Universal Control Device' is ideal for rainwater conservation, aquatic science, water softening and other applications that require the characteristics of cold water to be evaluated. Conductivity, temperature and other values are read in through three analogue inputs, enabling four digital outputs to control pumps, heaters and other apparatus.

An intuitive, menu-driven user interface with an LCD display and keypad is another feature of this design by Richard Servus (19th prize).

'Boter Kaas en Eieren' (Butter, Cheese and Eggs) — this is the Dutch name for the game you may know better as 'Noughts and Crosses' or 'TicTacToe'. Hans Michielsen wins the 20th prize for his project, in which you must beat the R8C with the aid of tri-colour LEDs and a mini joystick.

Yet more wizard wheezes

One of the most application-orientated entries comes from Helmut Posselt. The R8C is used to monitor a foundry. Fill levels in the mould are measured a

3rd Prize: M & M Sorting Machine

(Per Stegelmann)

This project offers a good insight into the world of process automation. Per Stegelmann has devised a machine that sorts M&M sweets (you may know them as Smarties) by colour.

The hardware comprises an R8C board combined with a D.C. motor, a servomotor and a colour sensor module. Also needed are some homebrew sensors and naturally some mechanical components for which a decent metal workshop is required…

The R8C software makes good use of the timers and counters available, producing PWM signals for the two D.C. motors and evaluating the colour sensor signal (more accurately, the frequency of the signal). Timer X generates the PWM for the measurement motor and Timer Z for the sorting motor. Both Timers are interrupt-driven and are reloaded afresh with the underflow of the Timer/Counter register. The colour sensor frequency is determined using Counter Y. The counting process begins when there's a Smartie directly beneath the colour sensor module, which is determined with the aid of a reflected light sensor that detects a piece of aluminium foil on the sorting wheel.

There's a demonstration of how the machine works on the video clip provided and you can download this from www.elektor.com!

hundred times a second using a float and any deviation from the optimal 'pouring curve' are detected without difficulty. The engineer has also developed supporting PC software (21st prize).

Roland Plisch was the only entrant to use two R8C controllers together. His project 'OsziSend' is a twin-channel DSO. On one of the R8C starter boards the crystal is removed and connected to the other board to provide synchronisation. This nifty idea stands in 22nd place!

In the 'DTMF Remote Control' entered by Markus Daum household gadgets are operated through telephone extension sockets (23rd prize). DTMF tones are employed. A practical and technically sophisticated application, albeit not one that would be guaranteed to work in every country.

Roland Essinger's entry with the rather brief name 'GPS' uses a GPS module and a Nokia display to indicate the coordinates. The R8C has the task of presenting, recalculating and formatting the data. For this effort the judging panel awarded 24th prize.

'DCF77 Clock' occupies the 25th position. Robert-Jan Wiepkes has developed several display modes for his DCF radio timecode receiver, including one using a circular ring of LEDs and another with an LCD display.

One of the prettiest entries comes from Germany: in Wilhelm Glauser's 'Mill' project the R8C drives an attractive model mill, earning it the 26th prize.

The 'Cardiotachymétre' project is the work of Eddie Brador. He developed a pulse monitor with a light-dependent resistor (LDR) as sensor to measure blood flow, for example in the thumb. The analogue section is particularly noteworthy — the weak signal is amplified and filtered in a very ingenious manner (27th prize).

Ivo van den Mooter sent in his 'Accelerometer'. A three-dimensional accelerometer by Freescale assisted by the R8C together measure acceleration, with the results displayed on the PC as crossing coordinates (known technically as an axis of abscissas). This was certainly no easy task for the programmer and certainly merited the 28th prize.

The 'Rotator Interface' by P. van der Wal enables an antenna to track amateur radio satellites (29th prize). After their position has been calculated by a PC, the data is transferred to the R8C, which now controls the motor in the rotator.

Last but not least in the judges' consideration for prizes was the 'ThermoAlarm' project of Diedrich Lamken. A single-wire temperature sensor by Dallas is employed, with boundary values entered on a keypad.

Creativity prize: TiltRocket

(Thomas Fischl)

TiltRocket is a small gaming device in which you control the trajectory of a rocket on a display. Using the console you guide its journey through Space. During the voyage you have to collect stars to use as fuel, which is fine, but as your speed accelerates it becomes harder to avoid crashing into space junk. And as the risk of collision rises, so does the danger of losing all the fuel you collected…

As the diagram indicates, the hardware of this game and the display characteristics are straightforward: the R8C/13 board is connected to the display of a Nokia 3310 mobile and an ADXL202 accelerometer. The latter provides the acceleration values measured on each of the two axes as a PWM signal, of which only the Y-axis is used here. Tilt control can also be applied for other operations such as menu selection, a 3-D mouse or a mobile phone.

The free GNU GCC was used for the firmware developed under Mac OS X, then translated and compiled for the m32c family using GCC Toolchain. Hints and tips can be found on Thomas Fischl's homepage at www.fischl.de/thomas/elektronik/r8c/.

Readers' result

Hang on though; aren't we missing something? Correct: the first prize, for the most commercially viable design, has not been awarded yet. Four projects that have already won the 4th to 7th prizes for their technical merit certainly deserve consideration (see panels). But why not let our readers decide? Is it the model speed controller that you're itcnhig to build? Would you like to test drive the 'Accelerometer' and 'Speedmaster' data logger? Does the 'MicroPLC' project fire you up or might the cheerful 'MusicTree' grace your living room table? Share your opinion with us — on the website at www.elektor.com, by e-mail (editor@elektor-electronics.co.uk) or by snail mail to the editor (address on page 6). The winning entry will get the full treatment in an upcoming issue as a major Elektor Electronics project.

Finally the *Elektor Electronics* team would like to offer a giant thank-you to everyone who submitted an entry or expressed interest in our competition. It has given us amazing pleasure to see the creative potential our readers have and the enthusiastic way that professionals and hobbyists, past masters and raw beginners have put the same effort into their designs. All R8C enthusiasts are invited to continue offering their ideas, either as editorial contributions for the magazine or else in our R8C Forum!

(060281)

[1] Elektor Electronics, May 2006, page 14. www.elektor.com

[2] All projects (including entries that didn't win prizes) are available for download on the Elektor Electronics website! Here you will find not just a ZIP file of documentation, circuit diagrams and of course software but also a brief description: www.elektor.com

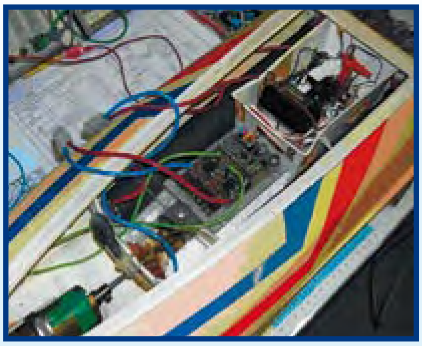
1st Prize: The decision is yours!

Deciding the first prize needs your participation! We have merely gathered an advance selection of projects that could sensibly be produced. One of the following entries will be turned into a major project in an upcoming issue of Elektor Electronics and our readers will determine which project. At our website www.elektor.com you can review each of the projects in greater detail and you'll also find a voting form there. You can also send in your opinion by e-mail or post (see page 6 for addresses.

As all of these projects display a high level of technical ingenuity (and to avoid any of these entrants walking away empty-handed) we have also awarded four additional prizes (4th to 7th) for their contributions.

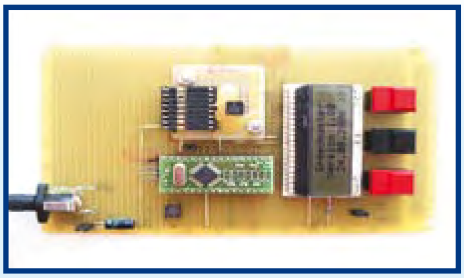
4th Prize: Speed and direction controller

(Marc Schneider)



The programmable controller is equipped with high-resolution PWM inputs and outputs, the ability to set motor direction and reversing, interference suppression and start protection. The controller is particularly suitable for model ships. The hardware comprises principally the R8C/13 with power supply and an H-bridge circuit with 45-amp power MOSFETs and related driver stages. A heatsink must be provided in addition (sized according to the space available in the model).

The project is ideal for model constructors who have not yet found a suitable application for their R8C/13 carrier board. The PCB is fully developed, enabling the project to be completed relatively quickly although some of the components used are not exactly cheap.



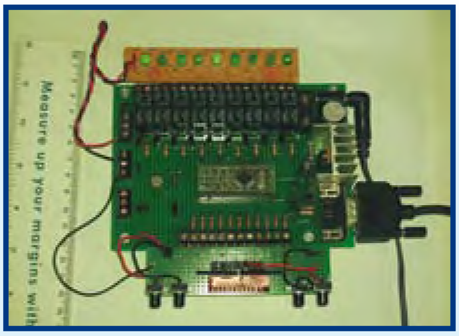
5th Prize: Speedmaster (Markus Simon)

Speedmaster measures acceleration, speed and distance covered by a moving object—in both two and three dimensions. Its basis is the MMA7260Q accelerometer from Freescale Semiconductor. Speed and distance are ascertained by integration. The device is best suited for short measurements, since the tolerances could add up to larger discrepancies in the longer term.

Potential applications include measurements in motor vehicles (acceleration, braking deceleration, speed and distance covered), in lifts (elevators), in free fall (parachute jump) and on board aircraft.

A printed circuit board has yet to be designed in the labs, meaning that 'time to market' might be delayed a little.

6th Prize: MicroPLC (Gérard Jacquemin)



MicroPLC is a PLC control system based on R8C/13 boards. The controller has an RS-232 interface, 11 digital inputs (6 of which can also be used as analogue ones), 9 relay outputs, 32 internal memory positions and 16 timing values.

The project includes a ready-made printed circuit board and a basic program for users' own control applications.

Although the photo shows a prototype, the finished PCB is now available, meaning it will not be long before your R8C/13 board can become a complete PLC board system. Total cost depends primarily on the number of connections and relays.

Check out the software to determine whether it will turn your dream applications into reality.

7th Prize: MusicTree (Alexander Steiger)

Could this be the ultimate Christmas project? Ten months after our February 2005 issue the PCB was put to festive use. The MusicTree project is a light and sound effects circuit created in the form of a Christmas Tree. A number of LEDs twinkle at random and an audio transducer produces melodies stored using Nokia format in the memory store of the microcontroller (enabling new tunes to be added without major difficulty).

The Christmas Tree is also equipped with a light level sensor that adjusts the light effects according to room brightness.

Construction costs are minimal and the project is built on matrix board. It would not take long to devise a PCB for this circuit, but only if you tell us you want it!

8th Position:
Isolation Transformer
(Michael Hasselberg)

This is an up-to-date reworking of an existing project from the late from the 1980s with the aid of the R8C printed circuit board. The object of Michael's modernisation is the device resulting from an article discussing isolation transformer peripherals plus improvements made by readers following the publication. The R8C/13 board enhances this well-proven laboratory device with digital technology. The goal of this design was to improve functionality without abandoning the analogue 'feel'. Operation uses two push buttons and a potentiometer, with analogue meters and LEDs used for indication. Precision rectifiers, effective value (root mean square) measurement and power level measurement are carried out in software. A simple adjustment process and self-testing round off the impressive characteristics of this device:

- Effective (RMS) measurement for voltage and current
- Thermal monitoring and blower control
- Output current limiting with indication and electronic fuse (circuit breaker)
- Self-test at power-on and coded flashing indications during adjustment, operation and fault condition.
- Apparent power and efficiency factor measurement
- Inrush current limiting

9th Position:
Transrapid'
(Markus Daum)

Markus Daum developed a simplified model of the Transrapid maglev train, demonstrating how a 'bobsleigh' made from Fischertechnik components can truly levitate! Three coils drive the bobsleigh from below with PWM-modulated D.C. along an steel rail and release when the magnets get too close to the track. When no current flows, the gap is 2.5 mm. In levitation mode an air gap of between 1.0 and 1.5 mm is produced. The circuitry consists of just a white LED and a phototransistor for measuring the gap, also an optocoupler with series-connected power transistor for controlling the three magnet coils — plus the R8C/13 board from Elektor Electronics February 2006

A PID regulator implemented in the R8C software handles control and this delivered good results from the outset. The bobsleigh settles cleanly and maintains (on the raised side) the predetermined distance above the track. Needless to say the time is still some way off before the first Transrapid train completes a circuit of Markus Daum's hobby room but the first successful step has been taken!)

10th Prize:
Digiclock
(Hedwig van de Moortel)

For this project an existing digital clock was equipped with a large LED matrix display. A heart transplant of the R8C board gave new life to the clock, with the old microprocessor disconnected from its peripherals.

The 50 Hz mains frequency is retained for reference timing, as this is always accurate enough for domestic timekeeping. The hours and minutes display occupies the upper section of the LED matrix, with the seconds below. Every complete minute the display is refreshed across the LED 'screen' with an attractive scrolling effect.

Included in the software is a kitchen timer function, for which the large, bright LED display is well suited. Time setting is carried out using four push buttons. In timer mode the clock time and countdown status are both displayed simultaneously.

Hotheads!

14 soldering stations compared for price & perfo

Thijs Beckers

Soldering irons are nearly indispensable in the professional world and hobby room alike. This key element of every electronics workstation is an essential tool for working on circuitry and thus deserves proper attention. Read on to learn what our professional test panel thinks of several popular soldering stations (and find out whether that expensive model you have your eye on is really worth the price…).

We subjected 14 soldering stations to a thorough assessment in this test. We considered several important aspects in order to obtain an overall impression of the good and bad points of each soldering station. Our findings are presented in this article.

With or without a station?

Soldering irons come in various forms, including soldering irons powered by a soldering station, soldering irons that connect directly to the mains, and portable soldering irons that operate on batteries or gas. And of course, there are also soldering stations that use hot air. We can't possibly test all of them, so we have to draw the line somewhere. In this test we decided to concentrate on soldering stations on the broadest possible scale.

Soldering stations allow you to precisely control the temperature of the tip, which certainly has its advantages in practice – the components and solder don't get too hot, the tip doesn't wear out as fast due to overheating, and so on. Temperature regulation is also handy for putting the soldering iron in a 'standby' state, so it can come up its the operating temperature quickly while at the same time reducing the rate of oxidation of the tip. Some of the more expensive stations do this automatically.

Like many things, soldering stations are available in all price ranges. The least expensive station that we tested costs around £ 27 (€ 40) and is clearly intended for hobby use. You would want something more robust for a professional workstation, since soldering irons for professional use must be designed for many years of continuous use. The most expensive of the tested stations would certainly be at home in a professional workstation environment, but in principle it is unquestionably suitable for hobby use as well. Naturally, a large number of even more expensive and more professional stations are available, but they fall outside the criteria we set for this test.

The price/quality ratio of the various stations is naturally one of the key concerns. That's why we asked a variety of well-known and respected manufacturers to supply several soldering stations so we could test them thoroughly in our own lab. Of course, the experience of our designers is also useful here, and with their help we were able to form a good picture of the various characteristics (good and bad) of the tested soldering stations.

The test

The new RoHS regulations have caused a few changes in soldering practice. The most important change with regard to soldering stations is that RoHS-compliant solders have higher melting temperatures. This means the soldering iron must have an adequate temperature range. As you can see from the summary table, almost all of the station can raise the tip temperature high enough to melt lead-free solders. Only the StarTec experienced some difficulty with lead-free solder and normal through-hole components.

To get an impression of the performance and ease of use of the soldering stations, a team of six experienced electronics professionals subjected each of them to a critical assessment. We have summarised their findings for each station individually. We tried to assess each of the stations as objectively as possible. We did not tell our team the

ormance

Hot air

Aoyue 852A (£69 / € 100) and Weller WAD101 (£425 / € 620)

We tried out two hot-air station in addition to the soldering irons with hard tips. The Aoyue 852A, which is especially inexpensive for a hot-air soldering station, is made in China (that explains the price…). It is a fully complete unit. The grip of the iron is actually too large for comfortable use, and the cable is a bit irritating.

The Weller unit is considerably better in this regard. The nozzles supplied with the 852A are usable, but the Weller nozzles are finer and thus once again better. Both stations have adjustable airflow, and it takes some practice to find the right setting. The relatively expensive WAD101 needs an external compressor for the air supply, while the 852A is self-contained (as already mentioned).

The Aoyue unit is thus clearly better in this regard.

Neither of these station is suitable for use with through-hole components, but they are perfect for desoldering and working with SMDs as long as the temperature and airflow are set properly.

The Weller station is clearly intended for professional workstations where compressed air is already available, while the 852A is nice for home use.

prices of the stations during the test. Of course, our testers were not exactly working in the dark. Everyone knows that a Weller iron is generally more expensive than a Velleman iron. However, the differences are mostly to be found in the construction, finishing and options.
In many cases, it is certainly worthwhile to find out what accessories and soldering tips are available for a particular station or iron. Of course, you should bear the intended use in mind in this process. If you want to use the iron to solder SMDs, you will do well to select a fine tip, while a somewhat thicker tip is better for normal components. A soldering tip that is suitable for both uses will always be a compromise solution.

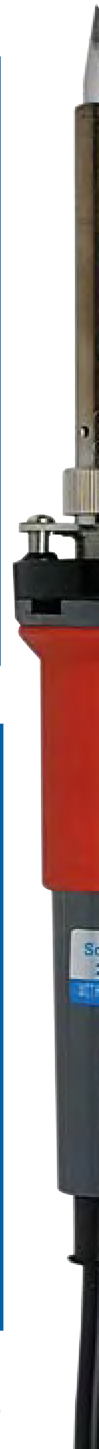
Antex 660TC (£130 / €190)

This unusually styled UK-made soldering station comes with a 50-W iron with reasonable to good handling characteristics. The cable is a bit on the short side, but it is reasonably flexible. The iron is connected to the station by a DIN connector, which also provides the earthing connection for the iron. The tip of the iron is connected to the mains plug earth contact via the earthed connector.

The soldering tip was not well received by our test panel. The round, obliquely flattened tip reminded them of old-fashioned soldering irons. Nowadays you expect more from the standard tip provided with an iron.

The iron is easy to operate, but that's hardly any surprise since this station has absolutely no bells or whistles. A sort of rotary knob adjusts the temperature setting. Two LEDs provide status indications, but the temperature of the iron is not shown anywhere. The station has two recesses at the rear so it can be fitted vertically, which leaves more space free on the work surface.

The appearance of the 660TC sets this station apart, but unfortunately its soldering characteristics didn't make such a good impression with us. At minimum, it needs to be supplied with a different tip..



Antex 690SD (£195 / €280)

Although the iron of this station and that of the 660TC appear to differ only in the colour of the grip, they are not interchangeable. They have different types of temperature sensors and different plugs (DIN 180° vs. DIN 270°). The temperature scale is set to Fahrenheit by default. It can be changed to Celsius via the menu, but we had to consult the manual to figure out how to do so. Two temperature memories are also tucked away in the station. Fortunately, the short user's guide describes all the operating options quite clearly.

Although the interconnecting cable is reasonably flexible, it is on the short side. This station also earths the tip of the iron via the earth contact of the mains plug.

The tip is a bit large and not really suitable for soldering SMD components. We also had the problem that the tip oxidised quite quickly if it wasn't tinned while heating up. Once the tip is oxidised, it's nearly useless for soldering and must be cleaned using a non-metallic scouring sponge.

In addition to normal soldering tips, a variety of desoldering tips are available for the iron.

All in all, this is a reasonably good iron, but you will want to have several different tips for it.

Conrad Toolcraft ST-50D (£55 / €80)

This attractively fashioned station with a separate iron holder and many little storage compartments is relatively inexpensive – you get a lot for your money. It has a nice two-line LCD with blue backlighting and a knob to set the temperature. It also has several presets. Operation is quite intuitive, and the only minus point for this station is that the LCD display is somewhat jittery because the temperature reading is updated too frequently.

This station was rated as 'reasonably good' by the test panel, but it is not intended specifically for professional use. The supplied soldering iron gives good results with relatively small components, but the tip is too fine for large components, and the heat capacity also comes up a bit short. The grip of the iron becomes rather warm after several hours of use. Unfortunately, the iron temperature shown on the display turned out to be quite optimistic, and in practice the set temperature fluctuated a lot more than what was indicated by the display.

Conclusion: a nice soldering station at a good price, and quite suitable for electronics hobbyists.

ELV LS50 & LA50 (£47 / €69)

This cream-coloured station with a large display (LS50) is an in-house product of the German mail-order company ELV. The iron holder (LA50) is a bit too light and thus tends to wander quickly over the work surface. However, the iron rests securely in the holder. The soldering iron appears to come from the same manufacturer as the Velleman irons. The cable, which is somewhat too short and stiff, connects to the station with a DIN plug. Next to the connector for the iron, there is a connector for earthing the iron (with a banana plug) to protect sensitive components against static discharge.
The station is easy to operate. The temperature can be set using two pushbuttons. There are also three preset buttons that can be used to select a user-programmed temperature.

The tip supplied with the iron is not suitable for SMD components. The iron is probably not intended for this purpose. Our testers had no problems with soldering 'normal' components. It's a pity about the stiff cable and the lightweight holder.

Ersa RDS80 (£125 / €180)

Next to Weller, Ersa is probably the best-known name in soldering irons. In addition to the Digital 2000A model, we selected the RDS80 model from the broad product line of this manufacturer. These two models differ completely in appearance. The RDS80 is attractively styled and has a separate station and iron holder. The station has a large, clear display that is easy to read, and it is very easy to operate – you actually don't need a user's guide.

The soldering iron provided with the station has a generous power rating of 80 W, but it is fitted with a fine tip with a flattened point. Most of the testers enjoyed using this station for normal soldering work, but the opinions regarding using it for SMD components were rather divided due to the flattened tip (a different tip might help). The grip of the iron is reasonably slim and comfortable, but the connecting cable to the station could be a bit more flexible.

Overall, the testers gave this midrange soldering station a largely positive rating.

Ersa Digital 2000A (£220 / € 320)

The Digital 2000A station looks quite modern with its silver-tone front panel. You can chose from several different irons for use with this station. We tested it with the Microtool iron, which is intended for relatively fine work. The cable of the iron is sufficiently flexible, but we sometimes found it a bit short. Unfortunately, the user interface of the station is not especially good. The menu is poorly organised and non-intuitive in use.

The supplied soldering tips were rated as reasonable to good. The fine tip is particularly suitable for densely populated SMD boards. More attention should be given to the design of the holder. The iron is held rather loosely if it is not placed in the holder just right, with the risk that the hot tip can touch the plastic of the holder.

The overall test rating was 'reasonable'. The Microtool is quite suitable for soldering SMDs. It also solders larger components reasonably well, and the warm-up time is reasonably good. Now if they could just fix the menu…

Star Tec ST081 (£27 / €40)

This compact blue station and matching soldering iron just about fit in your trousers pocket. Besides the on/off switch, a temperature setting knob and LED indicator, there is even a connector for potential equalisation. However, there is no temperature control feedback, which became quickly evident when we measured the temperature. The temperature knob adjusts how long power is supplied to the heating element. The higher the setting, the longer the station provides power (during each period).

Despite its budget design, the iron is reasonably comfortable in use. The interconnecting cable is flexible and sufficiently long, and the tip scored reasonably well. However, the 'holder' is very low-budget and was rated poorly. The connector for attaching the cable to the station is also no luxury model. It's just a standard Cinch connector. Of course, the small 7-W iron doesn't draw much current, so this isn't actually a problem. Neither of the StarTec stations has a cleaning sponge.

Considering its price, the ST081 is a good soldering iron for portable use and soldering small components. The station does not have enough power to do a decent job of soldering through-hole components..

StarTec ST301 (£27 / €40)

It seems strange that the second (and larger) StarTec model in the test costs the same as its little brother, but this is because they come from to different manufacturers.

The ST301 is a reasonably full-featured model that is supplied with two irons – a large one and a small one. The design of this station is also quite simple. Here again temperature regulation is provided by a sort of pulse-width control with the duty cycle set using a potentiometer. The irons are connected to the station by a normal Cinch plug. The iron holder of this station is also nothing special – it is the same as the holder for the small station.

The testers rated the soldering characteristics of both irons as generally reasonable, although the small iron has a rather flimsy construction. They also noticed that the grip of the large iron becomes rather warm after it has been in use for a while.

The low price of this set makes it attractive for people just getting started in electronics, but you shouldn't expect too much from it. It's best feature for hobbyists is that it comes with two irons as standard, so you can experiment conveniently with SMD components and normal components.

Velleman VTSSC40N (£48 / €70)

This grey-coloured soldering station has an iron holder fitted on the left side, which makes it somewhat unsuitable for use by right-handed persons (since the interconnecting cable is always in the way). However, the holder can be detached from the station with a bit of effort, so it can be fitted somewhere else.

The station has a rather simple design, with two pushbuttons for setting the temperature and a respectably large LCD that clearly displays the set and measured temperatures. The soldering iron is a generously sized model with a hefty tip, and it is fitted with a somewhat stiff, rather short cable. The cable is connected to the station by a robust threaded connector.

The majority of the testers found this soldering iron primarily suitable for relatively large components, The tip is not suitable for SMDs. The iron is not especially comfortable in use due to its relatively large dimensions. The grip of the iron becomes a bit warm after long periods of use, but this is not particularly irritating. The holder could be better – the iron occasionally slides partway out of the holder.

All in all, this is a reliable, affordable station for conventional soldering work.

Velleman Lab1 (£89 / €130)

The Velleman LAB1 is more than just a soldering station. The somewhat oversized enclosure also houses a simple power supply (3–12 V) and a digital multimeter (powered by a 9-V battery and thus electrically isolated from the power supply). The soldering temperature can be set using a knob. There is no display, and the station does not indicate how warm the iron is. If he temperature is set higher than 350 °C, the 'heater' lamp remains on continuously, and it appears that the station no longer actually regulates the temperature.

The soldering iron appears to be the same as for the VTSSC40N, except that the robust threaded connector on the cable has been replaced by a standard 5-way DIN plug. The holder was rated as 'reasonable'. A somewhat wobbly sponge drawer is located beneath the holder.

The overall response to this combination was positive. The space savings resulting from the 3-in-1 concept are an especially strong plus point. If we consider the soldering station by itself, the conclusion is that it is a reasonable iron for hobby purposes but not suitable for professional use.

Weller WD1M (£290 / €420)

We tested this attractively designed station with a large LCD together with the small, slim WMRP soldering iron. All testers said that the iron was very comfortable in use. The interconnecting cable is nicely flexible and neither too long nor too short. The soldering characteristics of the iron were rated as good. Due to its small tip, this iron is primarily suitable for soldering SMDs. It is somewhat less suitable for use with large components due its small heat capacity.

The iron comes with a holder that has an unusual design, but it turned out to be quite convenient in use. The holder enables the station to detect whether the iron is resting in the holder, and it reduces the temperature to a configurable stand-by value if it is. The warm-up time is very short: the iron takes only 5 seconds to reach its working temperature.

The soldering station has an extensive operating menu and is even fitted with a USB port. Besides enabling the station to be controlled by a computer, it supports storing and displaying temperature logs. Despite its hefty price, this is one of the best and most reliable of the tested stations. It received especially high ratings for soldering small components.

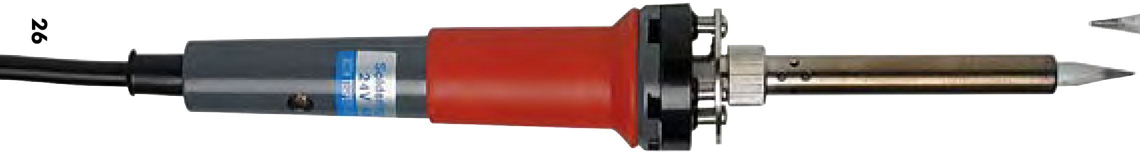
Weller WSD81 (£225 / €325)

The soldering iron supplied with the WSD81 was also rated as easy to use by our test panel. The cable was rated as 'good' without any exception. The soldering performance of the iron was rated as reasonable to good, although the supplied tip is only suitable for relatively coarse work.

However, Cooper Hand Tools has a broad range of solder tips in its catalogue, so you can always select a tip that meets your specific needs. A plastic ring makes it easy to swap tips while the iron is still warm.
The handgrip also remains remarkably cool. The simple iron holder is sufficiently heavy to prevent it from wandering over the working surface too easily.

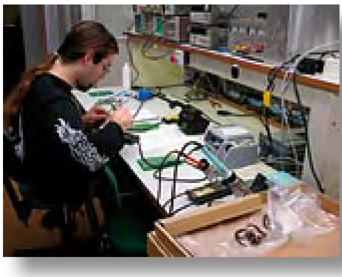
The restrained appearance of the station is offset by the professional 'touch' of the buttons and the feeling of solidity radiated by the set. This is simply a good unit that is made to be used every day and will last for years.

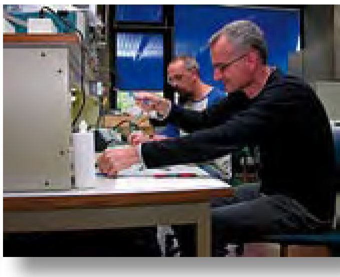
Our only negative comment is that the connector for attaching the iron to the station could have a more robust feel.



Manufacturer	Model	RRP (approx.)	Voltage	Power (W)	Temperature range (°C)	Earthed	Temperature indication	Special features	Time to heat up to 350°C (s)	Tip temperature (°C) (set to 350°C)
Antex www.antex.co.uk	660TC	£130	24 V	50	65~450	Yes, via mains plug	Analogue		50	336
	690-SD	£195	24 V	50	65~450	Yes, via mains plug	Digital	Can also be used as a desoldering station with the proper soldering tip	50	365
Conrad www.conrad.nl	ST-50D	£55	Not known	50	150~450	Yes, via mains plug	Digital	Programmable preset temperature	90	336
ELV* www.elv.de	LS50 & LA50	£47 + £9	24 V	48	150~450	Yes, via banana plug	Digital	Auto-power-off, standby, programmable preset temperature	70	384
ERSA www.ersa.com	Digital 2000A with Microtool	£220	24 V	30	50~450	Yes, via banana plug	Digital	Auto-power-off, standby, programmable preset temperature	35	334
	RDS 80	£125	24 V	80	150~450	Yes, via banana plug	Digital	Auto-power-off, standby, programmable preset temperature	65	355
Star Tec** www.startec-products.de	ST081	£27	12 V	8	100~400	Yes, via mini banana plug	Analogue		No setpoint temperature indication	310
	ST301	£27	12 V	25 / 7.5	150~450	Yes, via mini banana plug	Analogue	Supplied with two soldering irons	No setpoint temperature indication	408
Velleman www.velleman.be	VTSSC40N	£48	24 V	48	150~450	No	Digital		125	375
	LAB1	£89	24 V	48	150~450	No	Analogue	Digital multimeter, regulated power supply	150	360
Weller www.cooperhandtools.com	WSD81	£225	24 V	80	50~450	Yes, via banana plug	Digital	Tip easy to replace with hot iron	15	384
	WD 1M with WMRP	£290	24 V	40	50~450	Yes, via banana plug	Digital	USB port for PC operation and data logging, programmable preset temperature	5	374

* Only available from ELV ** Supplied by Conrad *** Supplied by ELV






Lab favourite

Our lab has had a clear favourite for many years now: the TE460 station and TE soldering iron from the German manufacturer Selektra. The iron has a thin, curved tip and a thin shaft, but it still has enough heat capacity to do a decent job of soldering leaded components. It is also suitable for soldering SMD components. The curved tip makes it easy to navigate past obstacles to reach every solder pad, and the thin shaft is less likely to touch other components and thus reduces the risk of melting them (electrolytic capacitors and large polypropylene capacitors are the most frequent victims). Thanks to the small diameter of the grip, the iron is comfortable in use. The station is a model of simplicity. There's no digital temperature readout or USB port. It has just one knob to set the temperature and one LED to show whether the iron is being heated.

Unfortunately, Selektra does not sell to private persons, and the large mail-order companies do not carry this brand. For this reason, we did not include our favourite in the test.

Conclusion

Our soldering station test drew a lot of attention from passers-by. Everyone wanted to know what was happening in the lab this time. The members of the test panel also had a great time. Besides cries of pleasure ('Great for SMDs!'), we also heard less positive expressions from time to time ('Do they think that everyone who works with electronics is left-handed?'). Fortunately, everything went well and we didn't have to treat any burn blisters with sticking-plasters or ointments.

Several differences became apparent quite quickly in the process of testing and collecting measurement data. The most striking differences were seen in the warm-up time. Generally speaking, the more expensive stations heat their soldering irons considerably faster than the less expensive ones. Naturally, this is largely due to the power capacity of the stations, but it also depends on the heat capacity and construction of the irons and the control circuit for the heating element.

All the more expensive stations have a digital readout, which means a display. The display also shows the measured temperature of the soldering iron, which is naturally not feasible with an analogue control knob. Another thing that quickly became apparent was the differences between the soldering tips. Some of the irons were supplied with a very fine tip that was clearly intended for soldering SMD components. Nevertheless, a few of the stations with such tips were also quite suitable for soldering normal (through-hole) components. Naturally, the irons with 'normal' tips are all suitable for soldering such components.

Some of the soldering stations in the test can be fitted with different soldering irons. For instance with the Ersa Digital 2000A you can select the Micro Tool (30 W), Tech Tool (70 W), Power Tool (105 W), X-Tool (120 W), or the Chip Tool desoldering tweezers (2 x 20 W). The Antex 660TC can also be used with the 25-W TC25 iron, and the Weller stations can be used with a broad range of irons.

Various types of soldering tips are available for nearly all of the soldering irons. You can thus decide for yourself (to a certain extent) what the iron will be used for. Most of the stations have sufficient power capacity to support the various tips and uses.

The winners

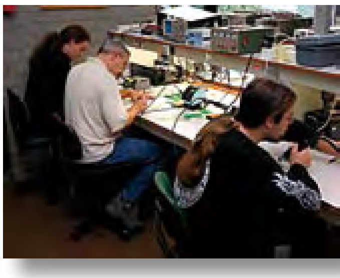
It is naturally impossible to make a single product that perfectly meets the needs of every user. Nevertheless, several of the tested stations come pretty close to meeting this objective. For example, the combination of the Weller WD 1M station and WMRP soldering iron received the highest rating. It is very easy to use, the iron heats up quickly, and the set makes a solid impression. The WD 1M is a professional station that is obviously built for many years of intensive use.

We can also recommend the Ersa RDS80 as a good mid-range model with an excellent price/quality ratio. The testers were quite satisfied with this model. Its only drawback is that it is not really suitable for extensive SMD soldering work, but that can be improved with a few additional soldering tips. The prize for the best price/quality ratio goes to the StarTec ST301. You get a soldering station with not just one but two soldering irons for just over 25 pounds. Although this station does have a few shortcomings, it is certainly not a bad choice for incidental use.

(060279-1)

We would like to express our cordial thanks to the various suppliers and manufacturers for their cooperation and for making the soldering stations available for this test.






Smartcards

ABC of blank cards for private applications

Christian Tavernier

After a somewhat hesitant start the chipcard has finally come into its own. Whether it's a bankcard, a subscriber's card for viewing encrypted TV transmissions, a SIM card from a mobile phone or a specific payment card for a car park or launderette, these days you'll find a chipcard everywhere.

In this article we'll tell you more about the design and insides of various types of smartcard, allowing you to start using them in your own applications. Since it is essential that you can read, write and program these cards, we'll take the covers off two designs for programmers in a second article.

Standard connector

The chipcard conforms to many worldwide ISO standards, of which the best known are ISO 7816-1 to 7816-4. These lay down the most important technical properties of the cards. Due to a lack of space we can't cover these in this article, but if you find this subject interesting you should refer to the work of the author [1]. We limit ourselves to the most important aspects and begin with a look at the internal circuit of cards that contain a microcontroller (**Figure 1)**.

As you can see, the design is very simple. In all cards we find that a microcontroller is used. Usually this is a well-known chip (e.g. a 68HC05 from Motorola, a PIC16F84 or 16F876 from Microchip or even an AT90S8515 from Atmel). On some cards the microcontroller is connected to an EEPROM memory or to a cryptographic processor, which is the case for the latest heavily protected cards. In this article we will not look at contactless (RFID) cards — these have been covered extensively in last month's issue. The chipcards described here communicate with the outside world via a number of gold plated contacts that are placed above the chip and which are also standardised, see **Figure 2**. These connections won't come as a surprise to you if you've studied the design in Figure 1:

- C1 is the positive (VCC) and C5 is the negative (GND) connection for the supply. The nominal supply voltage has been 5 V for a very long time. These days there is a development taking place towards a 3 V supply, due to the increasing use of digital logic that operates at this voltage.

- C2 is called RST. This is the reset input of the card and is connected to the reset pin of the embedded microcontroller. It has to be pulled to a Low level to activate it.

- C3 is called CLK and is just the external clock input of the card. The onboard microcontroller doesn't have its own clock and therefore needs to source this externally.

- C7 is the I/O connection and this is the only link with which the card can communicate with the outside world. It is implemented as an asynchronous serial input/output and all communications with the microcontroller take this route.

- C4 and C8 are shown in many documents as RFU, which stands for '*Reserved for Future Use*'. Strangely enough, we're still waiting to see what this use may be, even though the first chipcards appeared twenty years ago!

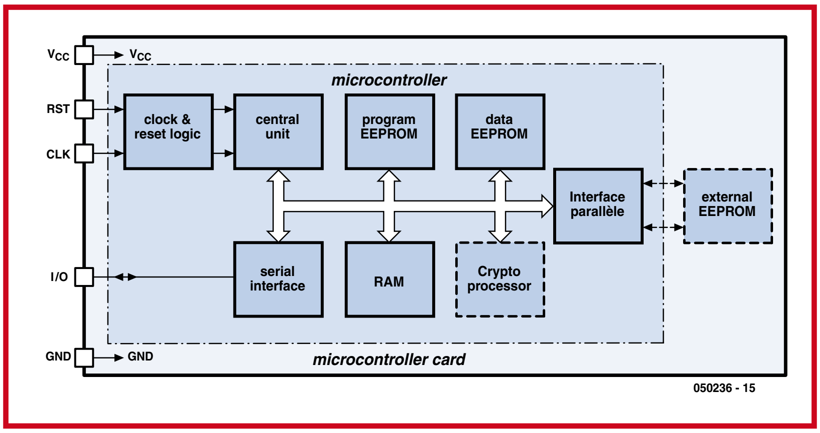


Figure 1. The internal circuit of a chipcard (the dotted elements are optional).

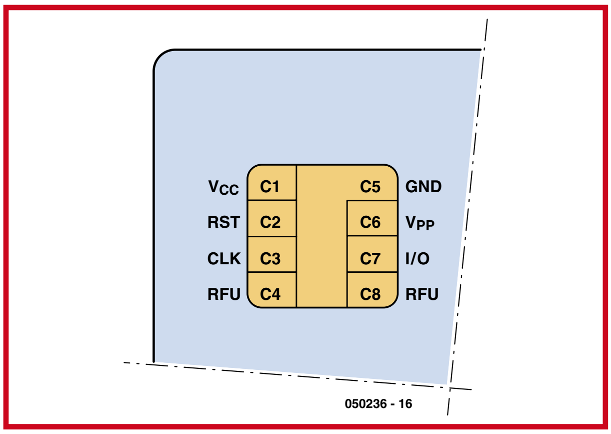


Figure 2. Connection details and position of the contacts on a chipcard.

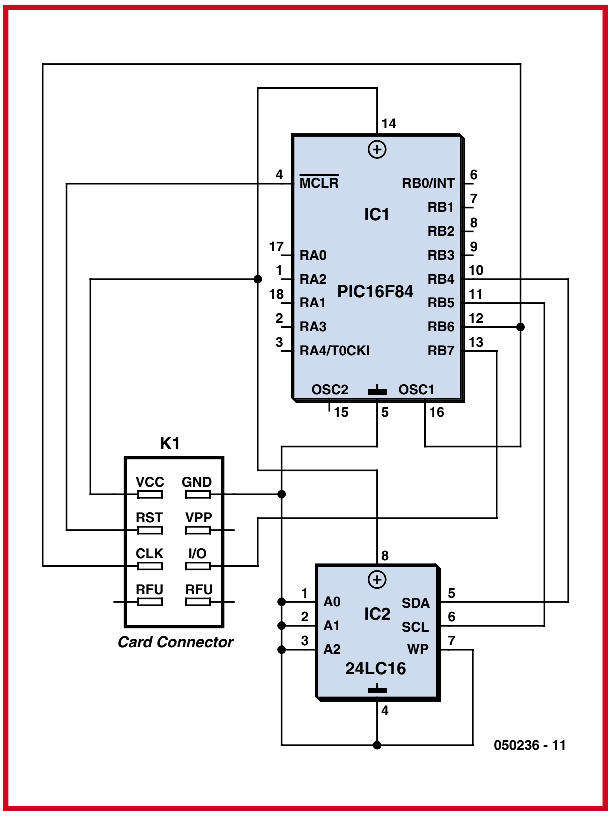


Figure 3. Circuit of a Goldcard.

- C6 was initially used for the VPP supply that was required by the first cards to program the EEPROMs. These days this secondary supply is no longer required and this connection is unused.

We don't have room in this article to explain the intricacies of the communications protocol, although it is straightforward. Depending on the response to this article we may put supplemental information for this on the *Elektor Electronics* website on the download page for this article.

Available cards

These days there are relatively many cards that are not fully documented. This may appear strange at first, but you shouldn't forget that most of these cards were designed for less honest applications. The innards of the cards were of little interest to most users, who only cared that they could program these blank cards with some 'miraculous' file from the Internet.
These days there is some reliable information available for several cards regarding their contents and internal circuitry.

The Gold card and Silver card

From a historic perspective these are the oldest, best known and most used cards. It is therefore logical to start our overview with these. We have grouped them together because both employ a PIC made by Microchip. If you

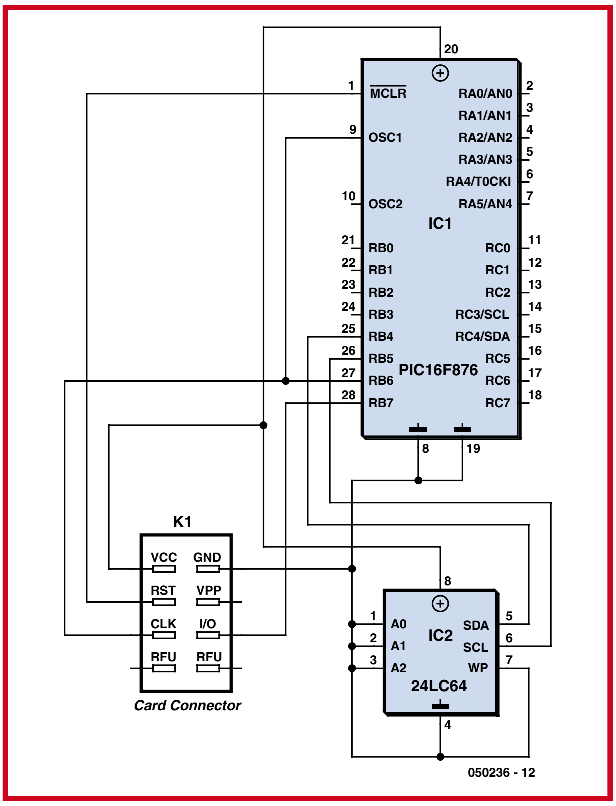


Figure 4. Circuit of a Silvercard.

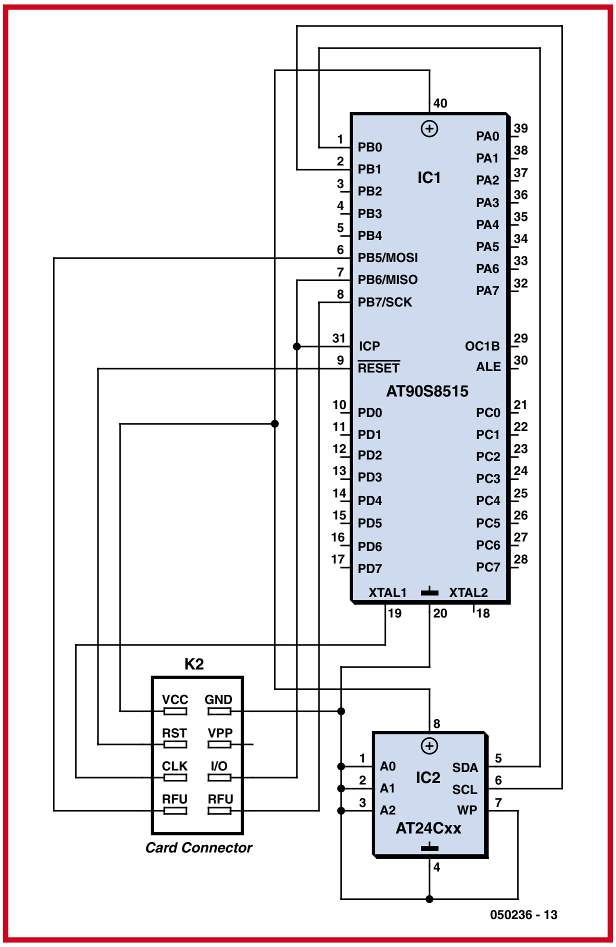


Figure 5. Circuit of a Funcard (or Purplecard).

are already familiar with this microcontroller family it should certainly be interesting to develop applications for use on a Gold card or Silver card.

Figure 3 shows the internal circuit of a Gold card, the older of the two, which therefore has an 'old' PIC, the 16F84. The way in which the PIC is connected to the card connector was kept as logical as possible: the reset input is connected to RST, while the clock input is connected to the CLK contact. RB6 of the controller is also connected to CLK, and RB7 is connected to the I/O input of the connector. In this way we have external access to RB6 and RB7 and the PIC can be programmed, because we only need these two lines (apart from reset) for this. This of course forces us to use PIC port RB7 as input/output to exchange data with the outside world during normal use.

Southeast

Because it usually gives access to 'sensitive' information, the chipcard has often caught the attention of software pirates and other hackers. For example, the notorious Yescard, a card that answered 'yes' to everything, was used for a long time to make counterfeit bank cards. The contents of cards used to view encrypted TV stations can still be found in a few places on the Internet.

Because of all this, it is often thought, undeservedly, that chipcards aren't secure. This assumption is wrong because pirates were only able to get round the cards' security systems because the associated programs didn't implement these security features properly. You can have a safe as strong as you like, but if the combination is written on an easily found piece of paper it will be child's play to get into the safe.

Because the EEPROM data memory of the PIC16F84 was too small for some applications at that time, an extra EEPROM memory was added (in this case a 24LC16 or equivalent). Since this serial EEPROM is provided with an I²C interface and the standard 16F84 does not have such an interface, ports RB4 and RB5 have been called in to help out with this along with a suitable software routine. If you don't use this memory it follows that the I²C routines in the PIC are no longer required either.

The circuit of a Silver card, shown in **Figure 4**, is just as simple as that of a Gold card since the designers have only replaced the PIC16F84 with a 16F876 and the 24LC16 memory with a 24LC64. This really was a very simplistic change, but we're not surprised, because the circuit was designed by and for video pirates. The EEPROM memory is again connected to RB4 and RB5, meaning that we still have to write the routines for the I²C interface ourselves. And this is while the 16F876 has an I²C interface on board, which is connected to pins RB3 and RB4! The only 'advantage' of this dubious decision is that it lets you switch from a Gold card to a Silver card without having to modify the program.
To write an application for a Gold card or Silver card you

have to program the PIC in assembly language, adding a software based I^{2}C interface for the external EEPROM when required. All you need for this is an excellent program called MPLAB that can be downloaded free of charge from Microchip's website.

When physically programming the card we have to bear in mind that the programming signals on ports RB6 and RB7 of the PIC are exactly in phase with the programming of the internal memory. We also have to make sure that the voltage on the reset line has to be 13 V during programming, which means that a normal card reader cannot be used to program a Gold card or Silver card. We will show you later in the construction article that a card reader, which can also be used as a programmer, is easy to construct.

Asia rules

It's ironic that these illegal activities also had a positive effect. Because the TV pirates required blank cards for the development of their 'applications', several manufacturers from Southeast Asia started producing chipcards with a range of processors and memory. The Gold, Silver, Fun and other cards that were the result of this can now be used in our own applications.

Southeast Asia has been a trendsetter in this area, which saw several 'standard' cards appear in a relatively short period. The names of the cards were inspired by the physical characteristics of the first cards released for sale. The Gold card, the oldest, was (and still is) coloured gold, whereas the Silver card goes through life wearing a silver jacket.

Fun, Purple, Pink and Jupiter

At about the same time when the first Gold card was developed, other developers who preferred microcontrollers from Atmel to those from Microchip developed two cards that used chips from this manufacturer. Although these cards were not as successful as the Gold card and Silver card, they were nevertheless manufactured in great numbers and one of the series is still widely available today.

The **Fun card**, which initially was also called a Purple card due to its colour, is provided with an Atmel AT90S8515 microcontroller, as can be seen in **Figure 5**. The connections are, as far as the clock and reset lines of the microcontroller are concerned, the same as for the Gold card and Silver card. On the other hand, you need to access the SCK and MOSI signals of the SPI interface when programming chips from the AT90S family. Because these signals are incompatible with those used on a standard connector, they have been connected to contacts C4 and C8, which were reserved for future use and which are normally not connected. Note that the MISO line of this SPI interface, which is also required during the programming phase, is connected to the I/O contact of the card connector. This means that during normal use you must use this pin for the exchange of data with the outside world.

Table 1.

Funcard type	External EEPROM memory
Fun (standard)	24C64
Fun 2	24C64
Fun 4	24C256
Fun 5	24C512
Fun 6	24C1024

The designers of the Fun card had the same problems as the Gold card and Silver card designers regarding the EEPROM size in the controller, which was too small. For this reason an external AT24Cxx type EEPROM has been connected to the microcontroller, where the xx depends on the version of Funcard and can have a value between 64 and 1024 (see **Table 1**). If there is no type number the Fun card will have a standard 24C64 mem-

Any Funcard is as amusing as the next.

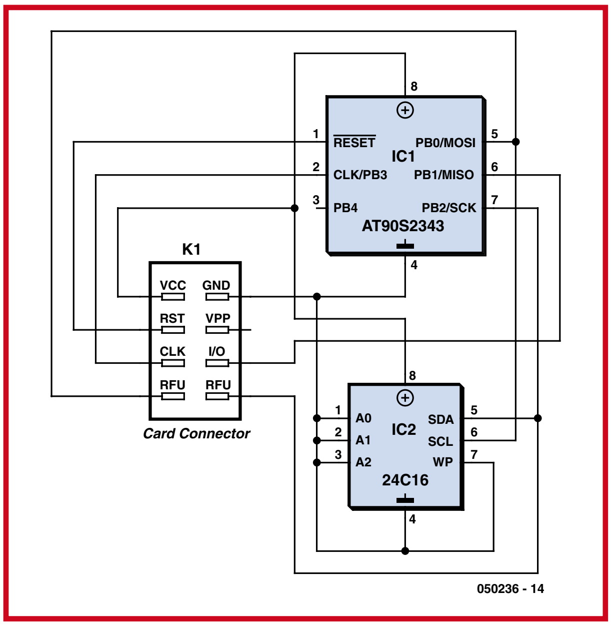


Figure 6. Circuit of a Jupitercard (or Pinkcard).

A card with memory or with a microcontroller?

The term 'chipcard' can be a bit misleading because it avtaully describes two different types of product. There are cards that have just some memory, which are called Memory cards. Then there are cards with some intelligence on board (a processor), which are called 'Smart cards'. These days especially we have to keep in mind the differences between these two types of card because their capabilities differ so much.

The Memory cards that we find in many prepay applications (cards for the phone, the launderette and access control) contain, as the name implies, just some memory in the form of an EEPROM, so that they can be electrically programmed and erased. Depending on the level of security for the card, the memory may be encrypted.

Before you are able to buy cards of this type and gain access to technical information you first have to sign an NDA (***N***on ***D***isclosure ***A***greement) from the manufacturer. Chipcards containing only memory are of little interest for most applications, so we won't look at them any further in this article.

Chipcards with a microcontroller on board are meant for more 'superior' applications, such as bankcards, SIM cards for mobiles, or for viewing Pay-TV programmes. Such cards are more interesting for the electronics engineer who wants to use them in his own project, as long as sufficient information is available and they can be bought in an unprogrammed state.

Basic Card
a card with a difference

This card, which is exclusively manufactured by the small German company ZeitControl, is also a card with an open OS. As the name indicates, it is programmed in Basic. The Basic on the Basic Card is nothing like the old, trusty Basic and has a fast, powerful instruction set. Furthermore, this programming language has been specially adapted for use on chipcards, which really simplifies the programming. On top of that it also comes with a number of cryptographic libraries and the calculation of a DES or 3DES comes down to a single instruction!

At this moment there are fifteen different Basic Cards, with varying amounts of memory and cryptographic capabilities. To develop an application for the Basic Card you will need a special development tool because of the unique programming language used. Fortunately this is free of charge and can be downloaded from the manufacturer's website. It's worth mentioning that this tool functions under Windows, as well as under DOS. It also includes a card simulator and a reader simulator. An application can therefore be designed without any hardware in a virtual environment, before trying it out with hardware in the real world.

Because the Basic Card contains an OS, it doesn't need a special programmer and can therefore be programmed by any programmer supported by the development kit. Under Windows this is very simple since you can use any PC/SC compatible device.

ory chip, which corresponds to 8 KB.

The **Jupiter card** (also called a Pink card because of the colour of the first cards) also uses an Atmel controller, but this is less capable than the one used in Fun cards. As you can see from **Figure 6**, a 'small' AT90S2343 has been used here, as always with an extra EEPROM, in this case a 24C16. The way this is connected is identical to that used in the Fun card, since the chip belongs to the same family as the AT90S8515 used in the Funcard. This card has been successfully used for a long period by hackers to crack encrypted TV signals, but these days it has clearly been superseded and we advise against using this card for new developments.
The design of an application for a Fun card again requires the use of assembly language, but this time for a microcontroller from the Atmel AT90S family. For this you could use a brilliant program called AVR Studio, that is free of charge like MPLAB, and just has to be downloaded from Atmel's website.

On the other hand, it isn't possible to use a standard card reader to program Fun cards because they provide no access to contacts C4 and C8 on the connector. We will show you in the accompanying construction article that you only need a handful of components to build a Fun card programmer yourself (which can also be used for the less common Jupiter card).

Titanium, Platinum, Knot and Opos

In an attempt to put a stop to all the piracy they suffered from, a number of pay-TV suppliers provided their systems with improved levels of encryption, which made it almost pointless to use Gold, Silver or Fun cards to get round the protection. As more and more encryption algorithms were used, the processing power and instruction set of a simple PIC or AT90S were no longer sufficient to do the calculations quickly enough.
As a result of this cards have started to appear that come with cryptographic processors, with fancy names such as Titanium (the oldest), Titan, Platinum, Knot and Opos.

Most of these cards come with an Atmel microcontroller from the AT90S12836 family or a similar device.
As can be seen in **Figure 7**, these microcontrollers are enhanced versions of the well-known AT90S family with an integrated cryptographic module (some more advanced than others). These modules perform very fast calculations of the cryptographic algorithms (DES, 3DES, RSA, etc.), so that the CPU just has to give them a command, rather than perform all these calculations itself.
Unfortunately, we can't tell you any more about these protected microcontrollers because the datasheets are unavailable, or more precisely, they're only available after signing an NDA (***N**on **D**isclosure **A**greement*) where you agree not to disclose the contents.
In theory it is not permitted to program these microcontrollers in assembler unless you've signed such an agreement. To get round this problem, smartcards containing such a microcontroller nowadays come with an open operating system (OS) where the names, functions and versions differ depending on the type of card, it's origin and... to what extent the supplier's stock is kept up to date!
In general these cards are programmed in C, using a compiler suitable for use with the microcontroller found on the card. The C compiler from IAR is often used for this, but in practice you should be able to use any compiler as long as it has a *plug-in* or the correct libraries for the chosen card.
If you decide to use this type of card in your own application you have to bear in mind that you will have to trawl the Internet for information. The *plug-in,* libraries and relevant datasheets can only be found on websites that are on the fringe of legality.
We can conclude that all cards that come with an open OS don't give rise to a single problem as far as programming is concerned and that they can be programmed using a simple reader as long as it is Phoenix compatible.
In the separate construction article on the following pages we will show you how that can be realised.

And finally...

Apart from the Basic Card (see inset), which from the outset was designed without shady purposes, all cards currently in circulation have been designed with prohibited applications in mind. Despite this, you can now find mass-produced, reliable and established products that can be legally used in your own applications.
We still have to be able to program them, however, and this will be the subject of the next article.

(050236-I)

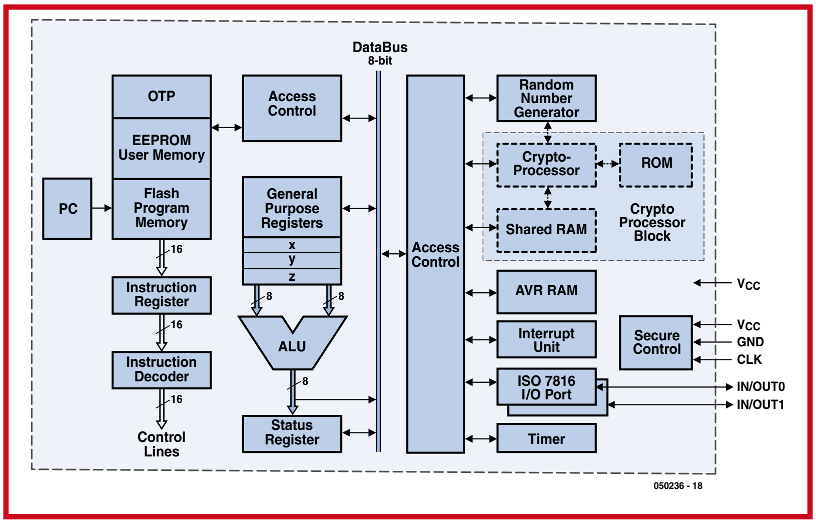


Figure 7. Internal circuit of an Atmel microcontroller from the AT90xxxx range with cryptographic functions.

Old chipcards (left) still used the AFNOR standard, but these days they conform to the ISO standard (right), which is an international standard.

Web links

Microchip (MPLAB download):
www.microchip.com

Atmel (AVR Studio download):
www.atmel.com

ZeitControl (developer of the Basic Card):
www.zeitcontrol.de

ZeitControl (Basic Card):
www.basiccard.com

Author's general website:
www.tavernier-c.com

Author's website dedicated to chipcards only:
www.cartesapuce.fr

The author

Consulting electronics engineer Christian Tavernier is an academic and a legal expert on electronics, information technology and tele-communications.

He is also the author of many books and articles covering a wide variety of subjects in electronics and IT, and has been working in these fields for over 25 years.

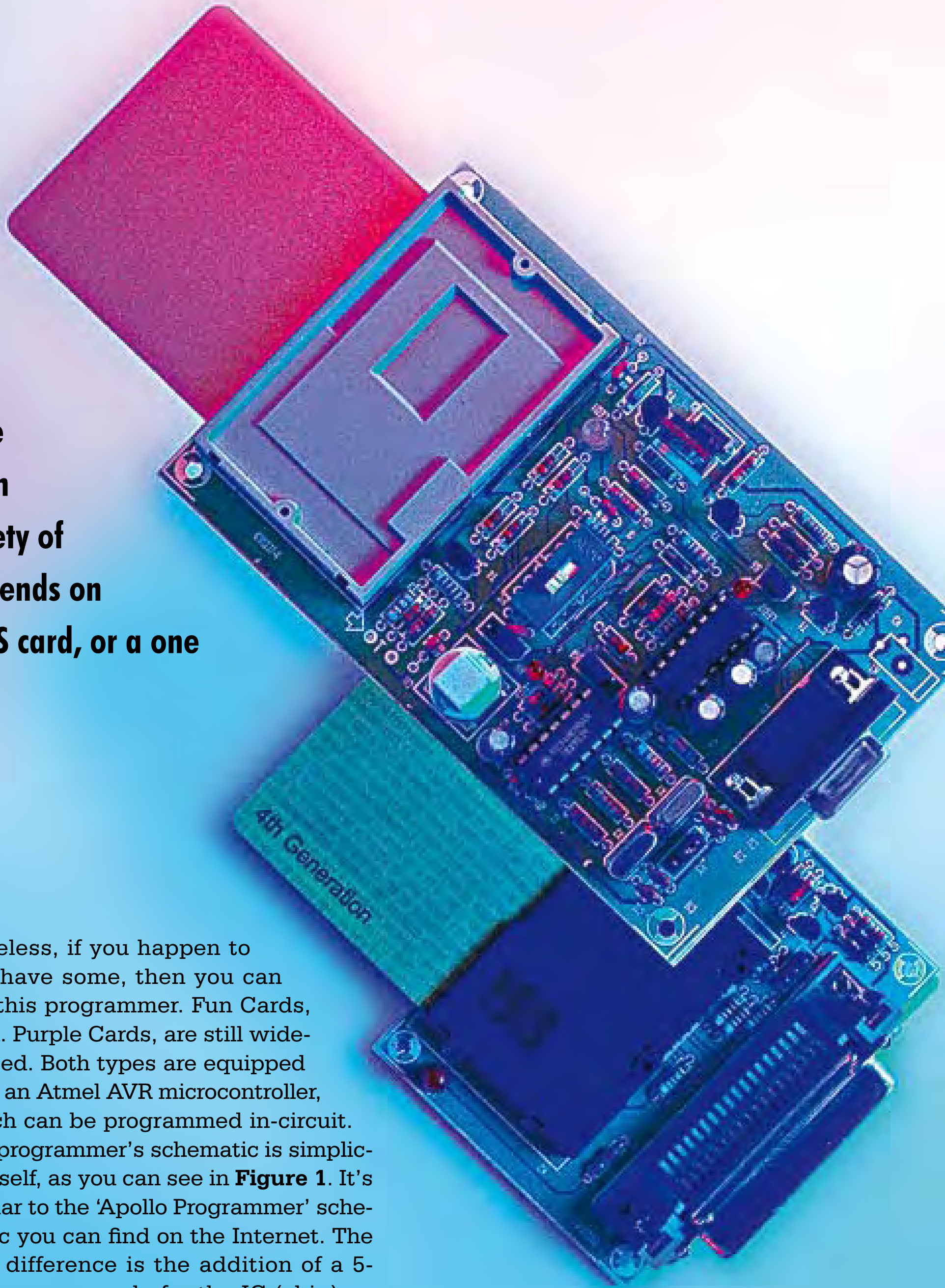
www.tavernier-c.com
contact@tavernier-c.com

A Tale of Two SmartCard Readers

...that read, write and program!

Christian Tavernier

Any application for Smartcard requires what's commonly referred to as a 'card reader'. If you've read the article on the various types of Smartcards elsewhere in this issue, you already know that a variety of card readers may be required. It all depends on whether you're dealing with an Open OS card, or a one that's still blank.



We will start with a short explanation of the theory behind the various Smartcards. Next we will introduce you to two reader/programmer designs, which are not only compatible with the vast majority of Smartcards available on the market today, but also — more importantly — ready for use with lots of free software obtainable from the Internet.

A programmer for Fun (Purple) and Jupiter (Pink) Smartcards

Jupiter cards, also known as Pink Cards, have become pretty much obsolete. Nevertheless, if you happen to still have some, then you can use this programmer. Fun Cards, a.k.a. Purple Cards, are still widely used. Both types are equipped with an Atmel AVR microcontroller, which can be programmed in-circuit. The programmer's schematic is simplicity itself, as you can see in **Figure 1**. It's similar to the 'Apollo Programmer' schematic you can find on the Internet. The only difference is the addition of a 5-volt power supply for the IC (chip) on the card. This is derived from three data outputs from the PC's printer (Centron-

ics) port. On older PCs, these outputs are usually strong enough, and with JP1 shorting S1 to Vcc, the power supply is perfectly adequate. Consequently the circuit around IC1, T1 and T2 could be omitted. On newer PCs and laptops, however, the voltage from the printer port barely exceeds 3.3 V, and that's not enough to ensure reliable communication. In those cases, an additional external power source is required. This will be connected to J3, stepped down and stabilised to 5 V by the circuit around IC1, T1 and T2. With JP1 shorting S2 to Vcc the data lines will now enable the external power source only — they do need to power anything.
LED1 will turn on when the card is being programmed, at the same time signalling that the card must not be removed from the reader!

Building the programmer

As you can see in **Figure 2**, all components will fit on one PCB. It's equipped with a Centronics connector, hence will easily connect to your PC's parallel port via a printer cable. Note the polarity of components when you're mounting them, but apart from that the PCB is easy to assemble. The external power source, if required, may be any unstabilised battery eliminator (a.k.a. wall-wart) capable of supplying about 9 volts DC at only 50 mA — proving that circuit's power consumption is quite low.

Software and practical use

There's lots of software available for free on the Internet that's compatible with this programmer. The author recommends two packages: one is the excellent **IC-Prog**, familiar to owners of a home-made PIC programmer, the other is the less well-known but nonetheless quite interesting **FunProm**.

You can find instructions for use of IC-Prog on the author's website (www.ic-prog.com). You will need a few specific drivers if you want to install it under Windows XP. Once installation is successful, all you need to do is configure IC-Prog according to **Figure 3**, selecting, of course, the correct printer port.

A reader that also writes

The device you put a Smartcard in is normally called a 'reader'. The name doesn't do full justice to these devices, because most will also happily write to the card. In some cases, depending on the card and the type of reader, it is also possible to program the chip on the card inserted into a 'reader'. Confusing? We will now first create some order in all of this.

To begin with, many Smartcards already contain an application. If your (PIN protected) bank card has an on-board chip, then that's one example. Another is the Basic Card, which is based on an open operating system ('Open OS'), or the Gold and Silver Smartcards. These can be read from, or written to, by any card reader. The software and computer controlling the card reader dictate whether it has to be compatible with either PC/SC, Phoenix or SmartMouse.

Blank Open OS cards are the only type that can also be programmed with such a reader. With any other 'virgin' card, functionality of the reader is limited to reading and writing. So, if you want to put your own application onto a Gold, Silver, Fun, or what-have-you card, you'll need a separate programmer.

Having read our discussion on the technical intricacies of all these different Smartcards, elsewhere in this issue of Elektor, it should be clear that a programmer device will need to generate very accurately timed codes. It may be even necessary to 'cleverly manipulate' pins on the chip that are normally never used, as is the case with Fun and Jupiter cards.

Obviously, an off-the-shelf programmer will not do the job, so you have two choices: either you buy one according to your own specifications, or you build one of your own. This latter option is the very subject of this article.

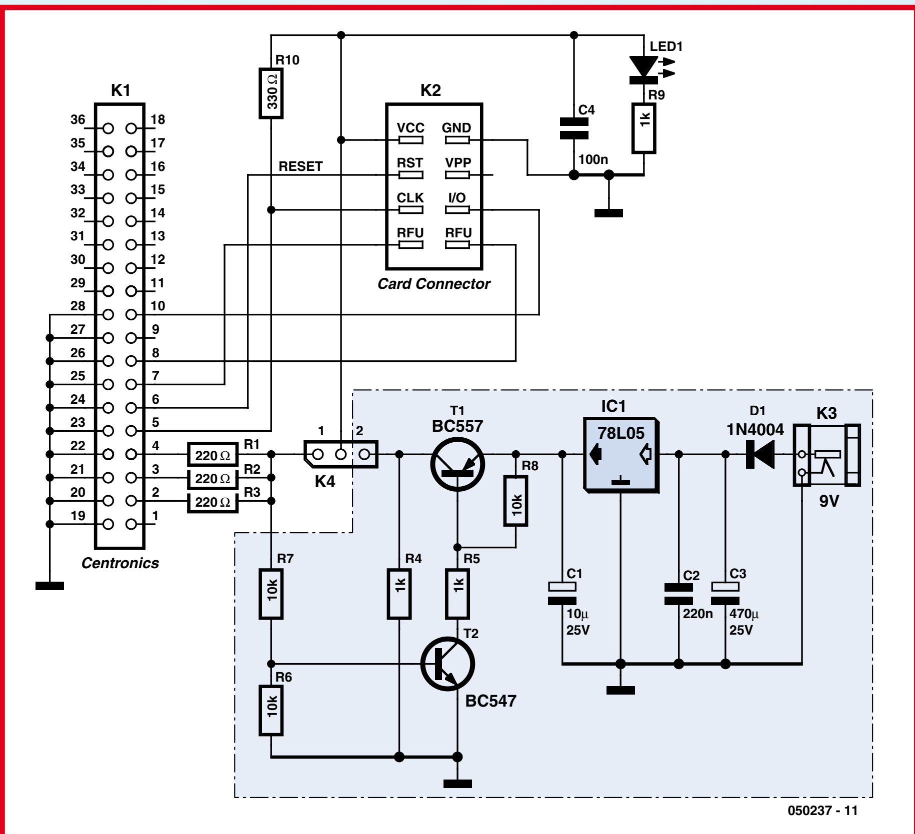


Figure 1. Fun (Purple) and Jupiter (Pink) Smartcard programmer schematic.

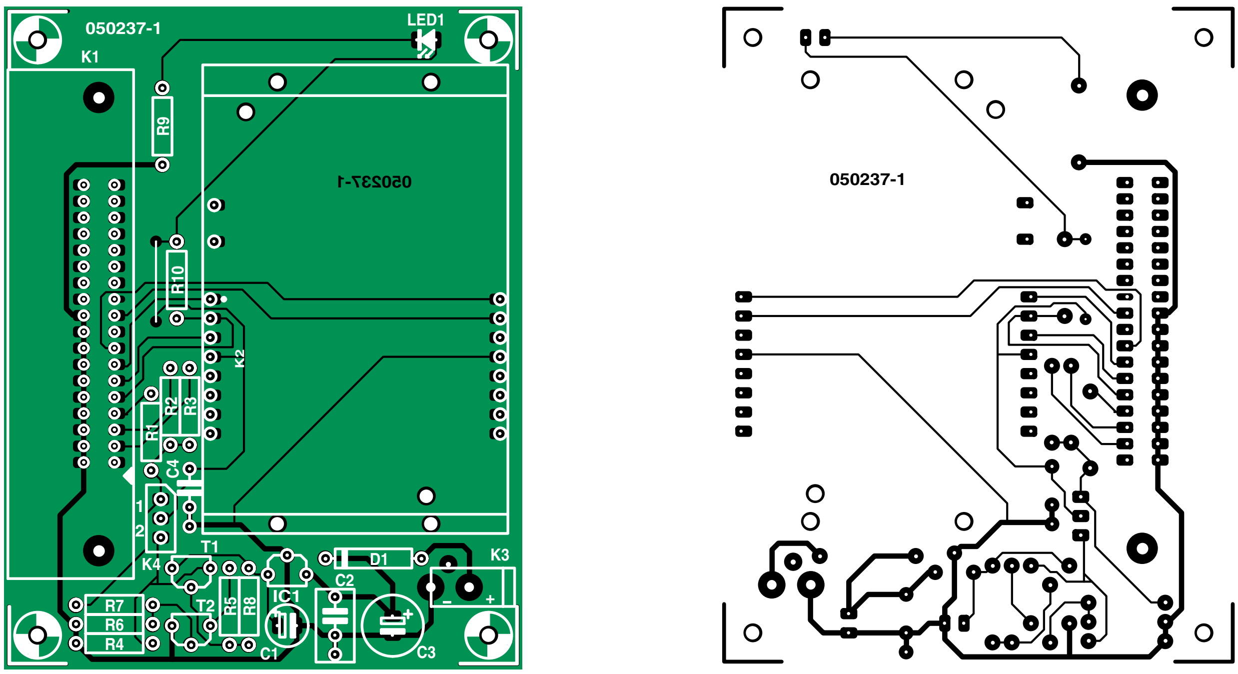


Figure 2. PCB layout for the Fun Card programmer.

COMPONENTS LIST

Fun/ Jupiter programmer

Resistors
R1,R2,R3 = 220Ω
R4,R5,R9 = 1kΩ
R6,R7,R8 = 10kΩ
R10 = 330Ω

Capacitors
C1 = 10µF 25V radial
C2 = 220nF MKT
C3 = 470µF 25V radial
C4 = 100nF MKT

Semiconductors
IC1 = 78L05
T1 = BC557
T2 = BC547
D1 = 1N4004
LED1 = LED, 5mm, red

Miscellaneous:
K1 = Centronics socket (female), right angle pins
K2 = standard Smartcard connector (e.g., Selectronic no. 60.9292)
K3 = mains adapter socket, PCB mount
K4 = SIL pinheader, 3 pins, lead pitch 2.54 mm, with jumper
PCB, ref. 050237-1 from The PCBShop

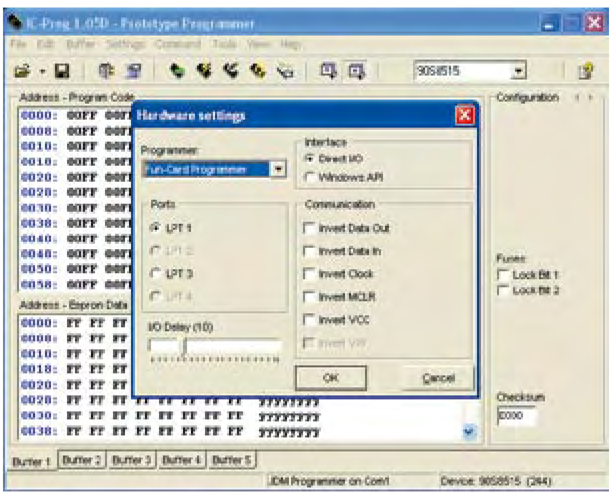


Figure 3. IC-Prog configured for use with the Fun Card programmer.

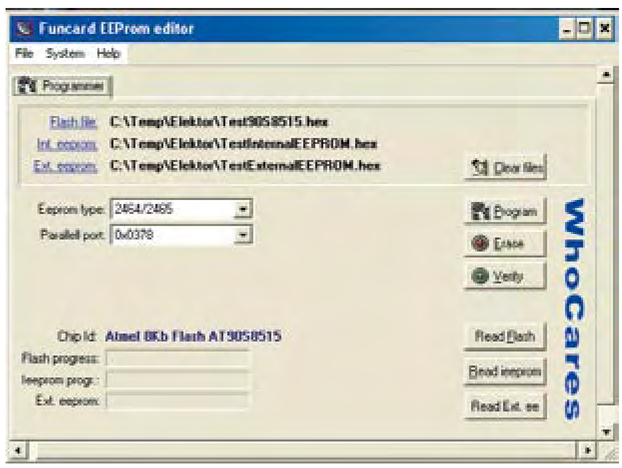
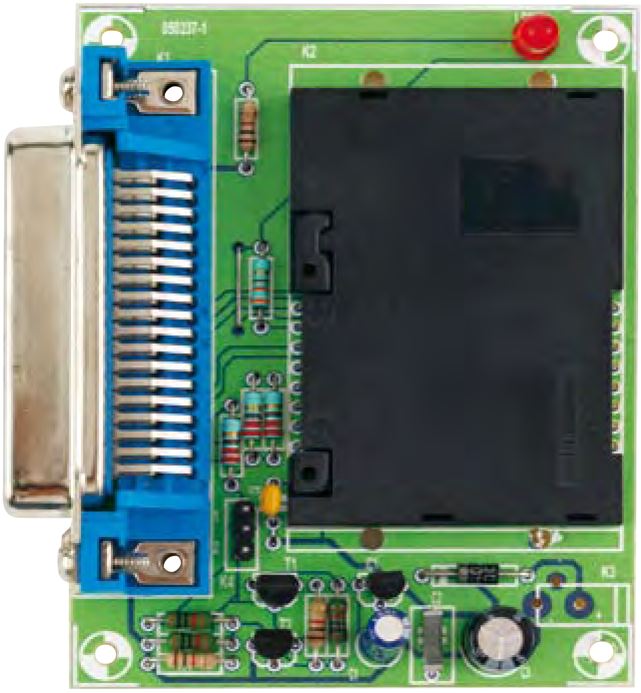


Figure 4. FunProm gives access to the external EEPROM on Fun cards.



For use with a Fun card, the processor should be set to AT90S8515, as illustrated. This will give access to both the program and the data memory of the chip on the card, and you'll be able to read, program, and verify it. There is one proviso: IC-Prog will not let you access the Fun card's external EEPROM. This is normally no problem at all if you've developed your own application, but can become a serious obstacle for 'other applications' that need to access the encryption keys stored there.

It is perhaps with this in mind that FunProm was made (see the weblink at the end of this article). Installing it is hardly more than unpacking a RAR archive file, and then you'll have access to that external EEPROM too, as illustrated in **Figure 4**.

A reader/programmer for Phoenix and SmartMouse cards

Shortly after the first Gold cards appeared on the market, the need arose for a reader that was both low cost and readily available. Card readers from large manufacturers didn't fit the bill, and offered only limited functionality. Necessity is the mother of invention: before long, two designs surfaced and started to circulate on the Internet. They're called Phoenix and SmartMouse. It soon turned out the two were very similar, and thus it wouldn't be too difficult to come up with a design that would handle both formats, selectable perhaps with one or two jumper settings. However, as already explained, this would still be just a reader, incapable of programming the microcontroller on Gold and Silver cards. So in response to this, a few designs emerged that allow for programming too. The better-known and also the simplest of these is JDM programmer for serial port. Unfortunately, it was incompatible with Phoenix and SmartMouse readers. Many electronics amateurs have had to build two devices and were forced to juggle between the available COM ports while moving cards from reader to programmer and vice versa.

Now, after in-depth analysis of both designs — and making the most of some of their limitations and shortcomings — we're able to present an all-in-one design: **a Phoenix and SmartMouse reader that doubles as a JDM-compatible Gold and Silver card programmer**. And it's dirt cheap to make too, as you can see from the schematic in **Figure 5**. It may seem rather complicated at first glance, but it's operation is not that difficult to analyse. In the centre you see a block of jumper headers S1-S4 for selecting between Phoenix mode (reader) and JDM mode (programmer). In reader mode, the well-known MAX232 (IC2) converts the RS-232 level at the COM port to TTL level for our circuit. Now, a Smartcard I/O channel is bidirectional, whereas the COM port has separate lines for input (RxD) and output (TxD). So, resistor R3 and Schottky diode D5 combine TxD and RxD from COM port to Smartcard, and separate them on the way back.

All Smartcards require an external clock. Two gates from an 74HC00 (IC3) are the amplifiers for two oscillators, with frequencies of 3.579 MHz (NTSC xtal) and 6 MHz, as dictated by the Phoenix and SmartMouse specifications. Many other cards require 3.58 MHz too, by the way. You can switch between clocks with the aid of a jumper on K5. Gate IC3d passes the clock on to the rest of the circuit. Those of you who wish to experiment with Smartcards at non-standard frequencies can also use an external clock. This will then arrive at R20, is shifted to TTL level by a 2N2369 (T4), and subsequently passed via a jumper on K6. It's probably not something that will be used very often, but you can if you want to.

A control line from the COM port provides a reset signal to the Smartcard. Phoenix requires a High reset, Smart-

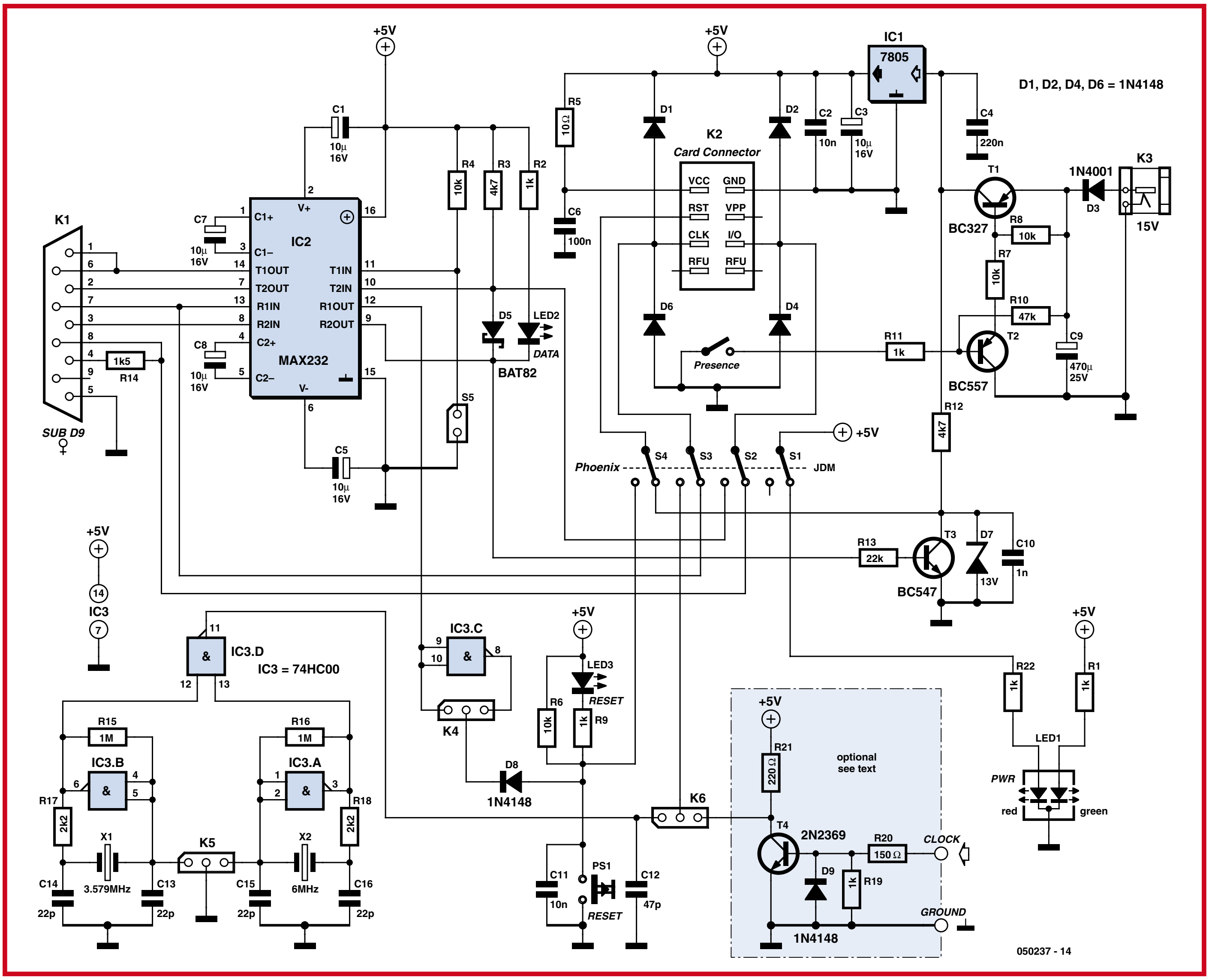


Figure 5. Schematic of a reader/programmer for Phoenix, SmartMouse and JDM Smartcards.

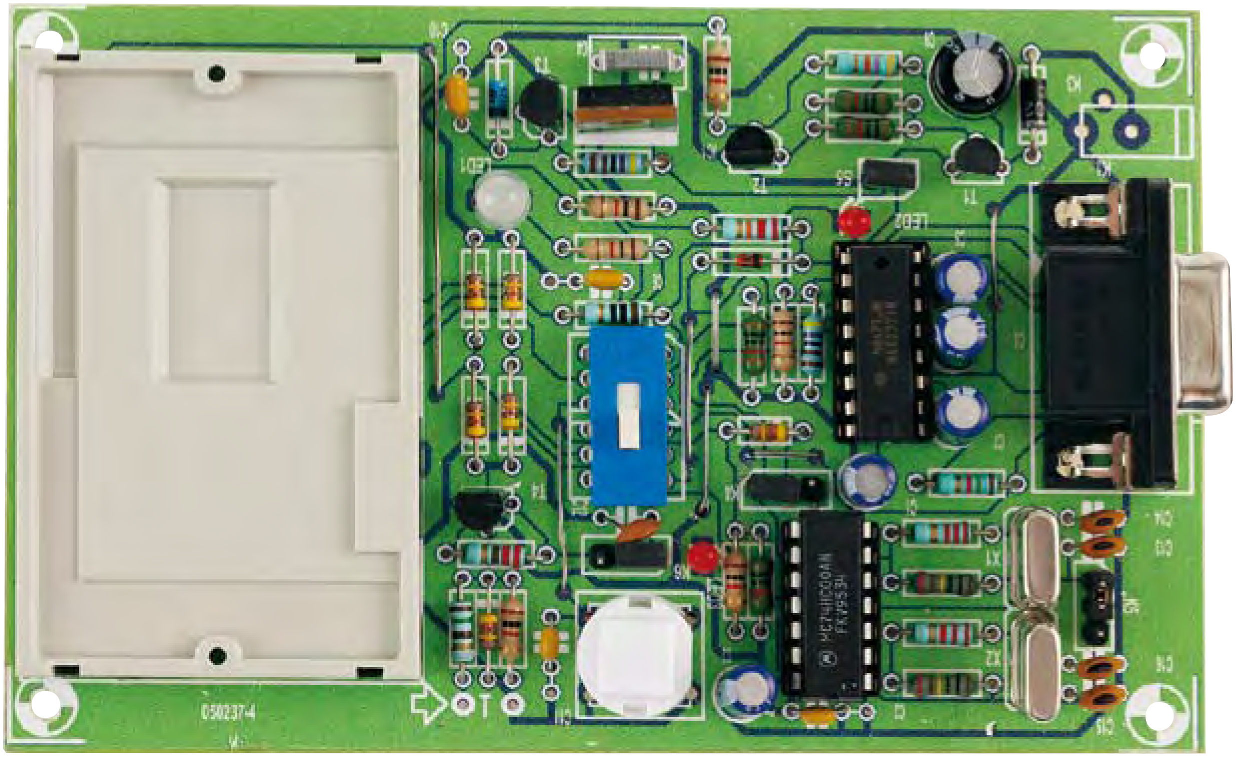
Mouse, Low. So the reset signal can be inverted if needed, using jumpers on K4. In addition, you can reset manually using switch PS1, with D8 affording short-circuit protection for gate IC3c. The reader section power supply is 5 volts, stabilised by a 7805 (IC1). The detector/switch will close when you put a card into the reader. It then turns on T2, which enables the power supply via T1.

We do need an external power source for the circuit, capable of providing about 15 volts unregulated DC, the reason being that we need 13 volts for programming the Smartcard. A bicolour LED indicates when power is on: depending on the position of S1, it will be green for Phoenix mode, or yellow (green and red together) for JDM mode.

Things are simpler in JDM mode: both the clock input and the I/O line on the Smartcard are controlled directly from the PC's serial port. When programming Gold and Silver Smartcards, these two are also being utilised. They then correspond to RB6 and RB7 (see also the schematics in the article elsewhere in this issue). PICs nowadays can be programmed with 5 volts.

The older 16F84 and 16F876 you'll find on Gold and Silver Smartcards, however, require 13 volts to the Reset pin in order to be programmed. An early version of the circuit comprised a voltage multiplier on the COM port power supply. However, on more recent PCs and laptops it turned out that the current you can source in this way is too small. So instead we tapped the 15-volt supply. Zener diode D7 steps the level down to 13 volts, and this can be turned on and off as desired with T3, which in turn is under control from software, via the serial port. Excepting LED1 which we've already discussed, all other LEDs in the circuit serve as an aid when using software of which the particular Smartcard liaison is unknown, or software that you're not yet familiar with.

LED3 will come on when the Smartcard is being reset. LED2 will be on when there's traffic between card and PC in Phoenix or SmartMouse mode. If, at the same time, the 13-V reset is active, then the circuit is in JDM mode, i.e., programming mode. As already mentioned, never remove the card from the reader while it's being programmed.



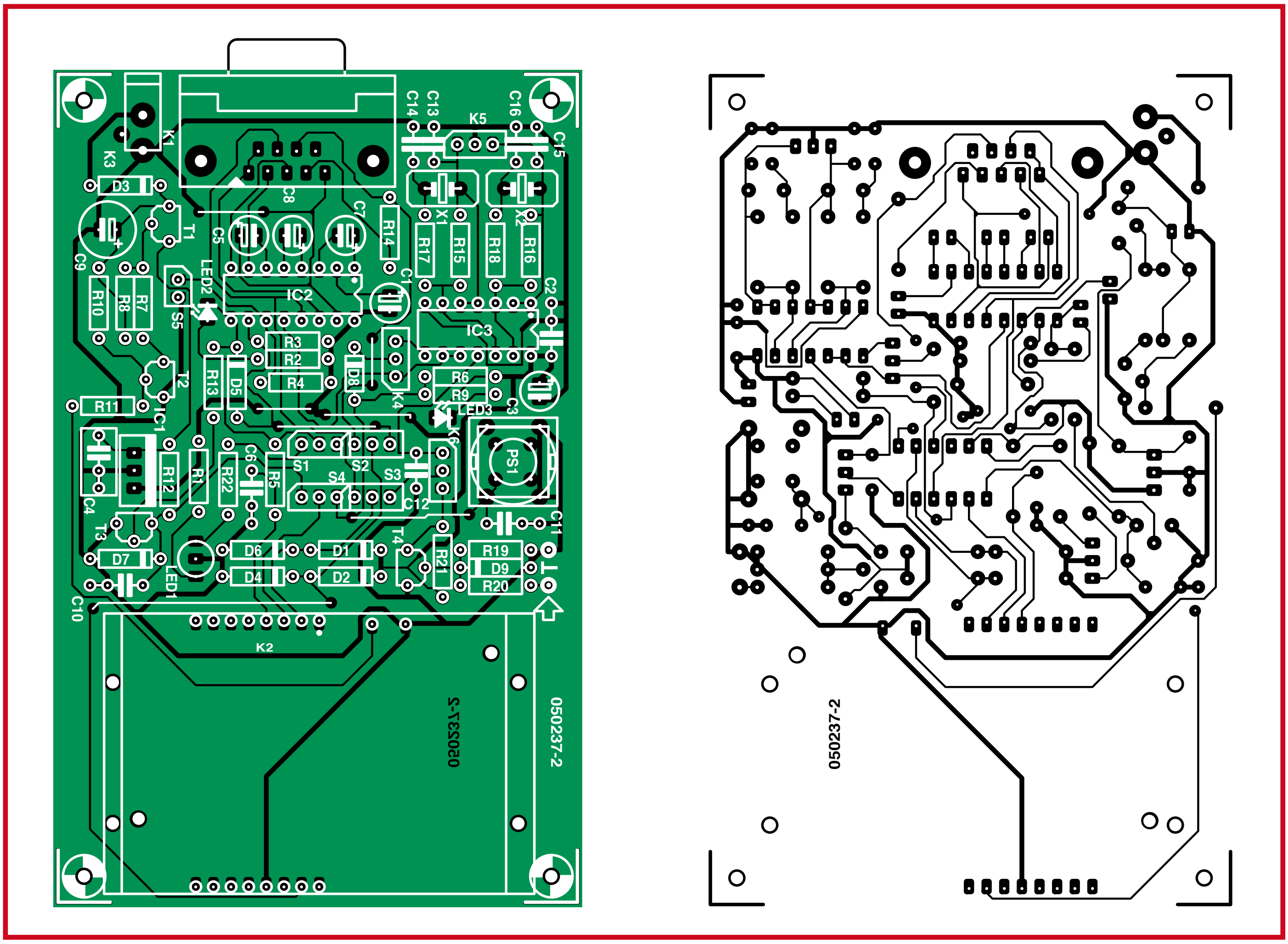


Figure 6. PCB layout for the circuit in Figure 5.

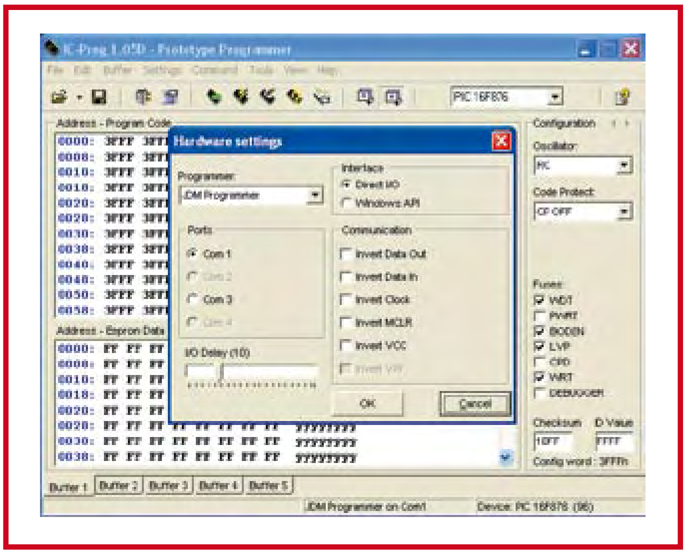


Figure 7. IC-Prog configured for the JDM programmer.

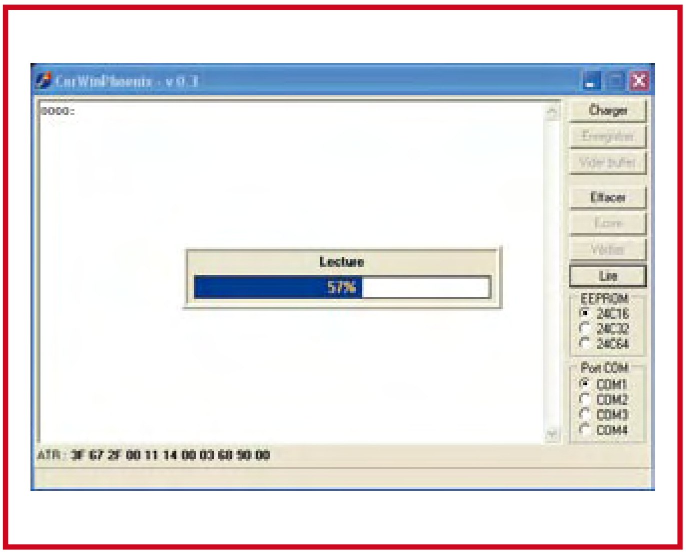


Figure 8. Using CorWinPhoenix you can access the external EEPROM on Gold Smartcards.

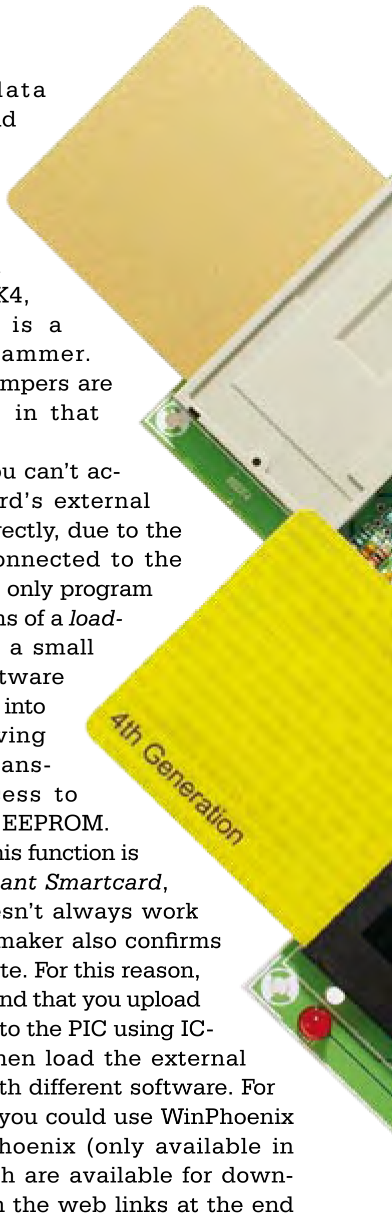
Building the reader/programmer

All components will fit on one PCB, of which the track layout and component mounting plan are given in **Figure 6**. If you follow the parts list and the component overlay, assembly should be piece of cake.

Software and practical use

Once again, we point out the excellent IC-Prog, configured this time as shown in **Figure 7**. Select 16F84 when programming a Gold card, or 16F876 if it's a Silver card. The full functionality of IC-Prog is then available, for programming both the PIC data EEPROM and the one for its firmware. With a jumper on pin 2-3 of K4, the circuit is a JDM programmer. The other jumpers are 'don't care' in that case.

However, you can't access the card's external EEPROM directly, due to the way it is connected to the PIC. You can only program that by means of a *loader*, which is a small piece of software programmed into the PIC, giving the user 'transparent' access to the external EEPROM. In IC-Prog, this function is called *assistant Smartcard*, but this doesn't always work well, as its maker also confirms on his website. For this reason, we recommend that you upload the loader into the PIC using IC-Prog, and then load the external EEPROM with different software. For Gold cards, you could use WinPhoenix or CorWinPhoenix (only available in French). Both are available for downloading from the web links at the end of this article. In both instances, you'll need to switch the reader from Phoenix



Programming in Visual Basic

Using software from others is a good thing, but developing your own is even better! Once you've started, you'll soon find yourself wanting to be able to control the Smartcard from your PC. Using the devices discussed in this article, you'll soon discover that this is not as complicated as it may seem at first: signals to and from the Smartcard correspond to those on a standard asynchronous serial port (see Figure 1 in the introduction to Smartcards elsewhere in this issue). However, a higher programming language is by no means the best tool for manipulating COM port registers on a PC, so we recommend that you download Phoenix UC for this purpose. (www.cartesapuce.fr).

The program was developed by someone operating under the pseudonym Phelix, probably because its use might be somewhat dubious. Nevertheless, it's an excellent piece of software! The file PhoenixUC.RAR contains various modules for use in a Visual Basic environment, and thus will give you a fully functional Phoenix compatible interface. It's easy to learn, and programming is very fast. Plus, you can also manipulate non-standard Smartcards with it.

The figure shows a simple example: the card has sent an Answer To Reset (ATR) and the full message is displayed on-screen. Full documentation is provided in the RAR file, and getting your first program to work will be a matter of minutes.

Example of a program in Visual Basic, made with PhoenixUC.

COMPONENTS LIST

Phoenix / SmartMouse / JDM reader/programmer

Resistors:
R1,R2,R9,R11,R19,R22 = 1kΩ
R3,R12 = 4kΩ7
R4,R6,R7,R8 = 10kΩ
R5 = 10Ω
R10 = 47kΩ
R13 = 22kΩ
R14 = 1kΩ5
R15,R16 = 1MΩ
R17,R18 = 2kΩ2
R20 = 150Ω
R21 = 220Ω

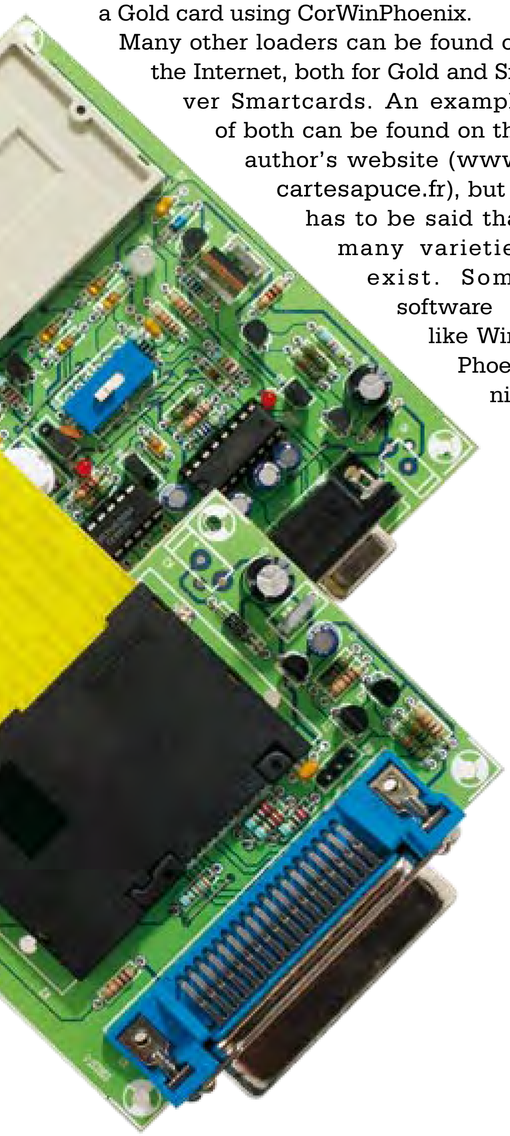
Capacitors:
C1,C3,C5,C7,C8 = 10μF 16V radial
C2,C11 = 10nF ceramic
C4 = 220nF MKT
C6 = 100nF MKT
C9 = 470μF 25V radial
C10 = 1nF MKT
C12 = 47pF ceramic
C13-C16 = 22pF ceramic

Semiconductors
IC1 = 7805
IC2 = MAX232
IC3 = 74HC00
T1 = BC327
T2 = BC557
T3 = BC547
T4 = 2N2369A
D1,D2,D4,D6,D8,D9 = 1N4148
D3 = 1N4004
D5 = BAT82
D7 = zener diode 13V 0.4 W
LED1 = LED, bicolour, 5 mm, with separate anodes
LED2 = LED, red, 3mm
LED3= LED, yellow, 3mm

Miscellaneous
X1 = 3.579MHz quartz crystal, HC18/U case
X2 = 6MHz quartz crystal, HC18/U case
K1 = 9-way sub-D socket (female), right angle pins, PCB mount
K2 = standard chip card connector (e.g., Selectronic no. 60.9292)
K3 = mains adapter socket, PCB mount
PS1 = switch, square, type D6 (ITT)
S1-S4 = 4-way DIP switch block (ASE42FN, Tyco/Alcoswitch) or 4 3-way SIL pinheaders with jumpers
S5 = 2-way SIL pinheader with jumper
K4, K5, K6 = 3-way SIL pinheaders with jumper
PCB, ref. 050237-2 from The PCBShop

to JDM mode. **Figure 8** shows an example of reading the external EEPROM on a Gold card using CorWinPhoenix.

Many other loaders can be found on the Internet, both for Gold and Silver Smartcards. An example of both can be found on the author's website (www.cartesapuce.fr), but it has to be said that many varieties exist. Some software like WinPhoenix replace your application on the card by their own loader, and thus give access to the external EEPROM. Quite handy, once you know how it works.



You can find an overview of all jumper settings in **Table 1**, to assist you when configuring the circuit. When in doubt, watch LED3: if this stays on, the card is being reset by the software, which effectively inhibits communication with the card. Swapping the jumper on K4 will remedy the situation.

Conclusion

There is a lot more to say about reading and programming Smartcards – we've hardly spoken about PC/SC cards, for example – but that may be the subject of a different article. For now, we've concentrated on Gold, Silver, Pink and Purple Smartcards, and you'll be able to put them to full use with the two circuits described in this article.

(050237-I)

Table 1. Jumper settings

Fun Card programmer		
Header	Position	Function
K4	1	external supply by parallel port
	2	supply by mains adaptor
Phoenix/SmartMouse programmer		
Header	JDM	Phoenix
S1	1-2	2-3
S2	1-2	2-3
S3	1-2	2-3
S4	1-2	2-3
(Numbering from bevelled side)		
S5	fitted	normal card detection
S5	absent	card always inserted
Header	**Position**	**Function**
K4	1-2	direct Reset
K4	2-3	inverted Reset
K5	1-2	6 MHz
K5	2-3	3.579 MHz
K6	1-2	internal clock
K6	2-3	external clock

Web links

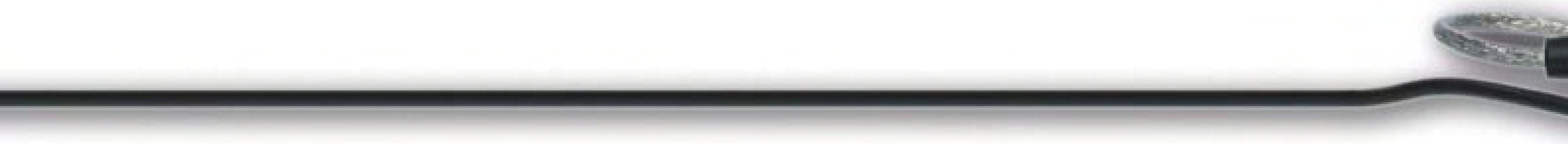
www.elektor.com

www.cartesapuce.fr
(author's site on Smartcards)

www.tavernier-c.com
(author's general website)

USB Stick with ARM

Gigabyte Flash drive for microcontroller



Ursula Engelmann-Schrader and Jürgen Engelmann

This neat stand-alone memory stick can store or transfer data from a microcontroller system in the field to a PC using its built-in USB and RS232 ports. Add to that an LCD and the simple to use datalogging mode is just the icing on the cake!

Some electronic systems are of necessity sited at remote locations where they may be collecting data from natural events such as wind strength or solar powered installations where measurements are performed and stored on site in the memory of a microcontroller system. Occasionally the data requires transferring to a PC where they can be fully evaluated and archived. Without the luxury of a radio link or telephone line to transfer the data it would seem a good solution to use a versatile memory stick which can both plug into a serial port of a microcontroller system and a USB port on a PC, well there is no need to look any further, that's exactly the function of the device described here!

A Janus memory

When the design for this 'microcontroller USB stick' was first sketched out on the back of an envelope it was decided not to use hard-wired memory chips for data storage but instead provide a slot for an MMC or SD-Card (FAT16 format). The flexibility of this approach means that your choice of memory for the card is not confined to just one supplier and allows you to take advantage of the falling cost and increased (gigabyte) capacity of the most recent memory cards.

Just like the Roman god Janus, the USB flash drive presents two faces to the world:

On the USB side it looks like a Windows and Linux compatible USB memory stick. Once plugged into a PC all files stored in the flash card can be viewed or edited on the screen. The PC user is free to begin work interpreting the data stored in the card previously by a microcontroller system (which may also still be attached).

The second face of the drive allows data stored in the memory by a PC to be read by a microcontroller system. The on-board ARM processor together with its firmware enables an external microcontroller system connected to the RS232 port to have simple read/write access to the flash memory. An illustration at the end of the article shows the USB Flashdrive connected to the ATmega controller board (050176-71) which was featured in the May 2006 edition of *Elektor Electronics*.

Access to the memory card by the microcontroller is performed by a driver which interprets a set of predefined instructions. The instructions are simple commands such as FileOpen, FileRead, FileWrite, FileClose, etc. The driver is contained in the software and not only controls access to the memory but also interprets commands for control of peripherals such as the LCD.

The C source code for the drivers together with a few examples of code suitable for 8051 compatible controllers are included in the free software download available at the *Elektor Electronics* website [1]. A number of additional Pascal files are also included for information — these were written for an earlier application of the unit. From the DOS point of view the memory card is treated just like an external drive connected to the serial interface. A Windows program ('Testsuite') is also included along with the other files and can be used to test the PCB. The flash memory card is also extremely easy to use in data logging mode (see text box).

The ARM7 Controller

The heart of the circuit shown in **Figure 1** is the ARM7 Controller AT91SAM7S64 (IC1). It is a 32-bit controller with a RISC core. The CPU instruction set includes instructions which allow switching between 16 or 32-bit instructions to enable optimum use of the processor for each application. The processor has a 64 kB Flash memory and 16 kB RAM. An on-board PLL multiplies the 12 MHz crystal frequency up to 48 MHz used by the processor.

The ARM7 controller is equipped with a

and RS232

s

whole range of additional features including a complete USB port integrated onboard so it is only necessary to connect to the D– and D+ signals on the USB port. Resistors R9 and R10 form a potential divider network which the controller uses to determine if a device is plugged into a USB port. A brief overview of the ARM7 microcontroller features are shown in the text box.

Those of you who would like to delve deeper into the workings of the ARM7 controller can use either a GNU compiler or any of the other available compilers. ARM technology was discussed in several articles in *Elektor Electronics*.

Main Features

Memory media:	MMC or SD card up to 2 GB
File system:	FAT16 (A maximum of four files may be open at the same time)
Interfaces:	1 x USB (2.0 and 1.1), 2 x RS232
USB Data rate:	12 Mbit/s
RS232 Data rate:	9600 bit/s to 230 kbit/s
Power supply:	5 V derived from the USB connector or external mains adapter.
Current consumption:	50 mA (approx).
Options:	LCD connector, TTL level serial interface.
Dimensions (approx):	41 mm x 77 mm x 18 mm (including connectors and memory card)

The interfaces

The USB interface (ST2) has a raw bit rate of 12 Mbit/s and can be used with either a USB 1.1 or USB 2.0 compliant USB port on a PC. High-speed operation is indicated by the PC via R11 on D+.

The RS232 interface is quite conventional, using a MAX232 (IC11) to perform the necessary level shifting for signals on the 9-way Sub-D connector CON2 providing ±12 V nominal on the RS232 side and TTL levels on the ARM controller side. A second serial interface is available on JP2. The RS232 interface can handle data rates ranging from 9.6 up to 230 kbit/s. On reset the communications rate is set to 9600 bit/s (Default). The serial receive and transmit signals are also available on pins 2 and 3 of JP1 at TTL levels. When this option is used it is necessary to remove solder jumper SJ1 to prevent any possible contention in the signal levels produced by the received data on CON2.

A 21-way pin header connector, JP3, provides connection for a standard LCD display using the HD44780 or compatible controller. Support is provided for displays using one, two or four lines of text up to 16 or 20 characters long. Power is derived directly from the USB bus. If an LCD display is fitted it will be necessary to fit the SMD preset R1 to allow control of the contrast. The display uses 11 pins on JP3; eight are for data, one for Register Select (RS), one for Read/Write (R/W) and one for Enable (E). With no display fitted, PA7 to PA20 can be used as general I/O pins.

The ARM controller also has an SPI interface for connection of a Flash memory card; the following paragraph looks at this interface in more depth.

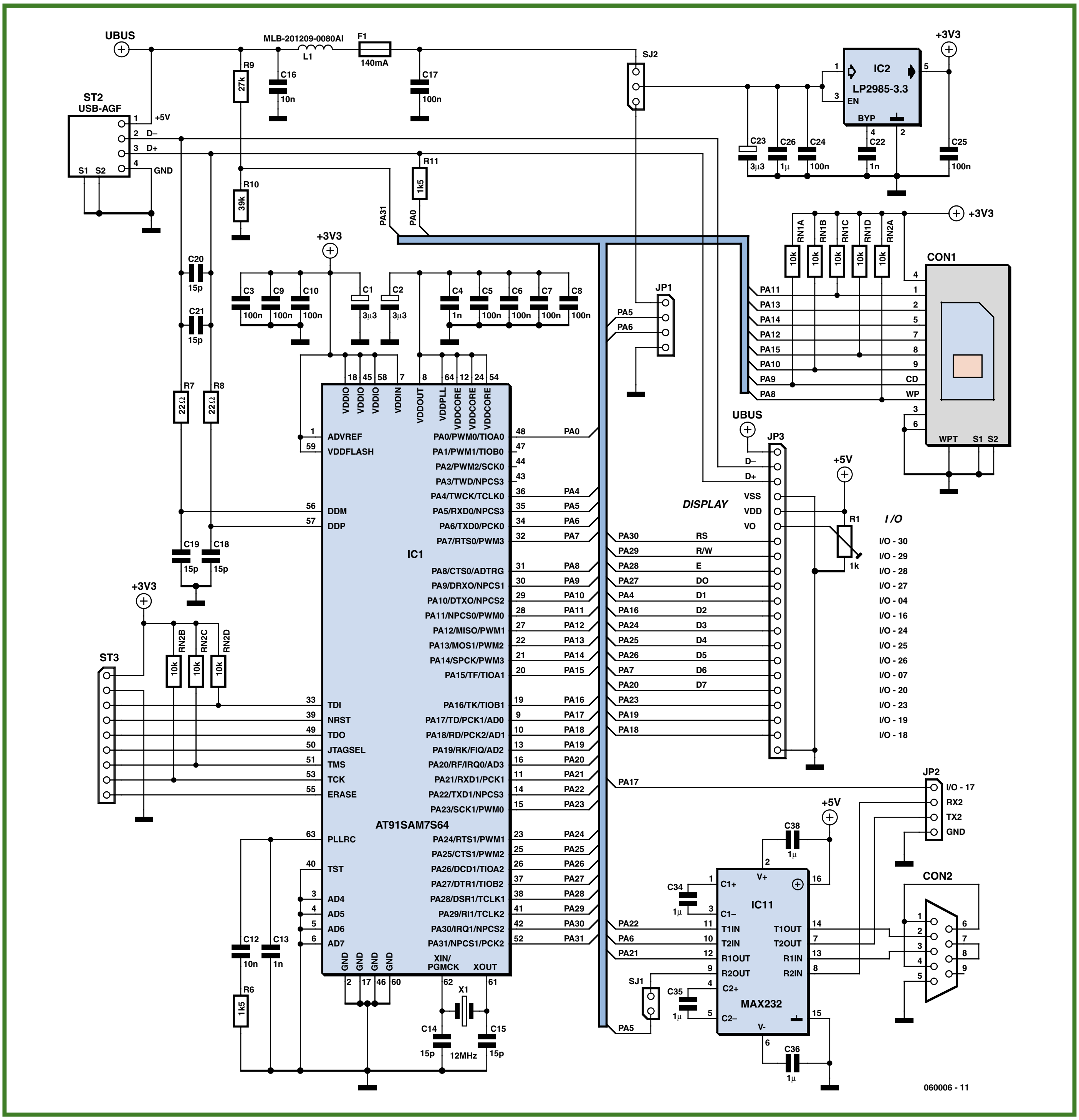


Figure 1. The core of the unit is an ARM7 controller which contains an integrated USB interface. Its firmware allows a microcontroller connected to the RS232 port read/write access to data in the flash memory.

The memory card

The Flash card connector on the PCB (CON1) can accommodate both MMC and SD cards despite their differing thickness. Both types of card are used for many other commercial applications such as digital cameras, palm tops etc. they are competitively priced and offer good memory capacity. The circuit supports cards with a capacity up to 2 GB.

Flash memory does have a limited number of erase cycles (which obviously limits the write cycles also). This 'endurance' figure is largely dependant on the type of technology used by the card (NOR or NAND Flash). Standard MMC and SD cards (NOR Flash) quote an endurance figure of 100,000 write cycles while industrial grade variants boast 400,000 cycles with an extended operating temperature range.

When a card is inserted into the connector the controller determines the status of the write protection switch. The card memory space is organised in sectors of 512 bytes, this is also the size of memory which can be read or written to in one step. The file system used is the industry standard FAT16 format so the card can also be re-

ARM7 Controller

Main features of the AT91SAM7S64

- 32-bit RISC Architecture
- 64 kB Flash, 16 kB SRAM
- Reset Controller, Brownout Detector
- 32 I/O Pins (Pullups)
- 2 UART, SPI (8 to 16-bit), TWI
- USB 2.0 Full Speed (12 Mbit/s), DMA controller
- several timers, e.g. 16-bit Timer/Counter, PWM Controller
- 8 channel 10-bit A/D converter
- JTAG, connection for emulation and debug
- 5 V tolerant I/Os, 4 I/O pins providing up to 16 mA

moved and used in other equipment such as card readers etc.

Communication with the memory cards can be performed using either MMC or SD mode and both types of card support the SPI interface mode. The ARM 7 controller uses SPI mode and needs just four connections to the card: MOSI (Master Out Slave IN), MISO (Master In Slave Out), SCK (Serial Clock), SS (Slave Select (active low)). The card communicates at a raw data rate of 12 Mbit/s. It is important

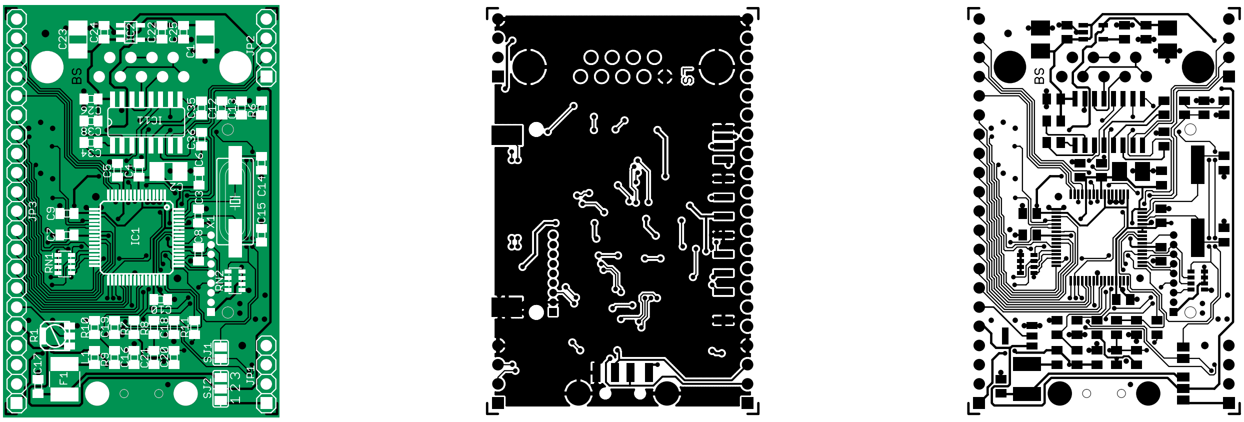


Figure 2. **SMD component placement on the PCB. This board is available ready populated and tested.**

COMPONENTS LIST

Resistors

R1 = 1kΩ potentiometer, SMD, 1% (optional, see text)
RN1,RN2 = 4-way 10kΩ resistor array, 5%
R6, R11 = 1kΩ5 (SMD 0805, 1%)
R7,R8 = 22Ω (SMD 0805, 1%)
R9 = 27kΩ (SMD 0805, 1%)
R10 = 39kΩ (SMD 0805, 1%)

Capacitors

C1,C2,C23 = 3µF3 (SMD 3528, tantalum, 20%)
C3,C5,C6,C7,C8,C9,C10,C24,C25 = 100nF (SMD 0805, 10%)
C4,C13,C17,C22 = 1nF (NP0, SMD 0805, 5%)
C12,C16 = 10nF (SMD 0805, 10%)
C14,C15,C18,C19,C20,C21 = 15pF (SMD 0805, 5%)
C26,C34,C35,C36,C38 = 1µF (SMD 0805, 10%)

Semiconductors

IC1 = AT91SAM7S64 (programmed, order code **060006-41**)
IC2 = LP2985A-33DBVT (SOT23, Texas Instruments)
IC11 = MAX232 (SO16, Maxim)

Miscellaneous

X1 = 12MHz quartz crystal (SM49)
F1 = 140mA Polyswitch
L1 = choke, MLB-201209-0080AI (Kitagawa)
CON1 = card holder for SD/MMC cards
CON2 = 9-way sub-D socket (female), angled pins, PCB mount
ST1 = USB-A plug, PCB mount, e.g. Assmann A-USB-A-SMT (Reichelt USB AGF)
JP1,JP2 = 4-way SIL pinheader, lead pitch 0.1 in
JP3 = 21-way pinheader, lead pitch 0.1 in

PCB, order code **060006-1** (unpopulated) or **060006-91** (assembled and tested, see Elekor SHOP on in this magazine or on website)
Project software, file **060006-81.zip**, free download from www.elektor.com (month of publication)

Table 1. Overview of commands

USB commands:

Mount	UnMount	CardAvailable	CardNotAvailable
Connect	DisConnect	WriteDisable	WriteEnable
Ping			

File related commands:

FileOpen	FileClose	FileRead	FileWrite
FileSeek	FileTell	Dir	ChangeDir
CreateDir	RenameFile	RemoveFile	QuickFormat

Commands to the peripherals:

InitDisplay	ClearDisplay	DisplayOff	DisplayWrite
Baudrate	SetDirection	SetOutput	GetInput
SetPullup	GetCardStatus	GetFirmwareVersion	

Example

MOUNT command to the controller:

41h 04h 00h 45h

- 45h: Checksum 41h XOR 04h XOR 00h gives 45h.
- 00h: High-Byte of the sum of bytes in the command sequence.
- 04h: Low-Byte of the sum of bytes in the command sequence.
- 41h: The command byte.

Controller response:

41h 01h 40h

- 40h: Checksum 41h XOR 01h gives 40h.
- 01h: The value 1 indicates that the MOUNT request was successful.
- 41h: Echo the command byte.

Figure 3. The USB socket, RS232 connector and MMC/SD card holder are the only components mounted on one side of the board.

to ensure that this card is not inserted or removed during operation!

Supplying the power

The complete unit draws its 5 V supply from the from either the USB connector or from an external mains adaptor via connector JP1.
A solder jumper (SJ2) is used to define which power supply option is used. Voltage regulator (IC2) produces the 3.3 V required by the microcontroller and the majority of the remaining circuitry. In normal operation just two pins of SJ2 will be bridged to define the source of power for the unit. It is not recommended but it is also possible to bridge all three pins together so that power can be supplied from either source but with both bridged you must make certain that power is not supplied to the unit from both the adapter **and** USB port at the same time!
Coil L1 and capacitor C17 form a low pass filter to remove any interference on the USB power supply line. The capacitors fitted across the USB data lines and also around the voltage regulator perform the same function. A 150 mA PolySwitch fuse (F1) prevents the circuit from drawing too much current if a fault occurs.

Printed circuit board

The PCB (**Figure 2**) shows that all the SMD components are mounted on one side of the board while the other side is used to mount the connectors (**Figure 3**). The largest devices on the component side (**Figure 4**) are the AT91SAM7S64 microcontroller, the MAX232 and the 12-MHz quartz crystal.
Soldering SMD components can be tricky (and expensive) if you are not experienced in this procedure, both the 64-pin LQFP package used for the controller and the 1206 outline resistor network require particular care. For those of you who are less confident, a fully populated and tested PCB can be ordered from the Elektor SHOP or alternatively the unpopulated PCB is also available for the more adventurous.

Software

All the software for this project is contained in an archive file no.060006-81.zip at www.elektor-electronics.com. The text box entitled 'Software files' gives an overview of all the program files and documentation. It contains mainly driver routines and example files for a microcontroller system attached to the RS232 port of the flash memory.

Software for the ARM controller (device available pre-programmed) takes care of the file system and executes commands sent over from the USB or RS232 interface. Commands originating from the operating system of the PC are received over the USB port and 'see' the flash memory as an additional drive. Commands from an external microcontroller system are received and responses are sent over the RS232 interface. The overview in **Table 1** shows that the commands can be divided into three groups:

- USB commands

All the instructions dealing with communication between the USB port, RS232 port, the PC and ARM7 controller.

- File commands

These allow files to be opened and closed, renamed and for the attached MMC/SD memory card to be formatted.

- Peripheral commands

Commands to control the display, the free I/O pins and communications speed.

All communications conform to the same basic structure; a command is sent to the controller followed by a reply from the controller. Each message to the controller contains a command field, a parameter field (if the command has any parameters associated with it) and a check sum. The main difference is in the number of parameters sent.

Instructions to the controller therefore have the following format:

[Command byte - [0 to 4 parameters] - Checksum]

Byte 1: command bye
Byte 2: LowByte of total length of command
Byte 3: HighByte of total length of command

Byte 4: LowByte of length of 1st parameter
Byte 5: HighByte of length of 1st parameter
Byte 6: data of 1st parameter (1-512 bytes)

[…] up to three more parameters

Byte *n*: 8-bit XOR checksum across full command

The controller reply has a similar format, typically consisting of a three-byte sequence. The first byte is a repeat (echo) of the command byte sent to the controller; the second byte is a token indicating either a successful or unsuccessful outcome of the command while the third byte

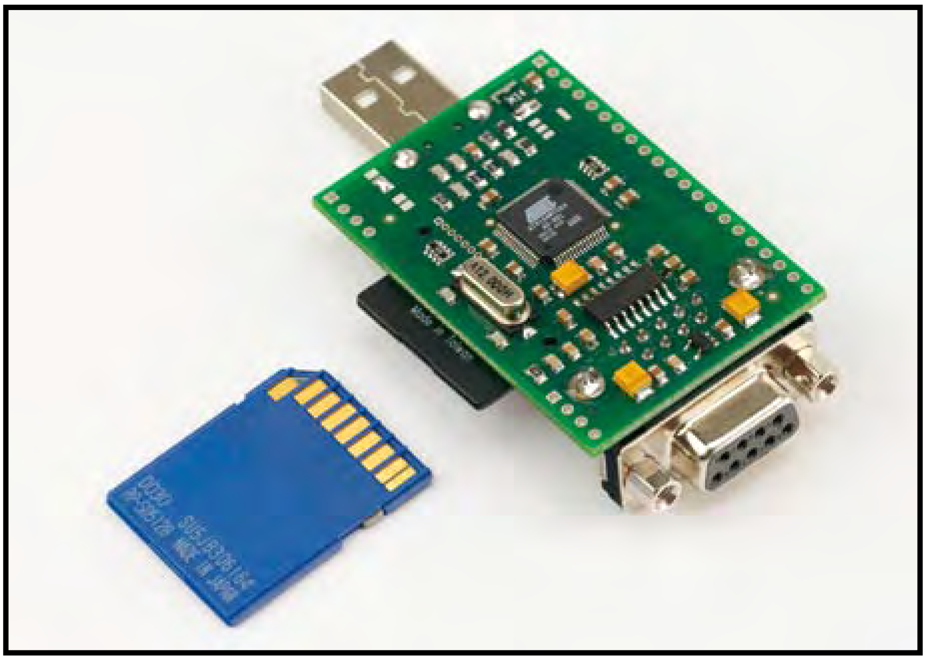


Figure 4. The AT91SAM7S64, MAX232 and 12 MHz crystal are the largest components on the underside of the PCB.

NAVTEX

NAVTEX meteorological radio broadcasts have proved useful to sailors for many years and also served as the source of inspiration for this project. The international NAVTEX (Navigational Warnings by Telex) network sends out information on sea conditions and storm warnings as situations develop. The station transmits internationally on 518 KHz or nationally (in the local language) on 490 KHz [2].

These text broadcasts can be picked up by dedicated receivers (see photo) some of them use a thermal printer to provide a hard copy of the messages while others use a flash memory to store the incoming message where it can be read simultaneously (or later) by a PC via a USB port.

Expanding on this concept the author produced this design which can store data from a microcontroller system and transfer it to a PC using an RS232 port, a USB port and a low cost, high capacity MMC/SD card as the storage medium.

Software Files

060006-81.zip
(Download from www.elektor.com
or order the CD):

Source text/drivers for C
File Stickdrv:
double.cpp Commands to the stick
double.h Header file
serial.cpp serial interface
serial.h Header file
File Stick51:
C examples for 8051 compatible devices

Source text and drivers for DOS-like commands:
File Stickdos:
COPYS.PAS Copy command
DELS.PAS Delete command
DIRS.PAS Dir command
TYPES.PAS Type command
MISC.PAS odds and ends
PARAM.PAS parameter handling of the above instructions
RS232.PAS serial interface
STICK.PAS commands to the stick

Windows Program (incl. source code)
File Sticktest with Testsuite for testing purposes

Documentation:
File Stickdok: Additional information describing the commands

is a checksum. When the command requests data this is transmitted before the sequence.
The controller response therefore has the following format:

[Command byte - success/failure token - Checksum]

Byte 1: repeat of command
Byte 2: '1' if command successfully completed; else '0'
Byte 3: 8-bit XOR checksum across above two bytes

To better illustrate the communication process the MOUNT command is detailed in Table 1. MOUNT is generally the first command in the program and does not have any parameters associated with it.
This command instructs the controller to load parts of the filing system (FAT, index) of the MMC/SD card into its RAM. It is necessary to retrieve this information from the memory card before some of the other commands can be used.
When all the bytes in the command and reply sequence are XORed together the result should equal 00h this indicates (with a high level of probability) that the communication sequence was not corrupted.
To check whether the command was carried out successfully it is necessary to examine the middle byte of the received sequence, if the byte is 01h it indicates that it was successful whereas a 00h indicates that it was not possible to carry out the command.
A more detailed description of each command is included amongst the files that can be downloaded [1] for this article (060006-81.zip).

(060006-I)

Web links

[1] www.elektor.com
(month of publication)

[2] http://en.wikipedia.org/wiki/Navtex

Data logger

The USB-Flash memory can also be used as a data logger. Firmware in the ARM controller switches into data logging mode when it detects a jumper connecting pins 17 and 18 of the pin header strip JP3.
Three additional components are required for this mode of operation:

- A pushbutton wired between pin 4 (GND) and Pin 7 (PA30),
- A 750 Ω resistor between Pin 8 (PA29) and Pin 12 (PA16),
- A red low-current LED (2 mA) with the anode connected to Pin 12 (PA16) and the cathode to Pin 13 (PA24).

Once the jumper is in place the LED lights continuously to indicate that it has entered data logging mode. When the pushbutton is pressed the message DATEN appears (if data is not available). The LED blinks and the controller waits for data from the RS232 port (9600 bit/s). When data arrives it is written to a file which is given the name 'DATEN001.TXT', if this file already exists it creates another with the name 'DATEN002.TXT' and so on up to 'DATEN999.TXT'.

Once the file has been transferred, another press of the pushbutton closes the file and the LED again lights continuously ready for the next file.

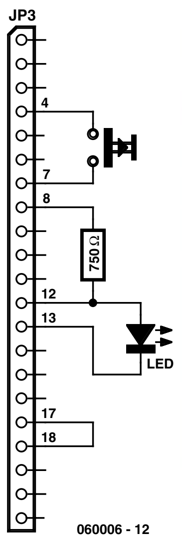
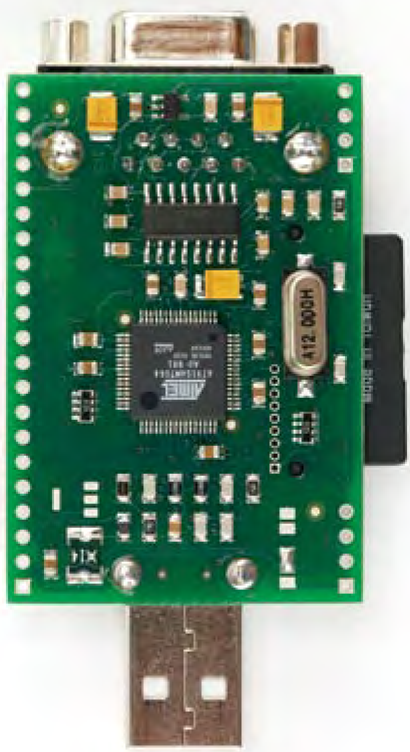


Diagram of the 21-pin header strip JP3 when used in data logging mode. Pin 1 is indicated by a square outline printed on the PCB.



16-bit Microcontrollers

16-bit PIC24 MCUs and dsPIC® Digital Signal Controllers

Unified 16-bit Architecture

- PIC24F, low-cost entry level
- PIC24H, 40 MIPS high performance
- dsPIC30F/33F for seamless DSP integration

Low-Risk Design

- Easy migration from 8-bit MCUs
- Common core instruction set and architecture
- Peripheral and Pin compatible families
- One development tool platform for all products
- Free MPLAB® IDE Integrated Development Environment
- Other tools include C-compiler, programmer and In-Circuit Emulator

Visualise...16-bit Microcontrollers with 32-bit Performance and 8-bit Simplicity

Today's embedded systems demand more. The 16-bit PIC® microcontroller families from Microchip give you the performance and flexibility you need with 8-bit simplicity. Pin and code compatibility lowers risk, and allows re-use of development tools, software and hardware designs. For the most demanding applications the dsPIC digital signal controller families seamlessly integrate high-performance DSP capabilities with the PIC microcontroller core.

Over 50 PIC24 Microcontrollers and dsPIC Digital Signal Controllers sampling today.
For data sheets, samples and pricing go to www.microchip.com/16bit

microchip DIRECT
www.microchipdirect.com

Now Pb-free! RoHS Compliant

MICROCHIP®
www.microchip.com/16bit

The Multi-Talented

Real-time multitasking operating system (RTOS)

Dieter Holzhäuser and Burkhard Kainka

Multitasking provides an elegant and simple way to solve complex control problems, and real-time performance does not necessarily suffer as a consequence. A few C routines (and a little discipline on the part of the programmer) let us obtain satisfactory multitasking performance even on microcontrollers such as the R8C.

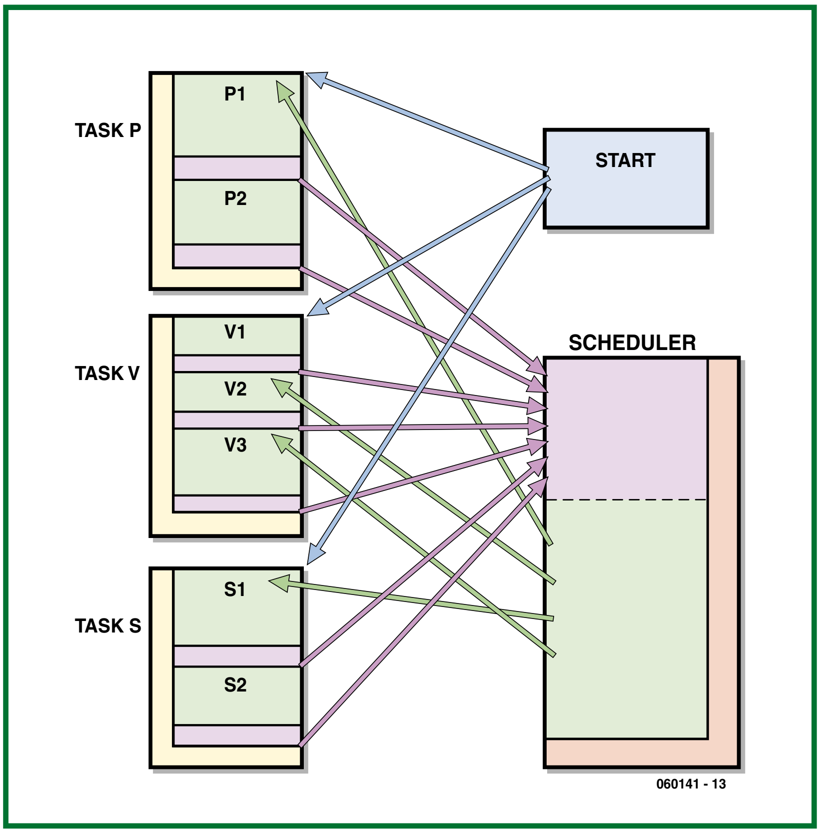


Figure 1. Structure of an mt program. The user program (shown in yellow) consists of various tasks ceding control to the scheduler (green), normally in order to wait for an event. Prior to this, a dedicated mt function (red) is called which registers the wait with the scheduler. This call also specifies the function which the scheduler is to start to continue the task when the event occurs (or if the event has already occurred). All tasks must be started using a start routine (blue).

In most microcontroller applications the software must run in synchrony with a series of events external to the CPU, however inconvenient this may be. Systems that operate in this way are called 'real-time systems'. Real-time programs are generally not written using time delay loops or polling.

Complex control problems can be solved by splitting them into smaller pieces. 'Multitasking' is the process whereby a program switches between a number of interdependent tasks under software control.

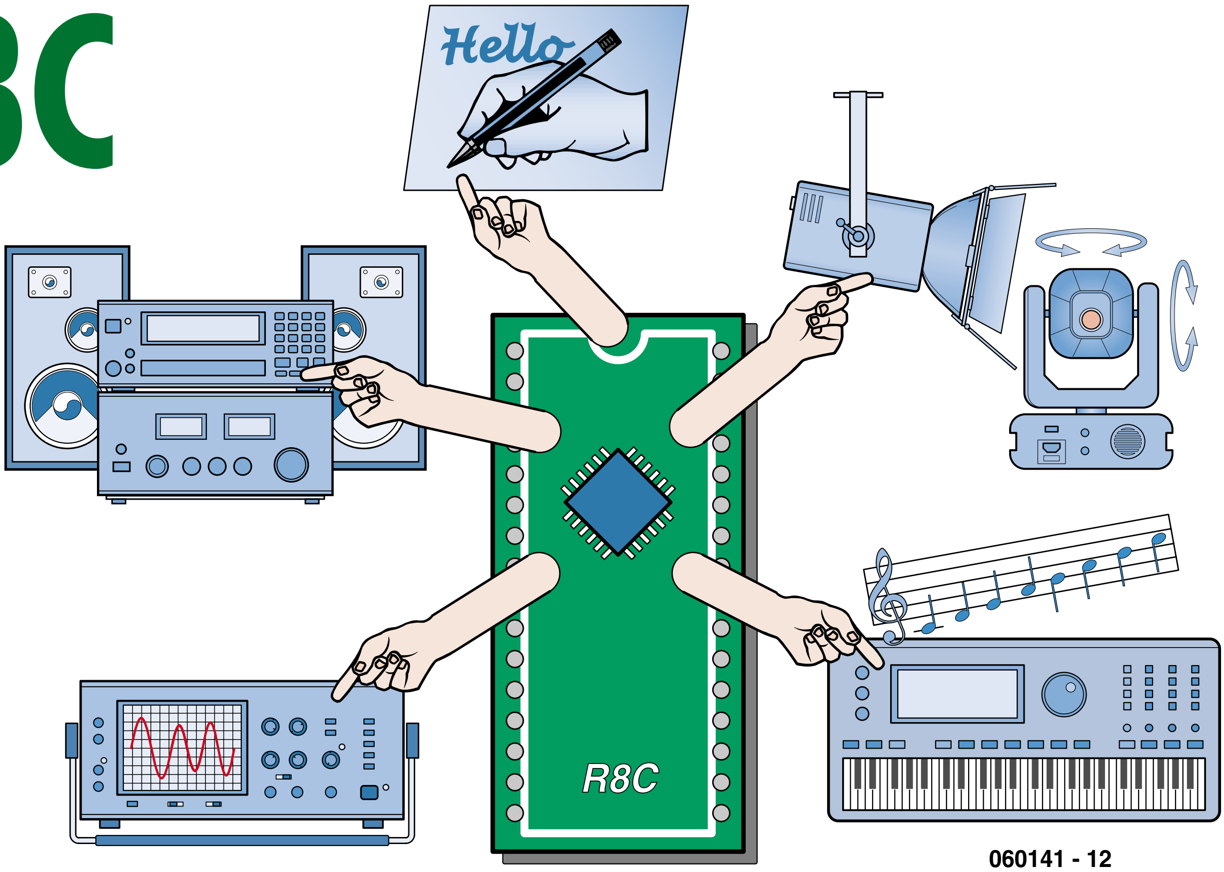
There are several varieties of multitasking. In each case we create the illusion of a number of programs or parts of programs, called (depending on the system) 'processes', 'tasks', or 'threads', running simultaneously. The term 'task' is used in the multitasking operating system described in this article. The operating system, written by *Elektor Electronics* reader and retired engineer and software developer Dieter Holzhäuser, is called 'mt'. To provide multitasking on a single processor we simply need to switch execution from one task to another sufficiently quickly.

Real-time operation is best achieved when task switching is event driven. This fits well with the fact that many tasks, especially in control applications, are normally in a state where they are waiting for an event before they can continue.

Task switching

The fundamental challenge in any multitasking system is task switching. In an event-driven system the appropriate task must be started as soon as possible after the trigger event occurs.

Tasks generally run in an infinite loop, which can be stopped only by an interrupt. A task can also cede con-



060141 - 12

trol, using a subroutine call provided for the purpose, if it needs to wait for a particular event before continuing execution. If a task switch then occurs, a different task will then proceed. The interrupt handler or subroutine will not therefore necessarily return to the point from which it was called, a feature not supported by many ordinary processors. A separate stack is required for each task in order to implement this mechanism. Unfortunately, each stack takes up precious RAM space.
The 'mt' system gets around this problem at the cost of a couple of minor restrictions. Rather than being written as a single function containing an infinite loop, an mt task is written as a number of separate functions which are called in turn (which is in itself an infinite process). A task which wishes to wait for an event returns control to the operating system so that it is no longer running. Before doing so it calls a special function to register which function in the task is to be called when the event occurs ('registration').

Scheduler

The scheduler is the central despatch point for task functions (see **Figure 1**). When a task cedes control it returns to the scheduler. The scheduler then called the registered function of the next task which, because its registered event has occurred, is ready to be run. See the text box for more information on the states that a task can be in. If no task is ready to be run the scheduler sits in an empty loop. If more than one task is ready to be run a choice between them is made based on the order of registration and a priority specified by the programmer.
We can now see what mt cannot do: an interrupt cannot lead to an immediate task switch. A task function that is interrupted will continue after the interrupt until it naturally comes to an end. This is only a significant disadvantage if there are long-running task functions and an interrupt causes another task to become ready to run. In a real-time system it is more likely that an interrupt will occur when the scheduler is in its empty loop: in this case, if the interrupt causes a task to become ready to run, the scheduler will start it immediately.
The possibility remains, of course, of writing tasks that must carry out lengthy calculations in a cooperative fashion, voluntarily giving up control at regular intervals. When using external library functions it is necessary to check that they execute quickly enough that the progress of other tasks is not adversely affected.

mt functions

Tasks continually switch between a state where they are running and a state where they are waiting for an event. During the waiting time of one task either the scheduler or another task will be running. For each type of event there is a corresponding mt function which registers the waiting task and records the function to be called when the event occurs. When one of the mt functions has been called the task function must return; otherwise task switching will be held up until it does.
The mt functions are system-independent, and can be found in source file mtsys.c. (Program files are as usual available for free download from the project pages on the *Elektor Electronics* website.) There are mt functions for the various kinds of event a microcontroller might typically encounter, such as the expiry of timers and level changes on input ports. Using so-called 'semaphores' a task can itself generate an event for another task (see the text box). Other features of mt are described in the additional documentation available on the *Elektor Electronics* website.

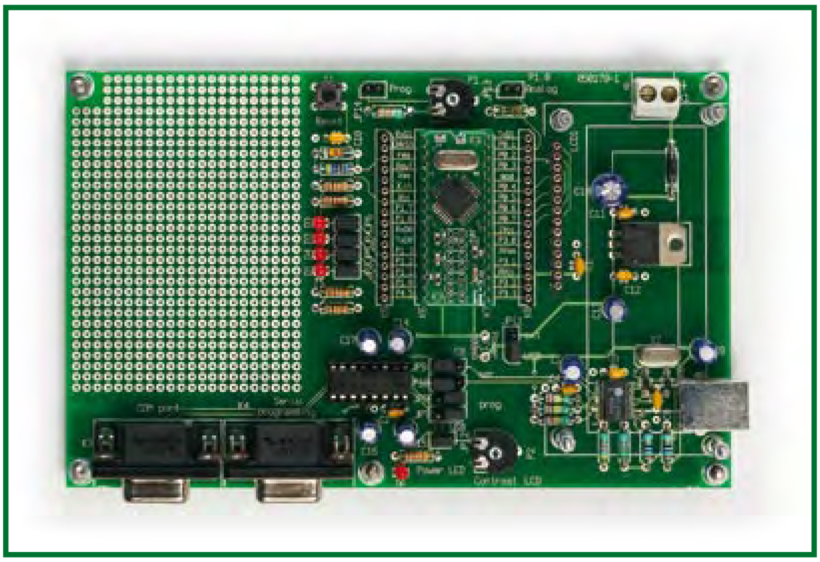


Figure 2. The Elektor Electronics R8C Application Board, published in March 2006, makes an ideal development platform.

The use of the mt functions is best illustrated with an example (see text box). Here the R8C plays a tune, flashes an LED and measures a frequency (which it produces itself), all at the same time! The *Elektor Electronics* R8C Application Board, published in March 2006, makes an ideal development platform.

The next step

Although the mt kernel provides a powerful basis for program development, as problems get more complex it is helpful to make use of ready-made modules. The following have already been developed:

- user interface with LCD and keyboard;
- DCF77 clock with time and date functions;
- serial input/output;
- flash memory interface (limited mt compatibility).

These modules are also available from the *Elektor Electronics* website. There is also a further article demonstrating the use of the LCD interface module (see links below). Plans are also afoot to create a network of R8Cs so that complex tasks can be distributed over several processors. Watch this space!

(060141-I)

Links

Dieter Holzhäuser: Email diehol@system-maker.de

Comprehensive information on the R8C, related articles and products can be found on the R8C project pages on the Elektor Electronics website. The project software including examples is also available for free download from the web page for this article, along with a free bonus article.
www.elektor.com, go to month of publication.

Task states

An mt task can be in one of four different states:

- running

At most one task can be in this state at any time.

- blocked

A task that is waiting for an event is 'blocked'. This is always the case when waiting for an external event such as the expiry of a timer or a bit changing state. Waiting for a semaphore blocks a task only when the semaphore is not raised: otherwise the task immediately enters the ready-to-run state. This also occurs when the mtcoop() function is called: see the text box on mt events. If several tasks are blocked, they are held in a queue.

- ready-to-run

Tasks whose event has occurred but which are not running (because another task is running) are 'ready-to-run'. If several tasks are ready they are held in a queue.

- terminated

Terminated tasks can only be returned to the running state using the start() function.

mt Functions

```
void mtdelay (unsigned long a , void (*b) (void)  );
void mtcoop ( void (*a) (void)   );
void mtwait (char a, void (*b) (void) );
void mtbitup (char*a , char b, void (*c) (void) );
void mtbitdown (char* a, char b, void (*c) (void) );
// in each case the last parameter indicates
// the continuation function to be called
```

- Timer

A time delay of a ms can be registered using the mtdelay() function.

- Bit change

A program can react to peripheral events by waiting for a bit to change. In the functions mtbitup() (for a rising edge) and mtbitdown() (for a falling edge), a is a pointer to a register, port or byte, and b gives the bit index.

- Semaphores

Tasks are on the whole independent entities. Nevertheless, they must be able to influence one another, and for this purpose we use semaphores. Once defined, they can be thought of rather like signals on a railway.
If the semaphore is cleared, the affected task must wait until it is set by another task. The function mtwait() waits for a semaphore. Parameter a specifies the semaphore which is being waited for.
Functions signal(char) and addsignal(char) set semaphores. Unlike the case of the mt functions, the task function need not now end, although you should consider whether it is worth allowing the possibility of a task switch at this point.
Time delays and bit changes are events external to the program. They arise from a timer interrupt which should preferably be arranged to occur at a frequency of 1 kHz. A regular timer interrupt is therefore essential to the operation of the system. In contrast, semaphores are events internal to a program and do not depend on interrupts for operation. If access is required to interrupts generated by peripherals, semaphores should be used to move a task to the ready state from within the interrupt handler.

● mtcoop()

The function mtcoop() does not wait. It is used to abandon the task function or to offer the scheduler the opportunity for a task switch (so-called 'cooperative multitasking').

Further details on the use of the mt functions can be obtained from the header file mtsys.h.

Example mtdemo1.c

The program files for this example are available for download from the Elektor Electronics website. The best way to proceed is to create a new R8C project called 'mtdemo1' under HEW and copy all the files into it, overwriting where necessary. Use Project/Add files to bring in all the C source and header files not already in the project. Set the project type to 'Release', disabling debugging.

The structure of an mt program is always the same. The included files are given at the beginning; there follow the definitions of task and semaphore names, which are simply offsets into an array. The array itself is defined later, although the relevant sizes (TLSIZE and SLSIZE) are given here.

Each task definition requires 16 bytes of RAM and each semaphore definition one byte of RAM.

```
#include "sfr_r813.h"
#include "mtsys.h"

// task names, numbered consecutively from 0
#define SIMU     0
#define SCAN     1
#define COPY     2
#define VF       3
#define PLAY     4
// count of tasks (greatest task number plus one, maximum
  30)
#define TLSIZE   5

// semaphore names, numbered consecutively from 0
#define SCANSEM  0
// count of semaphores
#define SLSIZE   1   // always specify SLSIZE (greatest
  semaphore number plus one, maximum 255)
```

The tasks appear next. To make the code more comprehensible it is a good idea to name the functions using the task name followed by a number in increasing sequence. Continuation functions that are used but not yet defined must have a forward declaration in the form of a function prototype.

The task PLAY plays a piece of music. It uses Timer X, configured as an adjustable frequency generator with output on p1_7 (pin 8). Interrupts are not required in pulse output mode, which is supported only by Timer X. Task function play1() starts a note or rest of the appropriate duration, and play2() produces a brief rest between two consecutive notes. Execution then continues with play1() again.

```
// PLAY: play a tune on p1_7
#define C  238   // note definitions
#define Csharp 224  // semitone ratio 1.059, whole tone
  ratio 1.122
#define D  212
#define Dsharp 200
#define E  189
#define F  179
#define Fsharp 169
#define G  159
#define Gsharp 150
#define A  142
#define Asharp 134
#define B  127
#define S18   5  // definition of note durations
#define S14  10
#define S38  15
#define S12  20
#define S34  30
#define S11  40

#define SONG radetzky

const
struct {char f; char t;}  radetzky [104 ] = {
{sizeof(radetzky) / 2, 25},            //length, tempo

{G ,S14}, {G ,S14}, {G ,S14}, {0 , S14},
{B ,S14}, {A ,S14}, {G ,S14}, {0, S18}, {Fsharp, S18},

{E ,S18}, {Dsharp ,S18}, {E, S18}, {Fsharp ,S18}, {G ,S14},
  {A, S14},
{D ,S12}, {0 ,S14}, {B ,S18}, {Asharp, S18},
{B ,S14}, {B ,S18}, {Asharp ,S18}, {B, S14}, {B,
  S18},{Asharp ,S18},
{B ,S14}, {A ,S14}, {G ,S14}, {B, S18}, {Asharp, S18},
{B ,S14}, {B ,S18}, {Asharp ,S18}, {B, S14}, {B,
  S18},{Asharp ,S18},
{B ,S14}, {E/2 ,S14}, {D/2 ,S14}, {D/2, S18}, {B, S18},

{C/2 ,S14}, {E/2 ,S14}, {D/2 ,S14}, {D/2, S18}, {A, S18},
{B ,S14}, {E/2 ,S14}, {D/2 ,S14}, {D/2, S18}, {B, S18},
{A ,S14}, {Fsharp/2 ,S12}, {E/2 ,S14},
{D/2, S14}, {D/2, S18}, {Csharp/2, S18}, {D/2, S18}, {E/2,
  S18}, {D/2, S18}, {C/2, S18},
{B ,S14}, {B ,S18}, {Asharp ,S18}, {B, S14}, {B,
  S18},{Asharp ,S18},
{B ,S14}, {A ,S14}, {G ,S14}, {B, S18}, {Asharp, S18},

{B,S14}, {B,S18}, {Asharp ,S18}, {B, S14}, {B, S18},
  {Asharp, S18},
{B,S14}, {E/2 ,S14}, {D/2 ,S14}, {D/2, S18}, {B, S18},
{Csharp/2 ,S14}, {B/2 ,S14}, {A/2 ,S14}, {0 ,S14},
{B, S14}, {A/2, S14}, {G/2, S14},  {0, S14},
{Fsharp/2 ,S14}, {0 ,S18}, {E/2 ,S18}, {D/2, S18}, {C/2,
  S18},{B, S18},{A ,S18},
{G ,S14}, {G/2 ,S14}, {G/2 ,S14}, {0, S14},
{0 ,2*S11}
};

char pb = 1;
void play1 ();
void play2 () {
  txs = 0;
  if (++pb == SONG[0].f )  pb = 1;
  mtdelay (25, play1);
}
void play1 () {
  if (SONG[pb].f) {
    tx = SONG[pb].f - 1;
    txs = 1;
  }
  mtdelay ( (int)SONG[pb].t * SONG[0].t - 25 , play2);
}
```

Task VF generates a variable frequency on an output which is connected to an LED. Each half cycle produced by function vf1() is approximately 10 % longer than the previous one. When the duration reaches 700 ms the task proceeds with function vf2(), which shortens each half cycle by approximately 10 % until a duration of 50 ms is reached. Function vf1()

is then activated again, and the process repeats.

```
// VF: generate a variable frequency on p1_2
void vf1 ();
int tvf = 100;
void vf2 () {
  tvf = tvf * 10 / 11;
  if (tvf < 50) mtcoop (vf1);
  else {
    p1 = p1 ^ 0x08;
    mtdelay ( tvf  , vf2);
  }
}
void vf1 () {
  tvf = tvf * 11 / 10;
  if (tvf > 700) mtcoop (vf2);
  else  {
    p1 = p1 ^ 0x08;
    mtdelay ( tvf  , vf1);
  }
}
```

Finally, as if it were not enough that PLAY and VF run simultaneously and harmoniously, we add considerably to the demand on the processor with tasks SIMU, SCAN and COPY. These ensure that the scheduler has something to do on each timer interrupt.

The job of SCAN is to measure a frequency. It is provided with an input of 500 Hz by SIMU in the form of a changing byte ('sim'), obviating the need for an external frequency generator. SCAN waits alternately for a rising and a falling edge on bit 0 of the byte sim. It signals its result to the COPY task using semaphore SCANSEM, which displays it on an LED. Correct operation can most easily be verified using an oscilloscope. These three tasks demonstrate that a program can continue to run smoothly even when the processor is under considerable load.

```
// SIMU: simulate input for SCAN in sim at 500 Hz
char sim = 0;
void simu1 () {
  sim = sim ^ 0xFF;         // alternate between sim = 0
  and sim = 0xFF
  mtdelay ( 1 ,  simu1 ) ;
}

// SCAN: scan bit 0 of sim and signal result using SCANSEM
void scan2 ();
void scan3 () {
  signal (SCANSEM);
  mtbitup ( &sim, 0, scan2);
}
void scan2 () {
  signal (SCANSEM);
  mtbitdown ( &sim, 0, scan3);
}
void scan1 () {
  mtbitup ( &sim, 0, scan2);
}

// COPY: wait for SCANSEM and copy SCAN result to p1_2
void copy1 () {
  p1 = p1 ^ 0x04;
  mtwait ( SCANSEM, copy1);
}
```

After the tasks we define the function startmt(). This carries out any initialisation required by the tasks and then starts them.

```
void startmt (void) {    // initialise and start tasks
  pd1 = pd1 | 0x0C;      // p1_2 used by COPY, p1_3 by VF

//PLAY
  asm( "FCLR I");   // disable interrupt
  txmr = 1;      // pulse output mode on pin 8 for Timer X
  tx   = 142-1;    // 125 kHz /142 = 880 Hz, corresponding
  to note at 440 Hz
  prex = 20-1;       // 2.5 MHz / 20 = 125 kHz
  txck0= 1;        // 20 MHz / 8 = 2.5 MHz
  txck1= 0;
  txs  = 0;    // Timer X stop
  asm( "FSET I");   // enable interrupt
  start (PLAY, 1, play1);

// SIMU, SCAN, COPY
  start (SIMU, 1, simu1);
  start (SCAN, 1, scan1);
  start (COPY, 1, copy1);

// VF
  start (VF, 1, vf1);
}
```

The final part of all mt programs is the same. The arrays tlist (data for the mt kernel) and semalist (for semaphore storage) are defined here.

Then comes the interrupt handler for Timer Y, which detects timer expiry and bit changes using mtint_handler(). It is essential to overwrite the dummy entry for vector 23 in the R8C variable vector table (file sect30.inc) with _timer_y, and make it global in scope.

```
.glb    _timer_y
.lword  _timer_y        ; vector 23
```

Function main() switches the CPU clock to 20 MHz and initialises Timer Y. The two final calls in main() must be startmt() and schedule(). Function schedule() is the 'engine' of the program, calling task functions as necessary and executing an empty loop when no functions are ready to run.

```
/* Code from here on is identical for all mt programs */
tlisttype tlist[TLSIZE];
semalisttype semalist[SLSIZE] = { 0 };

#pragma interrupt timer_y
void timer_y (void){
  mtint_handler ( );
}

void main() {
  asm( "FCLR I");   // change on-chip oscillator clock to
  main clock
  prc0 = 1;          // protect off
  cm13 = 1;          // Xin, Xout
  cm15 = 1;          // XCIN, XCOUT drive capacity select
  bit: HIGH
  cm05 = 0;          // Xin on
  cm16 = 0;          // main clock = no division mode
  cm17 = 0;
  cm06 = 0;          // CM16 and CM17 enable
  asm("nop"); asm("nop"); asm("nop"); asm("nop");
  ocd2 = 0;          // main clock change
  prc0 = 0;          // protect on

  tymod0 = 0;         // timer mode for Timer Y
  tysc = 0;           // 250 kHz / 250 = 1 kHz
  typr = 250-1;
  prey = 10-1;        // 2.5 MHz / 10 = 250 kHz
  tyck0 = 1;          // 20 MHz / 8 = 2.5 MHz
  tyck1 = 0;
  tyic  = 7;          // interrupt level
  tywc = 0;
  ir_tyic = 0;
  tys = 1;       // timer on

  asm( "FSET I");     // enable interrupt

  startmt  ();
  schedule ();
```

FPGA Course (6)

Part 6: connecting a keyboard

Paul Goossens and Andreas Voggeneder (FH Hagenberg)

You no doubt have an old PS/2 keyboard gathering dust somewhere. Now you can put it to good use again as an input device for the FPGA prototyping board. This instalment of our FPGA course tells you how.

Most prototyping systems use an RS232 link to send and receive data. This link normally goes to a PC running a terminal emulator program. The user thus uses the monitor of the PC as the actual output device and the keyboard as the input device.

You can dispense with the PC if you connect a monitor and keyboard directly to the prototyping board.

PS/2

Until recently, PC keyboards were always connected to the PC via the PS/2 bus. The FPGA prototyping board also has two PS/2 ports. Besides the power supply lines, a PS/2 port has a data line and a clock line. Both of the these lines are bi-directional, and here they are connected directly to several pins of the FPGA on the circuit board.
Data is transmitted from a device (such as a keyboard) to the host (in this case the FPGA) as follows. First, the device transmits a start bit. The start bit is always a 0. It then sends the eight data bits starting with the least significant bit. Next comes a parity bit with odd parity, which means the parity bit is a 1 if an even number of 1 bits are present in the transmitted byte. Finally there is a stop bit, which is always a 1.
The clock signal for the transmission is generated by the device. The signal level on the data line changes only when the clock signal is high (see **Figure 1**).

From host to device

Communication from the host to the device is somewhat more complicated. First, the host must indicate that it wants to transmit data. It does this by setting the clock line low, which terminates any communication that may already be in progress. After a brief delay, it sets the data line low. Finally, it sets the clock line high again.
As a result, the device knows that the host will be transmitting data. In response to this, the device generates a clock signal. The host then sends one data bit for each clock pulse. This starts with a start bit (0) followed by eight data bits. These data bits are also sent starting with the least significant bit. The next bit is a parity bit (odd). Finally, the host sends a stop bit (1), but the communication session is not yet complete. The final action is that the device sends an 0 as an acknowledgement (ACK) if the data was received correctly (see **Figure 2**).

Software versus hardware

Of course, it is possible to implement the PS/2 protocol in software. This approach was taken with the I²C bus in a previous instalment. A disadvantage of this method is that the processor must spend some of its time processing the signals. It also doesn't make the software any simpler.
An alternative approach is to design a hardware interface that looks after generating and processing the signals. Here we describe how the PS/2 interface can be implemented in hardware. With a hardware interface, the microcontroller (8051) does not have to be concerned with the details of how the PS/2 interface works.
Before examining the hardware the implementation of the PS/2 interface, let's have a look at the T8052 microcontroller.

T8052

We've already used the T51 softcore processor several times in this course. The microcontroller consists of a processor portion called T51 and several peripheral devices, such as a UART, timers, and so on. Like every MCS51 processor, the T51 uses a special system bus to drive the peripheral devices. The registers on this bus are called Special Function Registers (SFRs). The original microcontroller (8051) did not use all available addresses. This was done intentionally to allow room for other peripheral devices. This possibility can be used to add a PS/2 interface to the microcontroller as shown in our *ex17* example.

The code in *T51_Glue.VHDL* looks after decoding the addresses of the SFRs. We add the following lines here:

```
ps2_data_sel      <= '1' when IO_Addr = "1011001" else '0'; -- 0xD9
ps2_data_wr       <= '1' when IO_Addr_r = "1011001" and IO_Wr = '1' else '0'; -- 0xD9
ps2_ctrl_stat_sel <= '1' when IO_Addr = "1011000" else '0'; -- 0xD8
ps2_ctrl_stat_wr  <= '1' when IO_Addr_r = "1011000" and IO_Wr = '1' else '0'; -- 0xD8
```

This bit of code makes register *PS2_DATA* available at SFR address 0xD9. Register *PS2_CTRL_STAT* is available at address 0xD8.

PS/2 interface

The actual PS/2 interface is described in *PS2Keyboard-a.VHDL*. The interface with the SFR bus is defined starting with line 218. Line 218 is part of a process that is evaluated on a rising clock edge. If a rising clock edge occurs when *data_wr_i* is high, the content provided by the processor is loaded into register *CmdReg*. In addition, a 1 is loaded into bit 8 (which is the ninth bit!).

If *ctrl_stat_wr_i* is high, several registers are loaded with the corresponding bits present on the data bus. As you can clearly see, the interface is returned to the quiescent stat if bit 7 is a 1. It waits for data from the device when it is in this state.

The content of *SFR_Data_o* is read by the processor in case of a read operation. Line 236 causes the content of the internal *DataReg* register to be passed if it is selected by the *data_sel_i* signal. Otherwise the content of the status register is passed.
The actual data transfer to the processor is handled by the *T8051.VHDL* file.

The remainder of the *PS2Keyboard-a.VHD* file describes the communication between the FPGA and the PS/2 bus. The comments in the source code should make it reasonably easy to understand how this works. If you can't figure it out, you can always use the simulator to examine the interactions between the internal signals.

Example

The first example of how to use the PS/2 interface is *ex17*. Start by connecting a keyboard to the connector labelled 'KEYBOARD', and then use the accompanying configuration file to configure the FPGA.
If everything goes as it should, a message will appear on the LCD. From now on, all data sent by the keyboard will

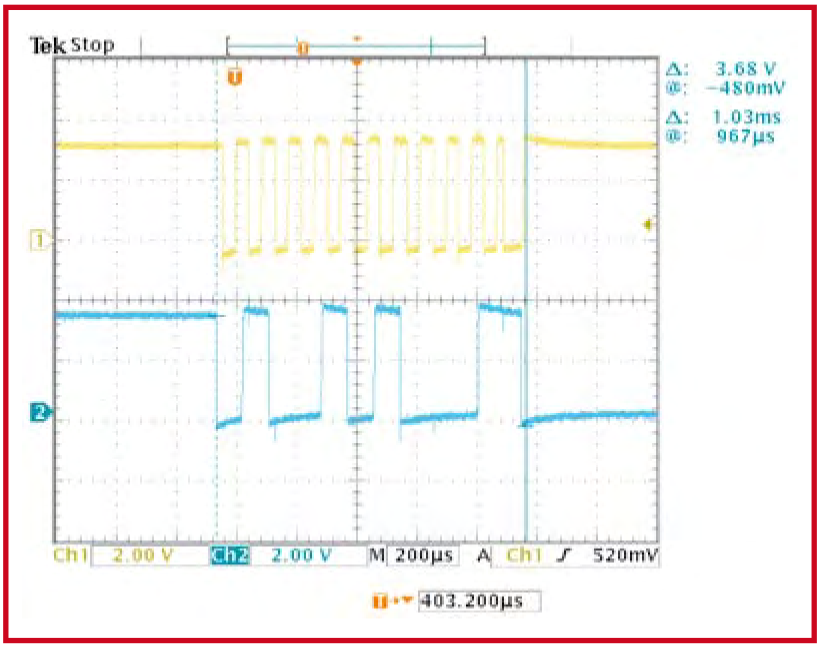


Figure 1. Data transmission from the device to the host. The upper trace shows the clock signa

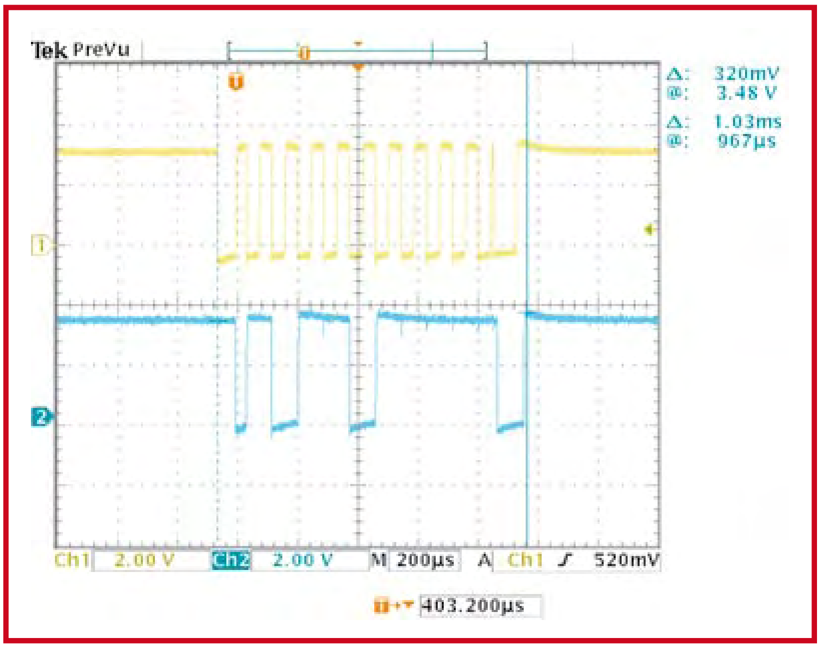


Figure 2. A data block transmitted from the host to the device.

be shown on the LCD in hexadecimal form. The keyboard will not send any data when it is not being used.
Start by pressing any desired key of the keyboard. The corresponding data will be sent immediately to the FPGA to report this action. If you hold a key pressed for longer than a certain interval, the keyboard will transmit the corresponding code repeatedly.
Let's suppose you pressed the 'w' key. According to the LCD, the keyboard sent the code 0x1D. The keyboard actually sends two codes when a key is released. The first code it sends is '0F', which indicates that the user has released a key. After this, it sends the code of the key concerned.

Firmware

How is all of this handled in the software? First, the LCD is initialised as usual. After this, the *init_kb()* routine is called. This is located in *kb.c*. Initial values are assigned to the variables here. After this, the final action is to call *InitKbd()*, which is located in *fpga_lib.c*. It shows how data can be sent to the keyboard and read from the keyboard. The first action is to send the code 0xFF to the keyboard to perform a reset. The keyboard returns an ACK (0xFA) if this code is received correctly. If the keyboard returns 0xFE, an error has occurred during the communication process.
If everything has gone as it should up to now, the keyboard will execute a self-test. This is indicated by briefly lighting the LEDs on the keyboard. If this test is completed successfully, the keyboard sends 0xAA as a sign that it is OK. From this point on, the keyboard operates the way it is supposed to.
The rest of the code has been kept very simple. Whenever data is received, the interrupt routine *ext_int2_isr()* causes the data to be stored in a buffer.

Scan codes

OK, now you can communicate with the keyboard. Keypresses are also being sent to the processor, but what you actually want to receive is normal ASCII characters. For this reason, we extended the interrupt routine of *kb.c* in a new example (*ex18*). The new version of the interrupt routine converts the scan codes into ASCII characters.
Our more inquisitive readers will have certainly also tried the CapsLock key in the previous example. If you did so, you would have seen that the associate LED did not respond at all. That's also the way it should be, since the LEDs are driven by the host. The routine *Set_LED()* in example 8 shows how you can drive the keyboard LEDs. In this example, the number of typed characters is counted and the result is indicated by the LEDs on the keyboard. As only three LEDs available, only numbers in the range of 0 to 7 can be indicated.

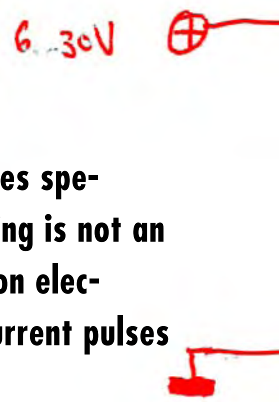
This instalment clearly shows that the full power of the FPGA can only be utilised if you make use of the advantages of configurable logic relative to conventional microcontroller systems. Of course, you could also implement the entire PS/2 protocol in software, but that would cost extra processing time. With the hardware implementation described here, the processor does not have to look after handling the electrical signals on the PS/2 bus, so it has more time for other tasks.
The I²C protocol, which was implemented in software in a previous instalment of this course, could also be implemented in hardware in a similar manner.

In the next instalment, we will add a fully functional VGA output to the microcontroller system of this month's instalment. Naturally, it will also be implemented in hardware.

(060025-VI)

Spot-welding wit

A truly flashing lab aid



Jeroen Domburg & Thijs Beckers

Repairing the connection between two cells in a battery pack actually requires specialised welding equipment. Alas, that kind of gear is expensive, and soldering is not an option either. So we cook up another solution, in this case using dead common electrolytic capacitors, conveniently abusing their ability to deliver brief, high current pulses for none other purpose than… welding!

Short circuiting a charged electrolytic capacitor results in nice sparks. Admit it — you, too have done or seen this on occasions, either accidentally or on purpose. The following is true: the higher the voltage and the larger the capacitance, the bigger the spark will be. Apart from a high entertainment value, this effect has other consequences. Every now and then the terminals of the poor capacitor will end up secured to the piece of metal that's used to short-circuit them. But hey, sometimes that's quite a robust connection! We can put this welding effect to very good use.

What are we going to do?

Battery packs are usually made by attaching metal strips with small spot-welds to the individual cells. The equipment that makes these kinds of spot-welds is unfortunately rather pricey, if not totally unavailable for personal use. In these types of situations the hobbyist with a broken battery pack is likely to reach (out of necessity) for the soldering iron. Soldering is actually a very bad and, what's more, dangerous method to interconnect batteries without solder tags. The worst-case scenario is that the over-pressure valves will open and the battery explodes if it becomes too hot.

Welding is therefore a safer solution. Because only a very small area of metal is heated for a short time, not much happens to the rest of the battery. Electrolytic capacitors are perfect for the currents that are required for this type of welding operation. In order to make the welding more controlled than the brute and awkward short-circuiting of the capacitor terminals, we designed a circuit that (kind of) controls the welding process. By obtaining the energy for the welding from a set of capacitors instead of from the mains voltage, the whole arrangement is also reasonably safe.

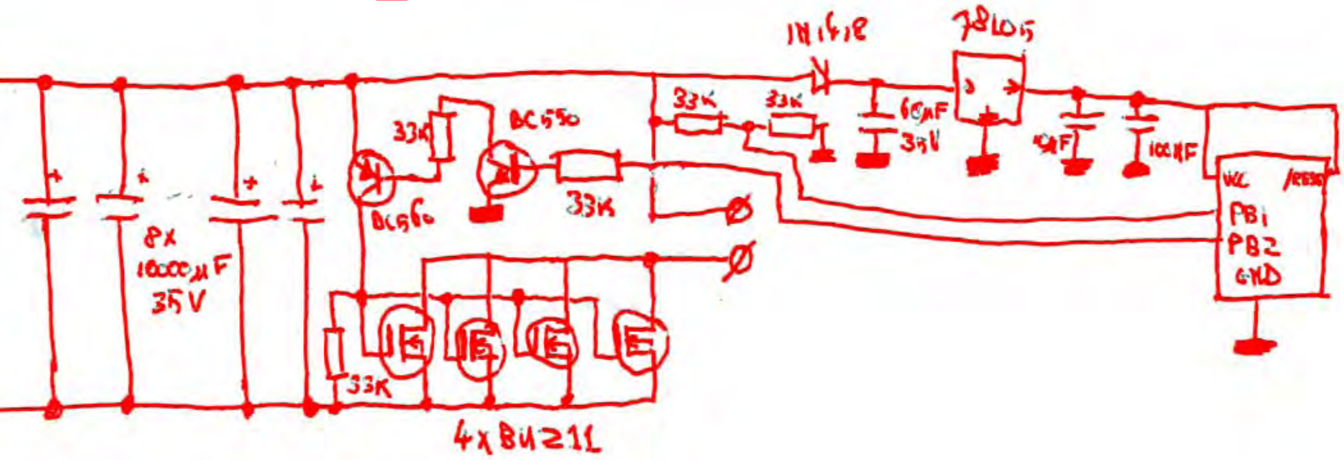
How are we going to do it?

The circuit consists of four parts: the power supply, the array of capacitors, the power stage and the 'ignition'. The capacitors form the heart and are probably the largest physical part of the circuit. They deliver the current surge required to spot weld. Eight capacitors of 10,000 µF each is enough, in principle, but more or bigger capacitors may be better in some cases.

The main part: the capacitor. This is a 10,000 µF-version. Eight of these are tied together with thick loudspeaker cable (the battery is an AA penlite, for reference)

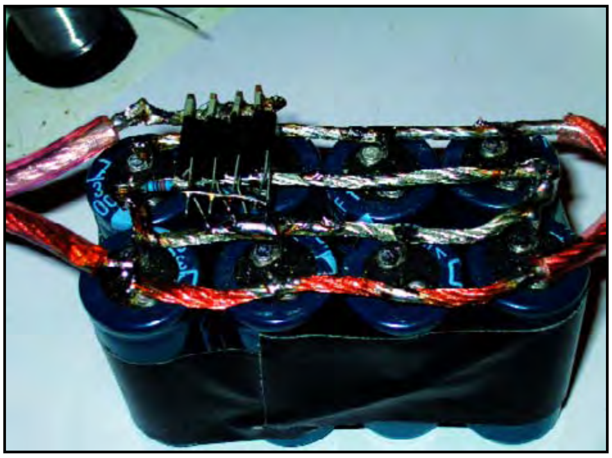
Like this. The loudspeaker cable has been stripped and well tinned at the places where the capacitors are soldered to it.

th Capacitors

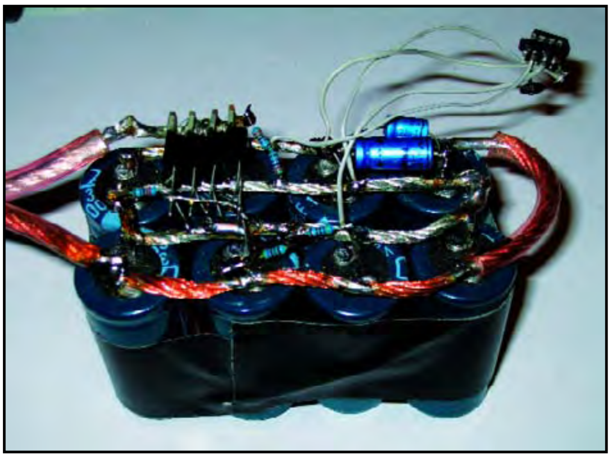


For the power supply, a benchtop power supply is best. This has as the advantage that the welding power can be adjusted to some extent by changing the voltage. The current that the power supply will deliver can also be limited. As an alternative, a short-circuit proof transformer followed by a rectifier will also work reasonably.
The power stage consists of a number of BUZ11 MOSFETs connected in parallel. These MOSFETS can usually be bought for relatively little money, yet can cope with 30 A. Determining the number of FETs required for the job is a bit of a wild stab in the dark. Afrter all, the amount of current that will flow depends on a number of factors that are not easily determined. Start with five or so MOSFETs. Should one burn out then you can come to the conclusion that you did not have enough of them. Because MOSFETs are voltage controlled components, adding more FETs does not require any other changes to the circuit.
The BUZ11 FETs need to be driven with a voltage on the gates. They will conduct harder as the gate-drain voltage increases. To make optimum use of this effect, the MOSFETs are not connected directly to the ignition circuit but via a transistor stage. In this way the MOSFETS are supplied with a higher voltage and are turned on harder.
A microcontroller controls the 'ignition'. It measures the voltage at the welding electrode which is connected to the MOSFETs (via a voltage divider, because 30 V is a little too high for its input). When this voltage goes high (that is, when the two electrodes are touching each other), the microcontroller will wait one second and then turn the MOSFETs on. This way there is enough time to put the electrodes in the right position and perhaps brace yourself for the 'bang'.

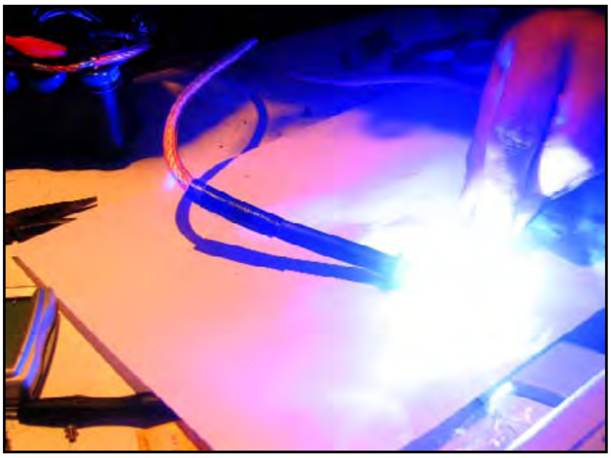
Although the logic in the microcontroller doesn't amount to much (a comparator and a couple of monostables could do the same job), we still chose an ATTiny13. Should a future application require it, a specific trigger or ignition pattern could then be programmed in the microcontroller.
There is also a 5-volt power supply included in the circuit, for the sole benefit of the microcontroller. The output voltage is quite well filtered and has some buffer capacitors to rely on, because the other parts of the circuit generate quite a few current and voltage surges. The biggest is a peak of more than one hundred amps while welding.



The MOSFETs. We had no need for blown up PCBs, so we built the prototype on top of the capacitors 'in the air'.

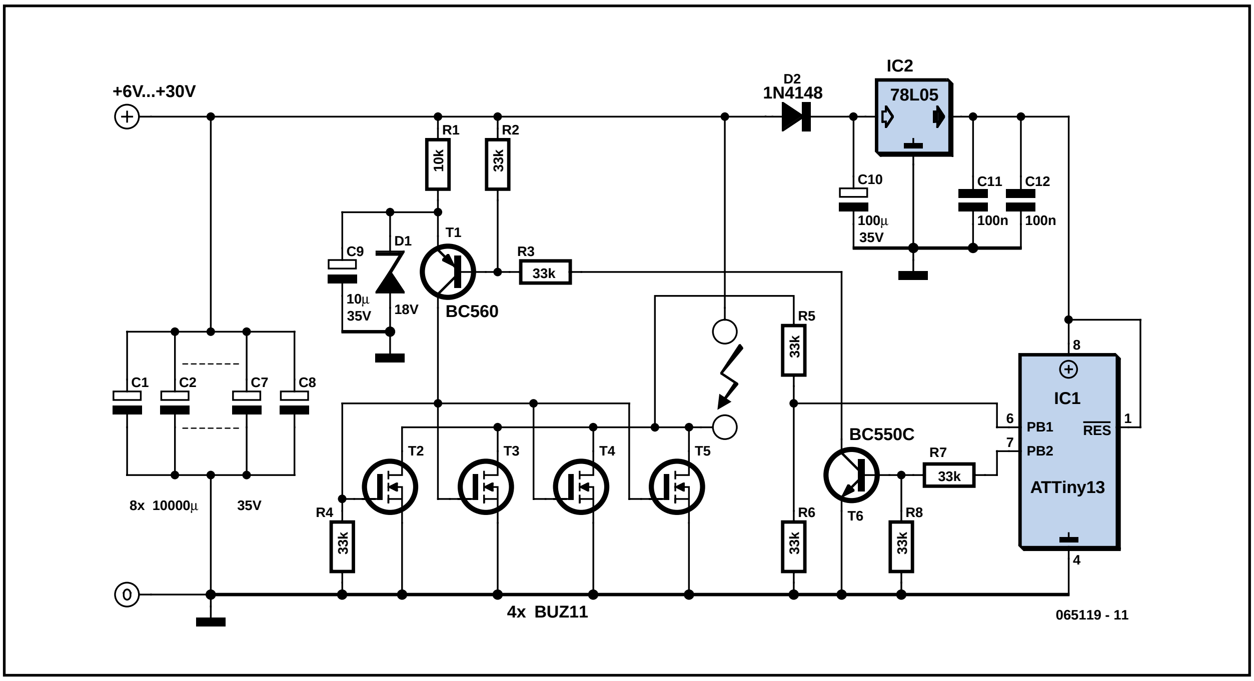


Here is the transistor driving stage (bottom left), the 5-V power supply (top right) and the microcontroller (on wires) mounted with it.



The first test:
drawing sparks! It appears that the capacitor array can get rid of its power fast. Be aware of small pieces of metal shooting away.

How do we use this to join two batteries to each other? First the items we need for this: the batteries and a little strip of metal for the 'solder tag (a piece from a tin can or such works well).



It helps to tin the metal well where is will be joined to the battery. Solder melts easier than the strip of metal or the metal end of the battery.

Attach the tag to one welding electrode and gently push it against the battery. Then push the other electrode firmly against the metal next to the tag and brace yourself for the flash.

Notes

The current that will flow through the weld depends on four things: the power supply voltage, the total capacitance of the capacitor array, the internal resistance of the capacitors and the resistance lurking in other parts of the circuit. The voltage is easily controlled. By using a transformer with a different turns ratio, or in the case of a lab PSU, by twirling the voltage knob, the welding current can be adjusted in a simple manner.
The resistance in the current path needs to be as low as is possible. That is why it is important to make the connections in the path electrode-capacitors-MOSFETs-electrode with as thick a wire as is practicable. To keep the total internal resistance of the capacitor array low, it is better to connect multiple capacitors in parallel instead of just one single large one. Low-ESR electrolytics are ideal for this application, but ordinary capacitors are much cheaper and also work well.
For the welding electrodes we used a pair of old, sturdy multimeter probes, but a thick piece of wire will do as just as well.

If all is well, the strip of metal is now firmly attached to the battery.

About the author:

Jeroen Domburg is a student at the Saxion Technical University in Enschede, the Netherlands. Jeroen is an enthusiastic hobbyist, with interests in microcontrollers, electronics and computers.

In this column he displays his personal handiwork, modifications and other interesting circuits, which do not necessarily have to be useful. In most cases they are not likely to win a beauty contest and safety is generally taken with a grain of salt. But that doesn't concern the author at all. As long as the circuit does what it was intended for then all is well. You have been warned!

The second weld is done the same way.

The source code for the microcontroller can be downloaded free of charge from the publisher's or the author's website.

Warning

Although the relatively low power of the capacitor welder makes it safer than a 'normal' welder, it is still very wise to take note of a few safety rules:

- Make sure that while building the circuit the capacitors are connected up with the correct polarity.
- Wear eye protection when welding. Even though it may not happen very often that small pieces of metal fly around, it will be very painful if debris gets into your eye.
- Discharge the circuit after use. This will at least avoid a sudden fright if the electrodes touch each other while you're putting the circuit away.

(065119-1)

And in the end, the two batteries are firmly connected to each other.

Web links

[1] www.elektor.com

[2] sprite.student.utwente.nl/~jeroen/projects/capwelder/

ZigBee with XBee

Fabrice André

Just about everybody realises that 'wireless' has become a fact of everyday life. If you look around you, you will see that you are surrounded by innumerable wireless devices, such as mobile telephones, alarm systems, garage door openers, keyboards, mice, and so on.

That tangled nest of cables has to go – or at least this seems to be the current trend. The demand for wireless technology just keeps on growing. Under the sponsorship of major manufacturers, several standards for wireless data transmission have already arisen – such as BlueTooth and Wi-Fi, which presently seem to be set to conquer the world. But everything seems to be rather complicated, even for an experienced electronics hobbyist whose hands are just itching to build some sort of wireless project. How can you tackle something like this? Numerous semiconductor manufacturers make ICs that can be used for wireless communication according to some commonly used technology or another. There are even microcontrollers that can do this trick, although most of them are rather costly and often not available from retail merchants. The Chipcon CFC2440 is a good example. Even if you manage to overcome the usual design problems, as a designer you know in advance that at some point in time a completely different sort of problem will arise: you need an RF output stage with a suitable antenna. This output stage is full of pitfalls. No matter how carefully you pay attention to parasitic inductances, they can still make your life miserable, and the performance of your design depends on them! Of course, electronics manufacturers are aware of this problem, so ready-made 'RF solutions' are now available. Here we examine a module of this sort, and in particular one that support the ZigBee protocol.

ZigBee at a glance

ZigBee is the name given to a standard for wireless communication that was essentially developed for industrial applications. From a historical perspective, ZigBee is a refinement of a previous standard called 'Home RF'. That standard had rather rosy prospects at first, but with the success of the competitive Wireless Fidelity (Wi-Fi) standard it lapsed into disuse. The relatively short lifetime of Home RF is at least something that provides food for thought, and possibly even somewhat worrisome. You can rightly wonder whether history will repeat itself. However, we can assure you that this worry is unfounded, since ZigBee is supported by major players such as Freescale (a spinoff of Motorola), Honeywell, Philips, Microchip and Mitsubishi, who have joined with around a hundred other manufacturers to form a consortium called the 'ZigBee Alliance'. This consortium also enjoys the support of Paul Allen, one of the founders of Microsoft, who recently invested several million dollars in it.

ZigBee is originally based on the IEEE 902.15.4 standard and uses the same frequency band as Wi-Fi (2.4 GHz). It has 16 separate channels, which means that up to 16 networks can be present in a single location without interfering with each other. The maximum data transmission rate is 250 Kb/s, with a range of 100 m. The data rate is rather low compared with the 54 Mb/s of Wi-Fi or the 1 MB/s of BlueTooth, and it can be regarded as the weak point of ZigBee. But as already mentioned, this protocol is intended to be used for industrial applications, for which speed is not a paramount consideration. ZigBee was developed to satisfy the need for low current consumption and above all low cost. **Table 1** presents a comparative overview of the three above-mentioned wireless communication options.

A close look at a ZigBee IC

XBee modules

MaxStream, a well-known manufacturer of components for wireless communication, has just added a product to its line with the quite fitting name XBee (pronounced ex-bee), which makes its own modest contribution to the already quite thick blanket of electrosmog surrounding us. XBee is a tiny but nevertheless complete ZigBee transceiver (transmitter/receiver). It is bi-directional in the sense that it can transmit or receive data alternately (half-duplex mode).

Two versions are available from MaxStream: XBee and XBee PRO. Both versions are functionally identical and pin compatible (which accounts for the designation 'interchangeable' in **Figure 1**). The only difference is the transmit power, which is 1 mW maximum for the XBee and 63 mW maximum for the XBee PRO. Of course, transmit power is an important factor because the range of the ultimate product depends on it, but it is certainly not the only thing you have to take into account.

Another consideration that is at least as important is that higher transmit power means higher current consumption. A transmit power of 1 mW already costs around 45 mA, while 63 mW from the antenna translates into a tidy 270 mA from the power source. That means you can forget about using batteries to power the circuit – just when what you wanted was a wireless module!

A further consideration is compliance with legal requirements. The maximum radiated power is regulated by law, and in Europe the applicable limit is 10 mW. To make it possible to comply with this requirement, MaxStream has implemented a configuration parameter in the XBee that can be used to set the transmit power.

Careful examination of the photos accompanying this article shows that the XBee is available with three different types of antenna (**Figure 2**):

1. Integrated into the chip. In this case the radiated energy is practically non-directional.
2. With an antenna connector for attaching an external antenna.
3. With an integrated vertical (whip) antenna, which gives better directional characteristics than option 1.

Software

This low-cost module can be interfaced quite easily via a standard serial port, such is commonly found with microcontrollers (UART) or the COM port of a PC (RS232), at maximum rate of 115,200 baud. However, the XBee is powered from a 3.3-V supply instead a 5-V supply like most digital circuits, as you can see from the block diagram in **Figure 3.** This means you cannot simply apply 'normal' digital signals to the XBee input, so a *direct* connection between the two types of logic is not possible. We'll have more to say about this later.

Other than that, you don't need to have any specific knowledge to use the module, so you don't have to delve into the ZigBee protocol before you start. The module does everything for you. It is an 'intelligent' system, which means the module contains control logic that can accept commands from the user. These commands are specified by the manufacturer.

If you're starting to fear that things are getting complicated again, we can set your mind at ease: it's not at all complicated in actual practice. Anyone who has a reasonable amount of experience with programming microcontrollers won't bat an eye here. The commands are actually just ASCII codes (character strings), just like you see with modems. You send commands to the XBee the same way as data, and there is a bit of software that tells the two apart. This works as follows.

Before you can send a command, you have to put the XBee in the 'wait for command' state. To do so, you send it a string of three + characters (hex 2B), or literally '+++'. After this, the XBee expects to receive a command in Hayes format, which always starts with 'AT' (which stands for 'attention') in ASCII code, followed immediately by the actual command and any command parameters that may be necessary. The command string is terminated by a Carriage Return (CR) character. **Figure 4** shows an example of all this. The XBee module executes the command and then reports whether the command was processed successfully. If everything went the way it should, the XBee returns 'OK', while otherwise you will receive an error string from the module.

MaxStream also provides a handy little program called X-CTU to make things even more convenient. It can be downloaded free of charge from the MaxStream website, and you can use it to configure all the parameters of the XBee module with a few mouse clicks. However, the XBee module must first be connected to a COM port of your

Figure 1. MaxStream uses a special logo to emphasise the interchangeability of the modules.

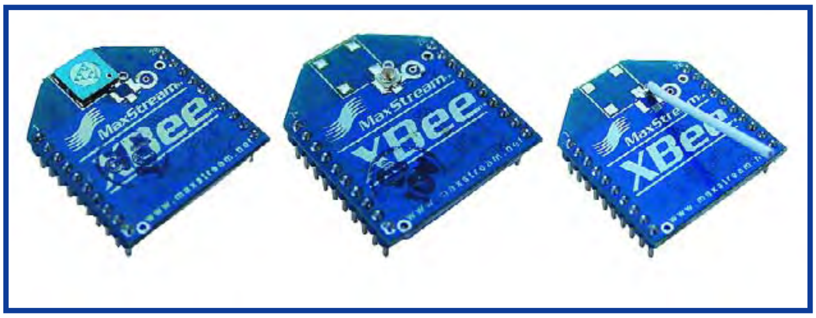


Figure 2. There are three different antenna options: on the surface of the chip, external via a connector, and external integrated.

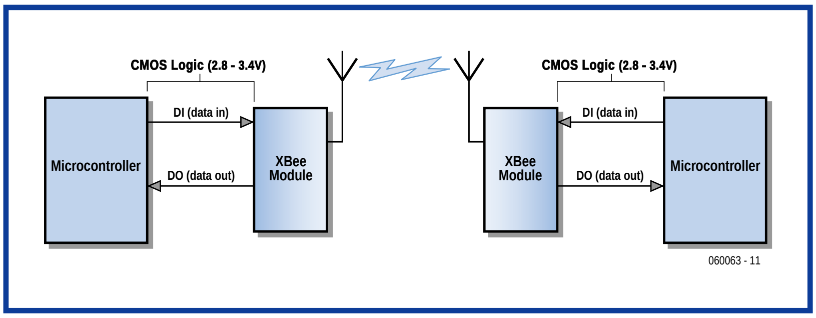


Figure 3. Block diagram of a data transmission system using two XBee modules.

PC (via an adapter due to the different signal levels). You can also use X-CTU to test and upgrade the modules.

Software buffers

A wireless link is always half-duplex. You can transmit or receive with a single antenna, but not both at the same time. However, your application can transmit and receive at the same time (full-duplex mode) via a serial link to the UART at your end of the interface. This is made possible by two software buffers. The principle is revealed in **Figure 5.**

There is a transmit buffer and a receive buffer, and each buffer provides a temporary parking place for 100 bytes. Data can arrive from both directions at the same time – the data to be transmitted coming from the UART, and the data received by the antenna from the RF link. When the antenna is receiving data, it cannot transmit data at the same time. For this reason, the data to be transmitted is parked in the transmit buffer for a while, and the received data is stacked up in the receive buffer. As soon as the data stream from the RF end stops, the XBee module switches the antenna from receive to transmit and empties the transmit buffer by sending its content out on the ether. At the same time, the UART empties the receive buffer by sending the data in it to your application.

This is an ingenious system, but it's not entirely perfect. An application with a large amount of data to send can easily overload the transmit buffer. MaxStream provides a 'full' alarm to deal with this problem. As soon as the application has filled all but the last 17 bytes of the transmit buffer (which means 83 bytes are waiting to be transmitted), pin 12 goes high to signal to the system that it has to stop filling the buffer for a while. Pin 12 goes low again after the content of the transmit buffer has been reduced to 66 bytes. This can be regarded as a sort of software hysteresis.

XBee in practice

Now it's time to talk about circuitry. A cautious designer generally starts with a bit of preliminary investigation for his circuit, and most designers are more than willing to be inspired by a schematic diagram of something that already works.

A bit of nosing around on the manufacturer's website turns up a wealth of well-organised information. You can look for ideas here to your heart's content or look for answers to any questions you may have:
www.maxstream.net/support/knowledgebase/full-list.php

Figure 6 shows the internal block diagram of the module, which forms the core of a specific application. The XBee module has 20 leads, which may remind you of the DIL packages used for digital ICs, but there you're mistaken. Due to the very compact dimensions of the module, the pins are separated by only 2 millimetres, so they won't fit in an IC socket. Fortunately for anyone who wants to keep the module replaceable, suitable PCB connectors are available from Radiospares under item number 131.9872 (they are often used in PC mice).

For good measure, we'd like to remind you again that the maximum supply voltage is 3.3 V. Anything more than this will unavoidably result in the premature death of your treasured module. The supply voltage must be decoupled by a 100-nF capacitor located as close as possible to pins 1 and 10.

Communication is provided by pins 2 and 3, and the direction is indicated by arrows. Some of the pins are marked with an asterisk (*). These pins are reserved for certain functions that are not yet available from the manufacturer. When they are available, you can download them from the MaxStream website and upgrade your XBee by flashing the firmware into the module. Up until then, you can simply leave them unconnected. The same applies to the pins marked NC ('not connected').

Pin 5 is more important: a logic 1 here (3.3 V) enables the module, while a logic 0 disables it. A 10-kΩ pull-up resistor from pin 5 to pin 1 ensures that the module will be enabled as soon as the supply voltage is applied. You have a choice of several functions for pin 9. An internal parameter determines which of them is active. The most important function is the sleep state. The module remains in deep sleep as long as the internal SM register is not at logic 0.

Pin 7 provides a pulse-width modulated (PWM) signal proportional to the most recently received RF signal. It has a period of 8.32 ms, which corresponds to 120 Hz. Fans of LED bars and other light effects can convert it into an analogue signal and use it as a signal strength indicator (all you need is an RC network and an LM3914). This can also be done using software, since the strength of the most recently received signal is stored in the internal DB parameter. As the name suggests, this quantity is given in units of dBm RF (decibels relative to 1 mW). You can use the following formula to convert between dBm RF and milliwatts (*P*):

$$\text{dBm} = 10 \log P \quad [\text{dB}]$$

or in the other direction

$$P = 10^{(\text{dBm}/10)} \quad [\text{mW}]$$

For example: 0 dBm = 1 mW, 10 dBm = 10 mW, 20 dBm = 100 mW, and 30 dBm = 1 W. All examples for RF.

Conclusion

The XBee module is very easy to use, and the interface is based on a simple dialogue with a serial port, which can be easily handled by a microcontroller or a PC. As it's not possible to present everything you have to say in a single article, the author is working on a follow-up article describing a specific application for these modules. You can look forward to seeing it in a future issue.

Additional information is available on the manufacturer's website: www.maxstream.net
X-CTU can be downloaded from:
www.maxstream.net/support/downloads.php?PHPSESSID=575749e0e95a4454cd0780d36f486fc7

(060063-I)

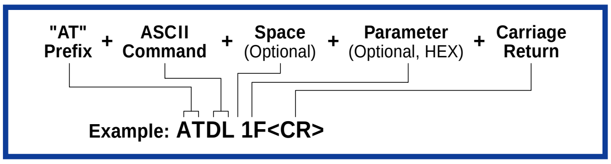


Figure 4. AT command structure. XBee modules recognise such commands.

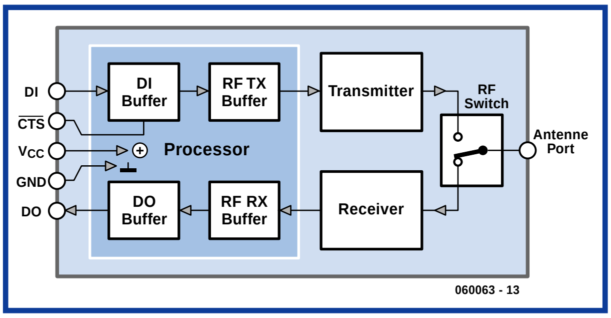


Figure 5. Internal block diagram of the XBee module.

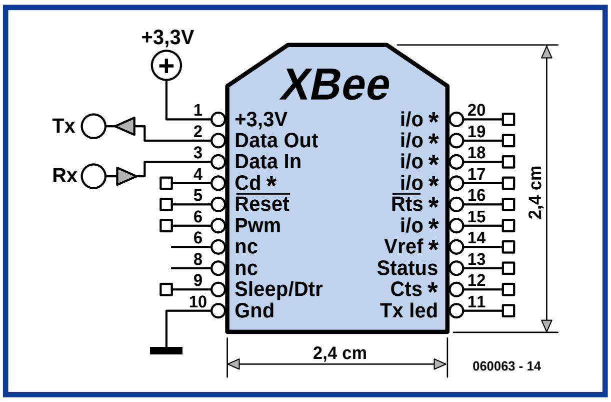
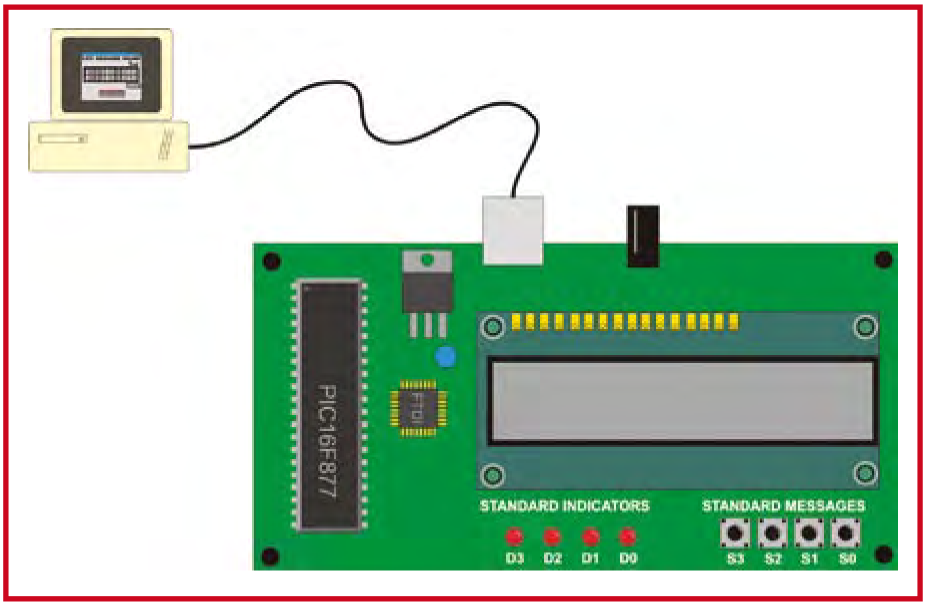


Figure 6. All this fits in a package measuring less than 7 square centimetres.

Comparison of the three most commonly used wireless technologies

	Wi-Fi	Bluetooth	ZigBee
Frequency band	2.4 GHz	2.4 GHz	2.4 GHz, 868 or 915 MHz
Protocol stack	ca. 1 Mbits	ca. 1 Mbits	ca. 20 kbits
Data rate	11 Mb/s	11 Mb/s	250 kb/s (2.4 GHz) 40 kb/s (915 MHz) 20 kb/s (868 MHz)
Number of channels	11 – 14	79	16 (2.4 GHz) 10 (915 MHz) 1 (868 MHz)
Signal type	Digital	Digital & audio	Digital & key-value
Point-to-point range	100 m	10 – 100 m	10 – 100 m
Number of systems	32	8	255 or 65 535
Power consumption	Moderate: several hours with one battery	Moderate: several days with one battery	Very low: several years with one battery
Market share	Large	Moderate	Tiny
Network topology	Star	Star	Star, tree or cluster
Used for	Internet inside buildings	PC and telephone peripherals	Low-cost monitoring and control

E-blocks Link VB t



Waraporn Supmak, John Dobson

Figure 1. Block schematic of display system.

E-blocks are like Lego bricks — you can piece them together to make all different kinds of shapes and structures. The modules are perfect for marrying standards too — in this article we use E-blocks and Flowcode to control hardware over USB, via RS232, while making clever use of Visual Basic. Great stuff for your own applications.

I was recently asked by a friend of mine how he could develop a small window display which gave instructions to couriers on where to leave parcels when he was not in the office.

The brief here was that he wanted to enter a text script (a neighbour's address) into a PC based application and have the message displayed in the Window. Now we could have another monitor which was visible from the outside of his house but that seems like overkill. Using a small LCD based circuit and a microcontroller would be much more appropriate. The essence of the task here is how to get a PC to communicate to a microcontroller based system. This happens to be a question that has been raised by a number of Elektor readers so I thought it would make a good project.

The concept

Figure 1 shows you the basic diagram of the final system we need. In terms of hardware, the display system we want needs a central microcontroller (in this case a PIC micro), a USB interface (from FTDI) and an LCD display. For good measure I have also included some LEDs and switches. The switches will allow us to make a standard display from one of several messages, and the LEDs might come in handy later. I happened to have a spare 'rats tail' power supply which gives 18 V output. A standard 7805 voltage regulator will provide the 5 V power rail the system needs.

Get out some E-blocks

My first action was to develop a prototype system from E-blocks. The result is shown in **Figure 2**. Most readers will by now be familiar with the E-blocks boards we have used here: a PICmicro microcontroller Multiprogrammer, LED board, Switchboard and LCD board. An overview of currently available E-blocks may be found in the SHOP section at www.elektor.com.

A PIC 16F877A is used as the core microcontroller. Sure, this is a bit of overkill but I reasoned that I can always use a smaller PICmicro device later on. One E-blocks board that may not be too familiar to you is the **USB232 module** shown in **Figure 3**. This is based on the highly successful USB to RS 232 interface supplied by a great Scottish company called FTDI. How the interface works internally is beyond the scope of this article — as far as using the device is concerned, the FTDI device converts a USB signal to an RS232 signal and the board is supplied with

o USB

Communicating to your hardware using USB

a set of virtual COM drivers which allow you to communicate with it using standard Windows software — in this case Visual Basic!

Let's do it 'virtual' first

For a test jig I set up a Visual Basic program that did more than the overall brief. I designed a screen with a display area, eight switches and eight LEDs. The status of the eight switches on port D of the Multiprogrammer is monitored by the eight LEDs inside the Visual Basic application.

Correspondingly the LEDs on port A of the E-blocks Multiprogrammer reflect the status of the switches in my Visual Basic application. These were really useful during the initial design phase of my program just to allow me to check that I could transfer data to and from the PICmicro device, and I left them in the software application as they might come in handy for further projects.

From virtual to real

In the final program to display a message on the LCD I simply type the message into the PC application's text box which updates the LCD display on port B of the Multiprogrammer immediately. The CLEAR button allows me to wipe the display. The host application is written in Visual Basic of which the result is shown in **Figure 5**. I think it is a little beyond the scope of this short article to delve deeper into how the code in the Visual Basic program works — but those of you who are interested can download the source files from the Elektor web site at www.elektor.com (you will need VB to view them). The archive file number is **065087-11.zip** and you will find it on the elektor.com website under MAGAZINE, then select month of publication.

And then — Flowcode

For the PICmicro microcontroller I developed a program in Flowcode version 3, which includes a handy RS232 icon that allows communication to the FTDI device. Almost the entire program is shown in the Flowcode printout in Figure 4. Those of you who do not have a copy of Flowcode can also download a 30-day demonstration version (which allows you to see how this program works). The url to the demo version will be posted on the project page for this article. On the elektor.com website, follow magazine > volumes > 2006 > november > E-blocks Link VB to USB.

Conclusion

The FTDI device is great for making the task of connecting to USB easier – we managed to create the whole application in less than a day and the re-

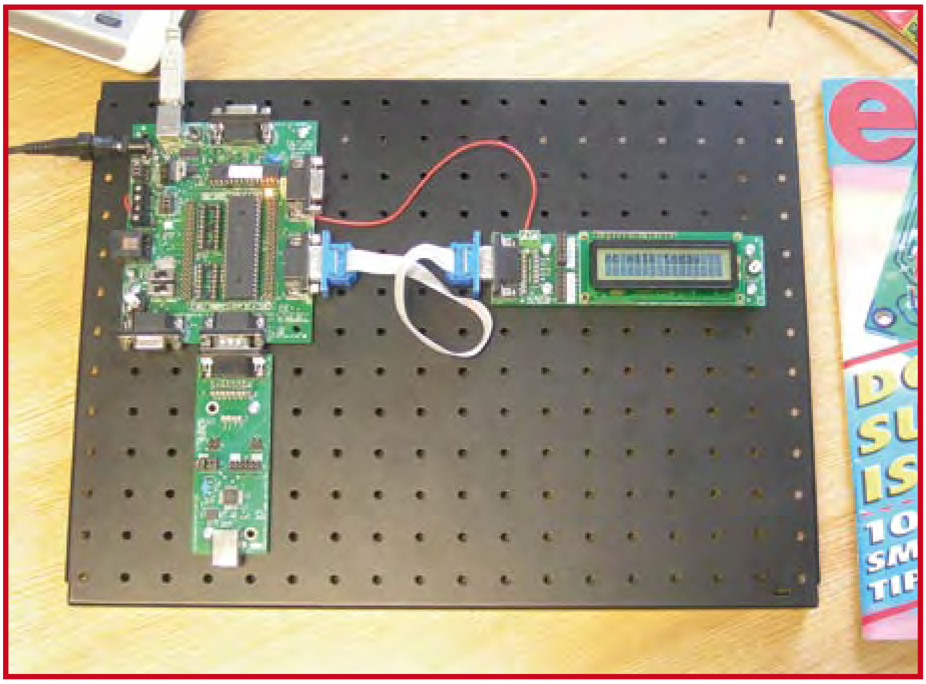


Figure 2. E-blocks prototyping system – note the short 9-way ribbon cable on the LCD.

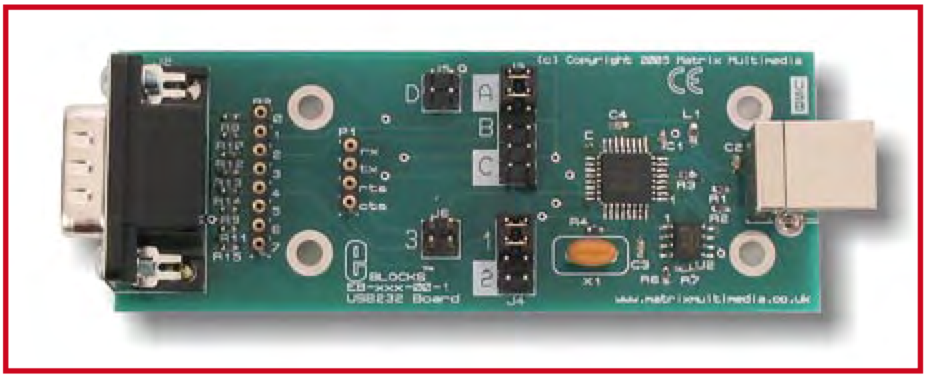


Figure 3. USB232 E-blocks board.

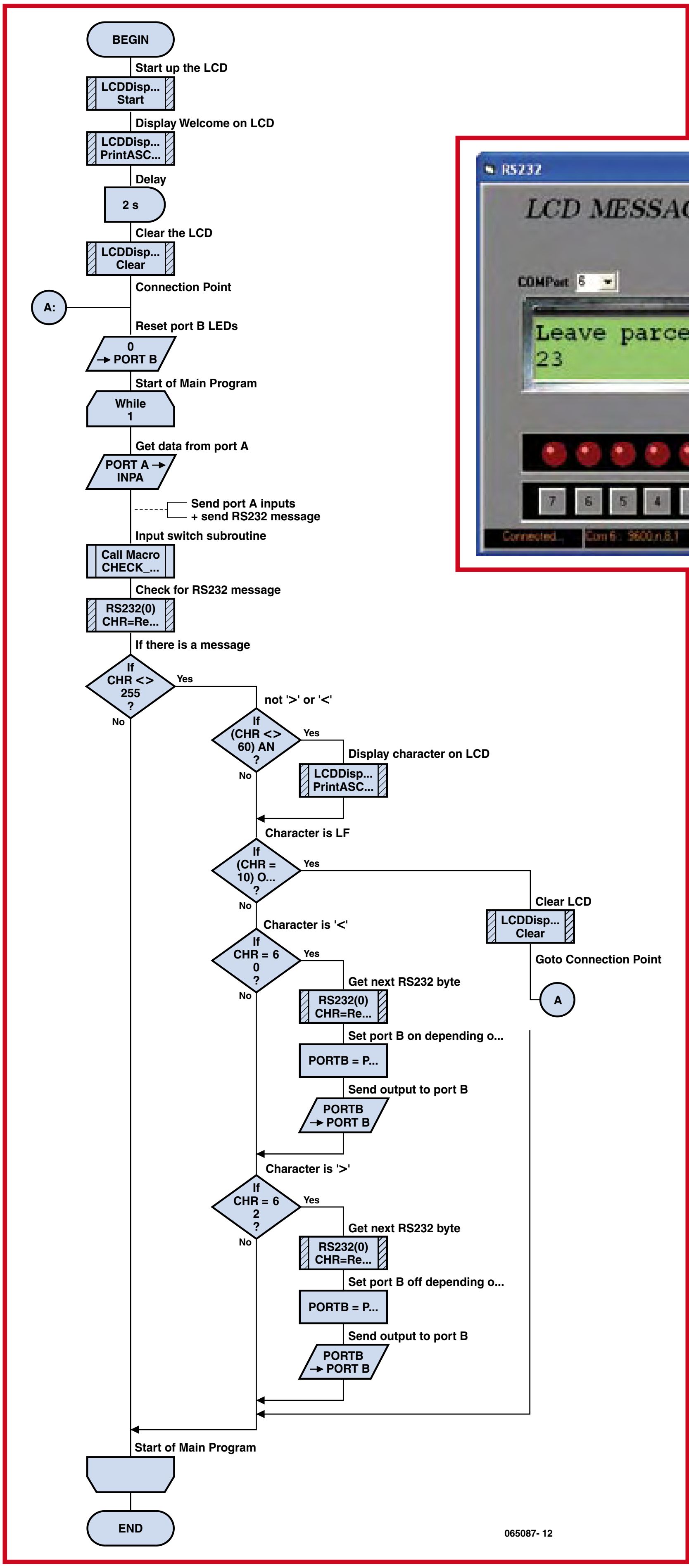


Figure 4. Flowcode 3 program.

Figure 5. Visual Basic application.

sults are great for a first prototype. The cost of the E-blocks involved was under £ 120 (approx. € 155) which meant that it was not even worth making a PCB — in the end we just used the prototype system shown in Figure 2 with a 60-cm long IDC cable to the LCD display. It worked fine.

(065087-I)

A word or two on the 16F877A program

If you examine the Flowcode chart in ***Figure 4*** you can see how the PICmicro program works.

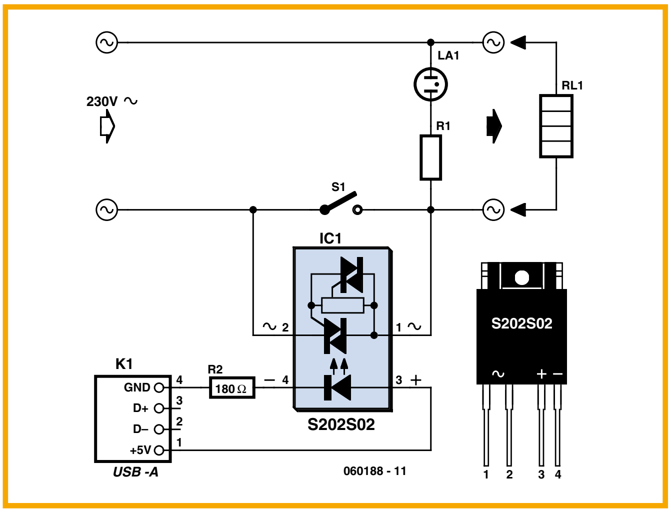
First we start up the LCD and show a welcome message. In the main program we get the inputs from the Port A switches — if any switches are pressed we send the data back to the PC using the input switch subroutine (not shown in detail). Then we check for an incoming message on the RS232 pins — if there isn't, i.e. '255' is returned from the subroutine, then round the loop we go again!

The VB program sends characters '<' and '>' as instructions for Port B outputs ('<' = pin output On and '>' = pin output Off). So, if there is a message then the next decision box checks the message is not a port B output message — otherwise the incoming character is displayed on the LCD. The second decision box detects a line feed character generated by the CLEAR button in the VB application. If one of these is received, the program clears the display and sends the program back to point A. The next decision box detects a '<' character and if one is received gets the subsequent RS232 character, containing pin information, and pulls the appropriate pin on port B High. The last decision box detects a '>' character and if one is received gets the subsequent RS232 character and puts the appropriate pin on port B Low.

Those of you who know a bit about LCDs will be aware of the fact that a 16-character display actually has 32 internal characters, so this program might appear not to work – in practice the VB program takes care of the extra spaces.

USB-controlled socket for WLAN router power supply

Dirk Gehrke



The idea behind this project is a simple one. The power supplies for a (A)DSL modem and accompanying WLAN router can draw a total power of around 13 watts when idle. Over the course of a year this can add up to a significant amount on one's electricity bill.
The first step to saving some of this energy is to insert an in-line switch into the mains lead. For the prototype we used a switch fitted with a Schuko (continental-style) mains plug and socket made by German manufacturer Düwi [1]. The switched socket allows the two power supplies to be turned off from a central switch.
The next step is to automate the switching. This can be achieved in a relatively straightforward manner with a special-purpose semiconductor device and a USB cable. The special component is an SSR (solid-state relay) made by Sharp, a readily-available device which will be a familiar sight to regular *Elektor Electronics* readers. The S202S02 IC switches the mains current at the zero-crossing point and therefore produces little interference and dissipates little power. Cooling is not required.

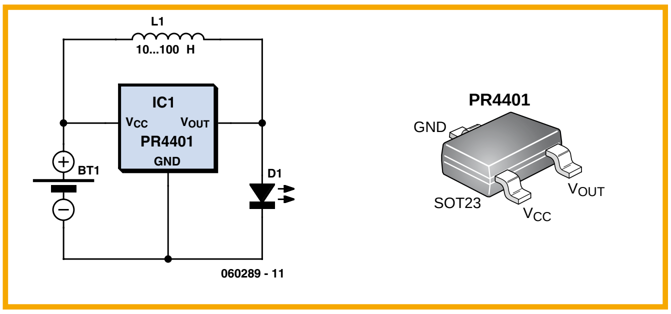
The USB port of a PC can deliver enough voltage and current to drive the solid-state relay. When the PC is switched on, 5 V appears on the USB port. This 5 V supply is used to drive an LED in the SSR via a 180 Ω resistor, which limits the current flow to 20 mA.
As you can see from the circuit diagram the SSR can be incorporated into the Düwi switched socket, bridging one pair of switching contacts in the mechanical switch. The other contact pair in the mechanical switch must be bridged using a wire link, as the SSR is only a single-pole switch. (Editor's note: for the sake of simplicity we have shown this bridged contact as a simple wire joining 230 V input and output.)
When the PC is booted up 5 V appears on the USB port and the solid-state relay contact closes. When the PC is shut down the 5 V supply disappears, the switch opens and the two power supplies are disconnected from the mains. The simple modification of the in-line switch has allowed us to switch the power supplies on only when the PC itself is on.
It is also possible to modify a switched extension lead in the same way. If it is desired to use the network when the PC is switched off (for example when using a laptop) it is always possible to use the mechanical switch to bypass the solid-state relay. Of course, you must not forget to switch the network devices off again when you have finished using the laptop or your efforts to save energy will have been in vain!

Internet link:
[1] www.duewi.de/main.php?lang=ENG

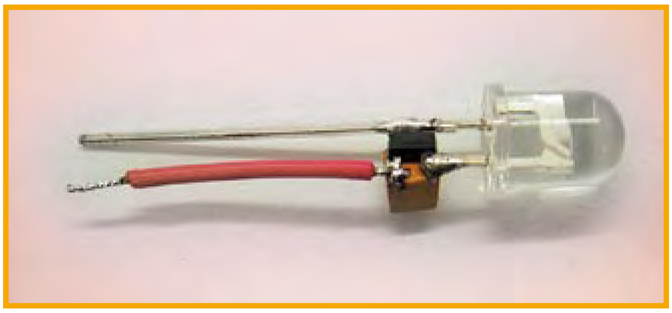
(060188-I)

PR4401 LED driver

Burkhard Kainka



White LEDs have a forward voltage drop of around 3.6 V. If we wish to operate a white LED from a single 1.5 V dry cell or 1.2 V rechargeable cell we therefore need a voltage converter. Until now, solutions to this problem, whether discrete or based around an IC, have required several components. The PR4401 from PREMA is a special-purpose IC designed to drive a white LED with a single small coil as the only external component. In principle the IC would even work using a piece of wire for the inductor!
The device has just three connections and comes in an SOT-23 package which can be hand-soldered. The voltage converter can be fitted into a very tiny space, for example in a pocket torch. Many SMD fixed inductors have the same pin spacing as the SOT-23 package and so the whole thing can be built without a printed circuit board, as the photograph illustrates.



The current through the LED is determined by the choice of inductor. With a 22 µH inductor the diode current is approximately 12 mA, and with a 10 µH inductor the current is approximately 23 mA. LED brightness is practically constant over a cell voltage range from 0.9 V to 1.5 V. Of course, the current drain increases as the cell voltage decreases. Deviating from the design suggested in the data sheet we experimented with a 100 µH inductor to make a low-current version of the circuit. With a cell voltage of 1.5 V we measured a current consumption of 10 mA, and the LED remained lit down to a cell voltage of 0.7 V.

Manufacturer: www.prema.com
Data sheet: www.prema.com/Application/whiteleddriver.html
Component source: www.ak-modul-bus.de (site in German only)

(060289-I)

Emergency recovery

Harddrive recovery trick

Thijs Beckers

Despite all those recent technical innovations we still can't guarantee that components won't break down. And so it was with the hard drive inside one of our Lab PCs, which contained important project details and which gave up the ghost ...

All moving parts suffer from wear and tear. This also applies to the hard drives inside our computers. Despite the very low probability of a hard drive failure (hardware-wise in this case), Murphy's Law dictates that it will always happen when you least expect it.

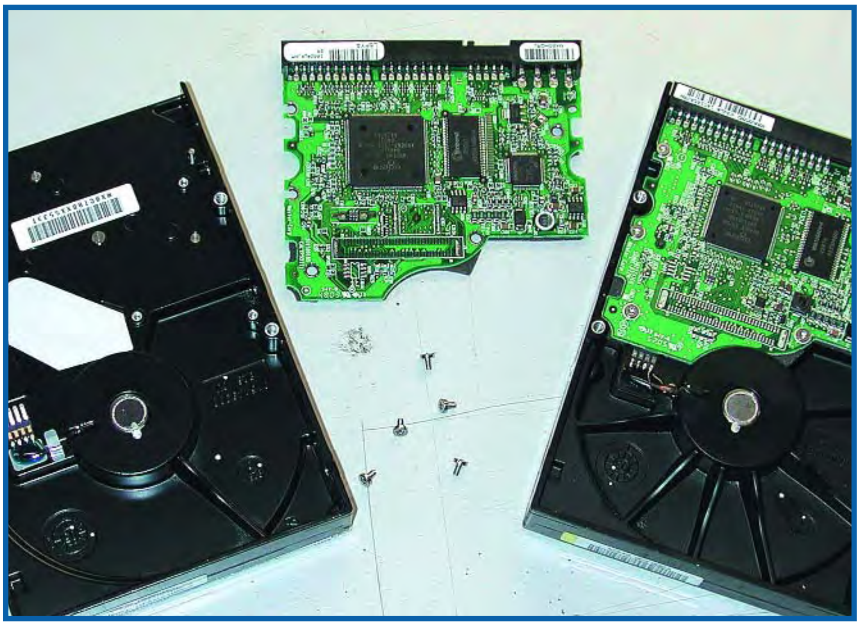
This was recently also the case for one of our Lab workers. Although we have a backup system in place, there will always be some (recent) information that hasn't been backed up yet. And that is of course very frustrating. Everybody who lost their important files in a similar way will know how frustrating that can be, and how much they wished that they had a full, up-to-date backup.

The hard disk concerned appeared completely dead. By this we mean that the BIOS no longer recognised the hard drive and the internal discs were no longer spinning — as dead as a doornail. Once it was in this state there was nothing that 'Scandisk' could do.

Fortunately we came across a somewhat risky 'trick', which could possibly recover the data. First you have to find a (working!) drive of exactly the same type as the broken one (i.e. the same capacity, cache memory, RPMs, part number, etc.). Then you swap the controller boards of the drives and hope for the best.

It seems that the type of hard drive we had (a Maxtor Diamond Max Plus 9) sometimes suffers from a failure of the motor driver. Oxidation can cause a break in one (or more) of the three driver phases for the motor, which causes a MOSFET to fail. This in turn results in the failure of a certain IC and a few other components around the MOSFET. And if you are really unlucky the read/write head interface chip packs up as well.

Unfortunately, the company where we previously bought an identical drive supplied us with a more recent type, a DiamondMax Plus 10 (normally this would be very welcome, but in this case it was the last thing we wanted). Since we were becoming rather impatient (with deadlines for articles looming ahead), we tried it with the new type, but the old drive protested loudly, with the heads apparently moving all over the place. The only positive aspect of our first attempt was that it established that the internal discs could still rotate. The motor itself was therefore not broken.



We were lucky to find an identical drive to the broken one in my own work PC. After making a complete disk backup of this drive we exchanged the controller boards again. And lo and behold, it worked! The BIOS immediately recognised the hard drive. We even found that the Windows installation started normally. However, we no longer trusted this drive so we quickly made a full backup and returned the drive for an exchange under warranty. We could call this a very successful operation. The Lab was happy that all their data was recovered, the borrowed drive was reunited with its controller board and put back into my PC, as if nothing had happened. I have to say we were very lucky this time.

We should warn you though: Maxtor *strongly* advises against using this method, since it could cause irreparable damage and invalidate the warranty. If you want to play it safe you should use an established data recovery company to extract your lost data. Bear in mind that this doesn't come cheap and you can easily spend a three or four-figure sum.

(065099-1)

Philips SDR314 manpack mobile (1953)

Jan Buiting

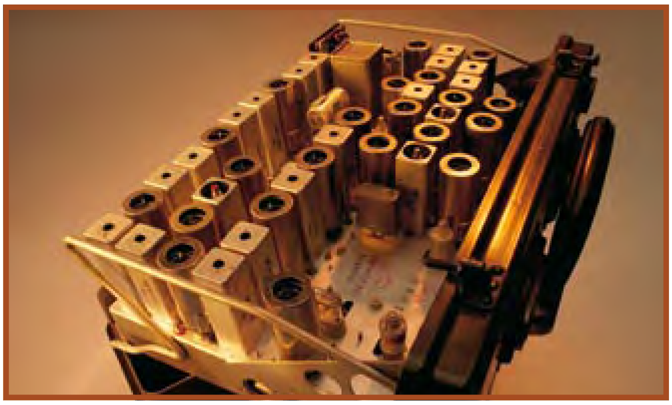
At the time of its introduction in late 1953, the SDR314/04 was described by Philips Telecommunication Industries as a "Portable F.M. transmitter/receiver for the frequency range 156-174 MHz (1.92-1.72 m). (…) The transmitter, which has a power output of about 150 mW, is capable of covering a distance of about 1 kilometer in densely built-up areas (i.e. highly adverse conditions), or about 3 to 5 kilometers in open terrain."

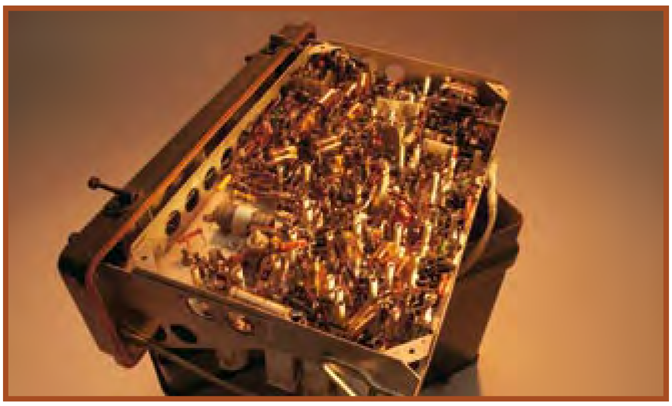
The SDR314 is powered by a 6-volt motorcycle battery. Like many WW2 and Cold War short-range 'manpack' radios like the famous WS38, the SDR314 is designed to be carried on the back using canvas straps. Fortunately, the radio can also be carried by a handle. Either way, you're carrying a weight of about nine kilos, so 'portable' has to be taken with a pinch of salt. The distances quoted for the SDR314 may seem small, but Philips later added that the figures refer to "two-way communication between two SDR314 radios". The distance between an SDR portable and a base station or a vehicle-mounted mobile should be of the order of 10-20 kms.

The SDR314/04 is invariably green which immediately suggests that it is an army radio. A false assumption, as the SDR314 was designed for use by (traffic) police and Home Guards only during the Cold War period and quite a few years later! It was never allowed for military use. Philips' brochures for the SDR314 suggested use by 'fire scouts' i.e., a person (to be pitied) who was supposed to assess the size and intensity of a fire and report on any imminent dangers over the radio.

The SDR314 employs 22 valves and a few germanium diodes. The valves are direct-heating types from Philips' very own DL/DF series. The anode voltage is left on all the time and the receiver and transmitter are switched on and off by means of the heater voltages. A compact vibrator power supply is used to generate the 70-V and 140-V anode voltages. In transmit mode, the SDR314 draws about 2.5 amps from the 6-V battery, which results in a total 'in-efficiency' of 0.15 W/15 W = 0.1%.

It has to be said that the SDR314 is let down by mechanical, weight and power supply aspects only. The transceiver proper is not only a lightweight construction but also a wonder of Dutch design ingenuity and efficiency. The radio performs extremely well when connected to a benchtop PSU and an external antenna instead of the half-wave whip. All parts used to build this radio, down to the last screw and washer, were Philips proprietary, so you will search in vain for, say, Sprague, RCA or General Electric logos or part numbers.





The NBFM receiver is a superheterodyne with a variable first IF and a fixed second IF of 1.5 MHz. The RF input valve is an EF95/6AK5 pentode. The transmitter multiplies the crystal frequency by 64 (!) to ensure the required FM deviation of ±15 kHz at the final frequency. The RF output valve is again an EF95 which also doubles as the AF output valve!

The radio can be aligned with no more than a micro-ammeter set to the 50 µA range. About 30 red, green and yellow test points are available on the chassis to check HT, grid current and filament voltages respectively and even people with 'modest' knowledge of electronics should be able to set up the radio on a channel.

The /04 pictured here is the original Home Guard version, complete and in very good condition. I also have the /05 civilian/utilities version which is grey and has 5 channels.

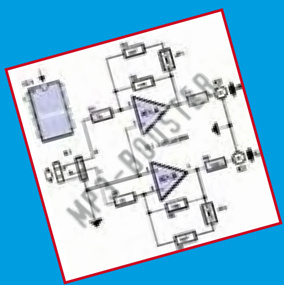
Originally, my /04 worked on a former Home Guard channel at 160.000 MHz but I crystalled and retuned it to work on 145.725 MHz to suit my local repeater. The FM deviation has been reduced from 15 kHz to 5 kHz to avoid upsetting the younger generation of radio amateurs used to Japanese plastic only. Stability and sensitivity are excellent and 150 mW from the TX is ample to cover 10 km or so. I'm told the vibrator supply produces a light whining sound on my microphone signal, helping to identify it as coming from a 'vintage' transceiver. Come to think of it, my latest GSM mobile will never cover more than 2 km or so to the nearest mast, and then, worst of all, people I do not want to talk to keep calling me. Not a chance of that happening on the SDR314.

(065080-1)

This Issue:

SOLDER STATIONS COMPARED

15 stations compared for performance



Next Issue:

24-PAGE ‘E-TRIXX’ SUPPLEMENT

escaped from the Elektor kitchen

Want to know everything each month?

SELECT YOUR OWN ANNUAL SUBSCRIPTION

AND RECEIVE A FREE 1W LUXEON LED TORCHLIGHT*

Fill out the Order Form with this issue today!

elektor electronics

Subscription rates and conditions may be found at the back of this issue.

* Offer available to Subscribers who have not held a subscription to Elektor Electronics during the last 12 months. Offer subject to availability.

Hexadoku

Puzzle with an electronic touch

Here's another Hexaduku puzzle, the Elektorised version of the Sudoku, but much harder to solve! Despite the degree of difficulty, our Hexadoku puzzles are graced by hundreds of correct solutions every month. We reward your effort, brain wrecking and pencil use with a couple of nice prizes. Simply participate, have fun and who knows you're among this month's winners!

The instructions for this puzzle are straightforward. In the diagram composed of 16 x 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 4x4 boxes (marked by the thicker black lines). A number of clues are given in the puzzle and these determine the start situation. All correct entries received for each month's puzzle go into a draw for a main prize and three lesser prizes. All you need to do is send us the numbers in the grey boxes.

The puzzle is also available as a free download from our website (Magazine > 2006 > November).

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

Participate!

Please send your solution (the numbers in the grey boxes) by email, fax or post to:

Elektor Electronics Hexadoku
Regus Brentford
1000 Great West Road
Brentford TW8 9HH
United Kingdom.
Fax (+44)(0)208 2614447
Email:
editor@elektor-electronics.co.uk
Subject: hexadoku 11-2006.

The closing date is
1 December 2006.

The competition is not open to employees of Segment b.v., its business partners and/or associated publishing houses.

Prize winners

The solution of the September 2006 Hexadoku is: 0EBAD.

The **E-blocks Starter Kit Professional** goes to: Rob Quinn (Kirkcudbrightshire).

An **Elektor SHOP voucher worth £35.00** goes to:

Hugh McCarry (Ballymacaw, IRL),
Leo Hallback (Malax, FIN),
Jonathan Gudgeon (Milton Keynes).

Well done everybody!

Solve Hexadoku and win!

Correct solutions received enter a prize draw for an

E-blocks Starter Kit Professional

worth **£248.55**

and three **Elektor Electronics SHOP Vouchers** worth £35.00 each.

We believe these prizes should encourage all our readers to participate!

ELEKTOR SHOWCASE

To book your showcase space contact Huson International Media

Tel. 0044 (0) 1932 564999 Fax 0044 (0) 1932 564998

ATC SEMITEC LTD

www.atcsemitec.co.uk

Thermal and current-sensitive components for temperature control and circuit protection;

- NTC Thermistors
- Current Diodes
- Thermostats
- Re-settable Fuses
- Thermal Fuses
- Temperature Sensors

Call today for free samples and pricing

Tel: 0870 901 0777 Fax: 0870 901 0888

BETA LAYOUT

www.pcb-pool.com

Beta layout Ltd Award-winning site in both English and German offers prototype PCBs at a fraction of the cost of the usual manufacturer's prices.

DESIGN GATEWAY

www.design-gateway.com

PalmLogic II .... US$ 399.00

- Compact Logic Analyzer (L116mm x W73.3mm x T3mm)
- High sampling rate (400 MHz/ 8ch, 200 MHz/16ch, 100 MHz/32ch)
- USB 2.0 high speed mode
- 8MB memory storage
- Bus Analyzer function
- Multiple waveform windows
- Waveform save/restore

DESIGN GATEWAY

www.design-gateway.com

True PCI Starter Kit .... US$135.00

- PCI Development Kit
- Based on 200,000 gates FPGA
- Extension connectors for 72 pin I/O
- Configuration support for JTAG and slave serial
- Free PCI Core for Target Mode

TRUE PCI

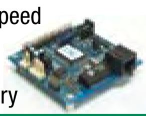
DESIGN GATEWAY

www.design-gateway.com

Ethernet IO .... US$115.00

- 8 bits embedded network microcontroller
- 6 channels available for 10 bits ADC
- Ethernet 10 BASE T 10 Mb
- UART port RS232/RS485, Max Speed at115200bps
- 35 bits general purpose I/O
- 500 bytes user area flash memory

Ethernet Io



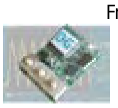
DESIGN GATEWAY

www.design-gateway.com

VariClock ... US$163.00

- Adjustable clock signal synthesizer
- 3 rotary switches for frequency setting
- Standard DIP pin arrangement
- Support both 3V/5V by on-board regulator

VC250M14P	Frequency range	: 25-400 MHz
	Frequency setting	: 1MHz step
VC100M14P	Frequency range	: 25-100 MHz
	Frequency setting	: 100 kHz step for 25-50 MHz
		: 200 kHz step for more than 50 MHz



VariClock

AVIT RESEARCH

www.avitresearch.co.uk

USB has never been so simple... with our USB to Microcontroller Interface cable. Appears just like a serial port to both PC and Microcontroller, for really easy USB connection to your projects, or replacement of existing RS232 interfaces.

See our webpage for more details. Only £29.99 inc vat.

BAEC

http://baec.tripod.com

"The British Amateur Electronics Club Archive Website. Archiving extracts from 140+ Newsletters from 1966-2002. Currently have interesting and useful selected articles from 12 Newsletters. Also a section about built electronics projects with schematics and photos. Plus useful info., downloads and links. NO ADVERTS!"

COMPULOGIC LTD

www.compulogic.co.uk

Internet Remote Control Starter Kit £139.99

Create a simple web based remote control interface for many applications

- Miniature Web Server Module
- Analogue/Digital Module
- PSU
- Manuals, software, example HTML code

CONFORD ELECTRONICS

http://www.confordelec.co.uk

Lightweight portable battery/mains audio units offering the highest technical performance. Microphone, Phantom Power and Headphone Amplifiers. Balanced/unbalanced signal lines with extensive RFI protection.

DANBURY ELECTRONICS

http://www.DanburyElectronics.co.uk

Transformer manufacturers since 1983. Visit our new site! Also link directly to Mike Holme's Valve/-Tube DIY amplifier site, featuring our standard Audio Transformers (Mains, Output, Chokes, PP, SE, etc).

EAGLEPICS

http://www.eaglepics.co.uk

Embedded Internet Solutions

- Stand alone TCP/IP module
- Platform independent
- Simple "AT-like" command set
- GPRS or modem connection
- E-Mail, FTP, HTTP, UDP
- Development board available
- Free development utilities
- Free UDP-only stack

EASYSYNC

http://www.easysync.co.uk

EasySync Ltd sells a wide range of single and multi-port USB to RS232/RS422 and RS485 converters at competitive prices.

ELNEC

www.elnec.com

- device programmer manufacturer
- selling through contracted distributors all over the world
- universal and dedicated device programmers
- excellent support and after sale support
- free SW updates
- reliable HW
- once a months new SW release
- three years warranty for most programmers

FIRST TECHNOLOGY TRANSFER LTD.

http://www.ftt.co.uk/PICProTrng.html

Microchip Professional C and Assembly Programming Courses.

The future is embedded.

Microchip Consultant / Training Partner developed courses:

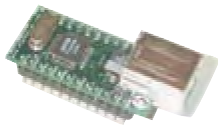
- Distance learning / instructor led
- Assembly / C-Programming of PIC16, PIC18, PIC24, dsPIC microcontrollers
- Foundation / Intermediate

FUTURE TECHNOLOGY DEVICES

http://www.ftdichip.com

FTDI designs and sells USB-UART and USB-FIFO interface i.c.'s.

Complete with PC drivers, these devices simplify the task of designing or upgrading peripherals to USB

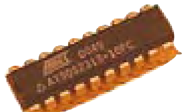


FUTURLEC

http://www.futurlec.com

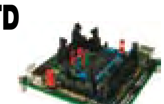
Save up to 60% on

- Electronic Components
- Microcontrollers, PIC, Atmel
- Development Boards, Programmers



Huge range of products available on-line for immediate delivery, at very competitive prices.

HEROS TECHNOLOGY LTD



www.herostechnology.co.uk

Introducing Modular Concept for microcontrollers.

Suitable for Developers, Pre-production, Educational and Hobby applications.

- WinPIC2006 USB full speed programmer.
- CPU microcontroller modules.
- Peripheral modules for all microcontrollers.

JLB ELECTRONICS

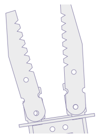
www.jlbelectronics.com

Suppliers of electrical / electronic parts and consumables. Including:

- Cable ties / bases
- Tools / hardware
- Bootlace ferrules
- Connectors
- Solvent sprays & cleaners
- PVC Tape
- Heat Sink compound

products and services directory

KMK TECHNOLOGIES Ltd.



http://www.kmk.com.hk
Low Cost DIY Robotic Kits and Computer Controller Boards.

LONDON ELECTRONICS COLLEGE

http://www.lec.org.uk
Vocational training and education for national qualifications in Electronics Engineering and Information Technology (BTEC First National, Higher National NVQs, GCSEs and Advanced Qualifications). Also Technical Management and Languages.

MODular ElecTRONics

www.modetron.com
- Plug and Program
- FREE application s/w
- Hobbyist ease-of-use
- Professional finish with enclosure and LEXAN faceplate
- We will design and brand your custom application
- Growing range of PSU's, i/o modules, displays and microcontrollers

MQP ELECTRONICS

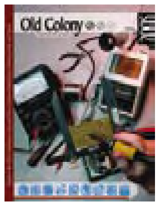
http://www.mqpelectronics.co.uk
Leaders in Device Programming Solutions.
- Online shop
- Low Cost Adapters for all Programmers
- Single Site and Gang Programmers
- Support for virtually any Programmable Device

NEW WAVE CONCEPTS

www.new-wave-concepts.com
Software for Hobbyists:
- Livewire - circuit simulation software, only £34.99
- PCB Wizard - PCB design software, only £34.99
- Circuit Wizard - circuit, PCB and breadboard design software, only £59.99

Available from all Maplin Electronics stores and www.maplin.co.uk

OLD COLONY SOUND LAB



www.audioXpress.com
Premier source for DIY audio for 35 years!
New catalog features:
- Books
- CDs
- Test & Measurement
- Kits

Full range of products and magazines for the DIY audio enthusiast!

PCB WORLD

http://www.pcbworld.org.uk
World-class site: Your magazine project or prototype PCB from the artwork of your choice for less. Call Lee on 07946 846159 for details. Prompt service.

ROBOT ELECTRONICS

http://www.robot-electronics.co.uk
Advanced Sensors and Electronics for Robotics
- Ultrasonic Range Finders
- Compass modules
- Infra-Red Thermal sensors
- Motor Controllers
- Vision Systems
- Wireless Telemetry Links
- Embedded Controllers

SK PANG ELECTRONICS

http://www.skpang.co.uk
- ELM OBDII IC
- VAG-COM Interface
- OBDII connector and cable
- Modtronix Micro X board
- Embedded Ethernet Controller
- PIC Microcontroller, CAN Bus driver

Major credit cards taken online.

SOURCEBOOST TECHNOLOGIES

http://www.sourceboost.com
Next generation C compiler and development products at highly affordable prices:
- C, C++, and Basic compilers for PIC12, PIC16, PIC18
- Modern IDE, with PIC simulator, source level debugger and virtual devices.
- RTOS for PICmicro.
- PIC based controller and Development boards.
- Download and try for Free from http://www.sourceboost.com

SYTRONIC TECHNOLOGY LTD

www.m2mtelemetry.com
Supplier of wireless modules and accessories for remote
monitoring M2M applications.
- GSM/GPRS TCP/IP modules
- Embedded GSM/GPRS modem
- Development Kits
- GPS modules
- GSM/GPS antennas
- Adapter cables

Online ordering facilities.
Tel (01394) 210911

ULTRALEDS

Ultraleds.co.uk

http://www.ultraleds.co.uk
tel: 0871 7110413
Large range of low cost Ultra bright leds and Led related lighting products. Major credit cards taken online with same day depatch.

USB INSTRUMENTS

http://www.usb-instruments.com
USB Instruments specialises in PC based instrumentation products and software such as Oscilloscopes, Data Loggers, Logic Analaysers which interface to your PC via USB.

VIRTINS TECHNOLOGY

www.virtins.com
PC and Pocket PC based virtual instrument for electronics enthusiasts, students, professionals and scientists, including sound card real time oscilloscope, spectrum analyzer, and signal generator. Free to download and try.

SHOWCASE YOUR COMPANY HERE

Elektor Electronics has a feature to help customers promote their business, Showcase - a permanent feature of the magazine where you will be able to showcase your products and services.
- For just £220 + VAT (£20 per issue for eleven issues) Elektor will publish your company name, website adress and a 30-word description
- For £330 + VAT for the year (£30 per issue for eleven issues) we will publish the above plus run a 3cm deep full colour image - e.g. a product shot, a screen shot from your site, a company logo - your choice

Places are limited and spaces will go on a strictly first come, first served basis. So please fax back your order today!

I wish to promote my company, please book my space:
• Text insertion only for £220 + VAT • Text and photo for £330 + VAT

NAME:.................................ORGANISATION:.................................
JOB TITLE:...
ADDRESS:...
....
.................................TEL:.................................
PLEASE COMPLETE COUPON BELOW AND FAX BACK TO 00-44-(0)1932 564998
COMPANY NAME...
WEB ADDRESS...
30-WORD DESCRIPTION...
....
....
....
....

E-blocks Starter Kits
now with a 30% discount!

Free downloads available on www.elektor-electronics.co.uk/eblocks !

E-blocks AVR-Kit

C for AVR microcontrollers single user	£	118.00
E-blocks AVR multiprogrammer	£	77.65
E-blocks LED board	£	14.65
E-blocks LCD board	£	19.30
E-blocks Switch board	£	14.65
Total value:	**£**	**244.25**
Special Offer: (-30%)	£	171.80

E-blocks Easy Internet Kit

Flowcode Professional	£	118.00
E-blocks LED board	£	14.65
E-blocks LCD board	£	19.30
E-blocks USB Multiprogrammer	£	77.30
E-blocks Switch board	£	14.65
E-blocks Internet board	£	71.95
PIC16F877	£	10.50
Ethernet ‘crossover’ cable	£	5.30
Total value:	**£**	**331.65**
Special Offer: (-30%)	£	232.50

E-blocks Starter Kit Basic

Flowcode student/home:	£	59.90
USB Multiprogrammer:	£	77.30
Total value:	**£**	**137.20**
Special Offer: (-30%)	£	96.00

NEW

E-blocks Easy ARM kit

C for ARM microcontrollers single user	£	118.00
E-blocks ARM programmer	£	89.20
E-blocks LED board	£	14.65
E-blocks LCD board	£	19.30
E-blocks Switch board	£	14.65
Total value	£	**255.80**
Special Offer: (-33%)	**£**	171.80

E-blocks Starter Kit Professional

Flowcode professional	£	118.00
USB Multiprogrammer	£	77.30
E-blocks LED board	£	14.65
E-blocks Switch board	£	14.65
E-blocks LCD board	£	19.30
Total value:	**£**	**243.90**
Special Offer: (-32%)	£	166.00

Extra: PIC16F877 microcontroller

E-blocks Easy CAN Kit

Flowcode Professional	£	118.00
E-blocks LED board	£	14.65
E-blocks Switch board	£	14.65
2 x E-blocks LCD board	£	38.60
2 x E-block USB Multiprogrammer	£	154.60
2 x E-blocks CAN board	£	67.00
2 x PIC16F877	£	21.00
Total value:	**£**	**428.50**
Special Offer: (-30%)	**£**	299.00

Learn more about E-blocks?
For more information, visit
www.elektor-electronics.co.uk/eblocks

Ordering
Use the order form at the back or go to
www.elektor-electronics.co.uk
E-blocks will be shipped after receipt of payment.
Prices are exclusive of postage.

eblocks

elektor SHOP

Order now using the Order Form in the Readers Services section in this issue.

Elektor Electronics (Publishing)
Regus Brentford
1000 Great West Road
Brentford TW8 9HH
United Kingdom

Telephone +44 (0) 208 261 4509
Fax +44 (0) 208 261 4447
Email: sales@elektor-electronics.co.uk

More information on www.elektor-electronics.co.uk

CD-ROM BESTSELLERS

USB TOOLBOX

This CD-ROM contains technical data about the USB interface. It also includes a large collection of data sheets for specific USB components from a wide range of manufacturers. There are two ways to incorporate a USB interface in a microcontroller circuit: add a USB controller to an existing circuit, or use a microcontroller with an integrated USB interface. Included on this CD-ROM are USB Basic Facts, several useful design tools for hardware and software, and all Elektor Electronics articles on the subject of USB. **£18.95 (US$ 34.95)**

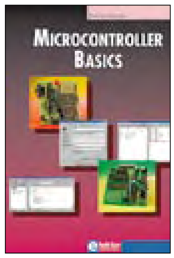
Home Automation

This CD-ROM provides an overview of what manufacturers offer today in the field of Home Networking, both wired and wireless. The CD-ROM contains specifications, standards and protocols of commercially available bus and network systems. For developers, there are datasheets of specific components and various items with application data. End-users and hobbyists will find ready-made applications that can be used immediately. **£12.95 (US$ 22.90)**

Robotics

A large collection of datasheets, software tools, tips, tricks and Internet links to assorted robot constructions and general technical information. All aspects of modern robotics are covered, from sensors to motors, mechanical parts to microcontrollers, not forgetting matching programming tools and libraries for signal processing. **£12.05 (US$ 21.25)**

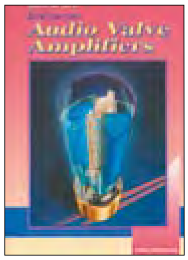
Microcontroller Basics



Microcontrollers have become an indispensable part of modern electronics. They make things possible that vastly exceed what could be done previously. Innumerable applications show that almost nothing is impossible. There's thus every reason to learn more about them. This book offers more than just a basic introduction. It clearly explains the technology using various microcontroller circuits and programs written in several different programming languages. In the course of the book, the reader gradually develops increased competence in converting his or her ideas into microcontroller circuitry.

ISBN 0-905705-67-X
230 Pages
£18.70 (US$ 33.70)

Build your own Audio Valve Amplifiers

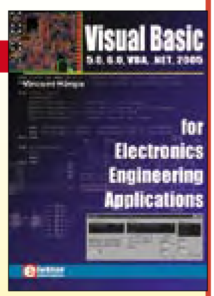


To many people, the thermionic valve or electron tube is history. However, whether it is nostalgia, interest in the technical parameters, the appeal of a gleaming amplifier chassis with softly glowing valves or perhaps the firm conviction that the sound of a valve cannot be bettered, it is a fact that the valve is making a come-back. This book contains, apart from construction projects for preamplifiers, power amplifiers, and amplifiers for musical instruments, information on the operation of electron tubes, while the first chapter gives a short history of the valve.

ISBN 0 905705 39 4
253 Pages
£15.55 (US$31.00)

BESTSELLING BOOKS

Top-5



1. **Visual Basic for Electronics Engineering Applications**
   ISBN 0-905705-68-8 **£27.50 (US$ 51.50)**
2. **Microcontroller Basics**
   ISBN 0-905705-67-X **£18.70 (US$ 33.70)**
3. **Build your own Audio Valve Amplifiers**
   ISBN 0-905705-39-4 **£15.55 (US$ 31.00)**
4. **PC-Interfaces under Windows**
   ISBN 0-905705-65-3 **£25.95 (US$ 22.90)**
5. **Handbook for sound technicians**
   ISBN 0-905705-48-3 £ 20.75 (US$ 42.00)

More information on www.elektor-electronics.co.uk

Elektor RFID-reader

(September 2006)

Ready-built and tested PCB with USB port for connection to the PC. Including USB cable; not including display and enclosure.

- Read and write 13.56 MHz RFID cards
- MIFARE and ISO 14443-A compatible
- Programmable

060132-91

£ 41.50 / $ 77.95

LC-display

030451-72

£ 7.25 / $ 13.65

Matching enclosure

060132-71

£ 8.90 / $ 16.85

CD-ROM (all project software)

060132-81

£ 5.20 / $ 9.75

GameBoy Programmable Logic Controller

(July/August 2006)

GBPLC Module

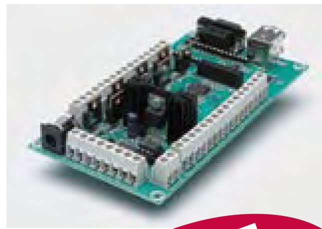
Ready-assembled and tested GBPLC Module and Programming Interface

050190-91

£ 84.95 / $ 159.95

GBPLC I²C I/O Box

Ready assembled and tested board



060098-91

£ 84.95 / $ 159.95

Combined package

GBPLC Module and I/O Extension

£ 149.80 / $ 279.00

PRICE SLASHED!

MORE READY-BUILT PROJECTS		£	$
ClariTy 300-W Class-T Amplifier			
030217-91	Amplifier board with SMDs pre-fitted; cores for L1 & L2	34.50	55.70
Electrosmog Tester			
050008-91	PCB, ready built and tested	50.00	94.25
050008-71	Matching enclosure	10.25	19.30
Flash Microcontroller Starter Kit			
010208-91	Ready-assembled PCB incl. software, cable, adapter & related articles	69.00	112.50
Gameboy Digital Sampling Oscilloscope (GBDSO)			
990082-91	Ready-assembled board, incl. the PC software and related articles	103.00	183.00
LPC210x ARMee Development System			
040444-91	Processor board, ready-made and tested	25.50	48.05
Micro Webserver with MSC1210 Board			
030060-91	Microprocessor Board, ready-assembled	75.90	142.95
044026-91	Network Extension Board, ready-assembled	44.50	83.95
044026-92	Combined package (030060-91 & 044026-91 & related articles)	117.50	220.95
NO. 360 NOVEMBER 2006			
USB Stick with ARM and RS232			
060006-1	PCB, bare	11.00	20.75
060006-41	AT91SAM7S64, programmed	27.60	51.95
060006-91	assembled & tested board	79.90	149.95
060006-81	CD-ROM, all project software	5.20	9.75
NO. 359 OCTOBER 2006			
PIC In-Circuit Debugger/Programmer			
050348-1	PCB	5.20	9.75
050348-41	PIC16F877, programmed	17.90	33.75
050348-71	Kit, incl. PCB, controller, all parts	34.50	64.95
GBECG – Gameboy ElectroCardioGraph			
050280-91	PCB, ready built and tested	55.20	103.95
ECG using a Sound Card			
040479-1	PCB	5.20	9.75
040479-81	CD-ROM, all project software	5.20	9.75
NO. 358 SEPTEMBER 2006			
Elektor RFID Reader			
060132-91	PCB, ready assembled & tested, with USB cable	41.50	77.95
030451-72	Standard back-lit LC display	7.25	13.65
060132-71	Matching enclosure	8.90	16.85
060132-81	CD-ROM, all project software	5.20	9.75
Experimental RFID Reader			
060221-11	Disk, all project software	5.20	9.75
060221-41	ATmega16, programmed	8.90	16.85
DiSEqC Monitor			
040398-11	Disk, PIC source & hex code	5.20	9.75
040398-41	PIC16F628A-20/P, programmed	5.50	10.35
USB/DMX512 Converter			
060012-11	Disk, all project software	5.20	9.75
060012-41	PIC16C745, programmed	6.90	12.95
NO. 356/357 JULY/AUGUST 2006			
RC Servo Tester/Exerciser			
040172-11	Disk, project software	5.20	9.75
040172-41	PIC16F84(A), programmed	10.30	19.40
040172-71	Kit, incl. PCB, controller, all parts	22.70	42.85
LED Thermometer			
030190-11	Disk, project software	5.20	9.75
030190-41	PIC16F873-20/SP, programmed	16.50	31.00
Toothbrush Timer			
050146-11	Disk, project software	5.20	9.75
050146-41	AT90S2313-10PC, programmed	6.90	12.95
Easy Home Control			
050233-11	Disk, project software	5.20	9.75
050233-41	PIC16F84, programmed	10.30	19.40
Universal LCD Module			
050259-11	Disk, project software	5.20	9.75
050259-41	AT90S2313, programmed	6.90	12.95
1-Wire Thermometer with LCD			
060090-11	Disk, project software	5.20	9.75
060090-41	PIC16F84A-04CP, programmed	10.30	19.40
GBPLC - Gameboy PLC			
050190-1+2	PCBs, bare, GBPLC Module & Programming Interface	11.70	22.00
050190-51	Programmed PAL, EEPROM and Flash IC	11.00	20.75
050190-91	Ready-built and tested GBPLC Module and Programming Interface	84.95	159.95

nline at
ectronics.co.uk

Due to practical constraints, final illustrations and specifications may differ from published designs. Prices subject to change. See www.elektor-electronics.co.uk for up to date information.

Elektor Electronics (Publishing)
Regus Brentford
1000 Great West Road
Brentford TW8 9HH
United Kingdom
Tel.: +44 (0) 208 261 4509
Fax: +44 (0) 208 261 4447
Email: sales@elektor-electronics.co.uk

Kits & Modules

PIC In-Circuit Debugger/Programmer

(October 2006)

Kit of parts including PCB, programmed controller and all components.

050348-71

£ 34.50 / $ 64.95

GameBoy ElectroCardioGraph

(October 2006)

PCB, ready built and tested

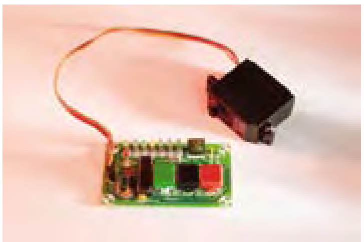
050280-91

£ 55.20 / $ 103.95

RC Servo Tester / Exerciser

(July/August 2006)

Kit of parts including PCB, programmed controller and all components.



040259-71

£ 22.70 / $ 42.85

A 16-bit Tom Thumb

(February 2006)

R8C Starter Kit comprising CD-ROM and R8C/13 microcontroller board with SIL pinheaders supplied separately.

050179-91

£ 8.30 / $ 15.60

GBPLC - I2C I/O Box

060098-1	PCB, bare	17.90	33.75
060098-91	Ready-built and tested board	84.95	159.95

Binary Clock

020390-11	disk, project software	5.20	9.75
020390-41	PIC6C54-04/P, programmed	8.05	15.10

No. 355 JUNE 2006

FM Stereo Test Transmitter

050268-1	PCB	11.70	22.00

Network Cable Analyser

050302-1	PCB	8.20	15.55
050302-11	Disk, PIC source code	5.20	9.75
050302-41	PIC16F874-20/P	16.90	31.85

NO. 354 MAY 2006

Onboard OBD-2 Analyser

050176-72	Kit of parts, incl. 050176-1, 050176-2, 050176-42, all components, excl. LCD and Case	24.80	46.70
050176-73	LCD, 4x20 characters with backlight	28.80	54.50
050176-74	Case, Bopla Unimas 160 with Perspex cover and mounting plate	15.80	29.90
050176-42	ATmega16, programmed	10.30	19.45
050092-71	OBD-2 Analyser: Kit of parts without cable	52.50	96.95
050092-72	OBD-2 Analyser: DB9 to OBD adapter cable	27.55	51.95

Mini ATMega Board

050176-1	PCB, includes adapter PCB 050176-2	8.95	16.85

NO. 353 APRIL 2006

Simple recharable A Cell Analyser

050394-1	PCB, bare	4.80	9.04
050394-11	Disk, PC Software	5.18	9.75

Universal SPI Box

050198-41	AT89C2051-24PC, Programmed	7.25	13.65

No. 352 MARCH 2006

Application Board for R8C/13

050179-92	Ready-assembled board	48.27	90.94
050179-1	PCB	13.77	25.94
030451-72	LCD with backlight	7.25	13.65
030451-73	Poly-LED display	25.50	48.05

FPGA-Prototyping board

050370-91	Ready assembled board		
	For subscribers	181.80	333.50
	For non-subscribers	216.30	398.50

Telephone Eavesdropper

030379-1	PCB	9.05	17.05

Versatile FPGA Module

040477-91	Ready assembled plug-on module		
	For subscribers	181.80	333.50
	For non-subscribers	216.30	398.50

NO. 351 FEBRUARY 2006

Brushless Motor Controller

050157-41	ST7MC1, programmed	3.80	7.15

A 16-bit Tom Thumb

050179-91	R8C Starter Kit	8.30	15.60
050179-C5	Set of 5 pcs. R8C13 microcontroller only	20.70	39.00

No. 350 JANUARY 2006

95-watt Laptop PSU Adaptor

050029-1	PCB	4.80	9.05

Automatic Attic Window Controller

050139-11	Disk, PIC source & hex code	5.20	9.75
050139-41	PIC16F84A-20I/P, programmed	13.10	24.65
030451-72	LCD Modue 2x16 characters	7.25	13.65
030451-73	PLED Module 2x16 characters	25.50	48.05

SMD Reflow Soldering Oven

050319-11	Disk, source and hex code	5.20	9.75
050319-41	AT89C52/24JI, programmed	7.60	14.25
030451-72	LCD Modue 2x16 characters	7.25	13.65
030451-73	PLED Module 2x16 characters	25.50	48.05

Timer Switch for Washing Machine

050058-1	PCB	8.90	16.70

Products for older projects (if available) may be found on our website www.elektor-electronics.co.uk

home construction = fun and added value

Theme Plan for 2006

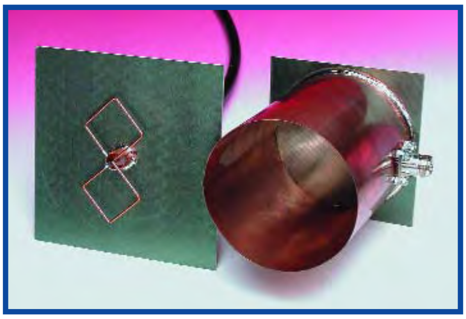
January	Recycling / Reverse Engineering
February	Motors / Propulsion
March	Development / Microcontrollers
April	Power Supplies / Safety
May	Soldering / Etching
June	Test & Measurement
July/August	Summer Circuits
September	RFID / Satellites
October	E-Simulation
November	Chipcards / Security
December	**Electromechanical / Enclosures**

DDS Shortwave Receiver

We present a general-coverage (150 kHz – 30 MHz) AM/FM/SSB receiver with some nifty features like a DDS chip for the VFO section and a DRM output for connection to your computer. The receiver is controlled by an 8-bit Atmel ARM micro. Other salient features of the receiver include 10-Hz resolution for fine tuning, an internal active antenna switch and three switchable bandwidths to match AM, FM, USB, LSB or DRM transmissions.

WLAN Antennas in Practice

Wireless networks 'rule' in most homes with two or more computers, and nobody seems to do cabling work anymore. The antennas on most off the shelf WLAN products are unsuitable for covering distances greater than a few metres, so our lab set out to test the claims for greater distances made for two 2.4-GHz directional antennas. You can read about the results in the December 2006 issue.



Free 'e-TRIXX' Supplement

The December 2006 issue comes with a free 24-page supplement stapled into the centre of the magazine: the e-TRIXX Collection. e-TRIXX stands for 'Elektor tricks (of the trade)'. Supplied by our in-house lab workers, e-TRIXX are short articles describing small circuits that can be slapped together from cheap, off the shelf parts. To help you through the Christmas holidays we have compiled 20-odd of the best e-TRIXX items into a free booklet that can be taken out of the magazine for easy reference, or to give to a fellow enthusiast as a Christmas present.

Also...

Spy Numbers Stations; Spread Spectrum for R/C Models; E-Blocks Flowcode v. 3 Review; Electronic Gadgets for Christmas; FPGA Course (7); Hexadoku.

RESERVE YOUR COPY NOW!
UK mainland subscribers will receive the magazine between 11 and 14 November 2006.

The December 2006 issue goes on sale on Thursday 16 November 2006 (UK distribution only).
Article titles and magazine contents subject to change, please check our website.

NEWSAGENTS ORDER FORM

SHOP SAVE / HOME DELIVERY

Please save / deliver one copy of *Elektor Electronics* magazine for me each month

Name: . . . .
Address: . . . .
Post code: . . . .
Telephone: . . . .
Date: . . . .
Signature: . . . .

elektor electronics leading the way

Please cut out or photocopy this form, complete details and hand to your newsagent. *Elektor Electronics* is published on the third Thursday of each month, except in July. Distribution S.O.R. by Seymour (NS).

www.elektor-electronics.co.uk www.elektor-electronics.co.uk www.elektor-electronics.

Elektor Electronics on the web

All magazine articles back to volume 2000 are available online in pdf format. The article summary and parts list (if applicable) can be instantly viewed to help you positively identify an article. Article related items are also shown, including software downloads, circuit boards, programmed ICs and corrections and updates if applicable.
Complete magazine issues may also be downloaded.

In the Elektor Electronics Shop you'll find all other products sold by the publishers, like CD-ROMs, kits and books. A powerful search function allows you to search for items and references across the entire website.

Also on the Elektor Electronics website:

- Electronics news and Elektor announcements
- Readers Forum,
- PCB, software and e-magazine downloads
- Surveys and polls
- FAQ, Author Guidelines and Contact

Order Form 11-2006

Please supply the following. For PCBs, front panel foils, EPROMs, PALs, GALs, microcontrollers and diskettes, state the part number and description; for books, state the full title; for photocopies of articles, state full name of article and month and year of publication.
PLEASE USE BLOCK CAPITALS.

Description	Price each	Qty.	Total	Order Code
CD-ROM USB Toolbox NEW	£ 18.95			
CD-ROM Home Automation	£ 12.95			
Visual Basic for Electronics Engineering Applications	£ 27.50			
Elektor RFID Reader	£ 41.50			
Matching enclosure	£ 8.90			
	Sub-total			
	P&P			
	Total paid			

Prices and item descriptions subject to change.
The publishers reserve the right to change prices without prior notification. Prices and item descriptions shown here supersede those in previous issues. E. & O.E.

Name

Address + Post code

Tel. *Email*

Date – – 2006 *Signature*

EL11

METHOD OF PAYMENT
(see reverse before ticking as appropriate)

☐ **Bank transfer**
☐ **Cheque**
(UK-resident customers ONLY)
☐ **Giro transfer**
☐ VISA / EUROCARD MasterCard / JCB / SWITCH

Expiry date: ....
Verification code: ....
SWITCH ONLY:
Start date: ....
Issue number: ....

Please send this order form to *
(see reverse for conditions)

Elektor Electronics (Publishing)
Regus Brentford
1000 Great West Road
Brentford TW8 9HH
United Kingdom

Tel.: (+44) (0) 208 261 4509
Fax: (+44) (0) 208 261 4447
Internet: www.elektor-electronics.co.uk
sales@elektor-electronics.co.uk

*USA and Canada residents may (but are not obliged to) use $ prices, and send the order form to:
Old Colony Sound Lab
P.O. Box 876, Peterborough
NH 03458-0876. Tel. (603) 924-6371, 924-6526,
Fax: (603) 924-9467
Email: custserv@audioXpress.com

Subscription Order Form 11-2006

Yes, I am taking out an annual subscription to Elektor Electronics and receive a free 1 W Luxeon LED Torchlight.

I would like:

☐ **Standard Subscription (11 issues)**
☐ **Subscription-Plus**
(11 issues plus the Elektor Volume 2006 CD-ROM)

** Offer available to Subscribers who have not held a subscription to Elektor Electronics during the last 12 months. Offer subject to availability. See reverse for rates and conditions.*

Name

Address + Post code

Tel. *Email*

Date – – 2006 *Signature*

** cross out what is not applicable*

EL11

METHOD OF PAYMENT
(see reverse before ticking as appropriate)

☐ **Bank transfer**
☐ **Cheque**
(UK-resident customers ONLY)
☐ **Giro transfer**
☐ VISA / EUROCARD MasterCard / JCB / SWITCH

Expiry date: ....
Verification code: ....
SWITCH ONLY:
Start date: ....
Issue number: ....

Please send this order form to

Elektor Electronics (Publishing)
Regus Brentford
1000 Great West Road
Brentford TW8 9HH
United Kingdom

Tel.: (+44) (0) 208 261 4509
Fax: (+44) (0) 208 261 4447
Internet: www.elektor-electronics.co.uk
subscriptions@elektor-electronics.co.uk

ORDERING INSTRUCTIONS, P&P CHARGES

Except in the USA and Canada, all orders, except for subscriptions (for which see below), must be sent BY POST or FAX to our Brentford address using the Order Form overleaf. On-line ordering: http://www.elektor-electronics.co.uk
Readers in the USA and Canada may (but are not obliged to) send orders, except for subscriptions (for which see below), to the USA address given on the order form. Please apply to Old Colony Sound for applicable P&P charges. Please allow 4-6 weeks for delivery.
Orders placed on our Brentford office must include P&P charges (Priority or Standard) as follows:
UK: £4.00 Europe: £5.00 (Standard) or £7.00 (Priority) Outside Europe: £8.00 (Standard) or £12.00 (Priority)

HOW TO PAY

All orders must be accompanied by the full payment, including postage and packing charges as stated above or advised by Customer Services staff.

Bank transfer into account no. 40209520 held by Elektor Electronics (Publishing) / Segment b.v. with ABN-AMRO Bank, London. IBAN: GB35 ABNA 4050 3040 2095 20. BIC: ABNAGB2L. Currency: sterling (UKP). Please ensure your full name and address gets communicated to us.
Cheque sent by post, made payable to Elektor Electronics (Publishing) / Segment b.v.. We can only accept sterling cheques and bank drafts from UK-resident customers or subscribers. We regret that no cheques can be accepted from customers or subscribers in any other country.
Giro transfer into account no. 34-152-3801, held by Elektor Electronics (Publishing) / Segment b.v. Please do not send giro transfer/deposit forms directly to us, but instead use the National Giro postage paid envelope and send it to your National Giro Centre.
Credit card VISA, Access, MasterCard, JCBCard and Switch cards can be processed by mail, email, web, fax and telephone. Online ordering through our website is SSL-protected for your security.

COMPONENTS

Components for projects appearing in Elektor Electronics are usually available from certain advertisers in this magazine. If difficulties in the supply of components are envisaged, a source will normally be advised in the article. Note, however, that the source(s) given is (are) not exclusive.

TERMS OF BUSINESS

Delivery Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders. **Returns** Faulty goods or goods sent in error may be returned for replacement or refund, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. **Damaged goods** Claims for damaged goods must be received at our Brentford office within 10-days (UK); 14-days (Europe) or 21-days (all other countries). **Cancelled orders** All cancelled orders will be subject to a 10% handling charge with a minimum charge of £5·00. **Patents** Patent protection may exist in respect of circuits, devices, components, and so on, described in our books and magazines. Elektor Electronics (Publishing) does not accept responsibility or liability for failing to identify such patent or other protection. **Copyright** All drawings, photographs, articles, printed circuit boards, programmed integrated circuits, diskettes and software carriers published in our books and magazines (other than in third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature. Notwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission. **Limitation of liability** Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods. **Law** Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

January 2006

SUBSCRIPTION RATES FOR ANNUAL SUBSCRIPTION

	Standard	Plus
United Kingdom	£41.90	£48.80
Surface Mail		
Rest of the World	£54.50	£61.40
USA & Canada	US$ 95.50	US$106.50
Airmail		
Rest of the World	£68.90	£75.80
USA & Canada	US$120.00	US$131.00

HOW TO PAY

Bank transfer into account no. 40209520 held by Elektor Electronics (Publishing) / Segment b.v. with ABN-AMRO Bank, London. IBAN: GB35 ABNA 4050 3040 2095 20. BIC: ABNAGB2L. Currency: sterling (UKP). Please ensure your full name and address gets communicated to us.

Cheque sent by post, made payable to Elektor Electronics (Publishing) / Segment b.v.. We can only accept sterling cheques and bank drafts from UK-resident customers or subscribers. We regret that no cheques can be accepted from customers or subscribers in any other country.

Giro transfer into account no. 34-152-3801, held by Elektor Electronics (Publishing) / Segment b.v. Please do not send giro transfer/deposit forms directly to us, but instead use the National Giro postage paid envelope and send it to your National Giro Centre.

Credit card VISA, Access, MasterCard, JCBCard and Switch cards can be processed by mail, email, web, fax and telephone. Online ordering through our website is SSL-protected for your security.

SUBSCRIPTION CONDITIONS

The standard subscription order period is twelve months. If a permanent change of address during the subscription period means that copies have to be despatched by a more expensive service, no extra charge will be made. Conversely, no refund will be made, nor expiry date extended, if a change of address allows the use of a cheaper service.
Student applications, which qualify for a 20% (twenty per cent) reduction in current rates, must be supported by evidence of studentship signed by the head of the college, school or university faculty. A standard Student Subscription costs £33.50, a Student Subscription-Plus costs £40.40 (UK only).
Please note that new subscriptions take about four weeks from receipt of order to become effective.
Cancelled subscriptions will be subject to a charge of 25% (twenty-five per cent) of the full subscription price or £7.50, whichever is the higher, plus the cost of any issues already dispatched. Subsciptions cannot be cancelled after they have run for six months or more.

January 2006

INDEX OF ADVERTISERS