

November 2009

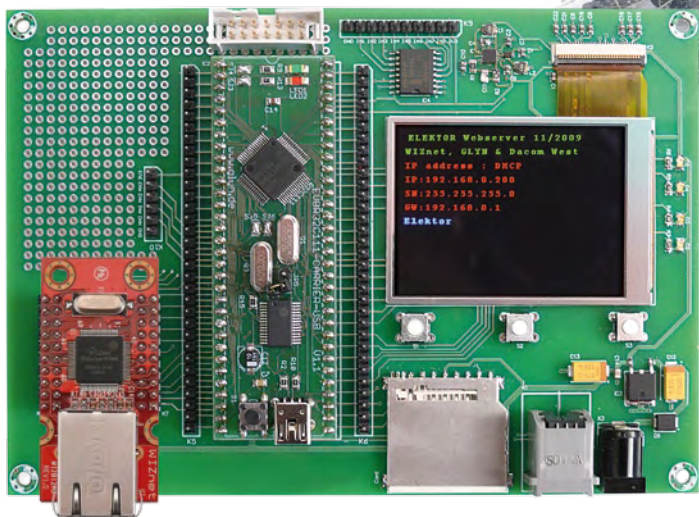
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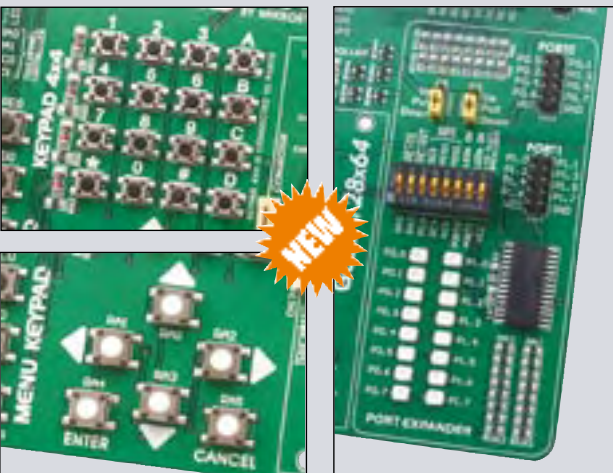
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Refresh — not just the readout

Those of you with an eye for detail will not have failed to notice that Elektor looks, well, different this month. After an analytical look at the existing page layout we decided to go for a less cluttered design without hairlines, slightly thicker lines, solid bars, shadows around boxes — to mention just a few styling elements. A new type font and an even tidier cover should give the magazine a fresh lease of life.

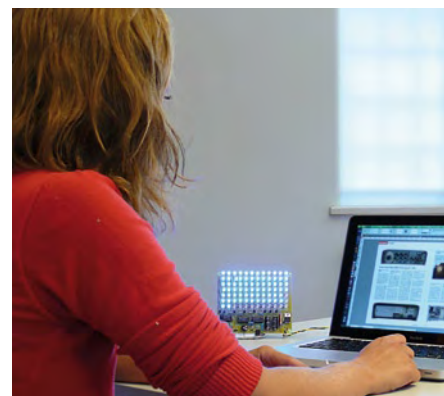
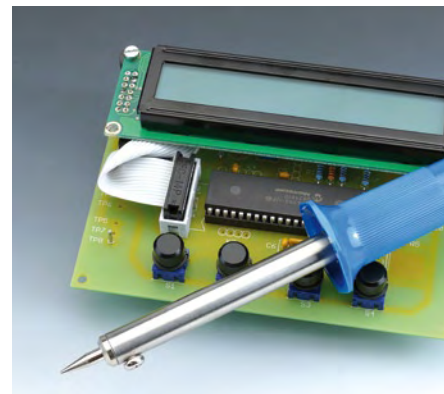
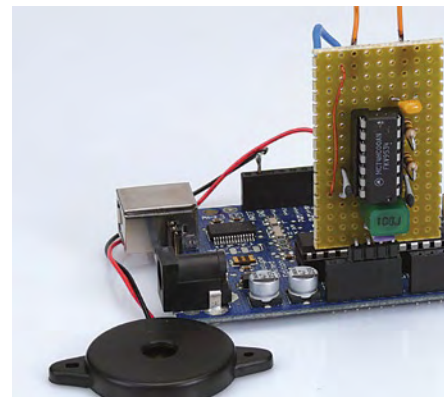
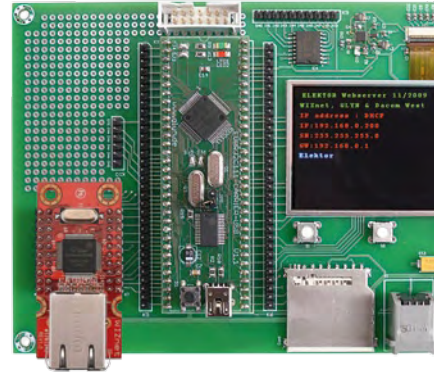
Your initial response might be “don’t bother, I read all your stuff anyway”. That’s highly appreciated, but there are more changes afoot at Elektor than just cosmetic touches to the monthly printed product. At a deeper level, we would like the magazine to remain up to date in terms of technology while keeping up the quality level our customers have come to appreciate over so many years.

Quite some time and effort was spent recently on the above issues and a number of conclusions reached. Here’s a quick summary of the main goals we hope to achieve: 1) Elektor should provide clearer pointers into the subject matter covered (see the five main areas we’ve defined in the text bar above the logo); 2) members of the editorial team should increasingly speak out on their personal fortes, interests and preferences (they already do in Editorial Board meetings); 3) the Elektor Lab has a central role in respect of the technical quality of the articles and consequently gets a central position in the magazine (‘E-Labs Inside’ section a.k.a the blue pages); 4) new online activities (to be launched later this year) should better serve the various communities out there; 5) all these changes should be transparent from, as well as underscored by, the magazine pages, hence the restyling as of this, your very own November 2009 issue. Will you change along?

Wisse Hettinga
Elektor International Editor in Chief



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A small add-on module for the application board from our September 2009 issue combines a TCP/IP chip plus Ethernet interface, a network connection with built-in transformer and status LEDs. This handy combination makes it child's play to implement a web server and many other Internet applications without getting involved in complexities such as TCP/IP protocol.



32 Arduino + Theremin = Theremino

This tiny oscillator circuit, when coupled with the software running on the Arduino microcontroller board, has a huge range of potential applications, allowing proximity-based control of any other circuit or system.



38 Solder Station 'Plus'

Thirty dollars or so would probably buy you a simple soldering station but it would not give you the same satisfaction as one that you built yourself and besides it would not have the energy control or DVM features of this design with its in-built microcontroller.



48 Light Therapy Box

During the winter many people suffer from Seasonal Affective Disorder (SAD), which is commonly known as the Winter Blues. With the help of blue light these symptoms can be reduced. The blue-light generator described here has a built-in timer and is perfect for this task.

48 Light Therapy Box

Blue LEDs fight SAD a.k.a. the Winter Blues.

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elektor international media

Elektor International Media provides a multimedia and interactive platform for everyone interested in electronics.

From professionals passionate about their work to enthusiasts with professional ambitions.

From beginner to diehard, from student to lecturer. Information, education, inspiration and entertainment.

Analog and digital; practical and theoretical; software and hardware.



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Elektor Personal Organizer 2010

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The Elektor Personal Organizer 2010 makes planning your appointments a real pleasure, and you always have ready access to have handy information that everyone who works with electronics needs to know.

In addition to the usual features such as an appointments calendar, address book and notes pages, this organizer has around 40 pages packed with useful information for you as an electronics specialist, both professionally and in your leisure time. For example, there is an extensive collection of formulas and tables for calculating current and voltage, component descriptions, physical constants, connector pin assignments, and much more.

The Elektor Personal Organizer 2010 at a glance:

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- Lined pages for your notes
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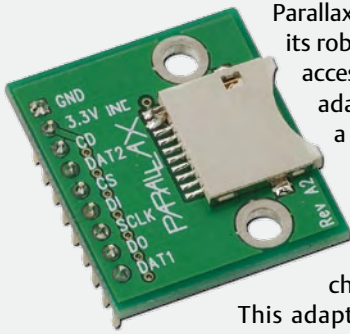
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Printed in the USA

Parallax releases new accessory products



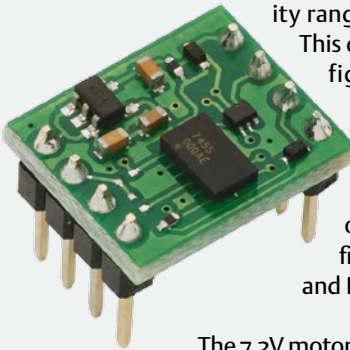
Parallax, well known to many Elektor readers for its robotics products, has released several new accessory products, including a micro SD-Card adapter, a 433-MHz RF transceiver module, a three-axis accelerator module, and a 7-V motor, bracket and wheel kit.

The micro-SD Card adapter (32312) makes it easy to connect a micro-SD Flash Memory Card to the Propeller chip or another microcontroller.

This adapter includes the components required for an SPI interface between the host microcontroller and a micro-SD memory card.

The Parallax RF transceiver (27982) is a very easy to use, low cost module capable of sending serial data wirelessly between microcontrollers or to a PC. Its low power consumption makes this module ideal for use in battery powered applications. This module sends and receives data by AM or CPCA modulation, providing higher average output power for extended range.

The Freescale Semiconductor MMA7455L 3-axis digital output accelerometer (28526) is a low power, micro machined sensor capable of measuring acceleration along its X, Y, and Z axes. It offers several convenient integrated features including an analog to digital converter (ADC), digital low-pass filter, and selectable sensitivity ranges of $\pm 2g$, $\pm 4g$, or $\pm 8g$.



This device can be easily configured to detect quick motion pulses such as single taps, double taps, and zero-g (free fall) conditions on any or all axes and provides configurable interrupt pins (INT1 and INT2) for each type of event.

The 7.2V motor, bracket and wheel kit (570-00070) offers versatility, durability and simplicity all in one box! The lightweight, sturdy aluminum brackets are machined from 6063 aluminum extrusion and anodized black for improved scratch resistance and aesthetic appeal. The high quality 7.2 Volt DC motors feature durable construction and all-metal gears that stand up to rough terrain and abuse, with a top speed corresponding to approximately 6.6 feet/second (2.0 m/s), which is ideal for most medium-size or small robotic projects.



www.Parallax.com
(090752-IV)



Avionics power supply boasts high reliability and light weight

Orchid Technologies Engineering & Consulting, experts in design of custom electronic products, has completed the development of a ruggedized power supply for use in demanding avionics applications.

Working closely with component vendors,

Orchid Technologies delivered a highly reliable, light weight product to its avionics client, which features a rated MTBF of 150,000 hours.



According to Paul Nickelsberg, CTO of Orchid Technologies, high output voltage stability with low current noise was essential over the entire operating range of the design, while optimization of the power supply size and weight were critical to the success of this ruggedized power supply.

Brownout detection, overvoltage/undervoltage protection, and thermal protection are provided by an onboard power supply controller. In addition, advanced error detection and power supply status monitoring achieve extraordinary output performance from the design.

Orchid Technologies develops custom electronic products for OEMs and has successfully completed hundreds of electronic product designs. Orchid offers its clients a skillful blend of innovative hardware and software design with practical production expertise.

www.orchid-tech.com

(090752-I)

OPTEK donates 200 high brightness LEDs to university bridge development contest

TT electronics company OPTEK Technology recently donated 200 high brightness LEDs to an engineering team at North Carolina State University participating in the 2009 North Carolina Engineering Day, which enabled the students to develop a flexi-

ble, high brightness LED solution that ultimately won design competition. OPTEK's OVQ12S30x7 flexible LED light strips were utilized in the design for illumination of a pedestrian bridge at the Legislative Complex in Raleigh, NC.

The team's concept included a Plexiglass panel with sandblasted designs, with the LEDs placed in the frame of each panel to provide just the right amount of light to illuminate the bridge without excessive light pollution to the surrounding areas. According to a team spokesperson, the OPTEK LEDs were a key factor in their success.

In addition to bridge lighting, the flexible LED light strips are ideal for commercial and residential illumination, under-counter lighting, media illumination, large area backlighting, small to medium channel letters, point of sale displays, and neon replacement lighting. Available with red, yellow, green, blue, white and warm white LEDs, the flexible LED light strips feature a 120° viewing angle and are available with 30



LEDs per unit and 300 LEDs per reel. Typical luminous flux is 32, 32, 50, 20, 68 or 60 lm with red, yellow, green, blue, white or warm white LEDs, respectively.

The OPTEK light strip product line consists of OVM12F3x7 3-LED module strips with 30 modules per strip in lengths from 3 inches to over 40 feet, with 12 V input voltage and power dissipation of 1.5 W; OVM18F4x7 4-LED module strips with 20 modules per strip in lengths from 3 inches to over 30 feet, with 18 V input voltage and power dissipation of 1.5W; and OVQ12S30x7 flexible LED light strips with 30 high brightness LEDs per unit in lengths up to 16 feet, with 12 V input voltage and power dissipation of 2.7 W for red and yellow LEDs or 2.3 W for green, blue, white, and warm white. All module strips are waterproof and have an operating temperature ranging of -30°C to +50°C.

<http://www.optekinc.com>

(090752-II)

The next sound you hear: Laser-Accurate® sound recording

What is billed as the next evolutionary leap in microphone technology was unveiled recently at the AES Convention in New York. According to its inventor, Laser-Accurate technology revolutionizes the basic concept of the microphone, replacing mechanical movement particulate matter suspended in air by a patented and extremely incredibly precise laser measuring system.

There have been several key milestones in the evolution of microphones, starting with the development of the basic transducer in the 19th century and followed by the condenser microphone in the 1920s, FET microphones in the 1960s, and more recently, multi-channel microphones used in surround audio applications. The next step in this evolutionary procession was introduced at the 127th Audio Engineering Society Show in New York on Oct. 9–12, 2009. Laser-Accurate® technology from Schwartz Engineering & Design (SED), the leader in optical microphone design, represents a revolution in microphone technology. Instead of a conventional diaphragm whose resonance creates electrical impulses in a coil or back plate, Laser-Accurate technology uses a laminar stream of air in a chamber holding a suspension of microscopic particles. Changes in the motion of these particles due to excitation by varying air pressure are detected by a laser beam that continuously passes through the chamber and strikes a photoelectric cell opposite the laser source. As a result, Laser-Accurate is claimed to produce the most accurate and precise transduction of any sound. It is billed as the perfect microphone, capturing sound unadulterated by the mechanical motion of the diaphragm and the inevitable time lags caused by this motion.

Conventional microphone design has numerous inherent idiosyncrasies. The response of traditional diaphragm innately limited by its physical size and shape, and the variety of the mechanical elements inevitably adds tonal coloration (distortion) to the recorded sound. In Laser-Accurate design, the diaphragm is replaced by microscopic particles dispersed in a gas-filled chamber with a constant laminar gas flow. Detection of the displacement of the air stream and particles by a laser and optical receiver creates a completely non-intrusive method for measuring air movement. With this arrangement, there is no significant mass between the source of the sound and transduction to a recording medium.



YouTube videos: www.youtube.com/watch?v=Gqe79RpbPxU
www.youtube.com/watch?v=V2K5LJHTouQ

(090752-V)

MCU for USB starter kit facilitates touch/motion sensing design

Microchip Technology Inc. has released its MPLAB Starter Kit for PIC18 microcontrollers, which comes with all of the components, documentation, schematics, debugging and programming capabilities necessary for USB and touch-sensing applications. It includes a development board with a 44-pin PIC18F46J50 MCU featuring nanoWatt XLP technology for extremely low power, mTouch capacitive touch sensing, a Bosch Sensortec BMA150 accelerometer, 64 KB flash program memory, and more.

The Bosch Sensortec BMA150 digital triaxial accelerometer enables the PIC18 Starter Kit board to detect acceleration in three perpendicular axes for sensing the board's tilt and



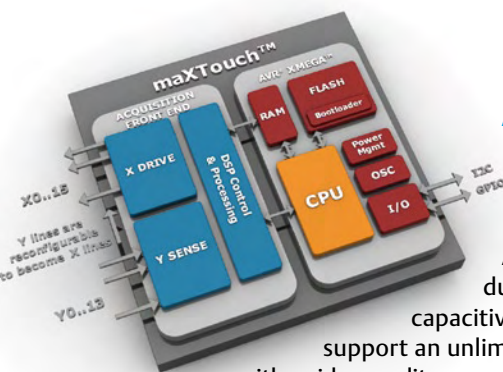
motion. The demo code included in the kit enables the board to operate as a USB mouse or joystick using the accelerometer. Acceleration on all three axes is used to compute the board tilt, which is then converted to movement of the mouse cursor on the X and Y axes. The accelerometer allows the cursor to move slowly when the board is tilted a small amount, or quickly when there is a steeper tilt.

Hardware debugging and programming come integrated with the MPLAB Starter Kit for PIC18 Microcontrollers, eliminating the need for a separate debugger or programmer. The kit is completely USB-powered. Pre-programmed touch-sensing code, as well as Microchip's free USB application stack and boot loader, eliminate the need for engineers to develop their own code.

Additionally, the board includes demo application software that enables it to read a memory card (MSD), operate as a USB mouse or joystick (HID), or function as a simple COM port (CDC) using the free Microchip stacks.

www.microchip.com

(090752-VI)

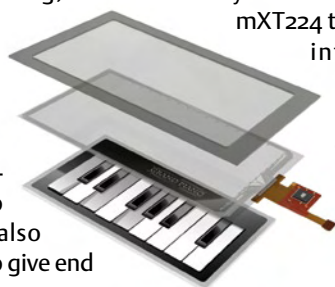


Atmel maXTouch™ human interface touchscreen solution

Atmel® Corporation has announced the production release of its new maXTouch™ family of capacitive touchscreen controller solutions, which can support an unlimited number of unique simultaneous touches with a video quality screen refresh rate of 250 Hz. Atmel's new maXTouch technology platform supports the development of touchscreens surpassing 10 inches with full zoom, rotate, handwriting and shape recognition functionality.

The first device in the family, the mXT224, has 224 nodes that allow it to accurately report the positions of unlimited simultaneous touches, and it can completely redraw the screen every 4 ms. The mXT224's large number of nodes and fast performance makes it the world's first touchscreen solution suitable for advanced touch screen functionality, including unintended touch rejection, stretch/pinch and rotate gestures, handwriting and shape recognition and face detection on mobile phones, mobile Internet devices (MIDs), and netbook screens surpassing 10 inches.

By integrating the entire capacitive sensing circuitry on-chip, the maXTouch products provide a fully integrated single-chip solution without the need for external components to support the capacitive sensing, thereby minimizing cost and PCB footprint requirements. Multiple mXT224 touchscreen devices can be used to provide smaller interspatial distances between touches on larger screens. The mXT224 is the first capacitive touchscreen solution able to support the use of a stylus for drawing or signature capture and character recognition, thanks to its 80:1 signal-to-noise ratio and extremely fast refresh rate. The maXTouch also provides advanced noise suppression algorithms to give end products high immunity to coupled noise.



The unlimited number of touches possible with Atmel's maXTouch technology is the result of its mutual capacitive sensor design, combined with Atmel's ChargeTransfer signal acquisition method. Unlike self capacitance technologies that sense individual rows or columns, leading to ambiguity in reported multi-touch positions, mutual capacitance sensors create a matrix of independent capacitive sensing nodes at the intersections of the rows and columns. Using Atmel's maXTouch technology, each of these nodes is independently scanned within the matrix to accurately sense the positions of an unlimited number of touches and deliver smooth movement everywhere on the screen.

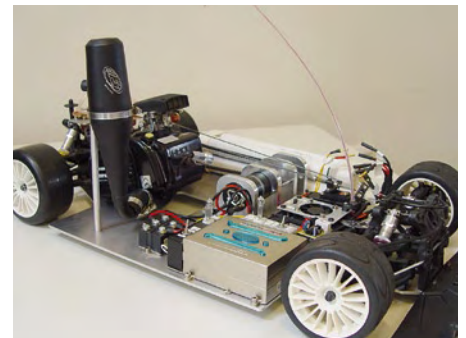
www.atmel.com/maXTouch

(090752-VII)

Redox batteries recharge by refilling

An interesting perspective for e-car batteries has been developed by the Fraunhofer Institute for Chemical Technology (Fraunhofer ICT): instead of time-consuming recharging, the electrolyte in the battery could be replaced in just a few minutes.

Their research focuses on redox batteries, which have a liquid electrolyte that produces electric energy in a converter similar to what is used in power generators based on fuel cells. Although the redox principle is not new, the Fraunhofer researchers have succeeded in significantly improving the energy density and thus the energy content of redox batteries. They managed to boost the energy density by the factor of 4 to 5, which gives redox batteries an energy density comparable to that of lithium ion batteries.



The redox system has several potential advantages. The first one is that at a filling station the exhausted electrolyte could be replaced by a fresh filling. This would take only a few minutes, compared with several hours to recharge a lithium battery. Second, redox batteries could be less expensive. While the converter is still rather expensive, the electrolyte is cheap, and the cost at the system level could be cut in half. High prices of lithium ion batteries are one of the major challenges for the design and acceptance of electric cars. Third, lithium ion batteries are rather tricky devices, and in some situations they can be dangerous. They can easily catch fire or even explode. For this reason, strict control of all operational parameters is mandatory with lithium ion batteries. Redox batteries, by contrast, are safe. According to a Fraunhofer Institute researcher, they are robust and non-hazardous.

www.ict.fraunhofer.de/EN/coreco/AE/Batt_tech/Redoxflow-Batterie/index.jsp
(090752-VIII)

Liquid OLEDs could power flexible displays and e-readers

The possibility of combining the rich color gamut of organic light-emitting diode (OLED) displays with enhanced flexibility is opened up by an academic paper on a liquid OLED display in a recent issue of *Applied Physics Letters*.

Denghui Xu and Chihaya Adachi of the Center for Future Chemistry at Kyushu University in Fukuoka, Japan, have reported an OLED with a liquid host of 9-(2-ethylhexyl)carbazole (EHCz) doped with a guest emitter of 5,6,11,12-tetraphenylnaphthalene, otherwise known as rubrene.

Up to now, OLED displays have been made using solid state devices and have the advantage over liquid crystal displays of not requiring a backlight. OLEDs are light emitters, so they can be energy efficient and be made



very thin. However, manufacturing infrastructures support cost-efficient LCD manufacture over a large range of sizes, while OLED displays have been kept to small sizes. According to the authors of the paper, although OLED displays have generally used fully solid-state organic thin films and partly liquid crystals, no attempt to examine neat liquid organic semiconductors has been reported, other than some reports using polymer solutions and solution-phase electroluminescent devices.

As well as being useful for flexible emissive displays, liquid semiconductors could also be useful more generally to enhance the reliability and longevity of organic semiconductor systems such as FETs and solar cells. The authors propose circulatory OLEDs in which the liquid organic semiconductor material is circulated or refilled into the active emitting layer so that fresh organic semiconductor media is available.

http://scitation.aip.org/journals/doc/APPLAB-ft/vol_95/iss_5/053304_1.html
(090752-IX)

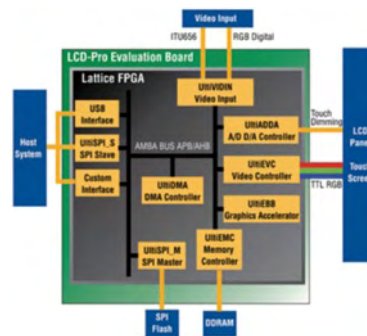
Lattice offers evaluation platform for touch-screen LCDs

Lattice Semiconductor an advanced FPGA-ing and control supported by Lattice part-the LCD-Pro evaluation low-cost LatticeECP2™ devices and the Ultics Intellectual Property The LCD-Pro platform of active matrix TFT to 23 inches, and it tion of advanced LCD controller IP for LCD applications in automotive, consumer, white goods, building automation and industrial control markets.

Designed to provide comprehensive graphic processing functionality, the LCD-Pro platform incorporates a 2D graphics accelerator and can handle picture scaling and cropping of real-time video. An IC interface facilitates plug-and-play LCD connectivity, while a backlight inverter provides on/off and dimming control.

LCD-Pro is a configurable, advanced, touch-screen video evaluation platform that can accommodate LatticeECP2 SRAM FPGAs and LatticeXP2 non-volatile FPGAs. It provides four-wire analog resistive touch-screen inputs, and overall system capability can be expanded by adding SRAM and flash memory. A high-speed USB 2.0 interface operating at 480 Mbps ensures the rapid transfer of graphics images and speedy system programming. The kit comes complete with an included 7" active matrix TFT display with touch screen capability, video camera, USB cable, power supply, and CD-ROM. In addition to the Lattice device, each evaluation platform features 64 Mbyte of DDRAM video memory and a powerful 16 bpp LCD video controller that can be configured for resolutions from QVGA to high definition in 4:3 and 16:9 formats, as well as a 16:10 format for the gaming industry. LCD-Pro supports composite video and analog VGA input and will accept real-time video input streams.

www.latticesemi.com/products/developmenthardware/verticalmarketsolutions/lcdproevaluationkit.cfm
(090752-X)



has released LCD-Pro, based LCD video imagn-tions platform. Devel-ner Exor International, platform is based on the and LatticeXP2™ FPGA Logic family of graph-(IP) Cores from Exor. addresses a wide range displays from 2 inches enables rapid evalua-video and touch-screen video display and HMI



ARM throws its weight behind the Linux Foundation

Processor intellectual property licensor ARM Holdings plc (Cambridge, England) has become a member of the Linux Foundation, a nonprofit organization dedicated to accelerating the growth of Linux.

ARM has contributed to the Linux kernel, the Linux Foundation said. ARM's partnership with leading semiconductor and device manufacturers will help to strengthen the mobile computing software ecosystem and extend the market reach for Linux-based products, the group added.

"Companies such as ARM are leading the mobile Linux revolution," said Amanda McPherson, vice president, marketing and developer programs, at The Linux Foundation. in a statement. "There is a transition taking place right now that moves computing from the PC to more innovative mobile and consumer devices," said Ian Drew, executive vice president of marketing at ARM, in the same statement. "ARM has been a leader in enabling this transition and joining the Linux Foundation is a natural step towards advancing innovation in the Linux community for a rich, always-connected, computing experience."

www.linux-foundation.org

(090752-XIV)

From 8 to 32 bit: PSoCs with 8051 and ARM cores

By Jens Nickel (Elektor Germany Editorial)
 The chip manufacturer Cypress Semiconductor is introducing two new variants to their PSoC (Programmable System on Chip) family of devices. The new PSoC3 architecture is based on an 8051 compatible core while the PSoC5 includes a 32-bit ARM Cortex-M3 processor. Since the original version using this architectural concept was introduced six years ago the company has shipped 500 million units but this new generation of devices with its improved capabilities promises to open up even more areas of application. In a time of credit crunch and recession it seems as though the embedded controller market is one area of growth in US manufacturing.

Just like the earlier version of this chip architecture (now renamed PSoC1) the new system-on-chip variants contain digital building blocks which are configured via software (just like a CPLD) to produce timers, counters PWM generator and a whole lot more. Uniquely the PSoC1 and the two new PSoC chips have the capability to configure analogue circuits also so that ADCs (with 20-bit resolution), DACs, mixers, PGAs (Programmable Gain Amplifiers), opamps and much more can all be implemented on-chip. The chip architecture is popular with designers because it often results in a true single-chip solution which reduces time spent in development and produces a finished chip which occupies much less space on the PCB compared with other solutions.

From Drag & Drop to finished circuit

Programming and configuring the new PSoC-Chips is accomplished using the 'PSoC Creator' Integrated Design Environment (IDE). This powerful tool is free to download from Cypress Semiconductor. The PSoC Creator environment allows the connectivity of the functional blocks in the chip to be defined using a 'drag and drop' graphical interface placing the blocks on a 'design canvas'. The IDE is supplied with a library of dozens of pre-configured analog and digital peripherals and the user can also develop new blocks and add them to a library as necessary. The user interface allows the functional block connections to be configured down to opamp level and 'parameterized' to make optimum use of the on-chip resources. An integrator for example could be reconfigured as a differentiator; the user

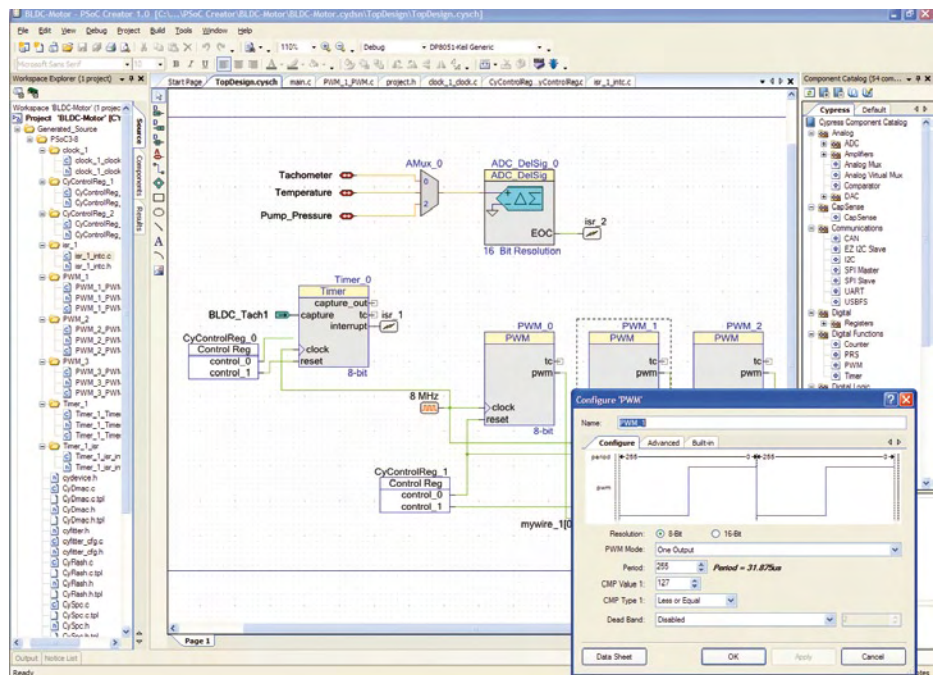


can select the amount of feedback and much more besides. At the press of a button the tool generates a set of APIs which allows the running software access to the functional hardware blocks. For controller software development there is a CA51 Compiler from Keil and a GNU GCC-ARM Compiler included in the IDE. The 'PSoC Creator' combines and expands on the functionality of the earlier 'PSoC Designer' and 'PSoC Express' tools which were developed for use with earlier PSoC1. PSoC Creator is a completely new development and not compatible with these older tools.

Faster, Better, Bigger, More

The introduction of these new variants to the PSoC family was spurred by the custom-

er's request for more processing power. The earlier PSoC devices are based around an M8C core and many have been put to good use in the design of computer keyboards and USB mice. Processing power is sufficient for jobs such as motor control and sensor interfacing e.g. the 'CapSense' capacitive proximity detector input sensor developed by Cypress to replace unreliable mechanical switches and sliders. More advanced applications such as audio/video processing, multimedia (now in the automotive sector) and high speed communication processing all demand significantly more processing power. The need for speed is ever present. Cypress estimates that the potential market for its 8 to 32-bit embedded controllers could be in the region of \$15 billion. Com-



peting manufacturers offering FPGAs and other similar programmable devices will also take some share of this market.

The new PSoC variants bring with them impressive processing power: The 8-bit 8051 processor achieves 33 MIPS while the 32-bit ARM Cortex-M3 can hit 100 MIPS and its DMA interface achieves fast memory access. In addition the number of programmable gates has risen from 1,000 on the original PSoC1 up to 20,000 on the PSoC3. Filter functions are now realised digitally rather

chips also provide support for full-Speed USB, I2C, SPI, UART, CAN and LIN interfaces. The PSoC5 is also fitted with a JTAG debug interface.

Starter kits from \$49 US

First samples of the PSoC3 chip should be available from November 2009 and it is anticipated that samples of the PSoC5 will be available by the beginning of 2010. Production is due to commence in the first quarter and second half of 2010 respectively. The chips will be available in a vari-



Renesas ultra low cost QVGA TFT direct drive demo set

Renesas Technology has announced an ultra low cost QVGA TFT direct drive solution based on the R32C/111 32-bit CISC MCU, which is part of Renesas' popular M16C microcontroller platform. The solution uses an R32C/111 Starter Kit and a TFT add-on board developed by Segger, who have recently become a Renesas Platinum Alliance Partner.

With a large embedded RAM and flash as well as the standard peripherals, the R32C MCU in the QVGA drive circuit eliminates the need for additional external components such as a display driver or external memory. To scale peripheral, performance and RAM usage, the set provides four color modes: monochrome, 4-bit greyscale, 8-bit greyscale, and 8-bit color.

Typical applications for this smart solution include the EPOS market, HVAC, power and security panels, and a broad range of industrial equipment where external memory requirements make a design with a 16-bit color TFT display too expensive.

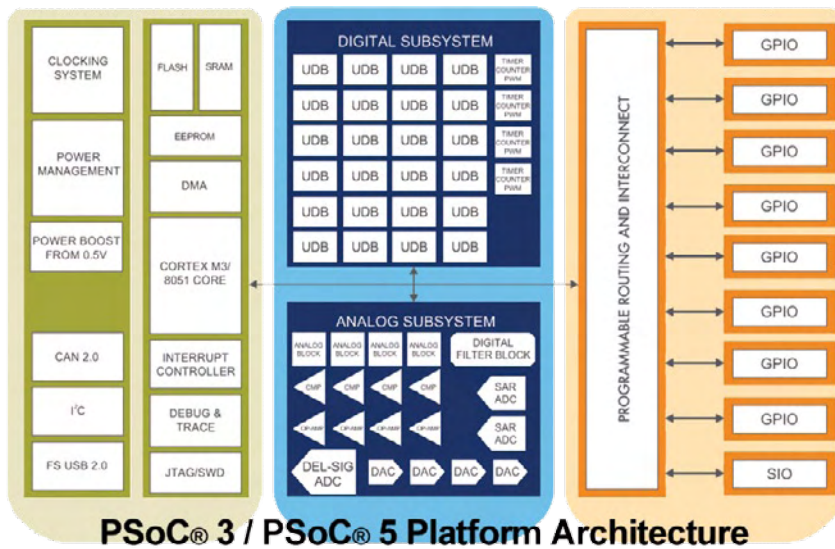
The combination of Segger's emWin GUI and embOS RTOS with the Renesas hardware forms the perfect foundation for the development of embedded product with QVGA displays. Both middleware products follow Segger's strict and efficient coding and documentation standards, which yield very small memory footprints as well as high execution speed and easily readable code. For easy implementation, Segger offers board support packages for embOS and emWin optimized for use with the R32C/11x group and TFT add-on board, as well as a complete trial package.

The QVGA TFT direct drive demo set is available now. Interested parties should contact the Renesas sales office or Segger directly.

www.renesas.com

www.segger.com

(090752-III)



than as analog blocks. This should increase available bandwidth; the original was good for signals up to 150 KHz before it ran out of steam. Prominent at the top of the data sheet are the power saving features of the design: firstly the supply voltage range is quoted as 5.5 V to 0.5 V (!) while 'hibernate' mode of the PSoC3 consumes just 200 nA which should be good news to designers of small mobile equipment, wireless sensors and other ultra low power applications.

A significant advantage of the family is the pin and API compatibility between the 8 and 32-bit architectures. This means that a designer can start system design with a PSoC3 and if later on more processing power is required the existing design can migrate up to the PSoC5 platform without problems. A good feature to simplify circuit layout is the free allocation of any GPIO pin to any signal in the functional blocks. The

ety of package outlines offering different levels of integration (memory size and GPIO count). The unit price is expected to be in the range between 1 and \$10 US. Two evaluation kits are available: the PSoC 3 FirstTouch™ Starterkit retails at \$49 US and includes a PSoC3, evaluation board and on-board acceleration sensor, thermistor and 'proximity detector' (we took a closer look at the starter kit in last month's edition of Elektor). A more comprehensive kit costing \$249 US is well appointed and contains both a PSoC1 and a PSoC3 processor board. This will give developers a hands-on opportunity to compare the two PSoC systems.

The Cypress Semiconductor website is the place to go for data sheets, application notes and also to download the 'PSoC Creator' software package, just follow the link below.

www.cypress.com/psoc

(090775-I)

Where (in the World) Can You Get It?

Ordering electronic components



By Thijs Beckers (Elektor Netherlands Editorial)

As far as electronic components are concerned, going out to do a bit of shopping is a thing of the past. Now you can order almost everything on the Internet. Email, plain English and a credit card go a long way. You just have to wait a little while for the courier service, and then you have what you want. Despite retail having gone e-tail, a visit to your local electronics shop can have its advantages. Here we present an overview of electronic component suppliers.

As opposed to five years ago, or even a bit longer, nowadays almost every electronic parts retailer or distributor has an Internet presence. In fact, the situation has completely reversed: in many cases there's only a webshop, so you unlike the glory days of London's Edgware Road you can't just pop in and pick up your components, or have them handed to you over the counter.

How does this affect the availability of electronic components? And what about service and prices?

Can you get anything you want?

There are now countless webshops on the Internet. Of course, most of them are aimed at consumers, but the situation in the

electronic components business is somewhat different. As this involves individual components instead of finished products, it is much more common for a company (OEM) to order these components (in bulk) with a view to making an end product, which is then ordered by an end user.

There are a number of large companies, such as Farnell, Mouser, DigiKey and RS Components, which can supply nearly all commonly used electronic components. If you are a commercial customer, they offer a good range of products and (in most cases) a good search engine. However, it is often difficult (or more difficult) for private persons to place orders with these companies, since they are used to handling orders for large quantities. In addition, you can often find components at lower prices elsewhere, such as in much smaller webshops that specialise in particular components. Naturally, this requires a certain amount of searching, but as a private person you can usually find the time for this — at much lower cost than, say, a 50-mile ride, or a bus ticket to the nearest city (and finding the shop closed).

Most large wholesalers and distributors only take orders from commercial customers. If you don't fall in this category, you can ask your acquaintances whether they know someone with a small business registration who would be kind enough to place an order for you. Here you have to bear in mind that prices on sites of this sort typically do not include sales taxes, which you have to pay as well.

Other sources

In addition to webshops, you can find electronic components on auction sites and sites that sell second-hand goods. The best known example is www.ebay.com, but if you ask your favourite search engine to look for auction sites you will find many more. On the eBay site, it's usually worthwhile to look for shops (eBay stores) that specialise in electronic components.

Service

If you take the traditional approach of visiting your local (or nearest) electronics shop, you can usually expect to receive suitable assistance from the sales staff. Their knowledge (with regard to more than just components) can come in handy when you are looking for a particular solution, so don't be afraid to ask for help.

When you search for components on the Internet, you are fully on your own. You have to personally pick the right component package (now then, what should it be: TQFP, LQFP, or something else?). You may be able to obtain useful information from forums oriented toward electronics, such as a number of the .alt and .sci Yahoo newsgroup clusters. Some sites provide component data sheets, which can be very helpful. They can be very useful when you're making a PCB layout or looking for a component with suitable specifications.

Tips!

- Many manufacturers let you order free samples. In this case, you can obtain a few components either free of charge or by paying the shipping charges only.
- In quite a few cases, you can also order directly from the manufacturer. This may not be the least costly approach, but it is certainly the most direct.
- Data sheet sites such as www.alldatasheet.com, www.datasheetarchive.com, and www.datasheetcatalog.com are especially useful.
- Exercise caution with orders direct from China and other far Asian countries, since they are a source of many fake items.

Group purchasing

Some components are only available in large quantities. As a private person, you often need only a small quantity or just one, so it's unreasonable and not affordable to buy 100 or more at once.

A group purchase often provides a remedy in such situations. Someone takes the initiative to organise the purchase of a particular component (or even a complete product) from a wholesaler at a reduced price. If enough people can be found to participate in the group purchase, the initiator orders the components or products and forwards them to the other members of the group after they are received.

These purchases are usually organised via a website in order to find enough participants. Group purchases of specific items, such as engines for model aeroplanes, are often organised on hobby sites.

As you are dealing here with an individual who organises the purchase, rather than a webshop, it's a good idea to first make sure that the person concerned is trustworthy, such as by looking for previous group purchases organised by this person. Of course, there's always a certain risk, but if you find many positive comments and few if any negative comments, you generally don't have to worry.

NOS and NIB

A noteworthy phenomenon is companies that sell what are called 'NOS components'. 'NOS' stands for 'new old stock', which means components that are unused (and thus new) but which are no longer in production and have been in stock for a while, perhaps tucked away in the back of a warehouse ('old stock'). In particular, there is a surge in demand for valves that were once produced by companies that no longer exist. 'NIB' (new in box) is also sometimes taken to refer to the above type of component.

This can even go so far that a company buys a full fabrication system — the complete production line with all the original machinery — in order to produce and sell 'old-fashioned' components. For example, Russian Sovtek valves are made using former Telefunken machinery.

Company	Web Site	Category / Notes	Country
Ack Supply	www.acksupply.com	Distributor - Audio Accessories	USA
Action Electronics	www.action-electronics.com	Parts - Equipment - Tools	USA
AE Associates, Inc.	www.ae4electronics.com	Distributor - Parts	USA
All Electronics Corp	www.allelectronics.com/	Parts, Emech, Audio	USA
Allied Electronics	www.alliedelec.com	Disributor - Electronic Parts	USA
Alltronics	www.alltronics.com	Parts - Surplus	USA
American Science & Surplus	www.sciplus.com	Parts - Kits - Weird Stuff	USA
Angela Instruments	www.angela.com	Audio - Tubes	USA
Antique Electronic Supply	www.tubesandmore.com	Parts - Tools - Equipment	USA
Apex Jr	www.apexjr.com	Excess & Surplus Stock - Audio	USA
Arrow Electronics, Inc.	www.arrow.com	OEM - Distributor - Parts	USA
Audio Lab of Georgia	www.audiolabga.com	OEM - Speakers & Drivers	USA
B.G. Micro	www.bgmicro.com		USA
BJM Electronics		out of business?	USA
BTX Technologies	www.btx.com	Cables and connectors	USA
C & H Sales		out of business?	USA
CE Distribution	www.cedist.com	Parts	USA
Circuit Specialists Inc.	www.circuitspecialists.com	Kits - Parts - Educational materials	USA
CTR Surplus Online	www.ctrsurplusonline.com	Surplus Outlet	USA
Digi-Key Corporation	www.digikey.com	Parts - Tools - Equipment	USA
Electronic Dimensions	www.el-dim.com	Surplus - Test Equipment	USA
Electronic Goldmine	www.goldmine-elec.com	Electronic Parts - Kits	USA
Electronic Part Supply	www.electronicpartsupply.com	Parts	USA
Electronic Surplus Ind	www.a1parts.com	Surplus - Parts - Equipment	Canada
Electronic Surplus, Inc.	www.electronic surplus.com	Parts - Audio & Video	USA
Carl's Electronics	www.electronickits.com	Robotics - Parts - Educational	USA
Electronics Emporium		Closeouts merchandise	USA
Electronics Information Line	www.eio.com	Parts - Tools - Equipment	USA
Electronics Plus	www.electronics-plus.com	out of business?	USA
Electronix Express	www.elexp.com	Parts - Kits - Tools	USA
Electus Distribution Pty. Ltd.	www.electusdistribution.com.au	Parts - Equipment - Tools	Australia
Excess Solutions	www.excess-solutions.com	Surplus - Parts - Equipment	USA
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Gateway Electronics of MO	www.gatewaycatalog.com	Parts - Equipment - Tools	USA
HSC Electronic Supply	www.halted.com	Parts - Equipment - Tools	USA
International Sales of Electronics	www.isesurplus.com	out of business?	USA
J&R Music World	www.jr.com	Consumer electronics	USA

Jameco Electronics	www.jameco.com	Full Line Parts - Tools - Equipment	USA
Jaycar Electronics	www.jaycar.com	Full Line Parts - Tools - Equipment	Australia
JDR Microdevices	www.jdr.com	PC - Parts - Kits	USA
Knopp Electronics	www.knopp.se	Tube amplifiers	Sweden
Krager Components	www.kragercomponents.com	OEM - Ferrites - Connectors - EMI products	USA
Leeds Electronics	www.leedselect.com	Parts	USA
Lenco Electronics	www.lenco-elect.com	Transformers	USA
Main Electronic Supplies Ltd.	www.mainelectronics.com	Parts, Emech, Audio	Canada
Mapletree Audio Design	www.mapletreeaudiodesign.com	Tubes	Canada
Mark Electronics Supply	www.markelectronics.com	Parts - Kits - Emech - Cables - Connectors	USA
Marlin P. Jones & Assoc., Inc.	www.mpja.com	Parts - Equipment - Tools	USA
Marshall Electronics Inc	www.mars-cam.com	LCD - Video - Cables - Multimedia	USA
Millennia Media	www.mil-media.com	Audio	USA
Minuteman Electronics	www.minute-man.com	Parts - Tools - Equipment	USA
Mouser Electronics	www.mouser.com	Full Line Parts - Tools - Equipment	USA
New Sensor Corp.	www.newsensor.com	Tubes - Audio	USA
Newark in One	www.newarkinone.com	OEM - Full Line Parts - Tools - Equipment	USA
NTE Electronics	www.nteinc.com	Parts - Equipment - Tools	USA
Partridge Electronics	www.partridgeelectronics.co.uk	Parts - Surplus - Kits	United Kingdom
Parts Connexion	www.partsconnexion.com	Audio - Parts	Canada
Parts Express	www.partsexpress.com	Audio - Video - Parts	USA
Pololu Corporation	www.pololu.com	Robotics - Microcontrollers	USA
Quickar Electronics, Inc.	www.quickar.com/	Audio - Parts - Surplus	USA
Radio Shack	www.radioshack.com	Parts - Tools	USA
Rainbow Electronics	www.rainbowelectronics.com	Parts - Emech	USA
Ramsey Electronics, Inc.	www.ramseykits.com	Kits - Parts	USA
Relay Specialties Inc	www.relayspec.com	OEM - Relays	USA
RF Parts Company	www.rfparts.com	RF parts - Broadcast Industry	USA
Saelig Company Inc.	www.saelig.com	Control & Instrumentation products	USA
Skycraft Parts & Surplus Inc	www.skycraftsurplus.com	Surplus - Parts	USA
Sound City	www.soundcity.com	Audio - Video	USA
Stark Electronics	www.starkelectronic.com	Parts - Tubes - Equipment - Tools - Surplus	USA
Surplus Sales of Nebraska	www.surplussales.com	Parts - Equipment - Obsolete Parts	USA
Test Equipment Depot	www.fotronic.com	Test Equipment	USA
TRG Components	www.trgcomp.com	OEM - Distributor	USA
Triode Electronics	www.triodeelectronics.com	Tubes - Parts - Audio	USA
Unicorn Electronics	www.unicornelectronics.com	Parts - Obsolete Parts	USA
You-Do-It Electronics Center	www.youdoitelectronics.com	Parts - Emech - Kits - Hardware	USA

Reader feedback

We received a few responses to our request in the i-TRIXX e-Weekly item for week 35, 2009. Here we would like to share one of them with you.

Dear Elektor,

sadly we have found that all the electronics shops in our region have disappeared. This is not such a great problem for us as a company, since we can do business with all sorts of distributors.

However, I was looking for MRF286 FF transistors for a personal project. We managed to find a few via HK Inventory, so we initiated a request for quotation (RFQ). We received several hundred responses to this request from the Hong Kong and China region, with unit prices ranging from \$5.50 to \$150.

I happened to know from one of my customers that prices in this region depend on whether you are a Chinese or non-Chinese customer. He has a native Chinese employee who requests prices for his needs and has the orders delivered to an address in China, and who personally organises the transport from that location. If suppliers have any idea that you are a foreigner, the prices increase sharply. In addition, the suppliers are not paid until the goods are delivered

to my customer in China, as otherwise you apparently never receive your goods.

Knowing this, I asked my customer for a favour: to have his buyer order the transistors for me. I was quite willing to purchase several hundred, as long as I got a fair price. The specifications were clear: this transistor in this package with this manufacturer code. I sent the buyer a list of the responses I had already received that appeared to me to be plausible. However, it turned out that things weren't that simple. Some people tried to tell me that there were different versions of the transistor (despite the fact that the specifications were so clear that there was only one possibility), while others did their best to sell me development services because it takes professional expertise to solder components on a circuit board.

It ultimately turned out that all the suppliers who initially responded to my RFQ were beating about the bush. They were presumably trying to get a foot in the door so they could supply other products. A year later, some of them are still sending me lists of their product lines. None of them include RF transistors, which is what I am interested in.

The friend of the Chinese buyer also told us that salvaged items are often sold as new. At that point, we put an end to the exercise and started looking for a different solution.

Jeff V. (Belgium)

Prices and charges

The enormous free market created by the Internet results in fierce competition and very price-conscious consumers. This naturally puts strong pressure on the prices charged by suppliers, but the downside is that shipping charges and import duties are almost always added to Internet orders because the shop isn't just around the corner or there simply isn't any shop where the components can be picked up.

Finding the lowest price is an entertaining challenge, but it is sometimes like looking for a needle in a haystack. It often happens that some of the components you need for a project are available at very good prices in one webshop, while some other components are less expensive in another shop. It sometimes takes a lot of calculation to figure out that it would have actually been less expensive to order everything from that webshop with the high shipping charges.

Overview

To make your searching a bit easier, we have put together two tables with some useful internet addresses. Unbiased and by no means exhaustive, it presents an overview of the best known suppliers of electronic components, along with their characteristics or special features. Where a supplier is marked 'distributor' in the Notes col-

umn it is not usually possible to order from them as a private individual — but feel free to try. "Broadband supplier" indicates that a wide range of components and materials is stocked, including passives, semiconductors, connectors, cables and electromechanical parts. These companies typically pride themselves in publishing catalogues "thicker than the Bible".

We welcome additions and updates to the tables, so all readers can benefit. Naturally, you can also visit our forum [1], where other users may be able to point you in the right direction and where you can tell other users about your favourite supplier or webshop.

(090592-1)

Internet Link

[1] www.elektor.com/forum

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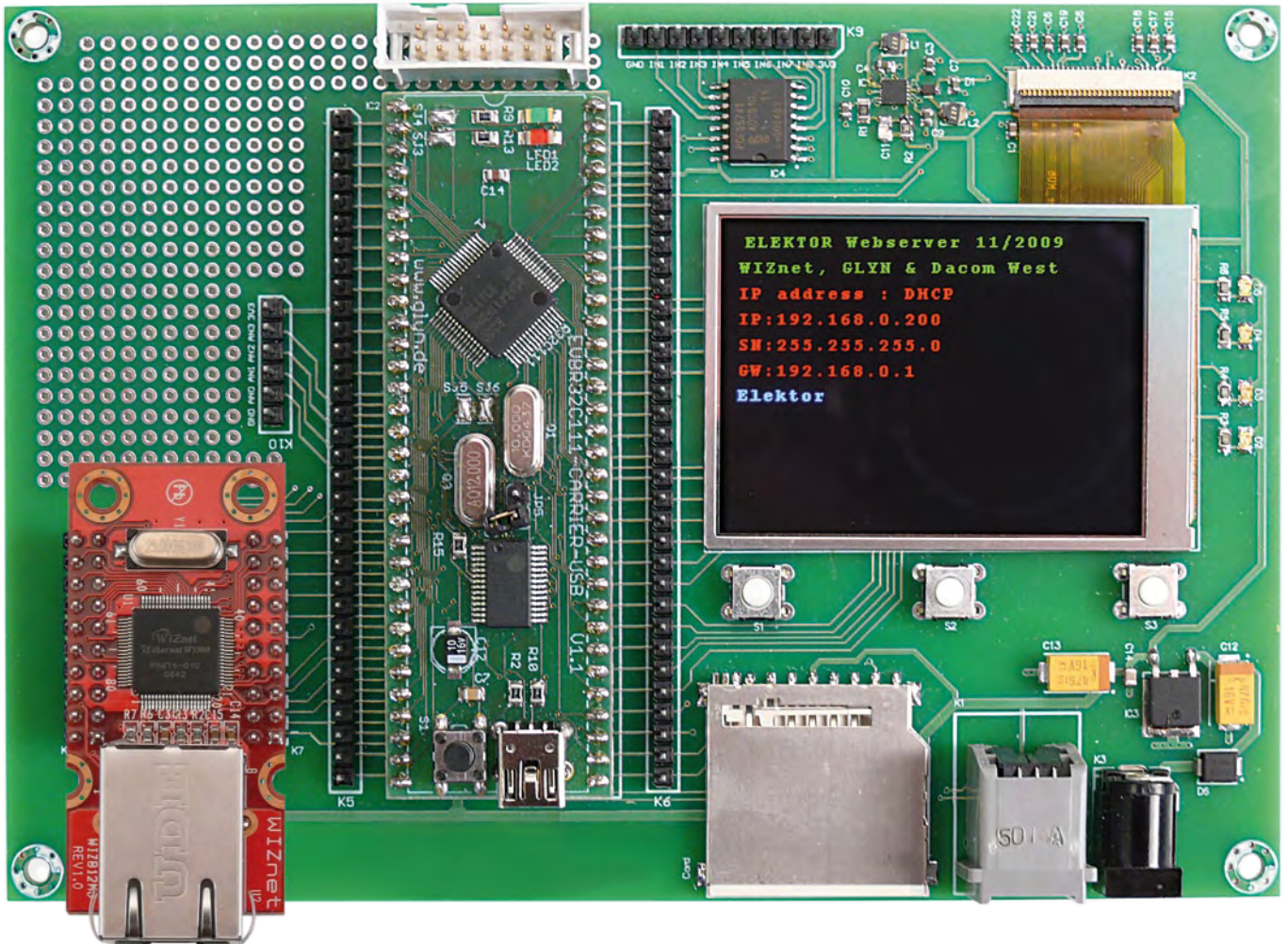
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R32C Web Server

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e-Mail, FTP and much more

by Jinbuhm Kim (South Korea) and Joachim Wülbeck (Germany)

The R32C microcontroller goes Internet! A small add-on module for the application board from our September 2009 issue combines a TCP/IP chip plus Ethernet interface, a network connection with built-in transformer and status LEDs. This handy combination makes it child's play to implement a web server and many other Internet applications without getting involved in complexities such as TCP/IP protocol. Free downloads of an Open Source driver, a short web server program and other sample software complete this attractive proposition.

The South Korean electronics company WIZnet [1] has its origins at the University of Seoul eleven years ago. Within a short

while it had produced the W3100, the first hardwired TCP/IP chip on the market with a 10/100 MBit/s Ethernet interface. The

Internet protocol stack in this was created in hardware, so as to relieve the MCU of complicated TCP/IP protocol processing.

The schematic in **Figure 1** shows a section of the application board, the connections for the W5100 and the hook-up with the network module. The WIZ812MJ consists of the W5100 plus a crystal, RJ-45 connector and some gates. These gates combine various LED signals from the W5100 in order to produce a steady (non-flashing) link signal. An inverter uses the SPI chip select (/SCS) output to generate the inverted SPI enable (SEN) signal. This means the /SCS connection between controller and Internet chip is all you need to initiate SPI mode.

The internal core voltage of 1.8 V is produced by the W5100 itself. These and all other operating voltages are stabilized by capacitors on the WIZ812MJ module, although for the sake of clarity they (and the external 3.3 V regulator) are omitted from the schematic.

The Physical Layer

A symmetrical transformer is integrated within the RJ-45 connector. This enables the PHY in the W5100 to swap RX and TX signal lines when necessary. This function is known as auto crossover (auto-MDIX for short) and avoids the need for crossover cables. Consequently you can use normal patch cables for the direct connection to the PC.

The auto-negotiation function determines the physical data rate (10 Mbit/s or 100 Mbit/s) automatically, together with other counterpart connection parameters such as full or half duplex. Once complete, point-to-point connection is made and the link is established.

Signals can be transposed within the pairs RX+/RX and TX+/TX. At

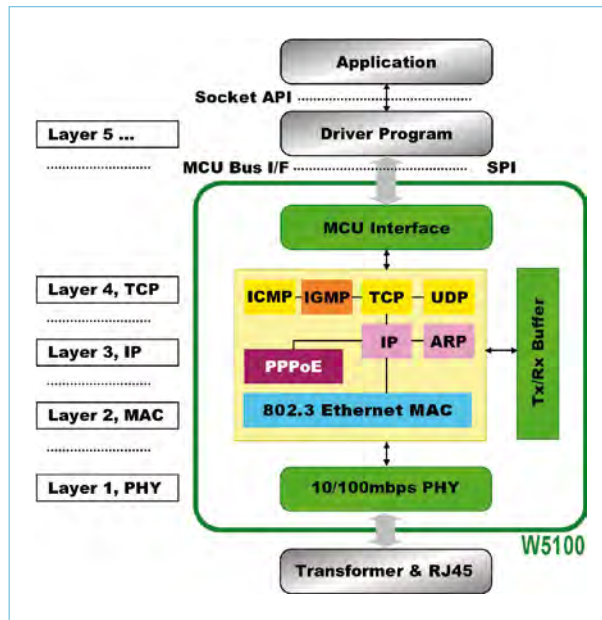


Figure 2. On the W5100 the PHY, MAC and TCP/IP protocols are embedded in hardware to reduce the load on the controller (and on the programmer!).

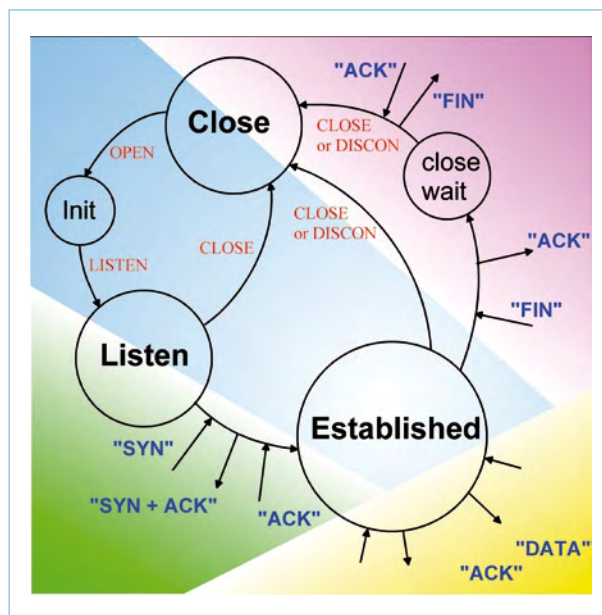


Figure 3. Status diagram of a web server. The W5100 takes charge of the boring details and corresponding driver functions, with the status management function operations clearly visible in the main program (see Listing 2)!

10 Mbit/s speeds the polarity of the PHY will be recognized and inverted when required (polarity reversal). A different technique is used at 100 Mbit/s. There is no longer any polarity here, as ones are signalled as a level change and zeros by breaks. To guarantee reliable clock retrieval, the bitstream is transcoded specially so that excessive numbers of ones or zeros are never sent in direct succession.

The TCP/IP protocol

Network connections are always regarded as layers that are constructed one above the other, defined in general terms in the so-called ISO/OSI levels model. In this system data and commands from a higher level are passed down to the next one below, with data and replies received back. In contrast to this kind of 'vertical communication' a virtual point-to-point connection is established horizontally between two equal levels on either side of the communication link. This calls for a number of protocols at the corresponding levels.

The inner construction of the W5100 and the protocol levels are shown in **Figure 2**. The W5100 handles all tasks in the first four layers (PHY + MAC + TCP/IP). Application and driver program activities are processed at Layer 5 and control the W5100. The driver needs to be interfaced correctly to the microcontroller employed and for the mode of communication required (SPI or parallel); WIZnet provides source code for various 8, 16 and 32-bit controllers free of charge. The tasks handled by the application program are confined then to status control (see below) and the specific application.

The application program also assigns the IP address. For this purpose the W5100 has its so-called Common Register in the memory range from 0x0000 to 0x0030, which stores all network-specific information (IP, Gateway and MAC addresses, Netmask, etc.). This register is cleared if you call a Reset. For this reason the network information needs to be stored in a non-volatile EEPROM location (integrated here in the R32C). This makes it possible to request an IP address and other networking details from a DHCP server (e.g. a DSL router) dynamically.

The Socket Registers (address range 0x0400 to 0x0800) store all configuration and status data for a maximum of four simultaneous connections ('sockets'). This is also where we define whether a socket is to operate as a client or server. A socket represents a virtual point-to-point connection and is effectively the interface to the outside world. Using this register the main program is also able to check the status of connections and react correspondingly following an interrupt or by regular polling. The send and receive store (16kB), address range 0x4000 to 0x8000, can be applied variably to serve up to four sockets.

Setting up connections

Figure 3 illustrates the states of a socket during a TCP connection. If we wish to implement a web server for example, the first thing to do is to configure a socket to Port 80 and initialize it. We do this using the two commands `socket()` and `init()`. The socket now changes from 'closed' status via 'init' into 'listen' state and is now in receive mode. A connection is not established a Client (for instance the browser in a PC) calls up data from this web server. TCP connections are always opened after double confirmation on both sides. These conformation data packets (handshaking) are generated independently by the W5100. Only after this is the horizontal connection created, when data can be transferred.

During the connection setup process the status of the socket changes from 'listen' to 'established'. The main program recognizes this status and can read out and analyze the

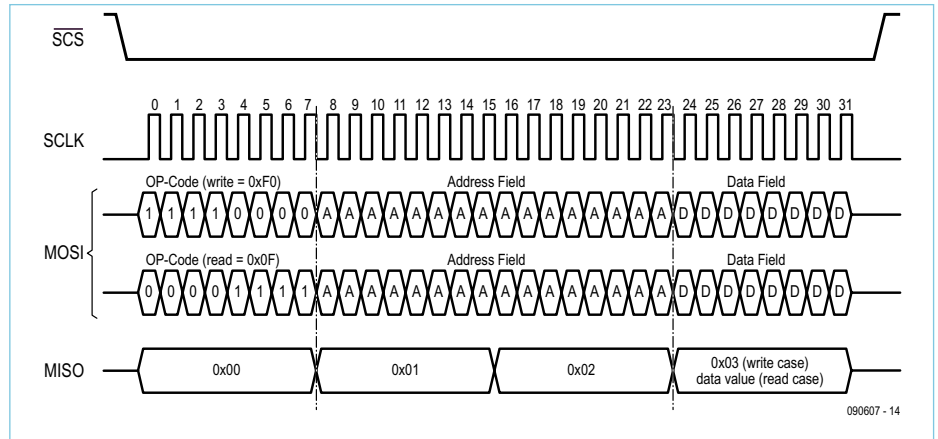


Figure 4. Reading and writing a byte over the SPI bus.

Abbreviations

ISO/OSI: Open System Interconnection (OSI) Reference Model. Defines the various levels of a communication process.

PHY: Physical Layer. Driver for data transmission in a specific medium, e.g. Ethernet. Lowest layer.

MII: Media Independent Interface. Interface between MAC and PHY.

MAC: Media Access Control. Packet relaying via MAC addresses (fixed addresses for relevant hardware, e.g. network cards) at the second lowest layer.

IP (IPv4): Internet Protocol. Address-oriented packet relaying at the third layer. IP addresses can be either fixed or assigned dynamically.

Net Mask: 32-bit word for dividing the IP address into the network address and a device address within the network.

DHCP: Dynamic Host Configuration Protocol. Enables automatic configuration of a network user. For instance DHCP is used to assign IP addresses dynamically to users.

Port: A single IP address can support several applications simultaneously, with each of these applications be assigned a different port. Specific port numbers are assigned by default for many applications.

TCP: Transport Control Protocol. Packet relaying for various services at the fourth layer with confirmation signal (acknowledgement).

UDP: User Datagram Protocol. Communication without acknowledgement, offering advantages of speed, e.g. for wireless Internet.

Socket: TCP/IP service or 'horizontal' connection at the fourth layer for delivering incoming data packets to the appropriate application process or thread. A socket is defined by a combination of IP address and port.

HTTP: Hyper-Text Transport Protocol. TCP service for retrieving web pages.

FTP: File Transfer Protocol. TCP service for transmitting files.

SMTP: Simple Message Transport Protocol. Used for sending e-mails.

Listing 1: Writing data over the SPI bus

```
uint8 WRITE(uint16 addr,uint8 data)
{
    IINCHIP_ISR_DISABLE();           // Interrupt disable
    SET_SCS(LOW);                    // CS=0, SPI start
    SpiSendData(0xF0);               // OP-Code for write
    SpiSendData((addr & 0xFF00) >> 8); // send address high byte
    SpiSendData(addr & 0x00FF);      // send address low byte
    SpiSendData(data);               // send data
    SET_SCS(HI);                     // CS=1, SPI end
    IINCHIP_ISR_ENABLE();
    return 1;
}

void SpiSendData(uint8 Val)
{
#ifdef USE_PORT_IO                    // software SPI
    uint8 i;

    for (i = 0; i < 8; i++)
    {
        W5100_P_SCLK = LOW;
        if (0x80 & (val << i)) W5100_P_MOSI = HI;
        else W5100_P_MOSI = LOW;
        W5100_P_SCLK = HI;
    }
    W5100_P_SCLK = LOW;
#else                                  // hardware SPI
    uart_begin( val );
    uart_end();
#endif
}

void uart_begin( register char cmd )
{
    te_u2c1 = 1;                       // enable tx
    uart_tx( cmd );                     // send the command
}

void uart_end( void )
{
    while( !ti_u2c1 );                  // wait for tx buffer to
empty
    while( !txept_u2c0 );               // wait for tx register to
empty
    re_u2c1 = 0;                        // disable rx
    te_u2c1 = 0;                        // disable tx
}
```

received data (for instance the URL of a website requested) from the receive store of the W5100. If requested, the reply data will be written to the output store and the command send() given. When the Client closes the connection, having received all of the desired data (in multiple packets should the need arise), the socket reverts to 'closed' after the corresponding handshake. The socket will now need to be initialized afresh before a Client can be registered again.

Additional protocol information, checksums, flags and so forth are processed by the W5100 internally during transmission and reception of data, with only the payload itself put into store.

The W5100 can handle a maximum of four sockets simultaneously and independently from one another. This means the server remains reachable when a socket is occupied (established), momentarily shut off (closed) or is just initializing itself afresh (init). Different sockets can also act simultaneously as a server or as differing clients and consequently monitor various ports or connect to servers. A socket can be a DHCP client first and when activated call up the network configuration from a DHCP server. Afterwards this socket can then become a web server. At the same time another socket can be forwarding an e-mail by SMTP. The third port is then (for example) another web server and the fourth an FTP server. Source code for all these applications is available free from the chip manufacturer. You can check out more on the subject of TCP/IP protocol on the Internet, for example in the 'TCP/IP Guide' [3].

Accessing the outside world

As already mentioned, the R32C application board provides not only SPI control but also parallel connection in indirect mode. Using parallel data transmission the W5100 is in a position to achieve data rates up to 25 Mbit/s. Anybody who feels like it is welcome to implement indirect mode and check out the maximum data rate of the R32C/111, but for this article we have concentrated on SPI mode. **Figure 4** sets out the signal timings of the SPI interface for writing and also for

Architecture and source code files

The web server application consists of a number of source code files that handle the functions listed above. In detail these are:

Main.c: The actual web server and status management controller. Can be customized for implementing an individual server.

Web server.c: Fundamental web server functions that can be used without alteration for users' own applications.

HTTPD.c: HTTP functions that can be used without alteration for users' own applications.

SOCKET.c: Functions for socket handling that can be used without alteration for users' own applications.

W5100.c: Driver (here in a version for hardware/software-SPI and the R32C controller). Requires rewriting if another form of communication (parallel) is employed.

hwsetup.c: R32C-specific hardware set-up.

OLED28.c: Driver for the OLED.

If a different controller is used then W5100.c and hwsetup.c will need to be adapted correspondingly (the chip manufacturer has, however, already produced drivers for some controllers [1]).

reading a byte. The protocol is extremely simple and consists of four bytes. The preamble (opcode) signals whether reading or writing is being performed. The middle two bytes contain the 16-bit address and the fourth byte the actual data. To read or write a single byte thus requires four bytes. Maximum clock rate at 14 MHz is so large, however, that a data rate of up to 3.5 Mbit/s can be achieved.

The SPI interface can be realized in software on any desired port pins of a microcontroller. The R32C/111 and many other microcontrollers support SPI with a synchronous serial interface but also in hardware. Renesas calls this method 'clock synchronous serial interface mode'. In the downloadable driver source code files you will find both implementations and can swap between them simply with the compiler directive 'USE_PORT_IO'.

Chris Vossen (Elektor Labs) und Jinbuhm Kim (Head of Application & Software for WIZnet) have written an SPI driver for the Renesas M16C product family, especially for the R32C. **Listing 1** includes extracts from the SPI driver. First the interrupts are switched off, in order to avert further interruptions. Then the SPI chip select (/SCS) is set and the four bytes are sent sequentially. Following this the SPI chip select is removed and interrupts are activated once more. Sending a single byte follows by software or hardware SPI.

Sample web server

A small, very simple sample application is shown in **Listing 2**. The Elektor server monitors Port 5000 and responds to any request that includes the string 'elektor'. The main loop splits into a switch case statement according to the status of the connection in the subroutines SOCK_ESTABLISHED, SOCK_CLOSE_WAIT and SOCK_CLOSED. If the socket is closed the socket is reactivated with the commands socket() and init(). If data is being received the server responds with („elektor“).

A step from this 'text server' to a proper web server is taken by initializing the socket on port 80 and performing an analysis rou-

Listing 2: Main loop 'Elektor Server'

```
socket(i, Sn_MR_TCP, 5000, 0x20); // open Socket, Port 5000
listen(i); // go into listen mode = Server
while(1)
{
    sock_status = getSn_SR(i); // get socket status
    switch(sock_status)
    {
        case SOCK_ESTABLISHED:
            len = getSn_RX_RSR(i); // get size of buffer
            if (len > 0)
            {
                if (len > MAX_BUF_SIZE) len = MAX_BUF_SIZE;
                len = recv(i, sock_buf, len); // return received size
                send(i, "elektor\r\n", 9); // send „elektor“
            }
            break;
        case SOCK_CLOSE_WAIT:
            disconnect(0); // send „FIN, ACK“
            break;
        case SOCK_CLOSED:
            close(i); // close Socket
            socket(i, Sn_MR_TCP, 5000, 0x20); // reopen Socket
            listen(i); // to listen mode
            break;
    }
}
```

tine for data received from the client (e.g. URLs from websites you have requested, etc.).

A small, proper web server is waiting for you to download at [4]. **Figure 5** shows what you see in the browser. The application first sends a request by DHCP automatically as client to obtain configuration from the router.

You now have a web server that will respond to requests as a simple website. This example is a web form with two check boxes for indicating the status of two LEDs on the application board. Naturally the user can also switch these LEDs on and off.

Marc Oliver Reinschmidt from Glyn has also integrated the OLED routines that were described in our May issue [5]. Messages can be written to the OLED display line by line using the text input box. Of course the WIZnet logo is included as well.

All the images shown on the website are compiled statically in our sample program. Anyone who wishes to can also implement an FTP server and bring on board image files from the external SD card. The source code files of the small web server (are well commented. Additional sample servers and clients for a variety of controllers are available to download from WIZnet [1] as free Open Source software.

The R32C application board [2], the R32C

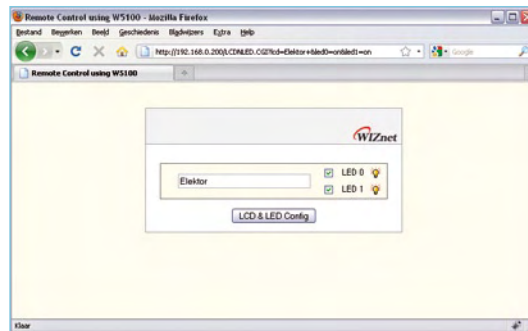
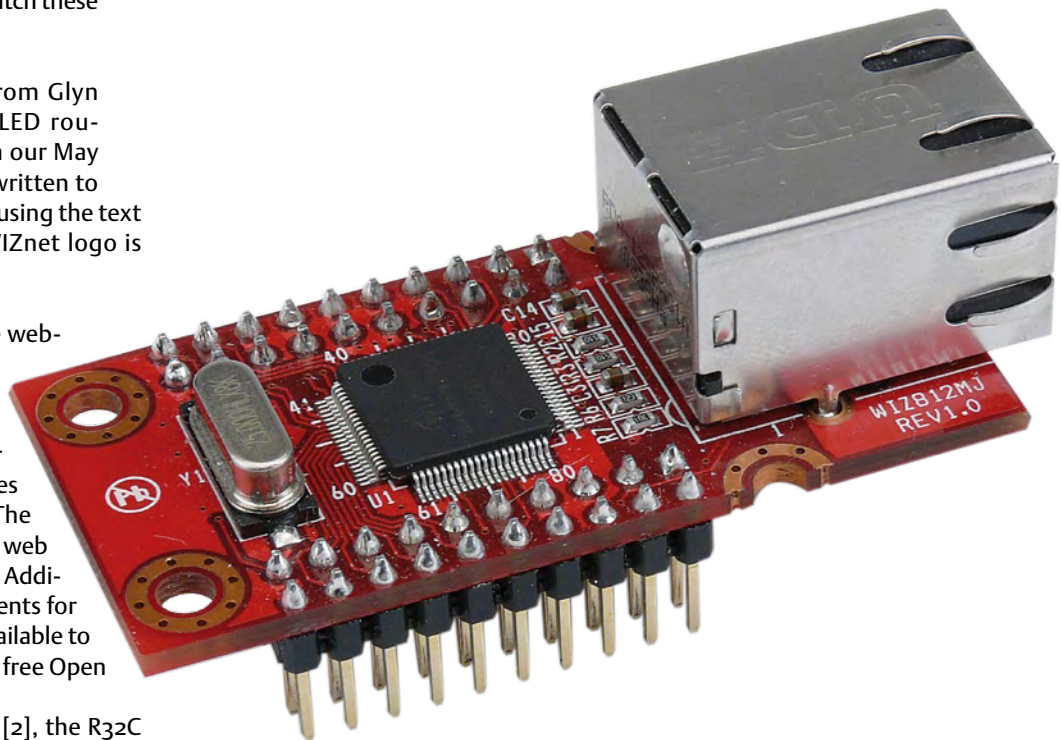


Figure 5. The sample web server software lets you control the LEDs on the application board across the Internet. Words that you type into the text box appear on the OLED!

starter kit including the controller board [6] and the WIZ812MJ network card are all available from Elektor [4]. This versatile and comprehensive range of hardware has in fact so many possibilities that it won't take long for Elektor readers to come up with their own ideas. Tips and suggestions to the editorial address will be most welcome!

(090607-1)



Internet Links

- [1] www.wiznet.co.kr/en/
- [2] www.elektor-usa.com/090209
- [3] www.tcpipguide.com/free
- [4] www.elektor-usa.com/090607
- [5] www.elektor-usa.com/081029
- [6] www.elektor-usa.com/080928

[7] www.dacomwest.de/e_index.htm

[8] http://en.wikipedia.org/wiki/OSI_model

The authors

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Joachim Wülbeck is a field application engineer with the distributor Dacom West [7], with responsibility for interfaces and sensor technology.

The authors can be contacted via their organizations' home pages.

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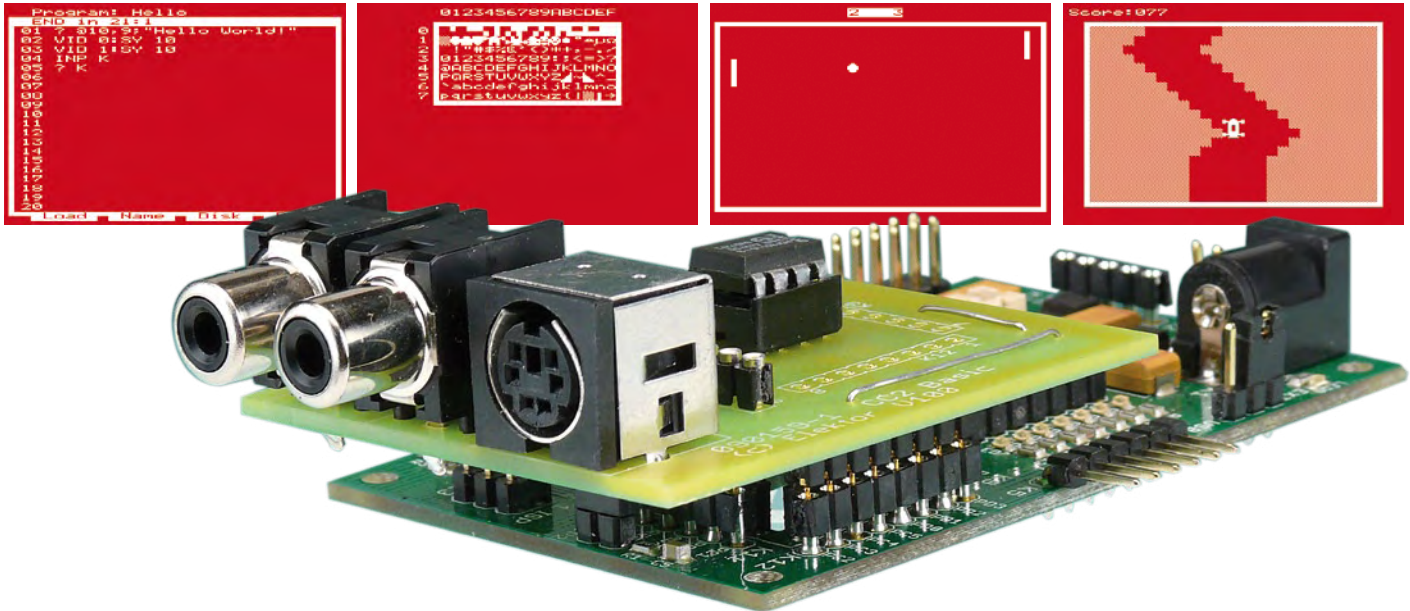
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ATM18 BASIC Computer

ATM18 simulates vintage home computers



By Wolfgang Rudolph and Jörg Wolfram (Germany)

The constantly escalating processor power of today's PCs makes it a doddle to simulate another computer in software without the user even noticing any difference. Our ATM18 is a feeble performer by comparison but it still does a fine job if all you need is a small BASIC computer. So cast aside all longings for stylish graphics and lavish sound capabilities and get back to basics with this fabulous retro machine. Not that it skimps on essentials though; it features a serial interface, an EEPROM connection for saving programs and a couple of I/O lines. Everything you need in fact!

Let's face it: computers are remarkably dumb devices. After all they're nothing more than hardware. Add some BIOS and you can start to carry out a few basic — and very simple — input and output tasks. Things only get interesting with an operating system, which is what transforms any-dyne hardware into a Windows machine, Linux box or some other characterful computer. Backing up these operating system are the drivers that make hardware-specific hook-ups possible. But even this level of sophistication doesn't let us do anything practical; certainly not write letters, edit photos, create spreadsheets or listen to music. Our maid of all work still needs programs to become a practical servant: equipped with one or more programs the computer is now a radio or a typewriter,

a calculator, a musical notation tool and a million and one other devices! It can even simulate other computers, perhaps many different ones. Devices like this are known as Virtual Machines and they exist not as hardware, only in software. Despite this we can use them as real computers. Making all this possible are the constantly improving combinations of hardware and software — and of course the burgeoning processing power of today's computers.

BASIC computer

So could our little ATmega do something similar? Could it simulate a totally different computer in the form of a virtual machine? Of course not; it's too slow, the memory is miniscule, there's no sound processor and no graphic chip onboard. It's a player all

right but in a totally different league from the big processors of the Pentium class. But is there a compromise position?

Elektor reader Jörg Wolfram has been giving this consideration and has implemented a small BASIC computer in software. What's more, the program (written in assembler) is so compact that it fits into an AVR controller. Remarkably this includes not only a BASIC interpreter but also an editor for programs! Jörg has modified the 'AVR Chip Basic 8-88' that he developed and optimised it for this ATM18 project.

To make it even better we've also provided convenient input and output capabilities with sound and graphics. Our BASIC computer requires only a normal PS2 computer keyboard for input plus a TV receiver (with SCART or video input) for the output, just

Features

- BASIC computer implemented in (AVR) software
- Program Editor with 20 lines of code and maximum of 25 usable characters
- 1 program in internal Flash memory
- 26 variables each of 1 byte
- Graphic output via phono socket
- Single-channel audio output (notes in 1 timbre + noise) with envelope curve
- Serial RS-232 interface (1200 baud)
- 4 Port pins deployable as I/O and analog inputs
- Interface for EEPROM (24C16) for 4 saved programs
- Upload/download of programs via serial interface

like in the old days. The video signal, like the sound, is produced entirely in software! For total authenticity the image is in black and white alone.

Daughterboard

The necessary I/O hardware is on a small auxiliary printed circuit board (PCB) that plugs in piggyback fashion into the motherboard/test board (directly above the controller, see heading photo). All connections required are made automatically into the multipin socket strips on the test board, without any need for flying leads (see circuit diagram in **Figure 1**). Beyond the Mini-DIN-6 connector for the keyboard the daughterboard provides one phono socket each for sound and vision. The output is a black and white video signal (75 ohms) and an audio signal. We tested the level of the latter signal on a TV set and found it worked fine; you may need to adjust the value of the 5k6 resistor for best matching. Finally there are two multipin connector strips on the board (serial interface and I/O).

Interfaces

The serial interface is implemented in software because the USART is fully occupied handling the keyboard connectivity. The nature of this system means that the TX (send) line is updated at the same rate as video lines are created on screen (in other words once every 64 μ s). This explains the rather low data transfer speed of just 1200 bit/s. The serial interface is accessed via pins 4 (RX) and 5 (TX) of the multipin connector strip K5, which are cross-connected to port pins PD5 and PB4. To this we can connect (for example) a TTL USB cable/converter. The allocation of the connector pins is exactly the same as on the ATM18 test board, right down to the jumper that lets you apply the +5 V supply voltage to pin 3 if you wish.

Using the four I/O lines (port pins PC0 to PC3, together with Vcc and GND available on multipin connector strip K4) we can read in and out digital signals. It's also possible to measure analogue voltages in the range 0 to 5 V here. EEPROMs of the type 24C16 using the serial I2C connection to save programs. The signals flow across two lines, SCL (Serial Clock) and SDA (Serial Data).

Commissioning

Once the controller has been flashed with the software from the project webpage [1] and the finished daughterboard has been plugged in, we can connect a keyboard equipped with a PS/2 connector. The video

cable can then be plugged into a TV receiver or video monitor equipped with a phono socket input. If the set has only a SCART connector it won't cost much to adapt a SCART cable, which will also enable you to inject the audio from the auxiliary board. SCART con-

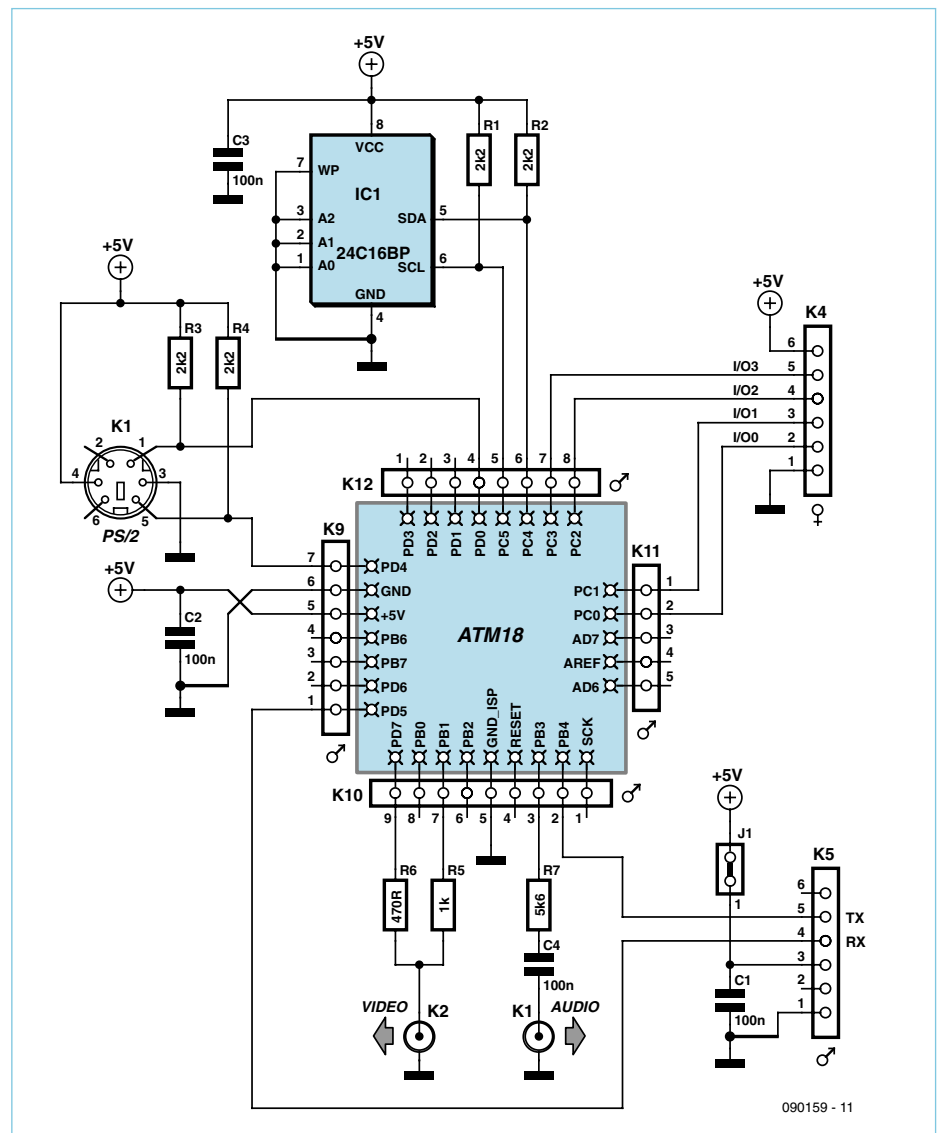


Figure 1. All necessary connections are grouped on the multipin connector strips of the test board.

The Editor

Programs are written and edited using a simple full-screen editor. At the top is the program name. Below this is the status line, where errors are flagged up for instance. The position of the cursor is indicated by an inverse flashing character. Editing takes place in 'insert' mode, with the characters entered below and to the right of the cursor shifting to the right. On the bottom line there are four menu options for which you use the keys F1, F2, F3 and F4 on the keyboard:

F1	F2	F3	F4
Load	Name	Disk	Run
Load	Load a new program into the Editor		
Name	Edit program name		
Disk	Shows programs saved in the 'Program Selection Box', if the EEPROM is provided		
Run	Saves and starts the current program		

The key F1 has a secondary function. If the CTRL key is also pressed

this enables a program to be input via the serial interface.

In addition the following keys and key combinations provide special functions:

DEL Deletes the character under the cursor; remaining characters move up from the right.

Backspace Deletes the character to the left of the cursor; remaining characters move up from the right.

ENTER Cause cursor to move to the start of the next line.

ALT+DEL Deletes the current line and fills it with spaces.

F11 Outputs the current program via the serial interface.

If the 'Program Selection Box' is displayed, the program to be read or written can be selected by the cursor keys. The L key loads the program into the Editor and the S key saves the program in the Editor into the EEPROM. This takes up to 20 or 30 seconds, as the transfer is made only one byte at a time. Hitting ESC returns you to the Editor without loading or saving.

nections are shown at [2]. An old computer monitor (a C64 one for example) with video and audio inputs would of course be ideal! The system is equipped with a simple auto-start arrangement. To enter normal mode a button must be pressed while the intro screen is being displayed. If no button is pressed or no keyboard is connected, the stored BASIC program starts automatically. This makes it possible to implant a chip running a preset BASIC program, without any need for a keyboard. The software supplied with this article requires a keyboard with keys set out in the German layout, which is mainly the same as those used in other countries but you may need to do some

minor tinkering to adapt the key assignments [3]. Note that the @ symbol is available only by hitting SHIFT+3.

To simplify operation a menu is provided at the bottom of the screen. This has four choices that you select by pressing keys F1, F2, F3 and F4.

There are also a few key combinations that may well be familiar from PCs:

- CTRL+ALT+DEL starts from new, deleting all previous variables and unsaved programs in the process
- CTRL+C interrupts the program at the nearest possible point in time
- CTRL+P sends a screenshot to the serial

interface.

The most famous program in the world

Now comes our first program, known to every computer enthusiast everywhere: Hello World!

We need to input the following (the line numbers appear automatically):

```
?@10,9;"Hello World!"
VID 0:SY 10
VID 1:SY 10
INP K
?K
```

Loading and saving programs via the serial interface

The following settings are required on the PC: 8 bits, 1200 Baud, no parity, 1 stop bit.

Normal text transmission is used for all functions. Under Windows you can install HyperTerminal for instance (send/record text) whilst Minicom or the program chiptrans8.pl are recommended for Linux users.

Sending to the AVR:

1. Select LOAD (CTRL+F1) in the Editor
2. Start transfer to PC with ./chiptrans8.pl -r Filename
3. Program appears on the AVR system, with status shown on the PC.

Receiving from the AVR:

1. Start transfer to PC with ./chiptrans8.pl -r Filename
2. Activate SEND (F11) to the Editor
3. Indicates status on the PC

You can configure how you send the New Line signal by means of the command CFG n. Currently only the lowest two bits of n are analyzed.

Value (binary)	New Line	PC Platform
00	no end of line	for test purposes
01	CR only	MAC
10	LF only	Unix/Linux
11	CR and LF	Windows

This setting is stored in the EEPROM and normally needs to be entered only once.

A small oscilloscope

This program scans the analogue input I/O 0, taking 50 samples a second. Pressing the space bar freezes the display.



```

PRG:SCOPE-01
01 CLS:B=30:BX 3,3,42,56
02 ?@0,0;"CB8-Oscilloscope"
03 ?@20,0;"0";
04 ?@3,0;"5";
05 A=AD(0)/7
06 DR 41-A,54,41-B,55:B=A
07 SUB 9:SY 1:SCR 3:GO 5
08
09 IF KY(0)=32 GO 9
10 RET
    
```

If we now start this program by hitting F4, the text 'Hello World!' appears on the screen (see Figure 3). After this the screen goes dark for 0.2 of a second, then the

money), with less functionality than our ATM18 BASIC machine. Today the processing power of the 'personal computers' of those days is easily matched by a small microcon-

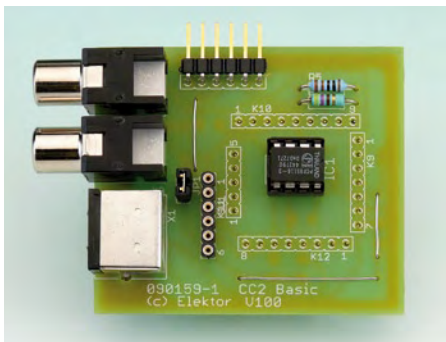


Figure 2. Next to the keyboard connector are twin phono sockets for the video and audio outputs from the board, plus some I/O pins.



Figure 3. The first program is naturally Hello World!

words appear once more and after another 0.2 of a second comes a prompt. The BASIC computer now waits for an input. All functions of the editor are described in detail in the panel 'The Editor'. The commands available are set out along with some examples in the 'BASIC Reference', available for download from the Elektor website [1].

Take a look at the short sample programs — it won't take long before you are scripting your own applications!

When your new baby boots up for the first time all those old feelings will come flooding back. Just like it was when you had a ZX81. Except that back in 1981 the ZX81 stung you \$100 (equivalent to about \$400 in today's

troller, which is able also to generate a video signal, produce the right sounds and even replicate the serial interface in software. Already a quarter of a century has passed since then!

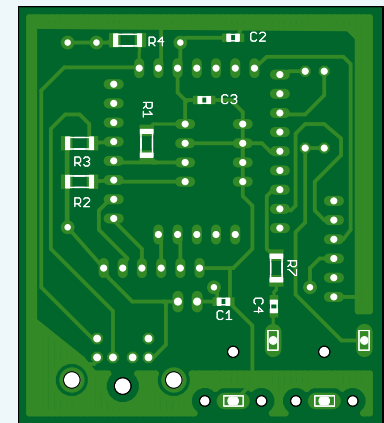
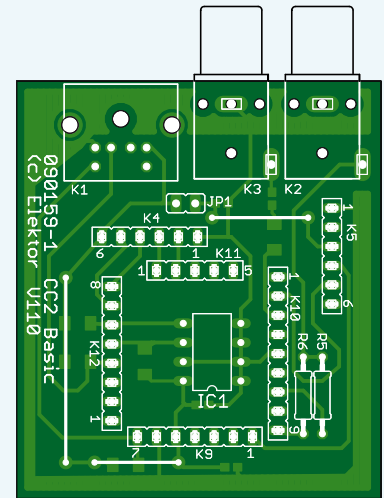
This project gives you a vivid insight into a past that really seems like another world now.

(090159-1)

Internet Links

- [1] www.elektor-usa.com/090159
- [2] www.theavguide.co.uk/view_page.php?page=23
- [3] http://en.wikipedia.org/wiki/Keyboard_layout

COMPONENT LIST



Resistors

R1-R4 = 2.2kΩ
R5 = 1kΩ
R6 = 470Ω
R7 = 5.6kΩ

Capacitors

C1-C4 = 100nF (SMD 0805)

Semiconductors

IC1 = 24C16

Miscellaneous

K1 = 6-way mini-DIN socket (female), PCB mount
K2, K3 = Cinch socket, PCB mount
K9 = 7-way SIL pinheader, lead pitch 0.1" (2.54mm)
K10, K12 = 9-way SIL pinheader, lead pitch 0.1" (2.54mm)
K11 = 5-way SIL pinheader, lead pitch 0.1" (2.54mm)
K4 = 6-way SIL socket strip, lead pitch 0.1" (2.54mm)
K5 = 6-way SIL socket strip, right angled, lead pitch 0.1" (2.54mm)
JP1 = 2-way pinheader with jumper
PCB # 090159-1, artwork download at [1]
Project source code and hex files, free download # 090159-11 from [1]

Arduino + Theremin = Theremino

Using a Theremin oscillator as a proximity sensor

By Martin Nawrath (Academy of Media Arts, Cologne, Germany)

The Theremin is one of the very first electronic musical instruments, dating back to the 1920s. It is played by the musician bringing his hands close to its two antennas. The oscillator at the heart of the Theremin remains an interesting circuit in itself, and in this project we connect such an oscillator to an Arduino microcontroller board. The processor can detect the shifts in the HF signal from the oscillator and convert them into an audible sound. However, this is by no means the only possibility: we can also use the circuit to convert hand and body movements into control signals for other musical instruments, servos and computers.

This tiny oscillator circuit, when coupled with the software running on the Arduino microcontroller board, has a huge range of potential applications, allowing proximity-based control of any other circuit or system.

The circuit has already found use in many installations and objects at the author's college. One example is where the device is interfaced to the Max/MSP music and multimedia development environment, which is capable of producing sounds that provide a pleasant contrast to the square waves that the Arduino can generate directly.

What makes a theremin a theremin?

The *Elektor* editorial team felt it was possible that calling this project a 'Theremin' might be a little misleading. The musical instrument named after Russian inventor and engineer Léon Theremin (born Lev Termen) consists of two antennas, each connected to an oscillator. One oscillator controls the pitch of the instrument and the other the volume. The original Theremin is a purely analog device, with the conversion from the modulated high-frequency signal to an audible frequency being performed

by a superhet circuit: the oscillator output is mixed with a fixed frequency generated by a further oscillator, arranged so that the difference frequency is in the audible range. Our circuit has just one oscillator, nevertheless designed around the same principle as the Theremin. The oscillator is connected to an antenna, and the oscillator's

frequency changes when a human hand (or other electrically conductive object) is brought near to the antenna. The additional capacitance of the hand affects the frequency of the resonant circuit in the oscillator (**Figure 1**). It seems reasonable to call this circuit a 'Theremin oscillator'. As in the original Theremin, we convert the modulated high-frequency signal into the audible range; but rather than using a superhet converter, we do the job in software on the Arduino board. Our 'Theremino' therefore replicates just the pitch control part of the original instrument. It would be possible to build a second Theremin, suitably modified to provide a volume control, to emulate the analog Theremin fully.

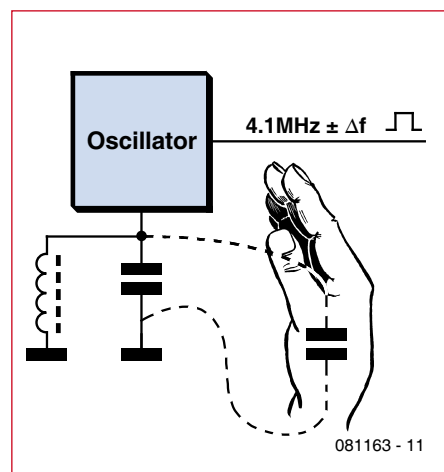


Figure 1. The parallel capacitance of a human hand near to the oscillator affects its frequency.

LC oscillator using a 74HC00

The circuit shown in **Figure 2** consists of an amplifier, made to oscillate by coupling its output signal back to its input. At the input to the amplifier is a parallel resonant circuit, made from a coil and a capacitor, which determines the frequency of the oscillator. Any extra parallel capacitance due to the connected antenna will affect this frequency.

The amplifier is made from two NAND gates from a 74HC00 connected in series. Each is equipped with a resistor (R_1 and R_2) to provide negative feedback, which causes the gates to behave as amplifiers. C_3 provides feedback from the output to the resonant circuit at the input consisting of L_1 and C_1 . C_4 couples the signal on the resonant circuit into the input of the amplifier. The resonant circuit is also connected to the antenna. The theoretical resonant frequency of the LC combination is 4.11 MHz.

The oscillator is followed by the two remaining gates of the 74HC00, used to square up its output waveform into a TTL-compatible signal. This signal is suitable for connection to a digital input on the Arduino board.

Components and construction

Capacitor C_1 in the LC network should be a ceramic NP0 type (such as Farnell order code 9411720) for best temperature stability. L_1 should have a high Q factor. A suitable type is the Fastron SMCC-100K-02, which has a Q factor of 65; it is difficult to do better than that, even with a hand-wound coil.

The circuit can be built, like the author's prototype, on a small piece of prototyping board. To reduce drift with temperature, it is a good idea to mount the board in a small plastic enclosure. The software running on the Arduino board also has features to help compensate for temperature drift and component tolerances.

The antenna that is connected to the LC circuit should be no longer than about one metre (3 feet). A loop of 1.5 mm (AWG14) copper wire (or, for greater mechanical strength, steel wire) works well.

With the antenna operating at 4 MHz metal objects and cables near to it (including USB cables) will also act as parasitic antennas. It is therefore important to keep the unit fixed in place to avoid unwanted frequency drift.

Arduino software

For our tests in the Elektor lab we used an Arduino Diecimila board [1] with software downloaded from the author's project website. In principle any Arduino board could be

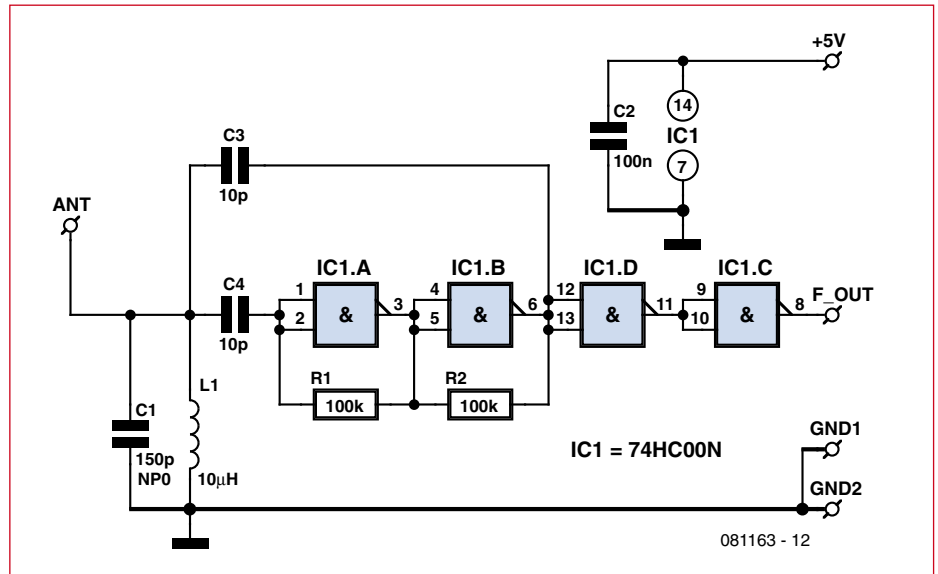


Figure 2. Circuit of the LC oscillator using the 74HC00. To increase the sensitivity of the circuit to the proximity of a human hand, an antenna, made from a length of wire, is connected to the LC network.

used, including the 'Elektorino' design that we published in February 2009 [2]. The oscillator circuit of Figure 2 is provided with +5 V and ground from the Arduino board and the oscillator output (f_{out}) is connected to digi-

tal pin 5 (PD5, pin 11 on the ATmega168 [3]). This pin has the extra function of acting as an input to hardware counter/timer Timer1 in the ATmega168. To detect the frequency shifts of the oscillator, an accurate fre-

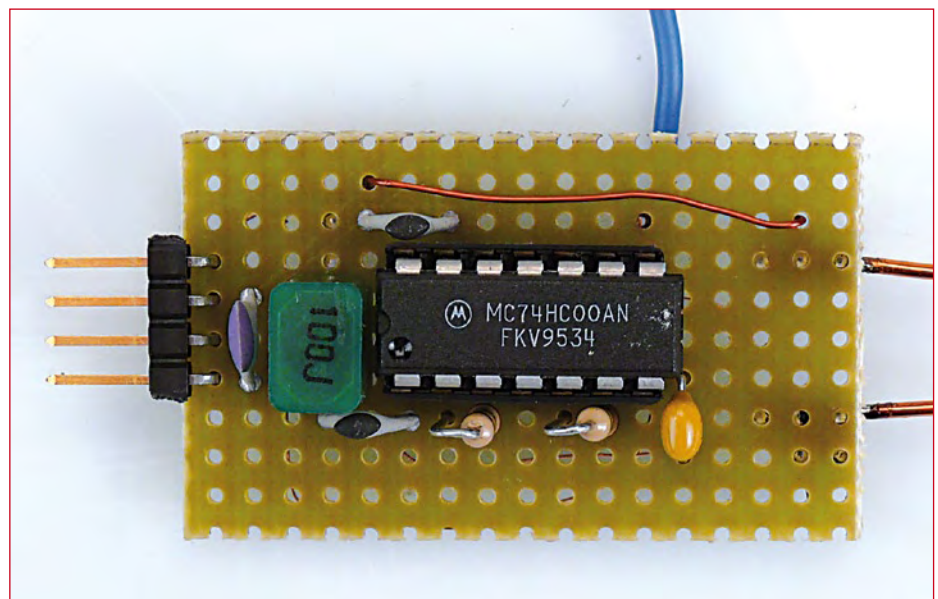


Figure 3. The oscillator can be built on a small piece of prototyping board.

Listing 1. Frequency is measured using Timer1 as a counter and Timer2 to measure the gate time.

```
//*****
void f_meter_start() {
    f_ready=0;           // reset period measure flag
    i_tics=0;           // reset interrupt counter
    sbi (GTCCR,PSRASY); // reset prescaler counting
    TCNT2=0;           // timer2=0
    TCNT1=0;           // Counter1 = 0
    cbi (TIMSK0,TOIE0); // disable Timer0 again // millis and delay
    sbi (TIMSK2,OCIE2A); // enable Timer2 Interrupt
    TCCR1B = TCCR1B | 7; // Counter Clock source = pin T1 , start counting now
}

//*****
// Timer2 Interrupt Service is invoked by hardware Timer2 every 2ms = 500 Hz
// 16Mhz / 256 / 125 / 500 Hz
// gate time generation for freq. measurement takes place here:

ISR(TIMER2_COMPA_vect) {

    if (i_tics==50) { // multiple 2ms = gate time = 100 ms
        // end of gate time, measurement ready
        TCCR1B = TCCR1B & ~7; // Gate Off / Counter T1 stopped
        cbi (TIMSK2,OCIE2A); // disable Timer2 Interrupt
        sbi (TIMSK0,TOIE0); // enable Timer0 again // milli-s and delay
        f_ready=1; // set global flag for end count period

        // calculate now frequency value
        freq_in=0x10000 * mlt; // multiply number of overflows by 65536
        freq_in += TCNT1; // add counter1 value
        mlt=0;

    }
    i_tics++; // count number of interrupt events
    if (TIFR1 & 1) { // if Timer/Counter 1 overflow flag
        mlt++; // count number of Counter1 overflows
        sbi (TIFR1,TOV1); // clear Timer/Counter 1 overflow flag
    }
}
}
```

quency counter is realized in the Arduino firmware using Timer1 as a counter and Timer2 as a timebase. When suitably configured by the software, the counter increments by one for each pulse on the input pin, typically over four million times per second. Timer2 provides a gate time of exactly 1/10 s (100 ms). With an input frequency of 4.1 MHz Timer1 will increment 410 000 times during the gate period, and the frequency can be measured to a resolution of 10 Hz. This precision is required in order to detect the relatively small frequency shifts caused by the Theremin effect.

Timer1 is only a 16-bit counter and so it will overflow several times in each gate period. The overflows are counted and combined with the counter value to produce a final result at the end of the gate period. All the timing work is handled by an interrupt func-

tion, called every two milliseconds under control of Timer2 (see Listing 1).

At the end of the gate period a global flag variable is set. This signals to the main code (see Listing 2) that a new result is ready. Since we are only interested in relative changes in the input frequency and not its absolute value, we subtract the first measured frequency after power-up from each reading. If after a preset number of readings the frequency shift is less than a certain threshold value, an automatic calibration is performed: this compensates for the effect of long-term oscillator drift. The two parameters (number of readings and threshold value) can be adjusted to suit a particular application. The calculated frequency shift value (variable 'tune' in the listing) can be used as a starting point for your own application ideas.

The frequency shifts and calibration values are output on the serial port for further processing or for viewing using a terminal program on a PC.

A rudimentary DDS tone generator function is implemented in software to produce an audible frequency on port B. The signal can be heard by connecting a piezo transducer or small loudspeaker to digital pin 8 (PBo, or pin 14 of the ATmega168) via a 1 k Ω series resistor. You can see and hear the circuit in action in a video on the author's project website [4].

(081163-1)

Listing 2. Excerpt from the main loop. The variable 'tune' contains the frequency shift as produced by the proximity sensor. Automatic calibration compensates for the effect of long-term oscillator drift.

```
void loop()
{
  cnt++;

  f_meter_start();

  tune=tune+1;
  while (f_ready==0) {          // wait for period end (100ms) using interrupt
    PORTB=((dds+=tune) >> 15);  // kind of DDS tone generator: connect speaker to portb.0 = Arduino pin8
  }
  tune = freq_in-freq_zero;
  // use the tune value here for your own purposes like control of servos, midi etc.

  // startup
  if (cnt==10) {
    freq_zero=freq_in;
    freq_cal=freq_in;
    cal_max=0;
    Serial.print("*** START ***");
  }

  // automatic calibration
  if (cnt % 20 == 0) { // try automatic calibration after n cycles
    Serial.print("");
    if (cal_max <= 2) {
      freq_zero=freq_in;
      Serial.print(" calibration");
    }
    freq_cal=freq_in;
    cal_max=0;
    Serial.println("");
  }
  cal = freq_in-freq_cal;
  if ( cal < 0) cal*=-1; // absolute value
  if (cal > cal_max) cal_max=cal;
}
```

Internet Links

- [1] www.arduino.cc/en/Main/ArduinoBoardDiecimila
- [2] www.atmel.com/dyn/resources/prod_documents/doc2545.pdf
- [3] www.elektor.com/080931
- [4] <http://interface.khm.de/index.php/lab/experiments/theremin-as-a-capacitive-sensing-device/>

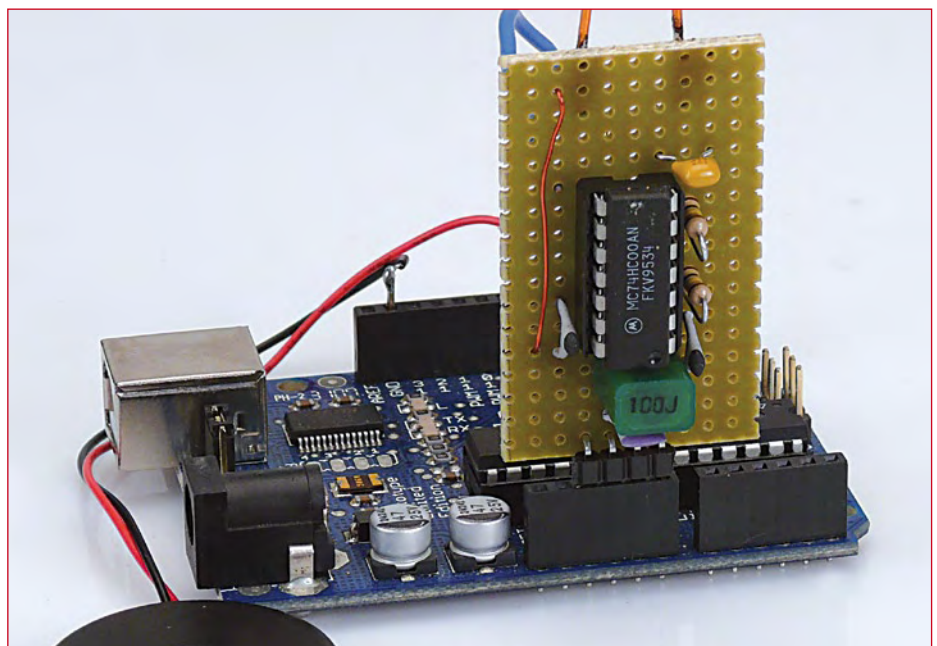


Figure 4. Arduino board with oscillator circuit and piezo transducer.

New Developments in Class D reduced EMI and no output filter

By Thijs Beckers (Elektor Netherlands Editorial)

There's no stopping technological progress, including Class D amplifier technology. New developments reduce the amount of electromagnetic interference (EMI) and enable amplifiers to work without an output filter. Read more to learn how clever designers managed to pull this off.

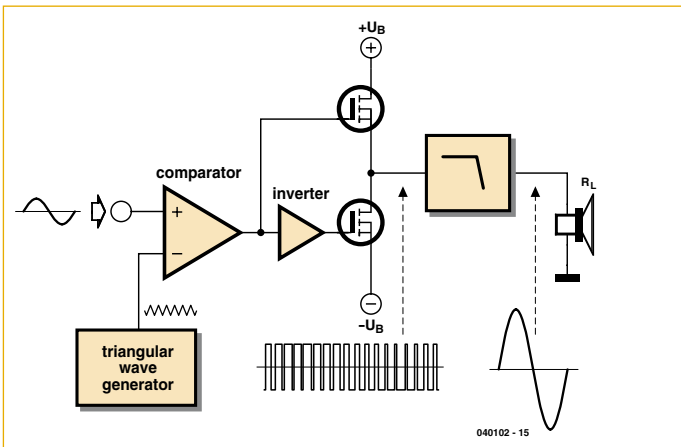


Figure 1. Simplified schematic diagram of a Class D amplifier.

Thanks to their high efficiency, Class D amplifiers are ideal for compact and portable applications. However, conventional Class D amplifiers need an external low-pass filter to recover the audio signal from the pulse-width modulated signal (see below). In addition, they often lead to EMI problems, and the distortion level (THD+N) is not especially good. However, advanced techniques are used in modern Class D amplifiers to overcome these problems and eliminate the need for an output filter, which not only reduces the amount of space necessary on the PCB but also in many cases reduces the overall cost of the compact or portable system.

Class D

First let's have a brief look at how Class D technology works. A Class D amplifier does not simply amplify the input signal as is (see **Figure 1**). Instead, it uses a technique called pulse-width modulation (PWM). The output voltage is proportional to the width of the pulse

(see **Figure 2**). Increasing the switching frequency improves the match between the output signal and the original signal. Unfortunately, high switching frequencies create all sorts of problems, such as interference and high switching losses. Consequently, a switching frequency in the range of 250 kHz to 1.5 MHz is commonly used, depending on the application.

The PWM signal is passed through a low-pass filter to recover the original signal in amplified form. The switching pulses are largely filtered out, leaving the 'average' value. The necessary filter not only increases the cost and the amount of space required on the PCB, but also increases the likelihood of distortion due to nonlinearities in the filter.

Filter-free

Due to the ongoing demand for circuits that are even more compact and provide even better performance, circuit techniques that do not require an output filter have been developed. An example is the technique used in the Maxim MAX9700 (see the schematic diagram in **Figure 3**).

This technique works as follows. Each push-pull output stage has its own comparator, so each output stage can be driven separately. The comparators are driven by differential audio signals and a shared sawtooth generator. When the outputs of both comparators are low, the two outputs of the Class D amplifier are both High. At the same time, the output of the NOR gate is High, but this signal is delayed by the RC network R_{ON} / C_{ON} . When the delayed output of the NOR gate exceeds a certain threshold level, switches S1 and S2 are closed. This causes OUT+ and OUT- to both go Low until the start of the next sampling interval. As a result, the two outputs are active (High) for only a minimum period $t_{ON(min)}$. The duration of this period is determined by the values of R_{ON} and C_{ON} .

If the signal level at the input is zero, the OUT+ and OUT- outputs are exactly in phase and the pulse width is $t_{ON(min)}$. When the amplitude of the audio signal at the input varies, the two comparators trigger at different times. In combination with the minimum t_{ON} circuit, this causes the pulse width of one output to vary while the pulse width of the other output remains the same ($t_{ON(min)}$). The average value of the signal present on each of the outputs corresponds to a half-wave rectified version of the audio signal. The difference between the two average values on the outputs forms the full audio signal.

As the outputs are in phase when the input signal is zero, there is no difference signal across the load under this condition and the power consumption is minimal, all without any need for an output filter.

The circuit also makes use of the impedance of the connected loudspeaker. This impedance consists of a real part (R_e) and an inductive part (L_e) where the subscript 'e' indicates the electrical component. They effectively form a first-order low-pass filter with a corner frequency

$$f_c = 1 / (2\pi L_e / R_e) \text{ [Hz]}.$$

With most loudspeakers, this first-order filter is sufficient to restore the audio signal and prevent excessive power dissipation (from the high switching frequency) in the loudspeaker. However, this requires the loudspeaker to maintain an inductive characteristic at the switching frequency of the amplifier in order to ensure that the maximum rated power can be achieved.

Power spectrum

Class D amplifiers typically emit a relatively large amount of power at the switching frequency in the form of electromagnetic radiation. The steep edges of the pulse waveform at the output of the amplifier make it difficult to design a circuit that can comply with the applicable EMI and EMC standards without an output filter.

One way to circumvent this problem is to use a ‘spread spectrum’ switching frequency. With this technique, the switching frequency of the amplifier is varied randomly over a certain range (such as 10%). Although this broadens the frequency band within which the amplifier emits HF signals, it considerably reduces the peak values in this band (which otherwise would often exceed the maximum permissible value), with the result that the amplifier remains within the allowable emission limits. Here it is important to ensure that the duty cycle of the PWM signal remains constant, as otherwise part or all of the audio signal will be lost.

In other words, the total amount of power in the output spectrum remains constant, but it is spread over a broader frequency range. The peak values of the HF signals are reduced, and the amount of EMI emitted by the speaker cables is lower.

Although spread-spectrum modulation significantly reduces EMI, it has the disadvantage that the length of the loudspeaker cables is limited. The amount of EMI increases with the length of the cables, with the result that at a certain point the circuit no longer complies with the CE mark of approval. At this point, a filter is necessary, although in many cases a simple ferrite bead is sufficient.

ERC

There is also another way to tackle this problem. The latest design innovations minimise EMI and THD+N without sacrificing efficiency. A technique called edge rate control (ERC) has been developed to further reduce the EMI generated by devices. The high-frequency power emitted by a Class D amplifier results from the edges of the pulses in the output signal. The shorter the rise and fall times of these pulses, the more HF power that produced by the edges. If these times are increased so the edges are not as steep, the amount of radiated high-frequency power is reduced.

However, putting this idea into practice is not so easy. Increasing the lengths of the transition times can have a negative impact on the performance of the amplifier. The longer the output stages remain in the state between fully on and fully off, the more power they dissipate in the form of heat, which reduces the efficiency. In addition, the PWM signal will deviate from the ideal pulse waveform, which will cause the distortion (THD+N) to increase.

Although ERC can have a negative impact on amplifier performance, designers are forced to use this technique to improve their designs in order to achieve potential EMI reductions. If the technique is implemented properly, power losses as well as THD+N can be minimized. The correct approach is to slow down only part of the edge.

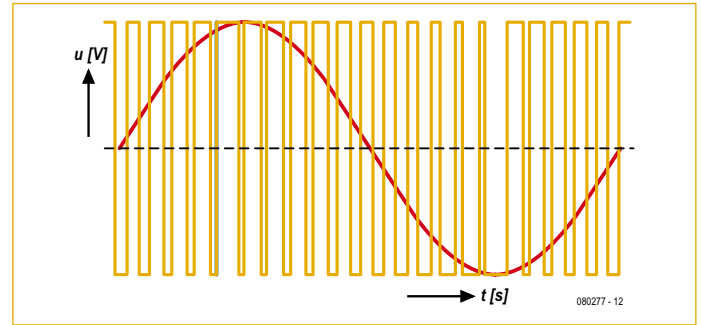


Figure 2. After filtering, the PWM signal (yellow) yields a sine-wave signal (red).

In this way, EMI is minimized and power dissipation is reduced to the same level as with a Class D amplifier that does not use ERC. Errors in the PWM audio signal are corrected by means of internal feedback.

Practical aspects

Despite the fact that the techniques described here can significantly reduce EMI, it is still necessary to observe certain design guidelines very closely when designing a PCB for a Class D amplifier. These guidelines include isolating the tracks that carry switched signals and separating the analog inputs and supply lines from all switching components.

With the constantly increasing demand for portable, energy-efficient devices, Class D amplifiers are being used more and more due to their high efficiency. Improvements in quality and EMI performance have considerably simplified the design of these amplifiers. Relaxed layout rules and fewer external components help reduce design time and drive down overall cost while enabling more compact designs and longer battery life in portable use, all without sacrificing the quality of the audio signal. As a result of all these improvements, Class D is no longer inferior to Class AB, and in the future it will probably be the only reasonable choice when energy-efficient, compact amplifier circuits are necessary.

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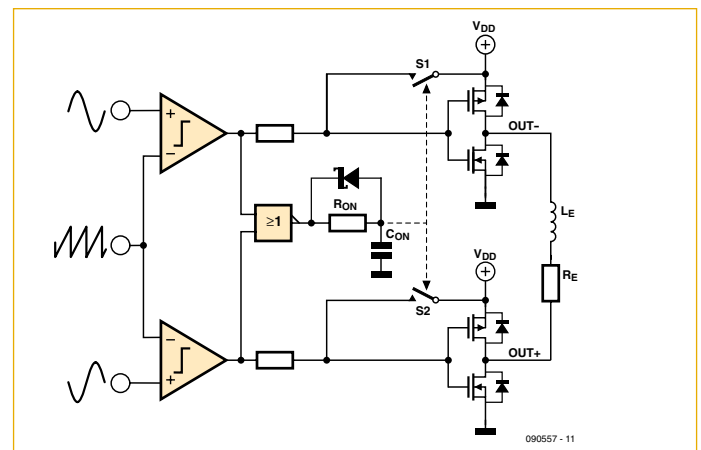


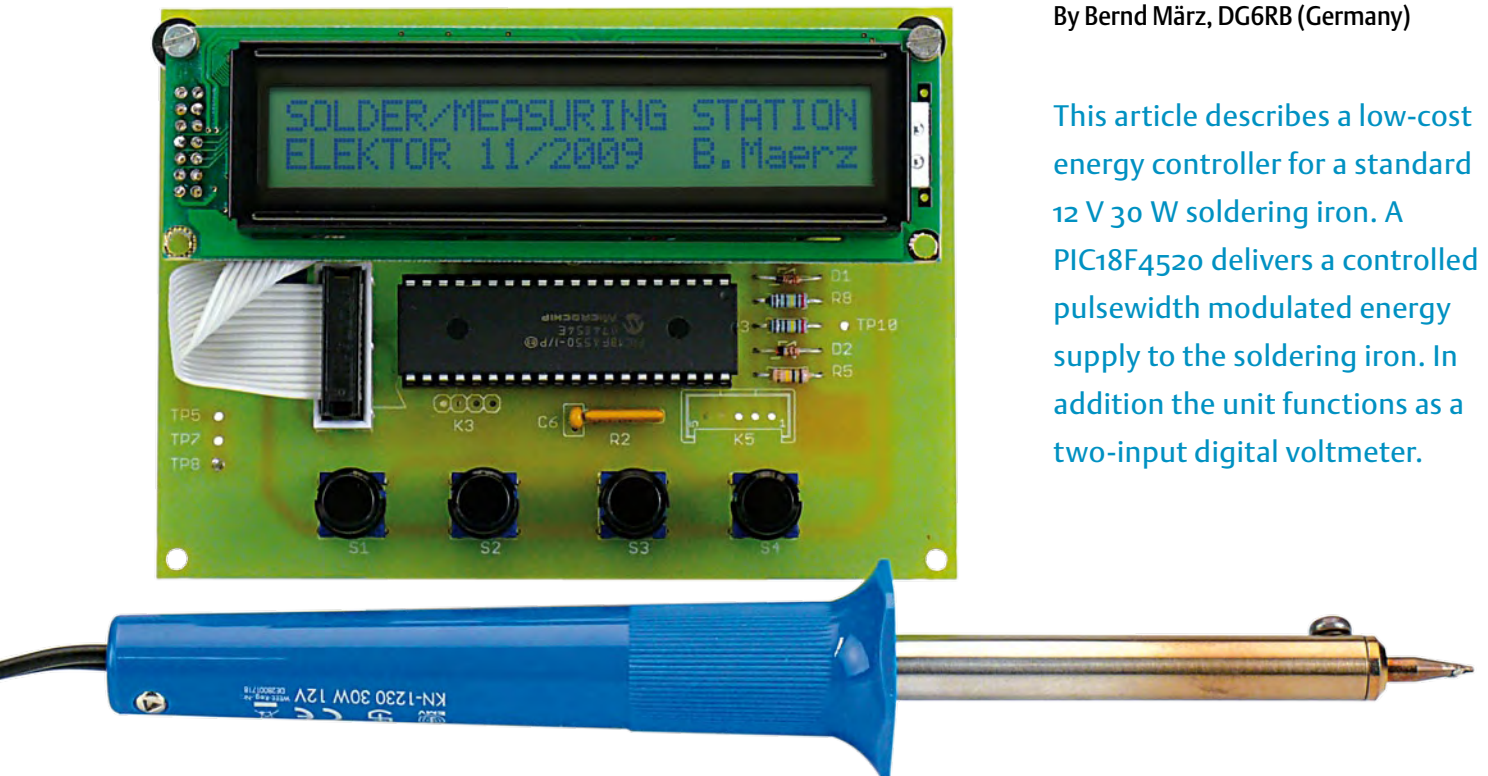
Figure 3. With suitable adjustments, a Class D amplifier can manage without an output filter.

Solder Station 'Plus'

temperature control and DVM in one unit

By Bernd März, DG6RB (Germany)

This article describes a low-cost energy controller for a standard 12 V 30 W soldering iron. A PIC18F4520 delivers a controlled pulsewidth modulated energy supply to the soldering iron. In addition the unit functions as a two-input digital voltmeter.



Main Features

- Suitable for use with 12 V / 30 W (max.) soldering irons.
- Temperature control using PWM.
- Power supplied from a low-cost 12 V / 3.33 A power adapter.
- Two DC voltage measurement inputs.
- Measurement ranges: 0 to 10 V (channel 1), 0 to 40 V (channel 2)
- Displays supply voltage.
- Microcontroller PIC18F4520 with flash memory
- LC display 2 lines of 24 characters (with HD44780 controller)
- Software calibration of measurement channels.

The author is a radio amateur and a member of the German Amateur Radio Club (DARC). Each year the club organizes a practical activity for the younger electronics enthu-

siasts to occupy them during the holidays. Every year the members come up with a new circuit design to build, the main criteria are that it should be low-cost, useful, simple and fun to build. The project described here was the subject of one of these events.

All together the materials for this solder station/DVM design cost around 35 dollars. The same amount of money would probably buy you a simple soldering station but it would not give you the same satisfaction as one that you built yourself and besides it would not have the energy control or DVM features of this design with its in-built microcontroller. A combined soldering iron and DVM would undoubtedly be a useful addition to the workbench of any young engineer or electronics enthusiast.

Measurement and Control

A low cost microcontroller type PIC18F4520 (IC2) from Microchip is the main element in

the circuit diagram shown in **Figure 1**, its clock is derived from an economical ceramic 4 MHz resonator (X1). The firmware stored in microcontroller flash memory performs temperature control of the soldering iron and all the measurement functions. The four push buttons (S1 to S4) are used to select menu options.

The display (LCD1) shows two lines of text with 24 characters per line. It is an LCD with an on-board HD44780 compatible controller. To reduce costs this type of display can often be salvaged from an old telephone or similar piece of redundant equipment. Alternatively it is a completely standard display which can also be ordered quite cheaply from the majority of component suppliers. To reduce the number of microcontroller I/O pins required by the LCD it is driven in 4-bit mode. The spare I/O pins are connected to the pin header K2 to K4. With suitably modified software these pins could

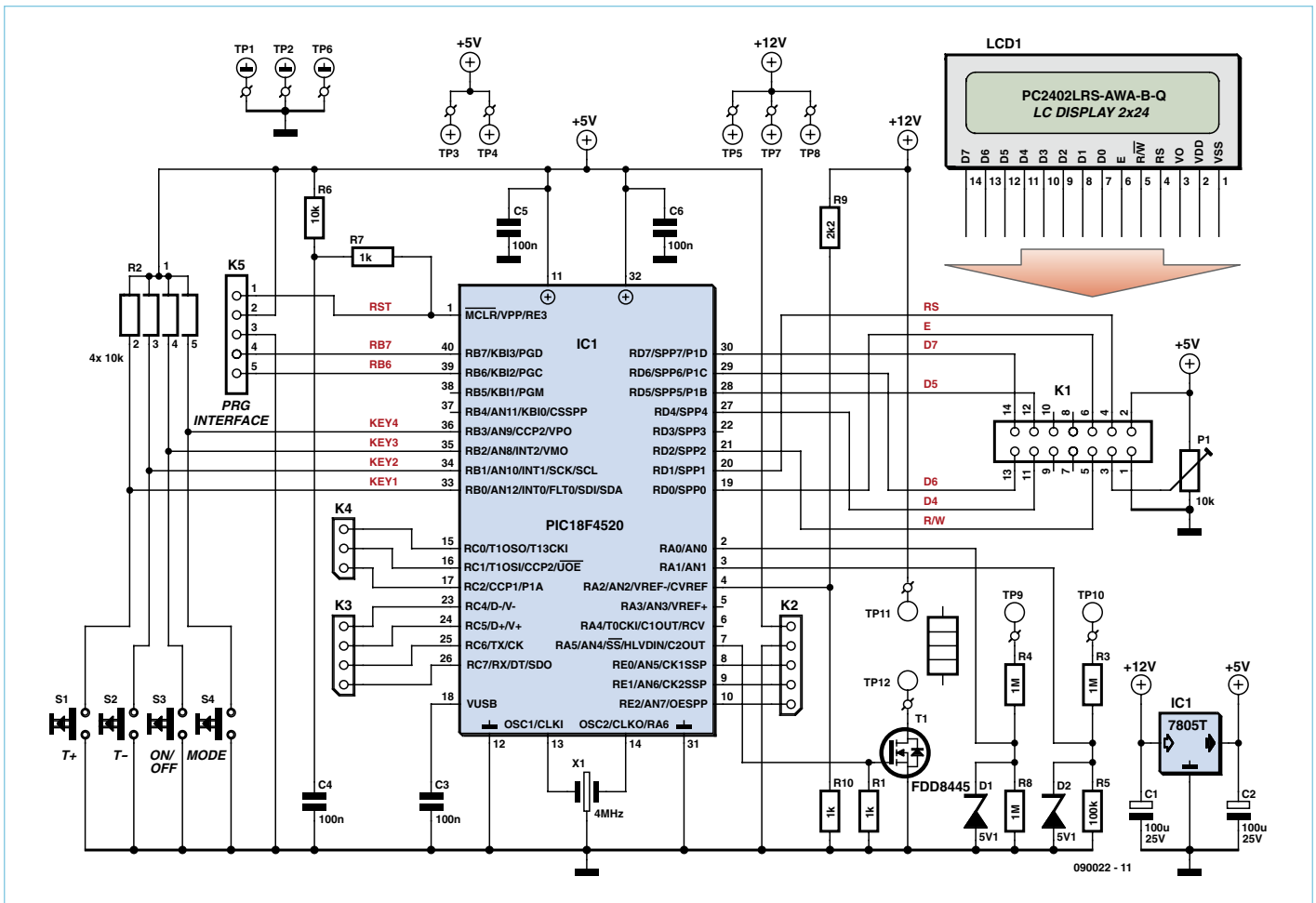


Figure 1. The simple circuit uses a PIC microcontroller for control and measuring.

be used in the future, for example, to measure values of capacitance. Pin header K5 is the programming interface to the microcontroller allowing the software to be updated or changed as necessary. A ribbon cable on K1 connects to the LCD and preset P1 is used to adjust the display contrast.

Push buttons S1 and S2 control the soldering iron temperature. These buttons change the on/off ratio of the Pulse Width Modulated (PWM) signal output from pin 7 of the microcontroller. The waveform switches power MOSFET T1 which supplies current to the soldering iron connected to points TP11 and TP12 on the circuit diagram. Power control is very smooth and the front panel display shows the amount of power supplied to the iron as a percentage of the irons power rating (30 W max). The type of soldering iron used is a standard low-cost 12 V iron without any temperature sensor.

The red measurement input sockets are wired to TP9 for channel 1 and TP10 for channel 2. Voltage divider networks on these inputs formed by (R4/R8 and R3/R5) scale the measured input voltages so that they are within the input range of the controllers ADC inputs pins 2 and 3. The 1 MΩ resistors define the impedance of the meter inputs. Zener diodes D1 and D2 prevent damage to the input if the applied input voltage is too high. The third ADC input of the microcontroller (pin 4) measures the power supply voltage (nominally 12 V) scaled by the voltage divider network R9/R10.

Power to the unit can be supplied by a 12 V DC mains adapter rated at 3 A (minimum). A quick trawl through some supplier's websites identified several 12 V switched-mode supplies with an output rated at 3.3 A retailing for less than 15 dollars. The 5 V supply for the circuit is produced by the 7805 voltage regulator IC1.

Putting it all together

The simple single-sided PCB layout (Figure 2) ensures that construction is quite straight forward even for a novice. Start by fitting the IC socket ensuring that pin 1 lines up with 1 on the layout. Next fit the ceramic capacitors, the wire link between TP3 and C1, the resistors, diodes (make sure they are the right way round) and the preset resistor. The resistor network R2 is fitted so that pin 1 is nearest to C6.

Both electrolytic capacitors C1 and C2 must lie flat on the board otherwise there will not be enough room for the LCD which is fitted 15 mm above the PCB.

Voltage regulator IC1 is mounted on the board using a short M3 nut and bolt. The power FET T1 has an SMD outline and is the only component mounted on the underside of the board. It is not necessary to make any connection to the middle pin (see Figure 3).

COMPONENT LIST

Resistors

R1,R7,R10 = 1k Ω
 R2 = SIL array 4x10k Ω (5 pins)
 R3,R4,R8 = 1M Ω
 R5 = 100k Ω
 R6 = 10k Ω
 R9 = 2.2k Ω
 P1 = 10k Ω multiturn preset, vertical, top adjustment, e.g. Bourns type 3266X-1-103LF

Capacitors

C1,C2 = 100 μ F 35V radial
 C3,C4,C5 = 100nF

Semiconductors

D1,D2 = zener diode 5.1V 0.5W
 T1 = FDD8445 (Fairchild, N-channel MOSFET, 40V, 5A, 8.7m Ω)
 IC1 = 7805
 IC2 = PIC18F4520-I/P, programmed, Elektor Shop # 090022-41

Miscellaneous

S1–S4 = push button, single contact, e.g. Multimec 3FTL6 with cap 1D09
 K1 = 14-way IDC connector for flatcable LCD module, 2x24 characters (5.55mm height), 118x36x14 mm, e.g. Powertip PC2402LRS-AWA-B-Q (Farnell # 1671511) with connector and flatcable.
 40-way DIL socket (for IC2)

X1 = 4MHz ceramic resonator, 3-pin
 1 M3x5 screw with nut (for mounting IC1)
 2 M3x20 screw with nuts (for LCD mounting)
 2 plastic spacers, 15mm length (for LCD

mounting)
 12V / 30W soldering iron simple version without temperature sensor
 PCB no. 090022-1 [1]

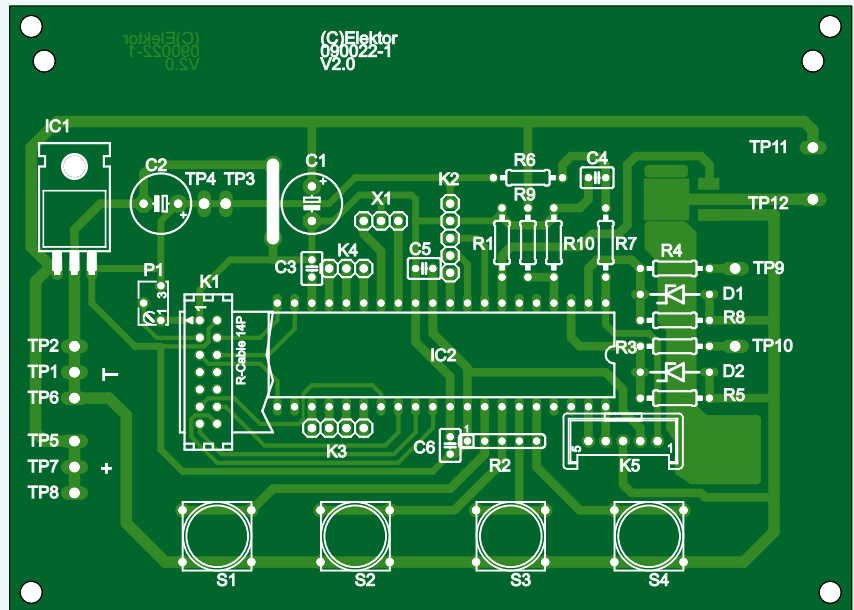


Figure 2. Fitting the components will be no problem on this single-sided PCB.

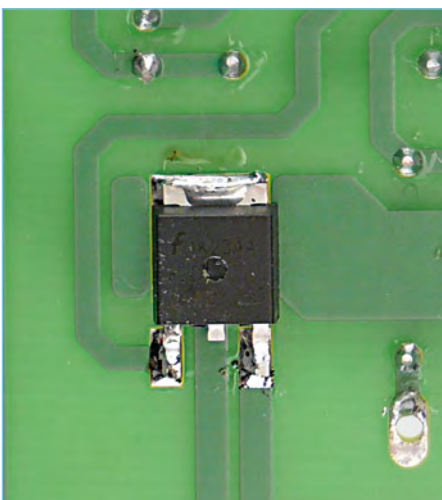


Figure 3. The power MOSFET is soldered to the PCB underside. No connection to the centre pin is necessary.

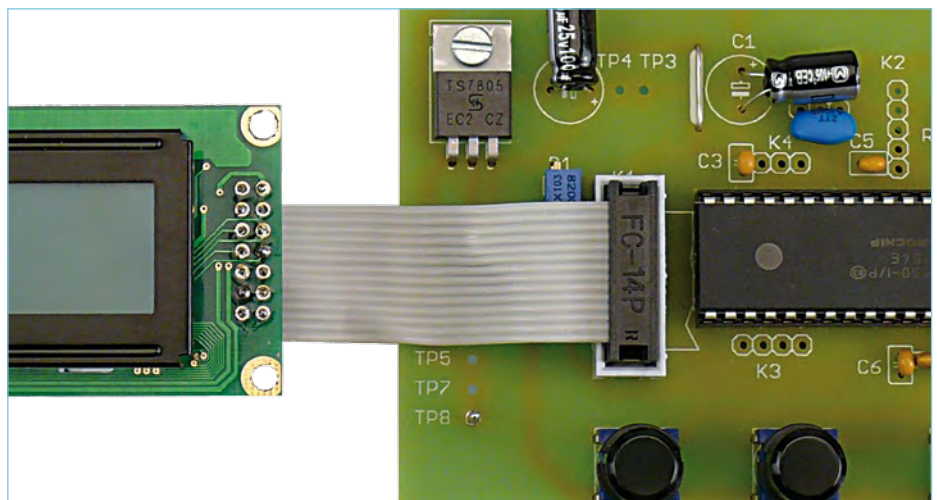


Figure 4. A 14-way ribbon cable connects the LCD module to the PCB.

The only cable required is a 14-pin connector and ribbon cable to connect between the PCB (K1) and the LCD module as shown in **Figure 4**. The pin headers K2 to K4 are available for future expansion of the circuit and K5 is not required unless you plan to program/reprogram the microcontroller 'in circuit'.

The 12 V mains adapter and 12 V soldering iron are the only two external components connected to the controller. The circuit does not include a diode in series with the input supply to protect against reverse polarity supply so it is important to ensure that the board is wired correctly to the AC power adapter output. The polarity symbols are printed on the PCB: plus to TP7, minus to TP2. The polarity of the supply to the soldering iron itself is not important; connect the two wires from the soldering iron to TP11 and TP12.

This only leaves wiring between the PCB and the voltage measurement input sockets (two red and two black). The black sockets are wired to ground (TP1 or TP6). As already described the red socket for channel 1 (10 V range) is wired to TP9 and red socket for channel 2 (40 V range) with TP10.

The mechanical layout is simplified if the 4 mm sockets for the measurement channel inputs are positioned to the right of the PCB and mounted on the front panel of a suitable enclosure. The PCB itself can either be mounted behind the front panel in which case cut-outs will be required for the display and push buttons or the simpler solution used by the author is to fit the PCB on the outside of the front panel. The result is not quite so neat but allows easy access to the circuit.

Programming and Function

The simple option is to buy the PIC controller ready-programmed from the Elektor Shop but alternatively if you prefer to compile and program the chip yourself all the C source files including the compiled program file are available for free download from the Elektor website [1]. The author has written the firmware in C using the CCS-C-Compiler for PIC18 processors [2] and the MPLAB

V8.20 development environment from Microchip [3]. The last link in the chain if you are programming yourself is the Microchip ICD2 programmer which connects to the target board at the pin header connector K5. Fuses HS, NOWDT, NOPROTECT and NOLVP must be set in the software.

Before the circuit is first powered-up spend a few minutes checking all solder joints and the polarity of the wires from the mains adapter to the PCB. Check that the microcontroller is correctly inserted in its socket (and of course don't forget to program the controller firmware into flash memory!). When the circuit is powered up it enters soldering mode and the display indicates the soldering iron power level (**Figure 5**). Should you see nothing on the display try adjusting the contrast (P1) failing that it could be a hardware failure (check your soldering!) or (hopefully not) a software problem. Push buttons S1 to S4 provide the following control:

S1: Increase bit temperature.
S2: Decrease bit temperature
S3: Soldering iron ON/OFF
S4: Switch the unit between soldering and voltage measurement modes.

Pressing S4 toggles the unit through the following modes:

1. Solder (Figure 5)
2. Voltage measurement on channel 1, DC 0 to 10 V (Figure 6)
3. Voltage measurement on channel 2, DC 0 to 40 V (Figure 7)
4. Voltage measurement on channel 3, the 12 V nominal DC input to the circuit (Figure 8)
5. Display all three measurements (Figure 9).

Calibration and use

Before we can have any confidence in the measured voltages it will be necessary to calibrate the unit. The circuit enters calibration mode when button S1 is held down as the circuit is powered up. The display shows Multi: 1000 indicating calibration mode for multimeter input 1 where 1000 is the mul-



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Figure 5. The start menu at power-up shows the soldering iron control.



Figure 6. Measurement using channel 1 (range 10 VDC).



Figure 7. Measurement using channel 2 (range 40 VDC).

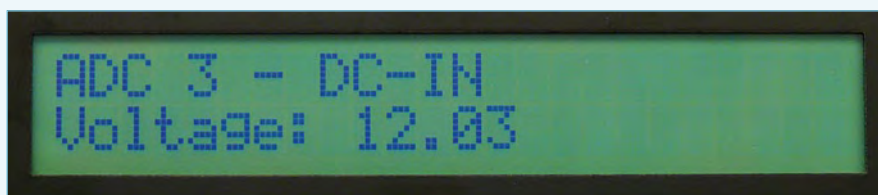


Figure 8. Channel 3 measures the supply voltage to the circuit (12 V nominal).



Figure 9. Display of all three channels.

tiplication factor of the measured value. Using the calculation: measured value x Multi/1000. The unit can be accurately calibrated using a reference level. Pushbuttons S2 and S3 are now used to change the displayed value. S4 switches to the next channel for calibration using S2 or S3 as before. The measurement functions of the unit are designed for low voltage applications only. This includes jobs such as measuring dry or rechargeable cell voltages, DC test point voltage level monitoring in a circuit or adjustment of DC input voltage to a circuit. It is vital that the input is **never connected to AC line voltage!**

Power control of the soldering iron is not as sophisticated as you might expect from a professional workstation costing a couple of hundred dollars but it is suitable for a beginner or anyone who only occasionally needs to use a soldering iron. It gives very fine control of power to the soldering bit and with a little practice it's possible to produce good results on different types of soldering jobs. Another advantage of this design is that it uses a low-cost iron which can be replaced quite cheaply. Any low-voltage 12 V iron, for example fine soldering irons with a power rating of 6 W or 7.5 W (up to 30 W maximum) are suitable for use with this design. The display indicates power supplied to the iron as a percentage of the iron rating.

(0900221)

Internet Links

[1] www.elektor-usa.com/090022

[2] www.ccsinfo.com

[3] www.microchip.com

AVR, dB and LDR collide at D/A Junction

By Daniel Rodrigues (Elektor Labs)

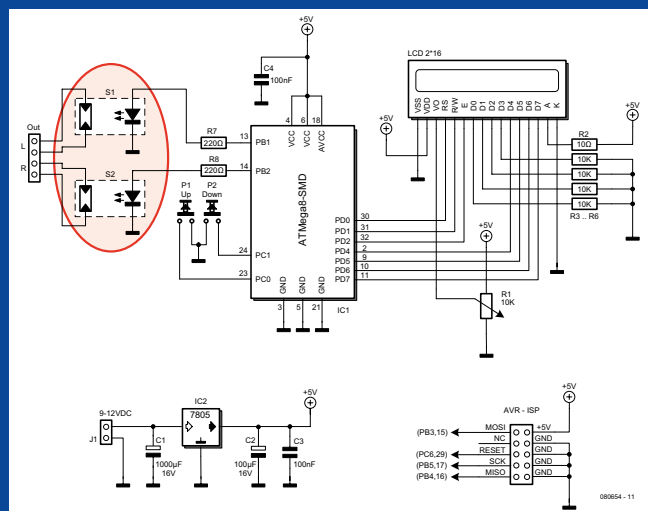
Nothing exceptional about it, I thought, and in line with most of the article proposals we have the pleasure of seeing in the earliest stages of publication. The circuit and the idea behind an 'Innovative Digital Volume Control' proposed by one of our very remote freelance authors was duly taken through our evaluation system and considered a fine candidate for the Summer Circuits edition by the joint editorial team. So we pressed ahead and the paperwork was landed on my desk.

In the original circuit, the key component was an LDR (light dependent resistor) in series with the loudspeaker connection. The LDR is illuminated by a white LED whose brightness is controlled by a PWM



In plain English, the power variation using that finest of LDRs is, oh dear, 16 dB, which is disappointingly low. As a practical example, 16 dB equals the variation of raising speech from a soft whisper to whispering, well, a little louder.

The idea proposed by our valiant author is still nice, but sadly not for an audio volume control as he had hoped. After all, what we have here is a nice and inexpensive gadget which can be safely called a digital potentiometer, or 'DigiPot' in electronics jargonese. Corny



signal produced by a microcontroller — there you have it: state of the art contactless audio volume control! However, when I started testing the device I realised the span of the volume control wasn't too impressive, to put it mildly. In an attempt to overcome the problem I looked for an LDR with a larger resistance variation and the best I was able to locate at the time was rated 50 to 2,000 ohms. Now let there be Science instead of AVR programming. If we take into account that the human ear is able to comfortably handle sound levels within a range of 30–90 dB we should expect something like 60 dB of span to be afforded with ease by our volume control. Let's not forget that power is inversely related to resistance, meaning the lower the resistance, the higher the power. So, the sound power level ratio can be expressed as

$$\begin{aligned}
 L_w &= 10\log(P_{\max}/P_{\min}) \\
 &= 10\log[(U^2/R_{\min}) / (U^2/R_{\max})] \\
 &= 10\log[(U^2/50) / (U^2/2000)] \\
 &= 10\log(40) = 16 \text{ dB}
 \end{aligned}$$

as it may sound, the use of the LDR based DigiPot is only limited by your imagination: control of currents, voltages, brightness, gain, you name it. All optically — sort of — but with better resolution, stability and dynamic control than some more traditional approaches.

Fine AVR programming, no doubt, but with insufficient attention paid to the real world of human hearing and some basic physics, specifically where the dB comes in.

(080654-1)

Daniel Rodrigues (1983) has a B.Eng. (Hons) degree in Electronics and Telecommunications Systems from ISEL Higher Polytechnic Institute in Lisbon, Portugal. Daniel's fortes and hobbyhorses include radio, digital communications and microcontroller systems. Daniel started working in the Elektor Labs in June 2008. When not pondering over electronics on his desk or computer screen, he enjoys hiking and cycling.

to be honest the libraries that came with Altium were a big disappointment initially

More than once you need to search where a settings is 'hidden' or think how you solved a particular problem on an earlier occasion. It is of course also a consideration that no one in our lab has a full-time job as PCB designer and the complexity of designs varies enormously. The more complex functionality of Altium is not used very often and it is then difficult to become very familiar with it.

Every now and then it's also difficult that there are multiple roads that lead to Rome in Altium. It is a frequent occurrence that you ask a colleague for help and that he happily uses a different set of menus than those that you are used to yourself, this is not always enlightening. On the other hand it can, of course, be very useful that you can obtain the same result using different methods.

Altium is very capable at importing PCB layouts from other CAD packages. Unfortunately the very popular Eagle is not one of them, this CAD software that is by far the most popular among our readers, for as far as we can determine. We have asked Altium whether this option can be added to the program, but unfortunately we have not yet received a positive response to this request. That is why in our lab we also frequently use Eagle to change board layouts so that they meet our needs or requirements.

Handy 3D viewer

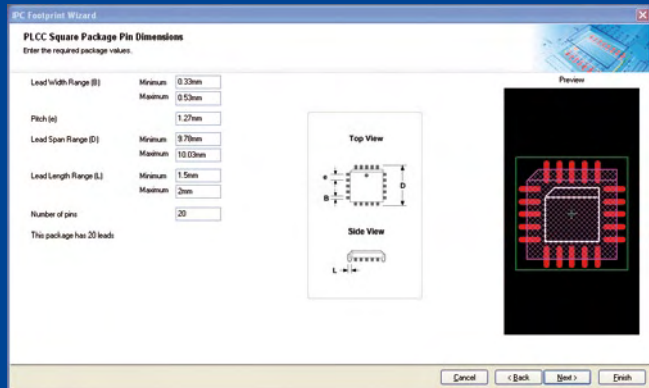
The Altium software even has the option of running Delphi scripts, but we have not used that feature yet. Such scripts could be used, for example, to generate parts lists to your own requirements or formatted appropriately, but can also be used to carry out batch operations on schematics or PCBs. We haven't looked into the details too deeply, but it appears that you could control just about anything within Altium. Although everything is extensively documented in the help files, looking at the number of questions on the Altium Designer forum it nevertheless appears to be quite challenging.

Like every (??) other self-respecting PCB design program, Altium has a 3D viewer which can show a model of the final assembled board from any angle. A prerequisite is that for each component there is a correct 3D model available. Not only does it result in nice pictures on the screen, it can also be of practical value if the finished board has to fit inside a particular enclosure.

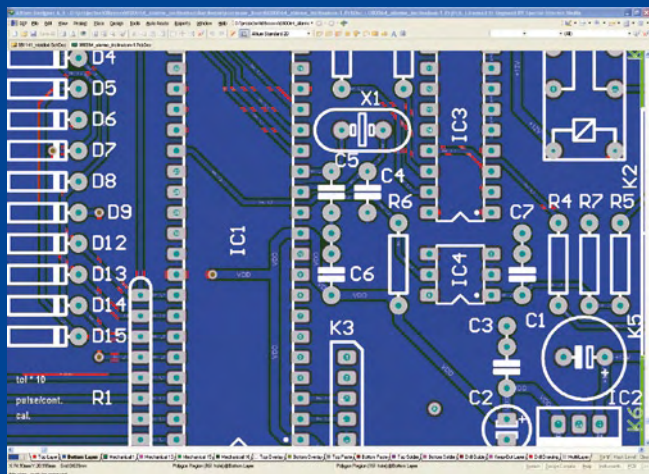
Altium also offers the functionality to develop FPGAs, core and embedded projects, programming and testing. The version 6.9 of Altium that we acquired three years ago does require a separate licence for that. At the time we bought only one such licence, which is sufficient for our lab. We mainly use the program for the 'classic' tasks, that is, drawing schematics and designing printed circuit boards.

Everything considered, it may appear that we are shooting at a mosquito with a cannon, considering the average Elektor design, but it does save a lot of time. As already mentioned, we have discovered a few drawbacks in the program, but it is still head and shoulders above the other CAD packages we have tested and used here.

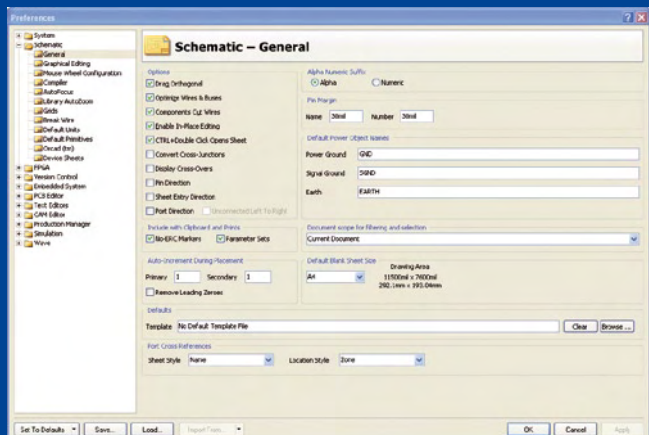
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Using the Footprint Wizard the Elektor designers have increased the size of solder pads and holes, so that hand soldering is made much easier.



Part of the circuit board for the October 2009 Car Tilt Alarm, developed in Altium Designer.



The Altium CAD program offers an overwhelming number of settings!

Sine Wave Service

By Jens Nickel (Elektor Germany Editorial)

We are lucky to have so many subscribers who have been reading Elektor long term. Occasionally when we get a plea from a loyal subscriber we have been known to go the extra mile...

A few months ago I took a call from a gentleman from Munich who had built a function generator featured in the December 1984 edition of Elektor. Unfortunately his trusty old 'scope had recently given up the ghost and he was faced with the problem of how to calibrate the circuit. Any chance he could maybe send the equipment in for us to have a look at?

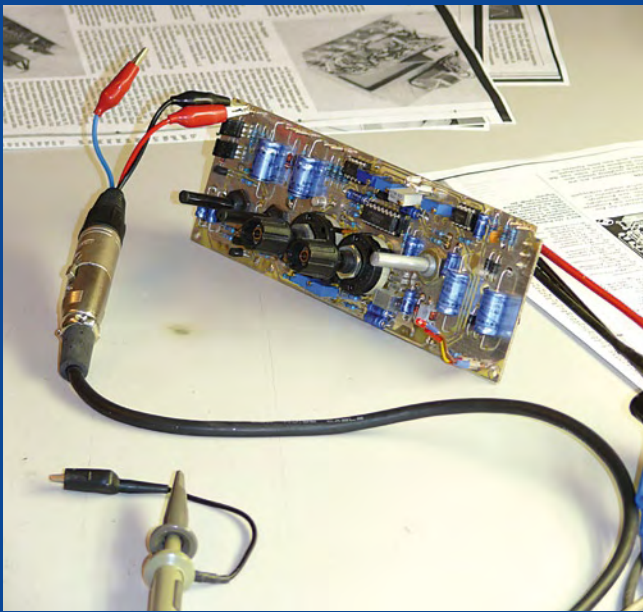
You have probably already guessed how it turned out... normally pressure of work in the lab means that there's no time at all to even consider looking at reader's builds and besides that's your job! Well he must have been in a good mood because after a short discussion the ICE (international coordinating editor) decided that for once we could make an exception and try to revive a 25 year old function generator originally published by Elektor.

those were the days: design engineers writing the articles and editors cheerfully soldering!

The 1984 design was an improvement on an even earlier generator published in the UK edition in January 1978. A rotary wafer switch on the front panel selects sine, square or triangular output waveform. One preset allows optimization of the sine wave purity. BNC sockets on the front panel provide SYNC output and VCO input. Although the output amplifier is built with discrete components it has the configuration of an opamp with a differential input stage and symmetrical output drivers. The PCB is double-sided but does not have through-hole plating so it is necessary to solder both top and bottom pads of some components on the board.

Twiddling the presets

Calibration of the unit requires adjustment of nine pots and presets. Thanks to the systematic description of the procedure provided in the original article, Ton Giesbert's expertise and an old Hameg



Those were the days...

I am probably the only one amongst the team of Elektor editors who was not raised from an early age on a diet of banana plugs and breadboards. This, I thought, is going to be an ideal opportunity for me to get to grips with some real engineering. The original article 25 years ago stated that "A digital solution (with the waveform stored in an EPROM followed by a D/A converter) would be very up to date but would require expensive, difficult to find components". For this reason the design used the Exar XR2206 function generator chip. The chip was not new in fact it had already been available for ten years (and is still available to this day!).

Ernst Krempelsauer, a venerable member of the Elektor editorial group, was keen to point out that a few years earlier he had worked on the design which first introduced the chip to Elektor readers. Ah

1507 oscilloscope it took around 15 minutes to get the generator working again. Out of interest we connected up an Audio Precision System 2 distortion analyzers (according to Ton "one of the best audio analyzer there is") to test sine wave purity. Harmonic distortion was around 0.5 % and it was possible to adjust the 1 kHz low end to within 0.5 Hz. Calibration complete, but a gentle tap on the case caused the output frequency to shoot up to the upper end of the scale plus around 5 %. Clicking the frequency band selector switch backwards and forwards settled it down to the correct value again. This intermittent fault is probably the result of a flaky connection; we checked all solder joints and switches before we wrapped up the case and sent it back to the grateful gentleman from Munich.

(090606-1)



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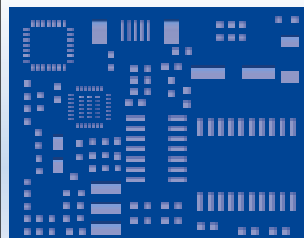
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Light Therapy Box

Blue LEDs combat the Winter Blues



By Ton Giesberts (Elektor Labs)

During the winter many people suffer from Seasonal Affective Disorder (SAD), which is commonly known as the winter blues. With the help of blue light these symptoms can be reduced. The blue-light generator described here has a built-in timer and is perfect for this task.

Specifications

Power line adapter (9 V / min. 0.5 A)

Current consumption:

0.03 A (minimum brightness)

0.46 A (maximum brightness)

Duty cycle: 8% (f = 1 kHz) to 92% (f = 750 Hz)

Programmable period:

from about 4 to 30 minutes

When the days become shorter after the summer months many people start to feel fatigued. This could manifest itself as anything from a slight tiredness to heavy depression. The most noticeable symptoms are lethargy and problems with eating and sleeping.

This condition is nowadays officially recognized and is called 'Seasonal Affective Disorder' although it is more commonly known as the winter blues.

When the days become shorter and the

amount of daylight reduces, Nature tends to slow down and this is therefore perfectly normal. However, some people with the winter blues are affected so much that their normal way of life is severely disrupted.

Much research has been carried out into the causes of the winter blues and most conclusions show that the biological clock is affected by the reduction in the amount of light that is experienced. The sunlight that strikes the retina triggers chemical processes that affect the working of the pineal gland in the brain. This pineal gland is responsible for the production of melatonin, a hormone that plays a big role in the sleeping process and regulating the internal biological clock.

It is assumed that an excess of melatonin has a depressive influence. It is possible that the production of melatonin has been adversely affected in people who suffer from winter depression. To counteract this phenomenon people are given light therapy, where the retina is exposed to bright artificial light

for a certain time every day. The result of this is that the production of melatonin is reduced.

Recent research has found that the light therapy doesn't necessarily have to be carried out using white light. It appears that it is predominantly blue light with a wavelength between 445 nm and 475 nm that is most effective at combating the winter blues. As a result of this, Philips developed a number of therapy lights (goLITE BLU) that uses a matrix with a large number of LEDs to produce a good amount of blue light.

These therapy lights are not exactly cheap and as electronics enthusiasts we have the tendency to see if we could make such a circuit ourselves (and cheaper). This resulted in the idea to make a blue-light lamp with a built-in timer in the Elektor lab, which was suitable for use by the whole family.

The circuit

For this project we decided not to use a microprocessor for a change. We've used

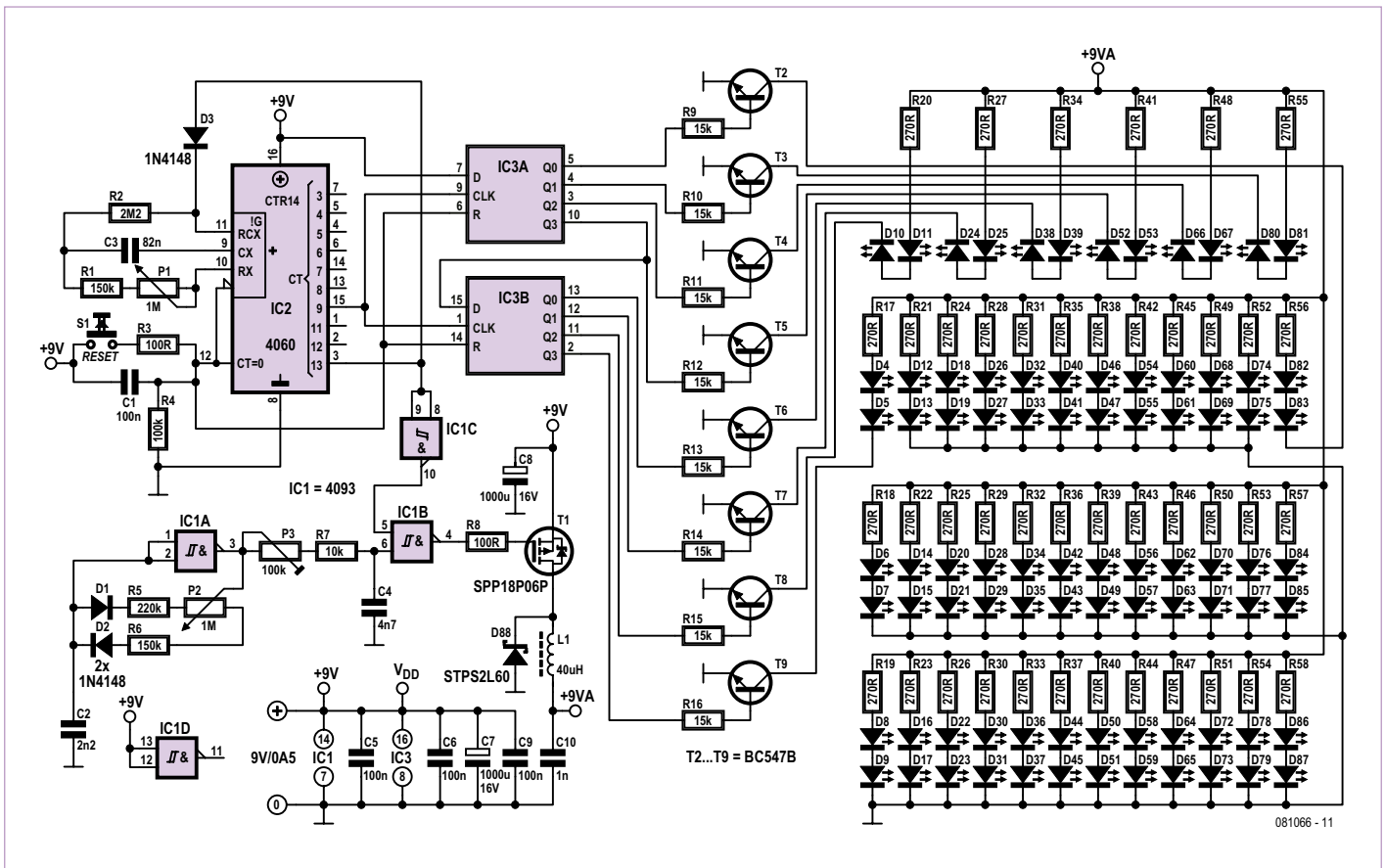


Figure 1. The most conspicuous part in this circuit is the matrix containing 84 blue LEDs.

ICs from the standard CMOS 4000 series in the trusted through-hole packaging. The largest part of the circuit in **Figure 1** is obviously taken up by the numerous LEDs: there are 84 of them. In this case it makes sense to buy 100 pieces, since that usually works out cheaper due to quantity pricing. The LEDs have been positioned fairly close together on the board, so they present a uniform area of light. One row of LEDs is used as a simple display for the timer. The time that the LEDs are lit for can be adjusted with a potentiometer from about 4 minutes to 30 minutes. After this period has elapsed the LEDs are automatically turned off. A second potentiometer is used to adjust the brightness of the LEDs steplessly. Because we've used pulse-width modulation instead of normal voltage regulation the brightness range isn't affected by the value of the forward voltage drop of the LEDs. As we wanted to make the turn-on time fairly accurate we've used a 4060 for the clock, which is an asynchronous counter

with an oscillator. Due to the long period involved we had to use an RC oscillator (if we used a crystal oscillator we required a much larger frequency division). By taking the output from the last stage of the divider (pin 3) and choosing a value of 1 M Ω for the potentiometer, the value of the capacitor used in the oscillator section (C₃) can be kept small. For the longest period the frequency is theoretically 4.61 Hz. The frequency of the RC oscillator is about

$$1 / (2.3 \cdot RC) \text{ [Hz]}$$

The time before the last (14th) divider output becomes high is then about 1776 seconds ($2^{13} \times 4.61^{-1}$), or 29.6 minutes. For the shortest period a frequency of about 35 Hz is needed, which results in a period of 3.86 minutes. In practice the period will be affected by various tolerances. Often the potentiometer, which can have a tolerance of 20%, will be the cause of a difference in the period.

The output of the last divider stage is connected via a diode to the oscillator section. When this output becomes high the oscillator stops and the 4060 will stay in this state until the reset input (pin 12) is pulled high. With S₁ the 4060 can be reset at any time, after which the turn-on period starts again. The indication of the time elapsed is achieved using a 4015 shift register. This twin 4-bit shift register is used as an 8-bit shift register by connecting the fourth output of the first register to the data input of the second register. This 8-bit shift register is clocked by output Q₉ (pin 15) of the 4060. The data input of the first register is connected to the positive supply line, resulting in ones being shifted along every clock pulse. The clock input of the shift register acts on the rising edge of the pulse. After 8 clock pulses from Q₉ the register has become 'full'. One clock pulse later output Q₁₃ of the 4060 goes high and blocks the oscillator via diode D₃. In this way the selected time period is visualized by the

COMPONENT LIST

Resistors

R1,R6 = 150k Ω
 R2 = 2.2M Ω
 R3,R8 = 100 Ω
 R4 = 100k Ω
 R5 = 220k Ω
 R7 = 10k Ω
 R9–R16 = 15k Ω
 R17–R58 = 270 Ω
 P1,P2 = 1M Ω potentiometer, linear
 P3 = 100k Ω preset, horizontal

Capacitors

C1,C5,C6,C9 = 100nF MKT, lead pitch 5mm or 7.5mm (0.2" or 0.3")
 C2 = 2.2nF MKT, lead pitch 5mm or 7.5mm (0.2" or 0.3")
 C3 = 82nF MKT, lead pitch 5mm or 7.5mm (0.2" or 0.3")
 C4 = 4.7nF MKT, lead pitch 5mm or 7.5mm (0.2" or 0.3")
 C7,C8 = 1000 μ F 16V axial, lead pitch 28mm (1.1")
 C10 = 1nF ceramic, lead pitch 5mm (0.2")

Inductor

L1 = 40 μ H 2A, axial (Epcos B82111EC23, Farnell # 9753354)

Semiconductors

D1,D2,D3 = 1N4148
 D4.–D87 = blue LED, 5mm, 300mcd, wavelength 465nm, (e.g. Optek OVLLB8C7, Farnell # 1678692)
 D88 = Schottky diode 60V 2A, (e.g. STPS2L60, Farnell # 9907637)
 T1 = SPP18P06P (P-channel MOSFET 60V 0.13 Ω , Farnell # 1056550)

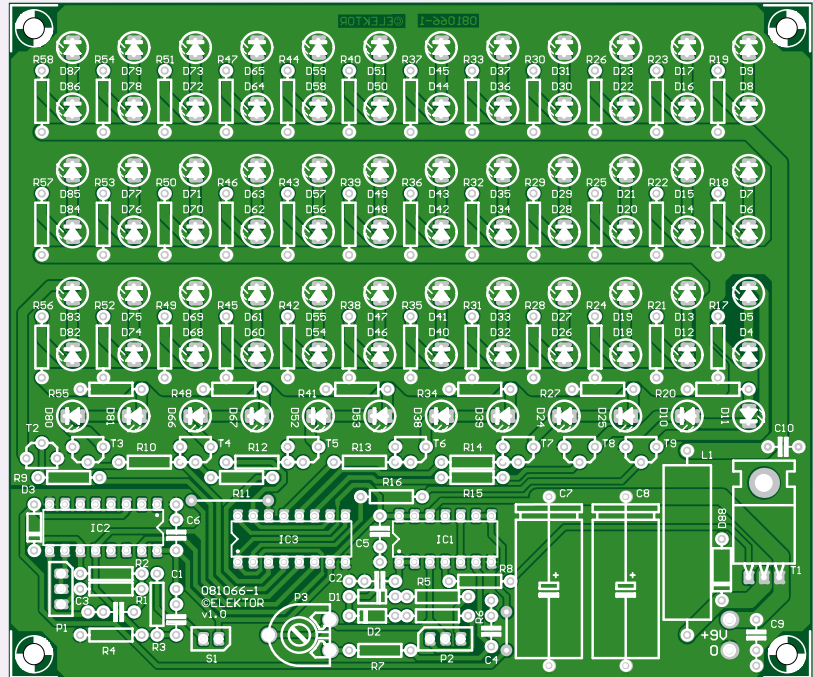


Figure 2. The size of the board is mainly determined by the LEDs.

T2–T9 = BC547B
 IC1 = 4093
 IC2 = 4060
 IC3 = 4015

Miscellaneous

S1 = push button, panel mount

2-way pinheader, right-angled
 2-way pinheader
 2 3-way pinheader, right-angled
 2 3-way socket
 PCB # 081066, see www.elektor-usa.com/081066

shift register on the LEDs in eight equal steps.

At the bottom of the matrix are eight groups of two LEDs that are driven by the register outputs via T2 to T9. In order to keep the intensity of these LEDs as similar as possible to the others in the matrix a ‘discrete’ circuit with normal transistors was chosen, instead of driver ICs (these often contain darlington, which results in too high a knee voltage; the knee voltage of T2 to T9 in the prototype turned out to be close to only 10 mV).

There are many ICs available for the pulse-width section that are specifically designed for this task. However, it can also be done simpler, using a modified Schmitt-trigger oscillator designed around the 4093 (quad NAND with Schmitt-trigger inputs). The standard resistor in the feedback loop is replaced by two resistors, each of which have a diode in series in opposite polarities, and a potentiometer in between. The ratio of the charge and discharge times of C2 is greater or smaller than 1, depending on

the position of the potentiometer. At one extreme the charge time is determined by R6 and the discharge time by R5+P2. At the other extreme the charge time is determined by R6+P2 and the discharge time by R5. Since the hysteresis of the 4093 doesn’t occur around exactly half the supply voltage, the values for R5 and R6 had to be adapted to provide an almost symmetrical control range, for example from 10% to 90%. Due to this asymmetrical behavior of the 4093 the frequency changes when the duty cycle is adjusted. In our prototype it was between 1 kHz and 750 Hz. This variation won’t be visible to the eye; it only reacts to the pulse width.

A simple integrator has been added after the oscillator in order to be able to turn the LEDs fully on or off. The time constant of R7+P3 and C4 can be adjusted using preset P3 such that the voltage across C4 won’t cross the threshold voltage of IC1B at the minimum pulse-width setting (for both pos-

itive and negative pulses) and the output of this gate stays low or high. The integrator has been made adjustable because the hysteresis window of the Schmitt-trigger is not the same for different manufacturers and can even deviate within the same series of a single manufacturer. The output of IC1B is the control signal for P-channel MOSFET T1, which in turn provides the driving voltage for the LEDs.

When the set time has expired, pin 3 of the 4060 goes high and is inverted by gate IC1C and the other input of IC1B is made Low. The output of IC1B stays High and T1 no longer conducts.

For the LEDs a type made by Optek was chosen (OVLLB8C7), which combines ample brightness (min. 170 mcd, typ. 300 mcd) with a large viewing angle of 85°. The wavelength of the generated light is 465 nm. The maximum DC current through the LEDs is 20 mA. The difference in brightness between an LED current of 10 mA and 20 mA was so small for this type that we decided to

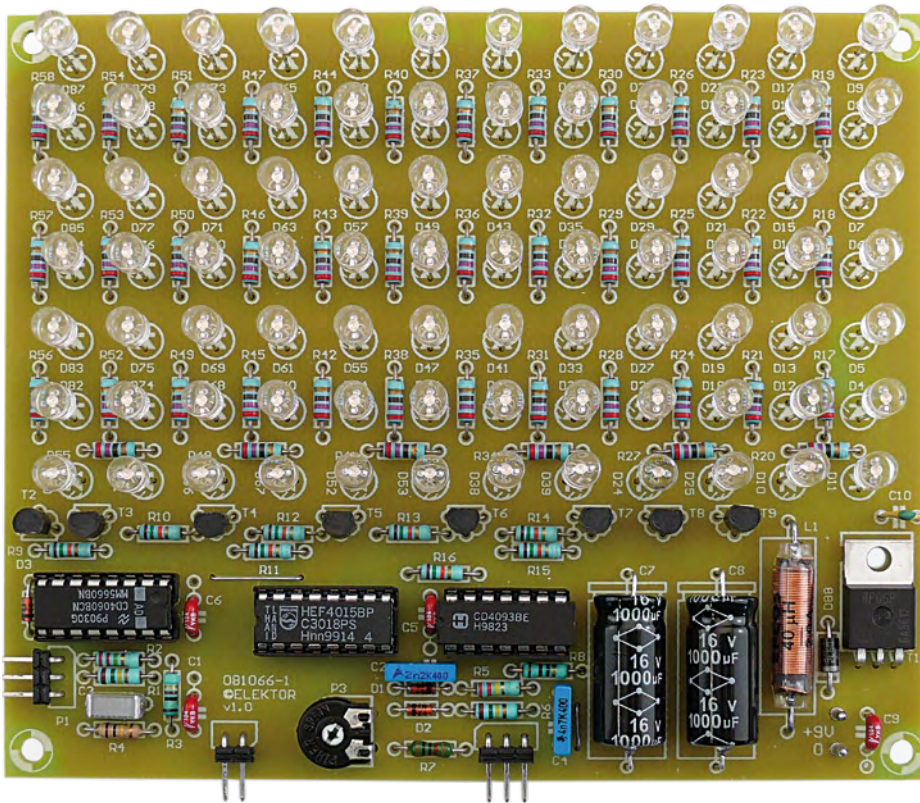


Figure 3. The completed prototype in all its glory.

limit the current to 11 mA.

A somewhat higher voltage drop across the series resistors was chosen in order to reduce the effect of any differences in the forward voltage drop of the LEDs. Using a 9 V power line adapter as a power source, we can connect two LEDs in series. The LEDs in the prototype were found to have a forward voltage drop of just over 3 V, which resulted in a value of 270 Ω for R17 to R58. The total current consumption of the LEDs adds up to almost 0.5 A (42 x 11 mA).

Inductor L1 has been connected in series with the positive supply to the LEDs for interference suppression. It is therefore not meant to smooth out the current through the LEDs. The same applies to C10. Schottky diode D88 is a freewheel diode that prevents negative spikes from damaging the LEDs.

Two electrolytic capacitors of 1000 μF have been placed close to L1 and T1 to provide decoupling of the supply voltage. A side effect of these relatively large decoupling capacitors is that when the supply voltage

drops below the forward voltage drop of the LEDs (temporarily unplug the AC adapter) the supply will drop very slowly and the circuit continues running for a considerable time.

Construction

The population of the board (Figure 2) is fairly standard. The LEDs are best mounted last. Start with the two wire links, followed by the resistors, IC sockets, preset, capacitors, transistors T2 to T9, L1, T1 and finally the two electrolytic capacitors (C7 and C8). For connecting the potentiometers and S1 you can use pin-headers (right-angled versions due to the height restriction) with sockets, but you can also solder the wires directly onto the board. To keep the height of all components to a minimum, we've used axial versions for electrolytic capacitors C7 and C8 and inductor L1, and T1 has been mounted flat on the board.

The LEDs can be mounted in different ways. The easiest method is to solder all of them

Instructions for use

- The recommended daily usage period is between 10 and 30 minutes. The exact period has to be found by trial and error, along with the optimum brightness setting. Start with a short period and see if it has any effect. If it doesn't work, try it for a longer period.
- Start with a fairly low setting for the brightness and increase this in step with the duration until you notice a result.
- The blue-light generator has to be positioned next to you at an angle, so you won't be looking directly into the light. The intention is that the blue light shines onto your eyes from the side. Place the circuit at a distance of about 2 to 3 feet, for example next to your monitor on the desk if you're working with the computer.
- This therapy works best if you start at the beginning of the winter (before any of the winter blues symptoms are noticed) and have a blue light session daily, preferably in the morning.

Warning: Don't look directly into to burning LEDs for long periods since they produce a significant amount of light at higher brightness settings!

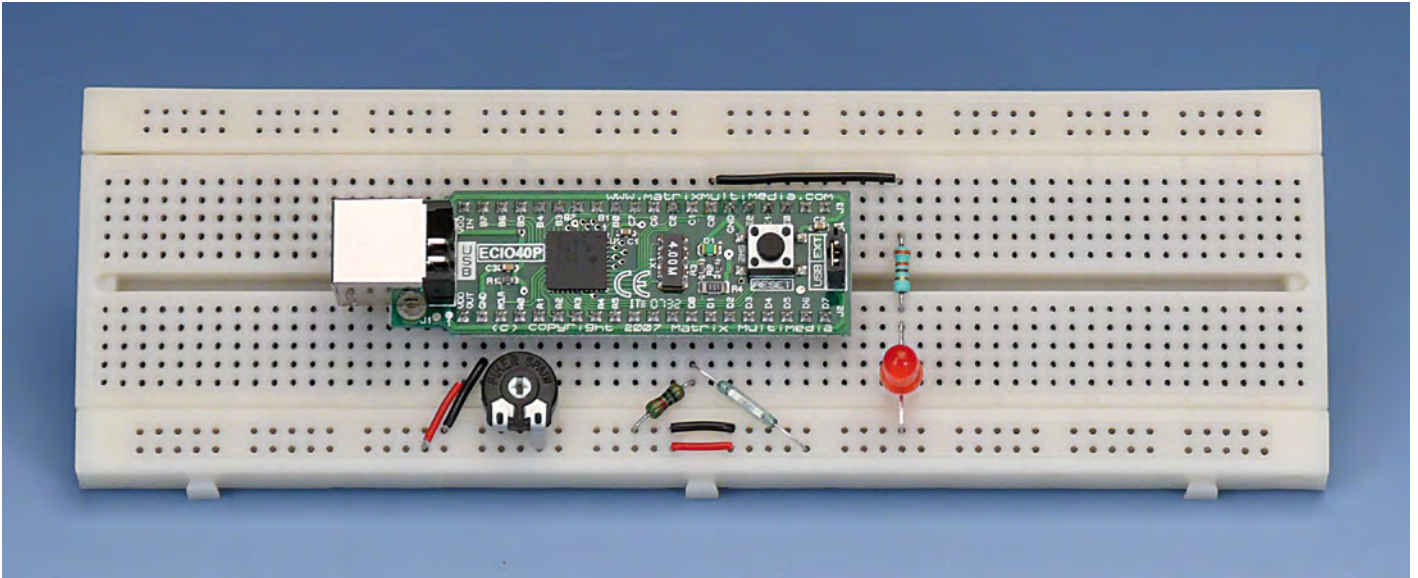
as closely as possible to the board. That way they will automatically be in position and may at worst have to be bent slightly into line. If you prefer to mount the LEDs through a front panel, and hence have to mount them about 2 cm above the board to stick out above the other components, things become more difficult. In this case it helps if you first make a template. Take a piece of experimenter's board and drill 5 mm holes in the right places (the LEDs are mounted at every fifth hole of the experimenter's board).

For the case it should be easy to find something to your liking. You can place a piece of Plexiglass in front of the LEDs. Remember to add a riser at the back of the case, so it will be angled when you place it on the table. And finally here is a little tip: if you're not interested in the time progress bar, you can replace transistors T2 to T9 with wire links (from emitter to collector). In this case there is also no need to mount IC3 and R9 to R16.

(o81o66-1)

Driver-free USB Interface

Data collection using ECIO and an HID



By Bert van Dam (The Netherlands)

The ECIO40 is a modern 18F4455 PIC microcontroller mounted on a miniature PCB and sporting a ready to use USB bootloader. The latter enables you to program the ECIO40 without having to buy an expensive programmer. The only things you need are a USB port on your PC and a small (free) program.

In the E-Blocks article published in the March 2009 issue of Elektor, you could read how to measure an analog and a digital signal using the ECIO40 and make these visible on your PC using the USB interface and a suitable driver. In this article we do *not* use a separate driver, but use the standard HID driver which is already present on all modern Windows based computers.

This is what we'll do

The purpose of this project is to send an analog signal via the keyboard interface to a PC, where this information can be used immediately in any software application. You can, for example, open a spreadsheet and position the cursor in the first cell. You now push a button on your circuit or press a key on your normal keyboard. The analog measurements will now be carried out and are entered into the spreadsheet completely

automatically. The data collected in this way can then be analyzed in Excel using methods with which you are already familiar, for example plotting the values in a chart.

HID

HID means Human Interface Device and is specifically intended for peripherals that are operated by people, such as a mouse or a keyboard. Devices in the category can be connected to the USB interface and do not need a special driver. The operating system in your computer (Windows XP in this project) does effectively take over the task of the driver.

When the device under consideration is connected for the first time, it sends (among other things) two numbers to the PC, the PID (Product Identification number) and the VID (Vendor Identification number). In this project we use a PID code of *F040* and a

VID of *12BF*. If the PC does not already know these numbers then the circuit has to supply additional information. First the type of device is supplied, this is called *usage*. In this case the usage is a keyboard. This is sometimes also called *usage page 7*.

The exchange of information takes place in groups. These groups are called a *report*. The next step therefore is to detail the contents of the reports, the so-called *report descriptors*. In this case two are required. One to send data to the PC and one to receive data.

Note: when the PC already knows the PID/VID combination, the connection is started immediately. Once you have established a usage page and report descriptors you cannot then change them very easily. That is because the PC does not request

them again and assumes that you have not changed anything.

Send report

The send report contains the data that the circuit will send to the PC. Note that because we use a standard HID (i.e. that of a keyboard), we cannot change the contents of these reports. The reports consist of eight fields. The first field contains the status of the special keys such as Alt, Ctrl, etc. The second field is reserved. This must contain a '0'. The remaining fields can be used for keystrokes. **Table 1** shows an example of a Send report.

Offset	Field	Length	Description
0	modifiers	1	status of keys such as Alt, Ctrl, etc
1	reserved	1	reserved (0x00)
2	keycodes[0]	1	keyboard code 1
3	keycodes[1]	1	keyboard code 2
4	keycodes[2]	1	keyboard code 3
5	keycodes[3]	1	keyboard code 4
6	keycodes[4]	1	keyboard code 5
7	keycodes[5]	1	keyboard code 6

In a normal keyboard there are two scan codes associated with every key. The first code is sent when the key is pressed and the second when the key is released again. In this way the computer can detect the difference between a very rapid series of key presses and a key held down for a long period of time. **Table 2** lists a few examples.

Key	Make code	Break code
A	1C	F0,1C
5	2E	F0,2E
F10	09	F0,09
Right arrow	E0,74	E0,F0,74
Right Ctrl	E0,14	E0,F0,14

There is fortunately a simpler method. When a scan code is followed by an empty report the PC interprets this as the release code for the most recently pressed key. In this project we do not worry about the make and break codes, we simply send the make code followed by an empty report. You have probably already noticed that the keyboard scan codes do not correspond to the ASCII-code that you are familiar with. **Table 3** shows an overview of the keyboard scan codes that are relevant to this project.

Table 3. Make codes of the keyboard with the ASCII code of the number on the key.

Key	HID make code		Number key	
	HEX	decimal	legend	ASCII
Return	28	40	-	-
Tab	2B	43	-	-
Num Lock	53	83	-	-
Keypad Enter	58	88	-	-
Keypad 1 End	59	89	1	49
Keypad 2 Down	5A	90	2	50
Keypad 3 PageDn	5B	91	3	51
Keypad 4 Left	5C	92	4	52
Keypad 5	5D	93	5	53
Keypad 6 Right	5E	94	6	54
Keypad 7 Home	5F	95	7	55
Keypad 8 Up	60	96	8	56
Keypad 9 PageUp	61	97	9	57
Keypad 0 Insert	62	98	0	48
Keypad . Delete	63	99	-	-

Receive report

The receive report (**Table 4**) contains the information that the circuit has to receive from the PC. We are actually only interested in the state of the LED for the NumLock key, but the report which contains that information also contains the status of other special keys. You can therefore easily add other functions to the circuit. This report consists of only one 8-bit number, where each bit indicates which LED is on or off. Among these are also the *Compose* and *Kana* keys which are used in Asia for the entry of, for example, Japanese characters.

Table 4. Structure of the receive report.

Offset	Field	Length	LED description	
0	indicators	1	Bit 0	NumLock
			Bit 1	CapsLock
			Bit 2	ScrollLock
			Bit 3	Compose
			Bit 4	Kana
			Bits 5...7	Reserved

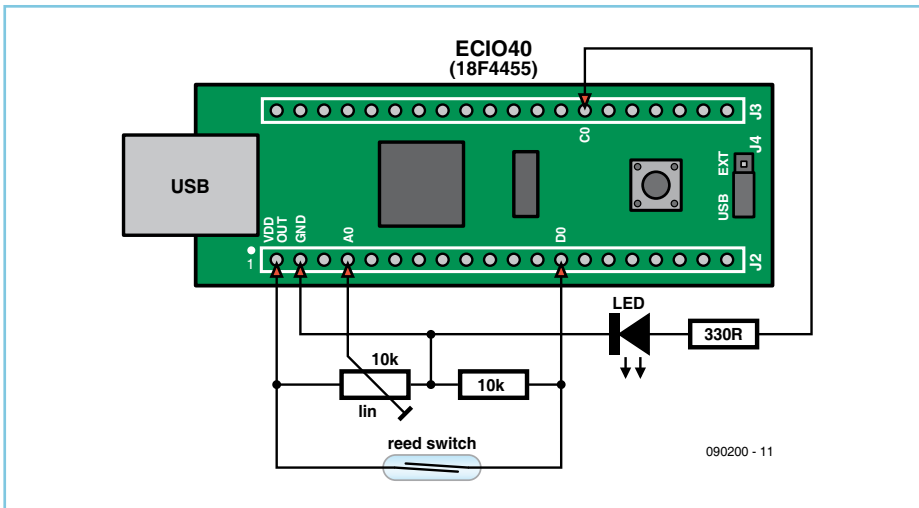


Figure 1. The 'schematic' of the circuit. Only five external components are required.

Hardware configuration

The analog signal is generated from a potentiometer which is wired as a voltage divider and can provide a voltage in the range from 0 to 5 volts to pin A0. An LED is connected to pin C0 via a series resistor of 330 Ω. Instead of using an ordinary push button for the switch you could also, for example, use a reed switch. This is a switch that reacts to a magnetic field. Such a switch, which consists of two contacts in a glass tube, is normally open. When a magnet is held in the vicinity of the switch it will close. Of course, you can also use a normal switch. The schematic is shown in **Figure 1**.

We start by building the circuit on, for example, a breadboard. The power supply for the circuit comes from the USB-port in the PC. You therefore do not require a separate power supply. The jumper link on the ECIO40 has the be in the USB position.

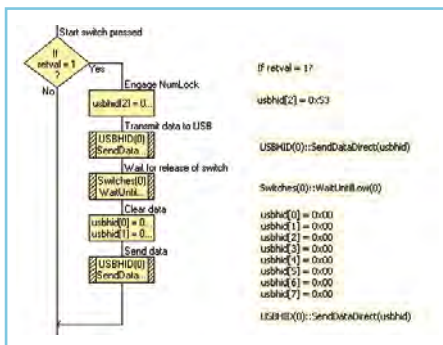


Figure 2. The generation and sending of a send report.

USB pack

If you are using Flowcode V4 then you already have the required USB functionality available by default and you can skip this section. If you are using V3 then you will have to install the USB-pack from Matrix Multimedia [1] into your version of Flowcode. It is probably a good idea to upgrade to the most recent version of Flowcode V3 first. After you have unpacked the USB pack, you copy the Flowcode V3 directory over the top of the directory with the same name in the Flowcode installation directory (this is usually C:\Program Files\Matrix Multimedia). You subsequently have to run the 'Install USBPack.bat' file in the Flowcode V3\components directory to register the new components. On most PCs you will have to be logged in as an administrator or have administrator rights. When you start Flowcode there will now be three additional hardware components in the component toolbar.

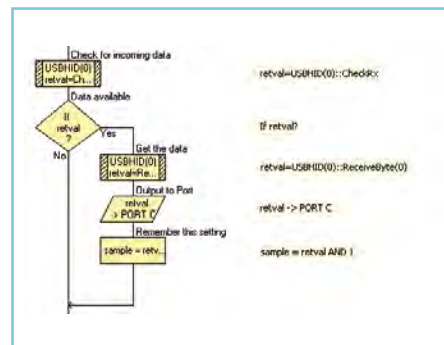


Figure 3. Part of the code for processing the receive report and possibly starting the data logging.

Software

In this article we use the 'HID' component. Click on this to add the HID component to your project and the following macros can now be used:

- Initialise_HID
- UpdateData
- SendData
- SendDataDirect
- CheckRx
- ReceiveByte
- ReceiveString

Open the USB component and ensure that the correct PID and VID codes are entered (PID F040 and VID 12BF). Select the HID Options tab. Here you have to indicate how large the packets are. A packet is the sum of all the reports. We are using one send report which contains eight bytes, so the total send packet is eight bytes. We also use only one receive report and that is one byte in size, so the complete receive packet is therefore only one byte. We increase the maximum current to 100 mA, so that there is sufficient current available from the USB-port for our circuit including the LED.

For the Subclass we select *Boot* and for the Interface *Keyboard*. Subclass *Boot* means that we want to make use of the standard reports that are loaded by the operating system when the PC starts up (boots). Now click on the HID Descriptors tab and select *keyboard*. The other settings are not relevant for this project.

We start the program with an *Initialise_HID* macro. When the USB connection is functioning properly the program ends up in an endless loop where first the state of the (reed) switch is checked. You can therefore use the Flowcode switch component. When the switch is closed an HID send report for the PC is generated which contains the keyboard scan code for the NumLock key, 0x53 according to **Table 3**, at offset 2, the first location where we may place our codes. This report is sent immediately, see **Figure 2**. After that, the program will wait until the switch is opened, after which an empty report will be sent to indicate that the 'key' has been released.

Before we actually send any information we have to wait for the answer from the PC. The PC has to confirm that the key has been received. Incoming answers are sent directly to port C. Only pin Co of this port is used (connected to a red LED), but you could easily extend the circuit by using the other pins of port C as well. This allows you to receive various different commands. Once the PC confirms that NumLock (Co) is turned on, the data logging can begin. To indicate this, the variable *sample* is given the value '1'. In the program the instruction

```
sample = retval AND 1
```

is used for that. When bit zero (that is NumLock) of the answer from the computer (*retval*) is equal to '1' then the value of *sample* will have the value of '1'. In all other cases the value will be 0 (you can therefore use this variable to check whether the USB connection has actually been established (*retval*=0) or not (*retval*=255). If *retval* is not equal to zero the program will stop in our project). The handy feature of this method is that it does not matter what the values of the other bits in *retval* are. Only the value of bit 0 is tested (see **Figure 3**).

By starting the logging only after the PC has sent the confirmation, it is also possible to start the logging by pressing the NumLock key on the keyboard of your PC. This also results in a confirmation from the PC, which is sent to both the normal keyboard and our circuit. For the same reason the NumLock light on your keyboard turns on and off at the same time as the LED in the circuit.

The analog measurements are done the familiar way using pin Ao. First the ADC component is placed on the work area and assigned to the analog-to-digital converter on pin Ao (that is, ADCo). From now on the ADC measurement is carried out which

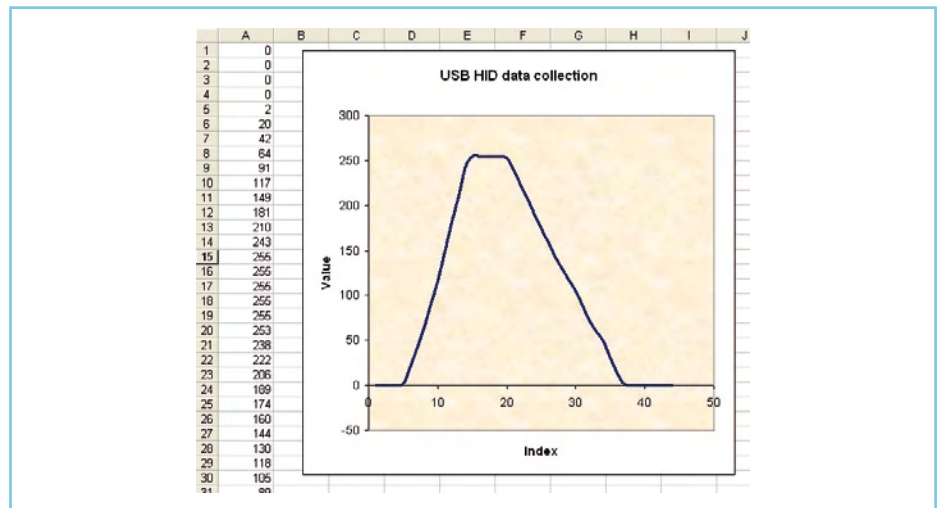


Figure 4. Example of collected data represented in a chart.

results in a data byte. The measured value ends up in the variable *retval*.

You cannot just send this value to the PC, when the value is 28, for example, you would first have to type the 2 and then the 8 on the keyboard, and not both at the same time. The circuit therefore also has to send the different digits of the measurement one by one. We do that by converting the value into a string and then taking the characters from the string one at a time in the form of an ASCII value. The next step is to convert these characters into keyboard scan codes. Since NumLock is active it makes sense to use the codes from the numeric keypad area of the keyboard. The easiest way is to add 40 to the ASCII value, see **Table 3**. This goes wrong with the number zero, but we correct for this afterwards. After each number we send an empty report to indicate that the key has been released. We finally send an ENTER, again followed by an empty report. In Excel this ENTER ensures that the cursor moves to the next cell down.

In practical use

To make practical use of this application, carry out the following steps:

1. Start an empty Microsoft Excel spreadsheet and place the cursor in cell A1.

2. Operate the (reed) switch or press the NumLock key on the keyboard.

3. The LED will turn on and every 100 ms the voltage on pin Ao is measured. This value is added to the column in the spreadsheet.

4. Operate the (reed) switch again and the data collection stops (and the LED turns off).

5. The data can now be processed into, for example, a chart (see **Figure 4**).

What if it does not work?

If it doesn't work as you expect, check that you have selected an unused PID/VID combination. When the circuit is connected there should be an 'HID keyboard device' in Device Manager. If that is not the case then you will have to use another PID/VID combination.

You can also check whether the jumper on the ECIO is in the USB position (if the jumper is in the EXT position an external power supply is expected).

The source code and the HEX file for the program discussed here can be downloaded from the Elektor website [2] as usual.

(090200-1)

Internet Links

- [1] www.matrixmultimedia.com/FlowcodeUSBPack.php
- [2] www.elektor-usa.com/090200

About the author

Bert van Dam writes books for Elektor: PIC Microcontrollers (50 JAL projects for beginners and experts), Artificial Intelligence (23

JAL projects to bring your microcontroller to life), Microcontroller Systems Engineering with Flowcode (45 Flowcode projects for ARM, PIC and AVR microcontroller).

IGLOO Nano & Icicle FPGA kits

Cool, cooler, igloo!

By Clemens Valens (Elektor Editorial France)

Often when we talk about FPGA, the first we think of are Altera or Xilinx (in alphabetical order) – but these are not the only manufacturers of this type of devices. Actel is another one. Among its ICs, we find the Fusions, the ProASIC3s and the IGLOOs. Actel is currently playing the low consumption card and states that its IGLOO ICs are the most energy-efficient on the market. We tried out two IGLOO evaluation boards, the Icicle and the nano. Here are the results we got.



You will have realized that the name of the IGLOO family refers to its power consumption, so low that the ICs always stay cool, round the clock. The Icicle board is the size of a ‘Magnum’[®] ice-cream (less the stick) – only it doesn’t melt in your hand! In spite of what you might think, the IGLOO nano board is more than twice as big as the Icicle, and its large number of pins (226) will undoubtedly delight the fakirs out there.

The IGLOO family

This currently comprises a dozen or so devices, from 15,000 to 3 million gates, and they’re almost all available in several different packages. The family breaks down into three branches: IGLOO (AGL), IGLOO nano (AGLN), and IGLOO PLUS (AGLP). The nanos are aimed at compact, low-consumption products, while the PLUS

offer more I/Os, with greater possibilities.

These ICs achieve their low consumption thanks to optimized power management, particularly through the Flash*Freeze mode. This stand-by mode makes it possible to ‘freeze’ the FPGA without losing what’s in it. Its memory stays intact, just like the register, and the output pins can maintain their levels. In the Flash*Freeze mode, the consumption is 5 μ W for the smallest IC, as against 114 μ W for the largest. Enabling or disabling this mode takes only 1 μ s and is achieved via a dedicated input.

Among other specifications, we can also mention a dual-port SRAM of 504 kb maximum, up to six built-in PLLs (phase-locked loops), and up to 620 input/outputs (in an 896-pin package). Certain members of the family are optimized to take a Cortex-M1 ARM processor.

Specifications of the nano kit (around US\$65.00):

- IGLOO AGL250 FPGA with 250,000 gates
- 8 LEDs
- 5 push buttons (one of which is a reset)
- 8 DIP switches
- Flash* Freeze
- USB serial port
- All pins accessible via an expansion connector
- Test points
- Programmable I/O and core voltages
- FlashPro3 programmer included
- Libero DVD
- two USB cables

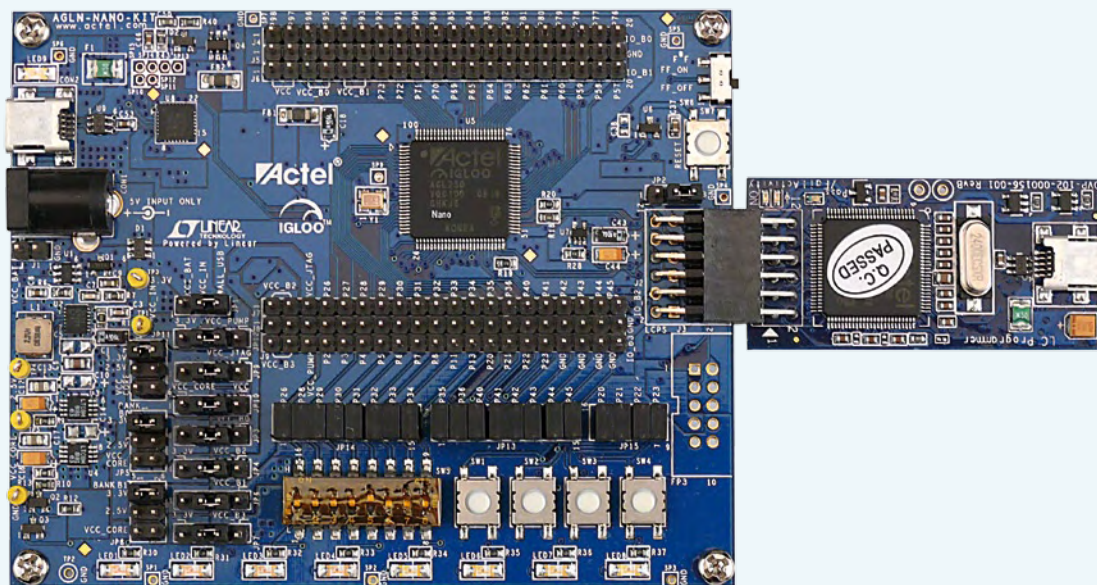


Figure 1. The IGLOO nano kit has lots of pins.

These ICs need no other components to operate, no configuration memory nor crystal, and they work as soon as power is applied.

The IGLOO nano kit

The nano board is a development and evaluation board. Its name may lead to confusion, since the board does not carry an IGLOO nano, but an AGL250 IC with 250,000 gates. It also includes a PSU, a USB serial port, and a few LEDs and switches. Numerous jumpers allow you to configure the voltages for the FPGA's I/O banks, or its core voltage. Certain contacts allow you to measure various currents — this is the evaluation side of the board.

On the development side, there are two strips of 3×20 contacts on a 2.54 mm (0.1") pitch that make almost all the FPGA's pins accessible. In this way, it's possible to fit a piggy-back board onto the nano

board and incorporate the FPGA into a personal circuit. Thanks to the JTAG programmer via USB, the FPGA is very easy to program.

In the kit box, we find two boards, two USB cables, a bag of screws and spacers, a bag with some jumpers, a Libero v8.4 DVD-ROM (Actel's development tools, see below) and a quick-start guide. The two boards are of course the nano board and the FlashPro3 programming board. The quick-start guide contains a table showing the jumper positions to make the demonstration application work. Once our board was powered up, via one of the two USB cables supplied, the demo application didn't seem to work, even with all the jumpers (except JP1) correctly positioned. Fortunately, the explanation was soon found: you also have to fit the 20 jumpers supplied in the bag onto JP13, JP14, and JP15. These jumpers make it possible to connect the boards LEDs and switches to the FPGA.

Specifications of the Icycle kit (around US\$135):

- IGLOO AGL125 FPGA with 125,000 gates
- 96 × 16 pixel OLED graphic display
- 3 LEDs
- 3 push-buttons (one of which is a reset)
- Flash*Freeze
- 120 mAh Li-ion battery
- USB serial port
- Expansion connector for 34 I/Os
- JTAG port
- Test points
- FlashPro3 programmer included
- two USB cables
- CD-ROM with documentation, tools, and software

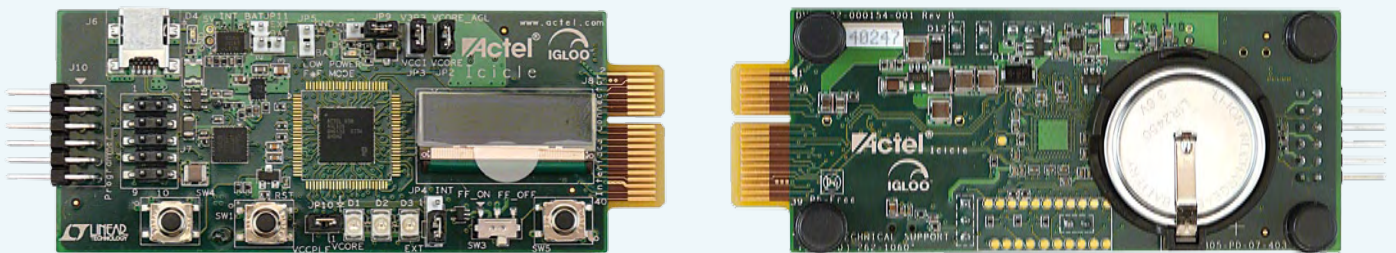


Figure 2. The IGLOO Icycle board is a bit lop-side due to the battery on the solder side.

With **all** the jumpers properly in place, you can play around a little with the LEDs by pressing the buttons or changing the switch positions. (It's worth noting that the references for the buttons and switches in the quick-start guide are wrong). The demonstration application also lets you check the board's USB serial port. If you run, for example, HyperTerminal on the computer and configure the serial port correctly (9600n81), the board will send back the characters transmitted by HyperTerminal. Our board passed this test too.

The IGLOO Icycle kit

About the size of a mobile phone, the Icycle board includes on one side of the PCB an AGL125 FPGA with 125,000 gates, a tiny (25×7 mm) green or blue 96×16 pixel OLED graphic display, three LEDs, three push-buttons, a switch, a few jumpers, a USB serial port, a JTAG port and an extended JTAG port for the FlashPro3 programmer. On the other side of the PCB we find an LIR2450 format Li-ion battery with a capacity of 120 mAh. The Icycle board can be used in one's own circuit thanks to a 2×19 contact (2×20 if you count the keyway) expansion connector in the Mini Edge Card format. This connector gives access to 34 of the FPGA's I/Os.

All the Icycle's devices are low-consumption, which means the board can be powered just from the battery. Note that when the battery is charged, the only way to turn off the power to the board is to remove jumper JP11.

Besides the Icycle board itself, the Icycle kit contains a FlashPro3 programmer, two USB cables, and a CD-ROM on which are found the data sheets for the Icycle board, the programmer, and certain

devices, and the circuit diagrams of the card, along with the programmer driver, the software for the FPGA, and other potentially interesting documents.

Everything is packed in a recyclable brown box made from recycled cardboard. So it's a kit with low environmental impact – it's 'green'!

The board's manual describes how to measure the current in the different parts of the board and the influence the Flash*Freeze mode has on these measurements. So we measured the core current running at 1.2 V (2.7 mA) or at 1.5 V (3.6 mA), but the In view of this problem, added to the fact that the pre-loaded application failed to behave as described in the manual, we decided to reprogram the board with the software found on the CD-ROM.

The latter compiled with no problem, though Libero v8.5 (see below) had to convert the project, which had been created with an earlier version. About a minute later, the time taken to reprogram the FPGA, the board worked as described. The LEDs worked differently now (a 3-bit binary counter) and the core current at 1.2 V had dropped to 1.5 mA, or 2.0 mA for a core voltage of 1.5 V. The most important thing is that now the Flash*Freeze mode was working. We measured around 28 µA at 1.5 V and around 16 µA at 1.2 V. As a result, the board's indicator, which shows if the core current is below 100 µA, also lights up when Flash*Freeze mode is enabled.

Libero

Like the other FPGA manufacturers, Actel also makes available a free version of its development tools. The suite, called Libero Gold, includes not only the manufacturer's own tools, but also 'light' versions of other software for FPGA programming specialists, like Mod-

Libero IDE v8.5 specifications:

- Windows XP Pro with SP2 or Vista Business Edition
- Graphical environment
- Design via circuit diagram entry or programming
- Synthesis
- Simulation
- Placement and routing
- Programming

eSim from Mentor graphics and Synplify from Synplicity. There's also a demo version of WaveFormer by SynaptiCAD.

We started off by installing Libero v8.4, supplied with the nano board. Note that Libero requires Windows XP Pro SP2 or Vista Business Edition as a minimum. The installation went off alright (though you do need to allow nearly 4 GB of space free on your hard drive) apart from a message at the end saying that the installation wizard couldn't find the drivers for FlashPro3, the little FPGA programmer. The Actel website^[2] mentions this error number SAR 46033. After obtaining a licence, we started the 'Libero IDE Quick Start Guide & Tutorial'^[3] (don't forget to download the Design Files as well, also available from^[3]) Concerning the error message at the end of installation, we had to manually create the links in Libero between the tools and their location on the hard drive.

Everything was going fine until we needed to use the WaveFormer Lite tool to create graphically a stimulus file for a simulation. This tool simply refused to recognize the temporary licence supplied by the manufacturer. There was nothing to be done about it, even with the help of the manufacturer's tech support. This was all sorted out by uninstalling Libero v8.4 completely – and manually, to boot, as the installation wizard that also takes care of uninstallation didn't want to know either. Fair enough, all this was probably owing to a slip-up on our part – but all the same, we preferred to order a free DVD of Libero v8.5 (the current version at the time of our experiments) from the Actel website before continuing. It is also possible to download the DVD.

We received the DVD a few days later, and it was as simple to install as the previous version, with the same error at the end. For your information, our test computer runs under Windows XP Pro SP3. The licence management seemed simpler, but perhaps because we hadn't (properly) deleted all the licences etc. from the previous installation. Once the IDE (integrated development environment) was running, everything worked and the tools were recognized. Windows recognized the FlashPro3 programmer when we con-

nected it to a USB port, and this time WaveFormer Lite worked perfectly. So go for Libero v8.5 (or better still v8.6, which had just come out as we were finishing off this article), and follow the instructions given in the messages accompanying the licences to the letter.

The tutorial refers to v8.4 of Libero, and certain details are no longer correct. There's nothing serious and with a bit of patience, you can get through all the stages. But there are a lot of them, and it can take one to two hours. The reward is a board that can make three LEDs flash thanks to a 3-bit counter. It's decidedly less spectacular than the demo application preloaded onto both boards (which you delete as you go through), but it's so gratifying that you stay watching, mesmerized, for a long time.

Just to finish, let's once again clarify one little subtle point. Libero needs to know which FPGA is being used, and offers a long list of all the models it knows, from which you have to choose the right one. In this list, there are two versions of the AGL250 on the nano board, V2 and V5 (the same goes for the AGL125 on the Icicle board). However, the version is not marked on the device itself, and on the Actel website^[1] the information is well hidden. But if you know where to look, you can find it – for example, on the AGL family data sheet^[5] (the note on page III, of course!) It's simple: if there is no version shown on the device, it's a V2. This model can operate with a core voltage between 1.2 V and 1.5 V, unlike the V5, which only works with a core voltage of 1.5 V.

Final remarks

Actel has gone to a lot of trouble to create comprehensive evaluation and development platforms that are easy to use and relatively cheap. The systems are not very complicated to use and are accessible even for novices. The two nano and Icicle kits are supplied with matching FlashPro3 programmer (blue for the nano board which is blue and green for the Icicle board which is green), which shows a certain attention to detail (or a lucky coincidence!) With such a complex product, encountering a few minor hiccups is acceptable.

(090528-1)

Internet Links

[1] www.actel.com

[2] www.actel.com/download/program_debug/flashpro/fpro85.aspx

[3] www.actel.com/products/hardware/devkits_boards/igloo_starter.aspx#docs

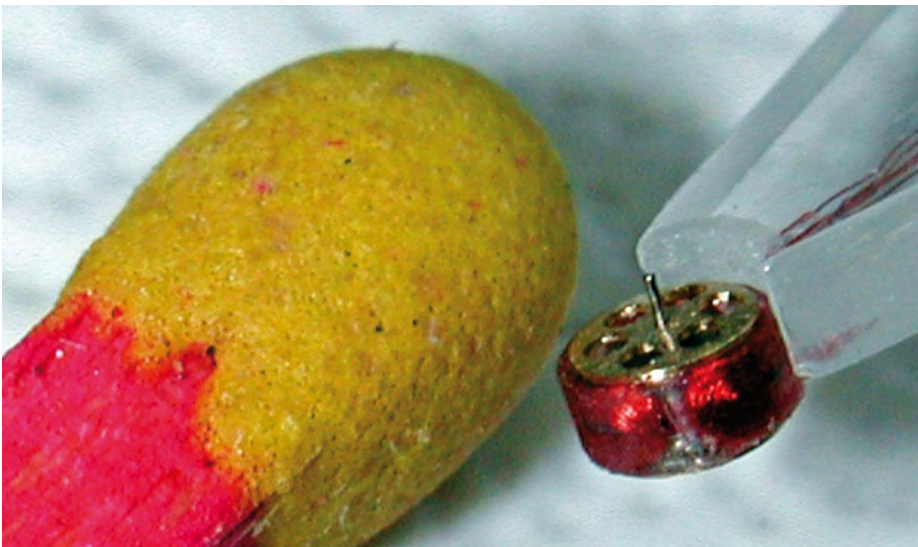
[4] www.elektor-usa.com/090528

[5] www.actel.com/documents/IGLOO_DS.pdf

The World's Smallest Electric Motor

Elektor reader listed in the Guinness Book of Records

By Harry Baggen (Elektor Netherlands editorial staff)



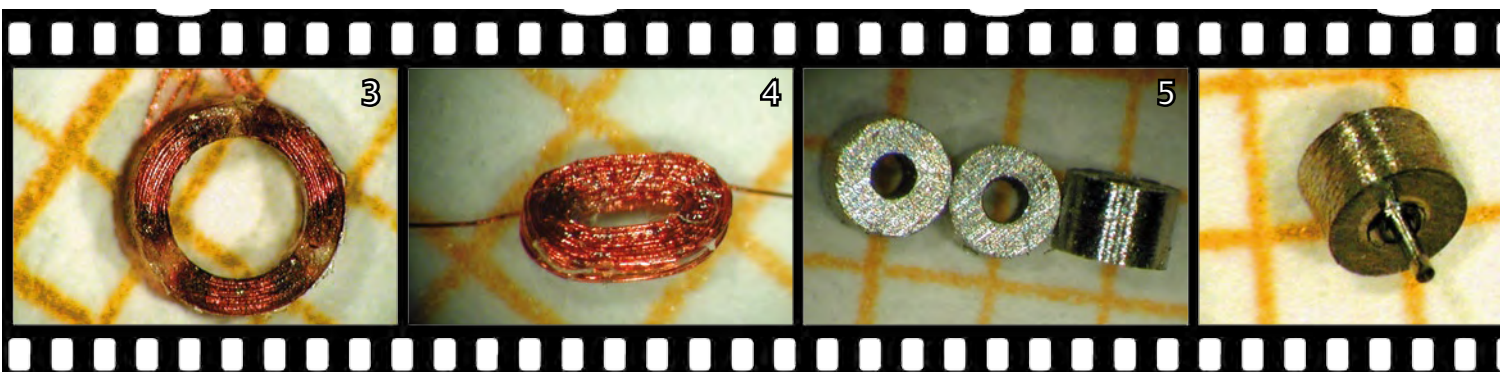
What would you say to an electric motor smaller than the head of a pin, and what's more, mostly hand made? It really exists. With this motor, Jos d'Haens recently established an official world record recognised by Guinness World Records.

Jos d'Haens is an especially versatile individual who has done many different things in his life. Although he was especially interested in technical subjects in his youth, he began his professional career as an economist with Bell Telephone in Antwerp. There he had an opportunity to switch to engineering and concentrate more and more on technical matters and electronics. He was especially interested in microelectronic and micromechanical aids for industrial and medical applications.

His first invention was a tiny electric motor for use in biomedical applications, which at the time (1958) was the smallest electric

motor in the world. In 1962 he developed an 'endomotor probe', which is a device for examining the gastrointestinal tract. To improve his theoretical knowledge, in 1966 he enrolled in a course of study at the Faculty of Science of the Sorbonne. His further career consisted of a variety of large projects, such as setting up and managing two PCB plants in Belgium and several electro-optical plants outside Belgium, as well as pursuing his own inventions. These involved a wide variety of devices, such as equipment for measuring air pressure and relative humidity and the very first European wristwatch calculator.

We could mention a lot more examples, but in any case it's clear that what we have here is an inventor and engineering adept who always has to be doing something. It should thus come as no surprise to our readers that Jos has been a faithful reader of *Elektor* magazine since the very first issue. Now that he is retired, he still keeps busy with electronics and engineering. In his well equipped personal shop, he works regularly on his favourite hobby: making micro-motors. His latest product is a hand-made miniature electric motor that, according to him, is the smallest mechanical motor in the world.



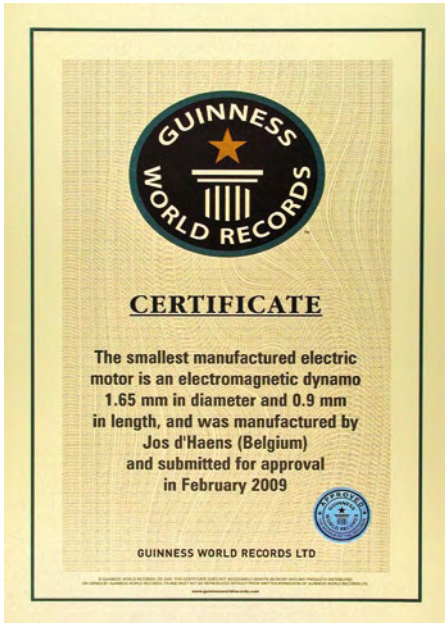


Figure 1. The Guinness World Records certificate.

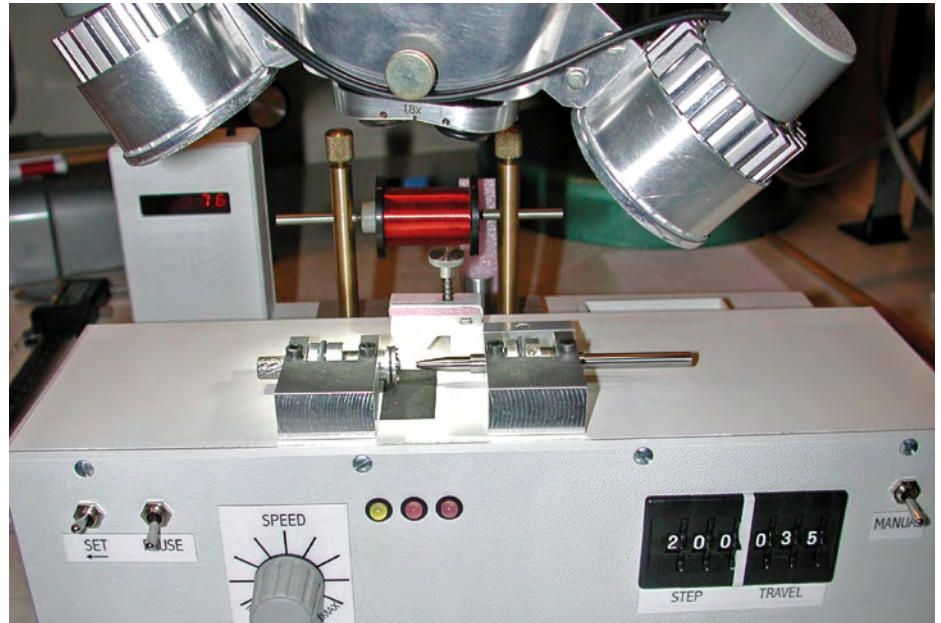


Figure 2. Special equipment was developed to fabricate the miniature components.

A few months ago, Jos reported this remarkable device to Guinness World Records, in the hope that his product would be recognised as the world's smallest electric motor. After a long wait, in February he received a certificate from Guinness World Records stating that his new electric motor established a new world record, which of course will be reported in the next edition of the *Guinness Book of Records*.

The primary stimulus for the development of a new, even smaller motor was a contest, but it is entirely possible that the resulting motor will be used in a practical application.

Although Jos can make use of special equipment of his own design (as shown in Figure 2) in the preparation of his prototypes, we imagine that Elektor readers would be especially interested in the design and construction of this motor. If the dimensions are enlarged somewhat, a motor of this sort can also be built using ordinary tools.

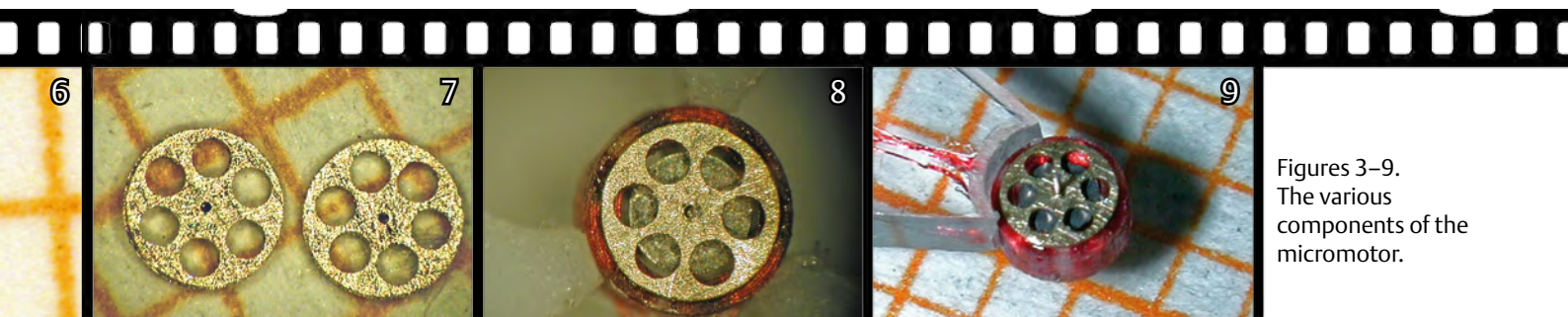
First let's have a look at some of the specifications of the micromotor:

- Diameter:** 1.65 mm
- Length:** 0.90 mm
- Weight:** 9.8 mg
- Volume:** 1.92 mm³

- Operating voltage:** 0.220 V
- Operating current:** 18 mA
- Speed:** 600 to 6000 rpm (variable)

The miniature electric motor has three windings that are driven by an electronically generated three-phase signal. It is thus an example of what is called a 'brushless DC motor'.

Figures 3 to 9 show the various components of the motor. Figure 3 shows one winding, which consists of 80 turns of 0.02-mm copper wire. A total of three such windings are necessary. They are formed into the proper shape (flattened and slightly curved) as



Figures 3–9. The various components of the micromotor.

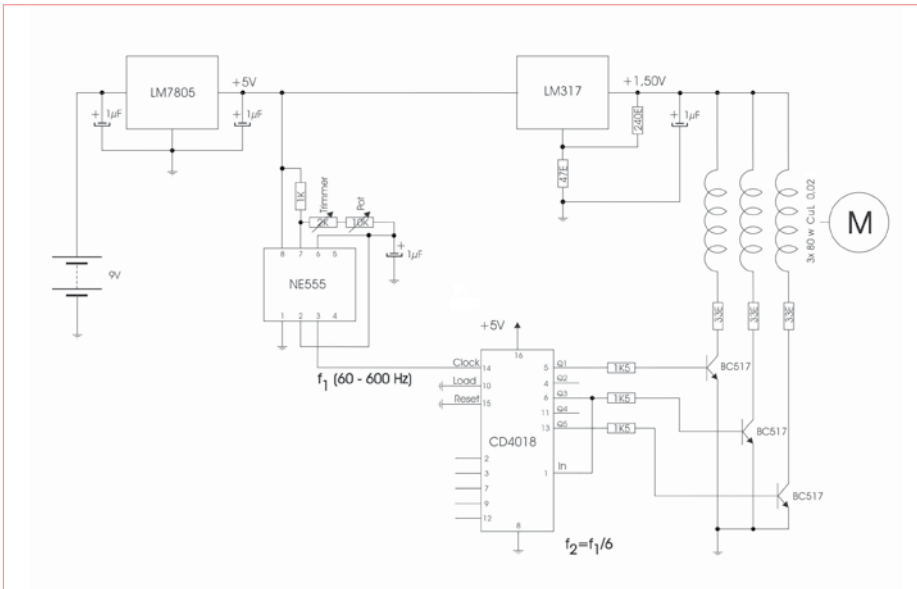


Figure 10. Schematic diagram of a micromotor drive circuit. With suitable modifications to a few component values, this circuit can also be used to drive larger motors with three windings.

shown in Figure 4. The rotor consists of a very small magnet (5) that is eroded and ground to the right dimensions and has a hole for the attachment of the shaft (6). Two tiny plates with cutouts (7) act as the upper and lower portions of the motor housing. Figures 8 and 9 show the complete assembly. The winding are glued in place between the upper and lower plates, so they effectively

form the rest of the housing. If you want to experiment with your own DIY motor, you can use the schematic diagram shown in **Figure 10**. This is the original circuit that Jos used to drive his micromotor. The design is simple but very effective. Starting from a 9-V supply voltage (provided by several penlight cells in a battery holder or a single 9-V battery, which is

adequate for a micromotor), a 7805 voltage regulator generates a stable 5-V operating voltage. This voltage is used to power the other ICs in the circuit. A second voltage regulator (an LM317) is used to reduce the voltage to 1.5 V, since the windings of the micromotor require a relatively low operating voltage.

The frequency of the three-phase drive signal is controlled by a 555 configured as a square-wave generator whose output frequency can be adjusted by a potentiometer over the range of 60 to 600 Hz. This signal is fed to the clock input of a CD4018 presettable divide-by-N counter. The Q1, Q3 and Q5 outputs of this counter drive the motor windings via a set of BC517 Darlington transistors with 33-Ω series resistors to limit the motor drive current. The CD4018 is configured to operate as a divide-by-six counter by connecting pin 6 to pin 1. The signals on the Q1, Q3 and Q5 outputs drive each of the windings in sequence with a certain amount of overlap, which creates a well-defined rotating magnetic field in the motor.

If you want to use this circuit for your own projects, you can modify the frequency and voltage of the winding drive as necessary. Bear in mind that the BC517 transistors have a maximum rated peak current of 1 A, so a larger type must be used if higher currents are necessary.

(090499-1)

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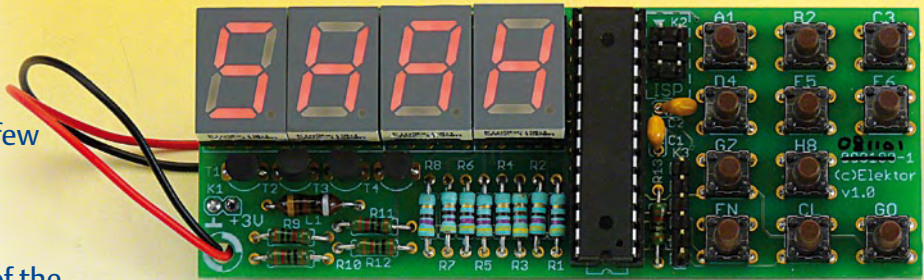
AVR-Max Chess Computer

A minimalist homebrew chess computer

With contributions by Andre Adrian (Germany)

For just a few dollars you can take a microcontroller, add a few pushbuttons and some 7-segment displays to build a chess computer reminiscent of the legendary Mephisto I.

The low component count (and no SMDs!) allows the entire machine to be shrunk onto a neat pocket-sized PCB. Despite LED displays it draws just 20 mA and will run until the battery supply falls below 1.9 V.



Following on from last month's feature on the ATM18 Mini Chess Computer for the Elektor AVR board we now present, as promised, a dedicated stand-alone chess computer featuring the same firmware with optimized hardware. This mini project originates from the SHAH computer developed by Andre Adrian, described in detail last month. The original firmware has been ported to run with 7-segment displays and the prototype PCB produced by the author was reworked in the Elektor Labs to produce a professional job just half the size of the original. The computer's basic operation has already been described in the previous article so we will just concentrate on construction and operation with the 7-segment LEDs which replace of the two-wire serial interfaced LCD display of the ATM18 project.

The circuit

The central element in the circuit diagram (Figure 1) is an ATmega88 microcontroller in a 28-pin skinny DIP package. The controller's clock is derived from its on-board RC oscillator running at 8 MHz (max). A 3 V supply is provided by two series connected AA or AAA batteries via coil L1. On power-up the network formed by R13/C2 generates a reset to the microcontroller. Connector K2 provides an ISP programming interface for either the AVRISP-MKII or compatible Elektor USB AVRprog [1]. The controller firmware is available for free download from the Elektor website [2].

A ready-programmed controller is also available from the Elektor Shop so you don't need to program it yourself.

Port pins PDo and PD1 connected to K3 provide a serial interface for a PC. The signal levels are compatible with the USB TTL adapter cable featured in Elektor June 2008 [3].

Features

- Minimal component count
- Low power (20 mA @ 3 V)
- Battery power using two AAA or AA cells
- Nine playing levels
- Look-ahead 20 halfmoves
- Elo rating approx. 1200-1399
- Display of principal variant mode (on/off)
- Opening set-up possible
- Select black/white at start of play
- Change sides during play
- Computer can also compete against itself

The rest of the circuit consists of a multiplexed interface to drive the 7-segment LED displays (LD1 to LD4) via transistors T1 to T4. Seven port pins read the push button matrix S1 to S11 in precisely the same way as the 'ATM18 Mini Chess Computer' described last month. The C routines driving the display and scanning the push button matrix are optimized to help reduce power consumption. The C source code is well documented and worth downloading.

And PCB

Construction is quite simple, despite the small (100 mm x 40 mm) PCB (Figure 2) no SMD components are used in the design. The layout is double-sided and through-hole plated. For simplicity all components are mounted on one side only (Figure 3). Connectors K2 and K3 need not be fitted if you do not intend to program the controller in-system. Use an IC socket for the ATmega88. The project is also available as a kit from the Elektor Shop, with all the necessary components. To make a really neat job the finished board can be fitted into a suitable enclosure.

Game on...

The chess engine and keypad input routines are identical to those used on the ATM18 mini chess computer described last month. The AVR-Max chess computer however has a more basic 4-digit LED display which allows it to display a maximum of four characters. Before powering the unit up take a few minutes to inspect all the soldered joints to make sure you have not accidentally bridged two pads with a blob of solder and that IC1 is fitted the correct way round. Once you are sure that the supply leads are correctly connected the unit can be powered up. If everything is in order the word 'SHAH' appears on the display. Pressing the CL button clears the display ready for your first move to be entered. Enter for example E2E4 and press the GO

COMPONENT LIST

Resistors

R1–R8 = 470Ω
R9–R13 = 10kΩ

Capacitors

C1, C2 = 100nF (lead pitch 0.1" / 2.54mm)

Inductor

L1 = 10μH (fixed inductor)

Semiconductors

LD1–LD4 = SA52-11 (Kingbright), 7-segment LED display, red, common anode, 13.2mm height
T1–T4 = BC559C (or -B)
IC1 = ATmega88P-20PU (Atmel), programmed, Elektor Shop # 081101-1

Miscellaneous

S1–S11 = push button, 1 make contact, PCB

mount, e.g. Multicomp MCDTS6-5N
K1 = 2-way pinheader or 2 solder pins
K2 = 6-way DIL pinheader
K3 = 6-way SIL pinheader, right angled (optional)
Battery holder for 2 AA or 2 AAA batteries

Kit of parts # 081101-71 (see Elektor-Shop, www.elektor-usa.com)
PCB # 081101-1
Project software, free download # 081101-11.zip from www.elektor-usa.com/081101

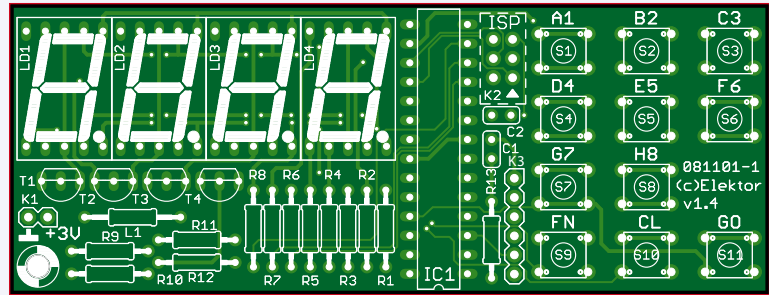


Figure 2. The double-sided PCB measures just 100 mm x 38 mm but does not use any SMDs.

button twice to enter the move and instruct the computer to calculate its move. An

attempt to enter an illegal move will generate 'ILL' on the display. A blinking display

shows the players move while a static display shows the computers move. When

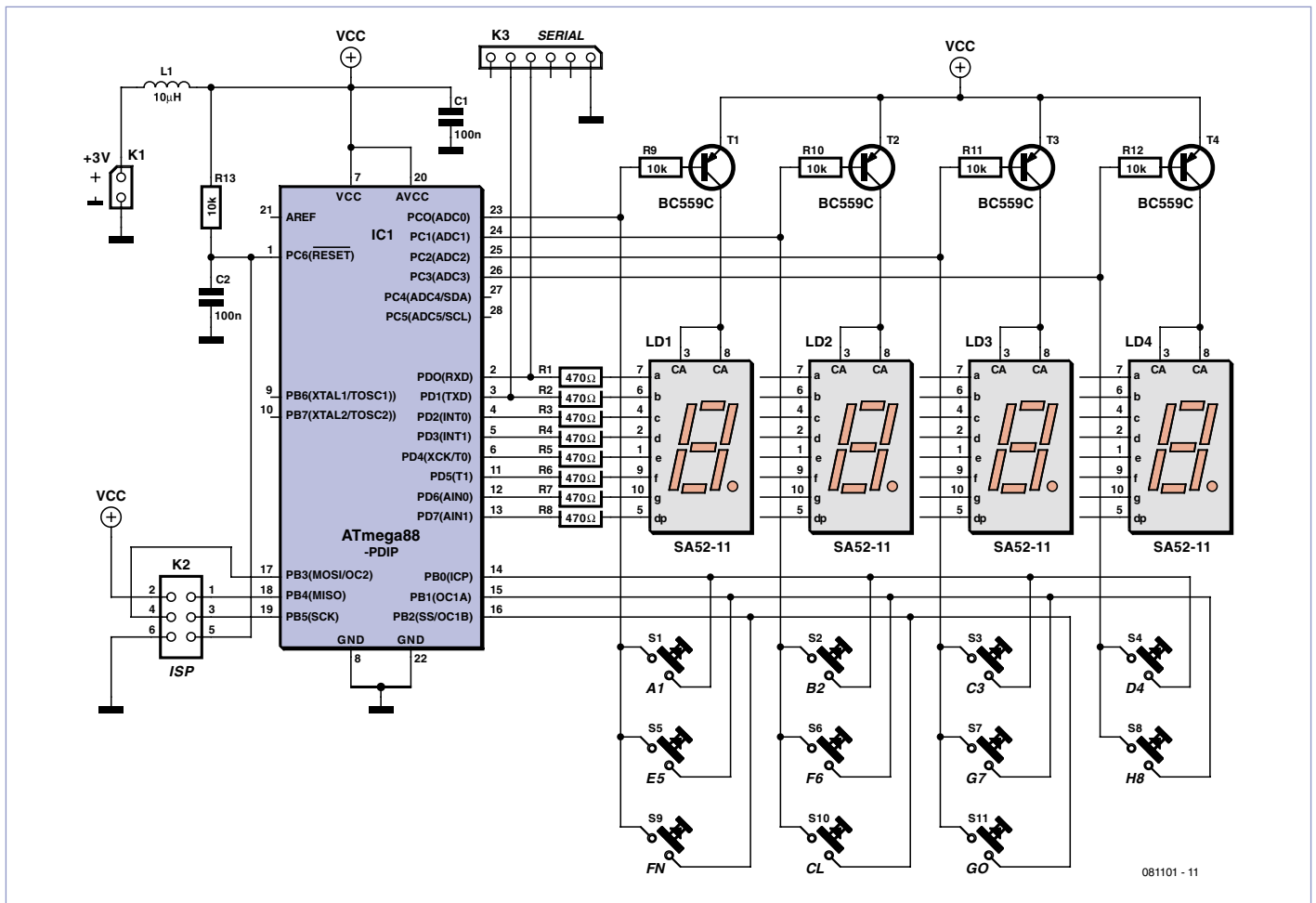


Figure 1. AVR-Max circuit diagram. The ATmega88V uses its internal 8 MHz RC oscillator.

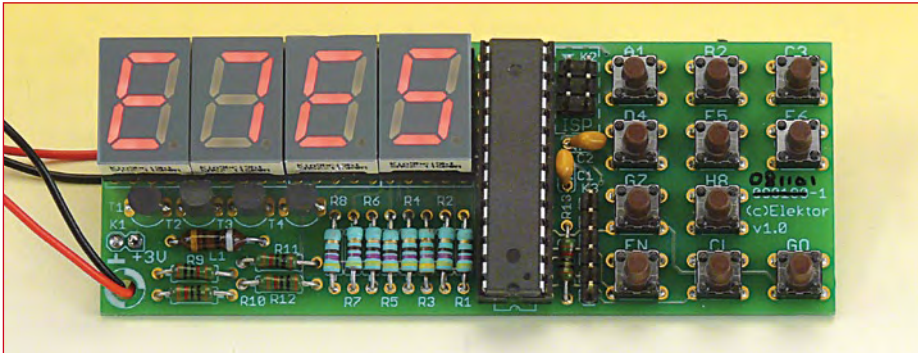


Figure 3. The fully populated circuit board.

checkmate occurs 'MATE' is displayed. At power-up the computer will always play black. To switch it to white press GO. To set up an opening position (e.g. E2E4, E7E5, G1F3 and B8C6) enter both black and white moves while pressing the GO button once only after each move. The FN button gives access to all the set up functions. FN and 1 starts a new game, FN and 2 changes the playing level (press GO

to return from play level setting). FN and 3 switches the principle variant mode off or on (see last month's 'ATM18 Mini Chess Computer' feature). The CL button clears input values. The philosopher and AI sceptic Hubert Dreyfus predicted that a computer would never be capable of playing chess at the highest level. Since then we have seen Grandmasters humbled by super-computing number

crunchers. One tip for the faint-hearted: When your situation looks a little grim during a game just press the GO button to swap places with the computer, see if it's smart enough to get itself out of the position it played you into! Too bad we don't have a GO button to get us out of tricky situations in real life!

(081101-I)

Internet Links

- [1] www.elektor-usa.com/080083
- [2] www.elektor-usa.com/080947
- [3] www.elektor-usa.com/080213

Author's website (German):

www.andreadrian.de/schach/

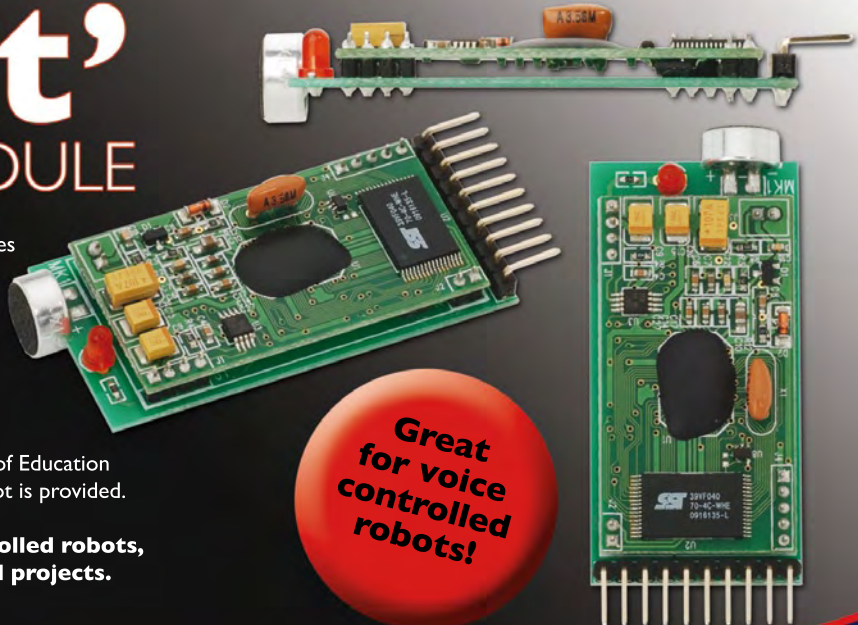
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There's more than sand in The Valley

a history of Silicon Valley, without most of the silicon

By Vincent Himpe (USA)

The San Francisco bay area and its surrounds have always been a hotbed of innovation and technology. Even before the “valley of heart’s delight” became known in the 70’s as ‘Silicon Valley’ a number of new technologies were pioneered here. Some of these remarkable events go as far back as the turn of the 20th century.

In this article we’ll take you on a trip through history and highlight some interesting developments, many of which still have remnants today, in and around Silicon Valley. Some of these go far beyond mere ‘sand’. That is, the sand of which silicon is made.

Alto to San Jose Valley into the technology hotbed it is today. Under impulse of Professor Frederic Terman, the Dean of Engineering the Stanford Research Park was launched in 1935. The idea was to stimulate local economical growth by keeping the graduates close by. SRP would thus become essentially the first venture capitalist company. www.stanford.edu



1853

Levi Strauss arrives in San Francisco and sets up a wholesale dry goods business. In 1870 Jacob Davis starts making pants using materials bought from Levi Strauss stores. On May 20 1873 Strauss and Davis receive US patent # 139121 on the usage of copper rivets to strengthen the pockets of denim pants. They incorporate as Levi Strauss & Co and begin marketing the first ‘waist overalls’ or blue jeans. Lot # 501 became the most popular jeans and is still manufactured today.

1906



1909

Pioneer Electronics Research Lab is established at the corner of Channing Avenue and Emerson Street in Palo Alto. Here Lee DeForest would go on and develop the first practical application of his Audion as an amplifier and oscillator. 910 Emerson Street, Palo Alto.

1876

At the request of James Lick construction is begun of an observatory at the top of Mount Hamilton in San Jose. First light was seen through the then largest telescope in the world, on January 1888. The station is still in operation today and is the world’s oldest permanent observatory. Several moons of Jupiter were discovered with this telescope as well as multiple extra-solar planets. www.ucolick.org

Cyril Ewell starts the Federal Telegraph Company after having acquired the rights to the Poulsen Arc Transmitter from Valdemar Poulsen. The first wireless telegraph station was built on 48th Avenue between Noriega and Ortega Street in San Francisco. In 1912 a second ground station was built at Point San Bruno, just south of San Francisco. At its construction it had the world’s largest antenna towers, rising up to 440 feet. The antenna itself contained 35,000 feet of wire.

1885

Stanford University, named after its founder former California governor Leland Stanford, is founded in Palo Alto. It would become one of the world’s leading universities and generate more successful graduates than any other university. The university started a technology grant that would be a highly successful incubator hatching the technological avalanche that would turn the Palo

Lee deForest (1873-1961) further develops the basic electron-valve made by Ambrose Fleming by adding a grid to it. This grid effectively controls the flow of electrons through the valve. A signal applied to this grid effectively allows the current through the valve to be controlled, thus creating the first amplifier element. Lee deForest called his invention the Audion. It would later be known under its more common name: the Triode. www.leedeforst.org

Charles D. Herrold creates the world’s first radio broadcast station, KQW (later KCBS), in the Garden City Bank building in downtown San Jose (today’s capital of Silicon Valley). To date a broadcast studio is in operation in the building at the southwest corner of First and San Fernando. www.kcbs.com

1927

Philo Taylor Farnsworth invented and patented the first all-electronic television sys-

tem. Farnsworth had his 'lab' in a cellar on 202 Green Street, San Francisco. In September of that year he successfully transmitted the first all-electronic television image.

1935



William Hewlett and David Packard graduate from Stanford University and decided to start their own test equipment company. Spurred on by a grant from Frederic Terman, professor at Stanford University, they set up shop in one of their parents' garage in Palo Alto. The first successful product was an audio oscillator that was used by Disney Studios to produce audio for the movie Fantasia.



HP quickly went on to develop a wide range of test equipments. The emerging micro-computer industry proved a new stomping ground for the corporation, which quickly developed scientific computers to control test equipment and crunch numbers. After the acquisition of Apollo and Compaq in 1999 the company decided to focus on computer and peripheral systems and spin off its test and measurement and semiconductor division as Agilent Technologies. The original garage and house at 367 Addison Ave, Palo

Alto is a state protected monument. It was bought by the Hewlett-Packard Corporation and restored to its former look in 2005.

1939

The Ames Research Center was founded as a laboratory for aeronautics applications in Sunnyvale. Initially under the control of National Advisory Committee of Aviation (NACA) it moved to the National Aeronautics and space Administration (NASA) in 1958. Amongst the most notable projects



run from this site are the Pioneer spacecraft, of which Pioneer 10 and 11 are the first manmade objects to leave our solar system, The Pioneer craft that landed on Venus, the Lunar Prospector, the Kepler observatory and SOFIA, a modified Boeing 747 carrying a telescope. NASA Ames was instrumental in the flight software for Space Shuttle, the International Space Station and the software that controls the two Mars rovers Spirit and Opportunity. It also hosts some of the most powerful computers currently in existence such as the Columbia super-computer and the Pleiades system. Moffett Blvd., Mountain View.

1944

Alexander M. Poniatoff starts AMPEX in Redwood City. Initially a manufacturer of small electric motors and generators, they ventured off in the audio, and later video, recording and playback technology. AMPEX became the de-facto standard for studio and broadcast registration and playback equipment. 500 Broadway Street. Redwood City.

1948

The brothers Varian (Russell and Sigurd) , and associates start Varian Associates in San Carlos, just south of San Francisco, to

develop and sell the Klystron tube and other high frequency components. They would move to Palo Alto in the early 50's to occupy a building in the then new Stanford Industrial Park. Originally focusing on the klystron and its applications like radar and TV transmission tubes, Varian Associates would also enter other fields such as particle accelerators for medical purposes, radiation equipment and x-ray equipment. When the semiconductor boom began, Varian was heavily involved in the development of the first ion-implantation equipment that today is crucial for semiconductor manufacturing.

1952



IBM opens a laboratory at 99 Notre Dame Avenue in San Jose. The fundamental research done in this lab culminated in the development of the hard disk drive.



1954

The Berkeley National Lab begins operating the Bevatron Particle accelerator, then the largest particle accelerator in the world. This synchrotron allowed elementary particles to be accelerated to very high speeds, and then smash them into each other, allow-

ing the study of the fundamental building blocks. Many a discovery was done here, amongst which the anti-proton, and the research done with this machine yielded four Nobel prizes. The machine was decommissioned in the 1990's and is currently being dismantled.

1955



William Shockley, co-inventor of the transistor, sets up shop as Shockley semiconductor Laboratory in a former produce store building at 391 San Antonio Road, Mountain view. The building still exists today and is once again a vegetable store.

1956

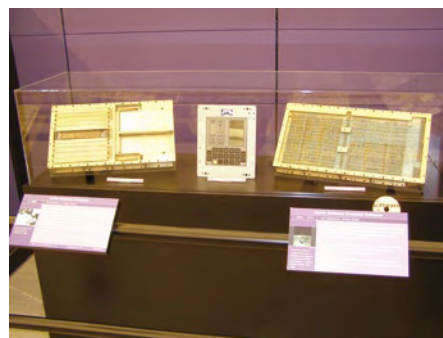
IBM sets up a brand new plant at 5600 Cottle Road in San Jose and starts mass producing the first commercial hard disk drive.

1957



Eight of Shockley's associates break away after Shockley decided to give up on silicon and pursue only germanium. The rebels Robert Noyce and Gordon Moore start up Fairchild Semiconductor in Mountain View and alter set up offices in Palo Alto. Even though the integrated circuit was invented by Jack Kilby at Texas instruments, it was Gordon Moore from Fairchild semiconductors in the building at 844 Charleston Road that made the first mass producible integrated circuit.

The device would be the basis of the flight computer for the Apollo missions and ultimate moon landing.

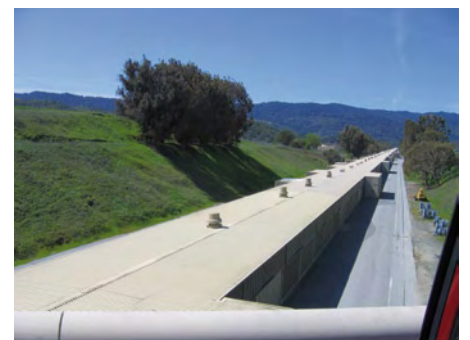


1958

The Cold War era prompts the US Air force to set up an early warning radar system on top of mount Umunhum on the southern edge of Los Gatos. Its powerful radar could oversee all of northern California's airspace. It was decommissioned in 1984 and demolished. The only visible remnants is the radar antenna pedestal on top of the 3486 feet tall mountain that's clearly visible from ground level in San Jose and Campbell.

1962

Stanford University decides to develop and build a linear particle accelerator for fundamental physics research. The Stanford Linear Accelerator Center, commonly referred to as SLAC, houses an immense machine that is buried about 10 meters underground and runs over a total length of roughly 2 miles through the Californian country. It is so long, a tunnel had to be built to allow it to pass underneath highway 280. Its structure can be seen from various points in the valley. This remarkable machine has yielded some very impressive results. Not the least of which are four Nobel prizes. It was instrumental in the development of many a technology required for these machines. Amongst these spin-off technologies is the Klystron, in essence a high power microwave amplifier tube. As an aside: The computer center associated with SLAC hosted the first www server outside of Europe.



While working at Stanford research Institute, Douglas Engelbart and Bill English apply for a patent on a wooden box with two metal wheels and described as an 'x-y position indicator for a display system'.

This device would revolutionize computer input and later be known to the world as the 'mouse'. Douglas had a lot of other ideas like hypertext, networked computers and graphical user interface. His fundamental work would culminate in the NLS or on-line system.

1968



Robert Noyce and Gordon Moore leave Fairchild to set up their own company: Integrated Electronics or Intel for short, in Santa Clara. This is where the first true boom of the semiconductor technology happens. After the first single chip processor Intel went on to develop many computer related technologies such as DRAM, bubble memory, EPROM, EEPROM, flash and many more. It would grow to be the almost unbeatable no. 1 in semiconductor manufacturing.

During the Fall Joint Computer Conference at the convention center in San Francisco a demonstration is given of the NLS system including the use of a computer mouse, live video broadcast and hyperlinked documents. This would essentially become the world's first 'netmeeting' in which two people could see and talk to each other and share information using a computer terminal with a graphical user interface under control of a mouse. Nobody had even imagined such a system let alone envisioned how to build one. At the end of the 90 minute demo the audience gave Douglas Engelbart and his team a standing ovation. This was truly a marvel of modern engineering and would open limitless possibilities in collaborative work. This event was truly the mother of all computer demos.

1969

The world's first electronic computer network ARPANET goes live with the establishment of a link between the Stanford Research Institute, UCLA, UC Santa Barbara and the University of Utah. They use Douglas Englebart's NLS system, an early form of hypertext. The first email was sent on this system in 1971, and by 1973 the first file transfer took place using FTP.

1970

Xerox Corporation opens a new research center in Palo Alto: The Xerox PARC (Palo Alto Research Centre). Many notable inventions and developments can be traced down to this site. Amongst the most notable are the laser printer, the computer mouse, the first wysiwyg user interface, bitmap graphics, the Alto Computer, Ethernet, LCD displays, optical disc technology and the Smalltalk language. 3333 Coyote Hill Rd. Palo Alto



1971

Nolan Bushnell and Ted Dabney found an engineering firm at 2962 Scott Blvd in Santa Clara that would get world renowned status as ATARI.

1972

Although not inside the Bay area, but really close, Gary Kildall begins experimenting in Monterey with early Intel microprocessors

and writes the first optimizing high level programming language for microprocessors: PL/M (programming Language for Microprocessors). Using this PL/M language Gary goes on to develop the CP/M disk operating system. He founded the Digital Research Company and started producing and marketing what would become the first popular operating system for microcomputers. Later on Gary would also develop, amongst others, the Logo computer language the GEM graphic desktop system and the file system for CD-ROM.

1973

The Xerox Palo Alto Research Centre (PARC) develops and patents Ethernet: a multipoint data communication system. This would go on and become the backbone of many computer networks worldwide.

1975

Start of the 'Homebrew Computer Club'. This hobbyists club was founded by enthusiastic members that wanted to experiment with a budding new technology called the microprocessor. Notable members include Adam Osbourne who would start Osbourne Computers, and Steve Jobs and Steve Wozniak who later founded Apple Computer. The main focus of the group was to help each other build computer systems so they could experiment with this new technology at home.

IMSAI incorporates in the city of Fremont and starts producing the first do-it-yourself kit for a computer system. Essentially a cloned and heavily improved MITS Altair, this machine had the capability to drive a video display and run the CP/M operating system. One of these IMSAI machines was immortalized as the computer used by Mathew Broderick in the 1983 movie Wargames. In a nod to Silicon Valley, the video game company in the movie was purportedly located at a fictional address in Sunnyvale.

DARPA, the government's founder of Arpanet, Xerox PARC and Stanford University come up with a new set of protocols for data transfer over networks: TCP/IP. This is today still the 'glue' that holds the Internet together.

1976

The first national computer retail store 'ComputerLand' opens its doors in Hayward. Sprouted from the mind of William H Mallard this was the first company that would offer full service to early computer adepts. It would soon have franchises all over the US.

Steve Jobs and Steve Wozniak set up camp in Mountain View as Apple Computers to sell their build-it-yourself computer kit. After a rework of the Apple-1 into the Apple II, Steve jobs sees the Xerox Alto graphical user interface at work and decides that is the way forward. The Apple Lisa is the world's first commercially available machine with a graphical interface. Fairly unsuccessful due to the hefty price tag the machine is re-engineered and becomes the Macintosh. The rest ... is history.



1979

Alan Shugart and Finis Conner set up Shugart Technology. Having both worked on hard disk drive technology. Alan Shugart having worked on the IBM RAMAC drive and the floppy disk, and Finis Conner having worked for Memorex on magnetic recording technology, the duo formed a formidable alliance. The company changed name the same year and sold the ST-506 drive under the name Seagate Technology.

1980

Quantum Corporation is founded in San Jose. As an early manufacturer of hard disk

drives, tape drive and duplication equipment this company has made several major breakthroughs in data storage technology.

1981

Jim Clark and Abbey Silverstone found Silicon graphics in Sunnyvale. SGI capitalized on technology developed at Stanford University to produce the world's first high performance 3D workstations and operating systems. SGI went on to develop their own processor architecture (MIPS) that today lives on in many graphics intensive systems such as DVD, Blu-ray and navigation systems, and graphics rendering library (OpenGL). SGI later on also acquired the assets of Cray computers, Intergraph and notable software companies like Alias and Wavefront. SGI systems were instrumental in the making of the first computer generated animation movies and special effects.

1982

Another set of students from Stanford University decide to start their own company. Andy Bechtolsheim is joined by Vinod Khosla and Scott McNealy to start SUN Microsystems, SUN itself standing for Stanford University Network. The company was almost immediately profitable and produced a wide line of powerful workstations and servers for the high-tech industry. Initially running on Motorola 68K processors and a port of the BSD operating system, they quickly developed their own processor architecture, dubbed SPARC, and operating system called Solaris. The development of the Java programming language catapulted Sun to become a household name.

James McCoy, Jack Swartz and Raymond Niedzwiecki set up Maxtor in Milpitas to design and develop hard disk drives. The company was later acquired by Seagate.

1984

Len Boasck and Sandy Lerner found Cisco systems together with Richard Troiano. Their first product was a multiprotocol network router. Cisco would go on to become the largest networking hardware company in the world. It has multiple sites spread across San Jose, Santa Clara and Sunnyvale.



1985

The Fry brothers open the first computer and electronics megastore in Sunnyvale. Still in operation today these stores sell anything from resistors, IC's, test equipment like oscilloscopes, computer parts to kitchen appliances and TV, video and audio equipment.

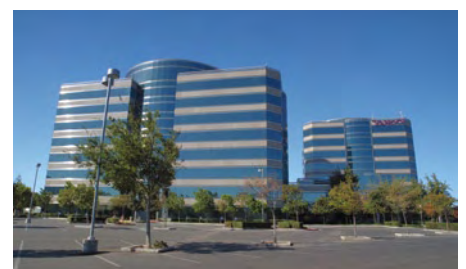


1992

Jeff Hawkins, Donna Dubinsky and Ed Collihan set up Palm Computing to launch a personal digital assistant (PDA). They set up the company in Sunnyvale California. The company today still designs and markets a line of smartphones.

1994

Jerry Yang and David Filo build Jerry and David's Guide to the World Wide Web,

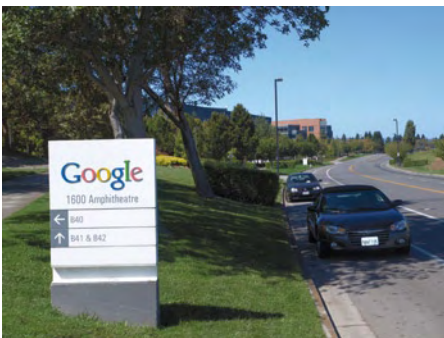


while graduate students in Electrical Engineering at Stanford University. A couple of months later they renamed the site to Yahoo. By the end of that year they had over a million page hits.

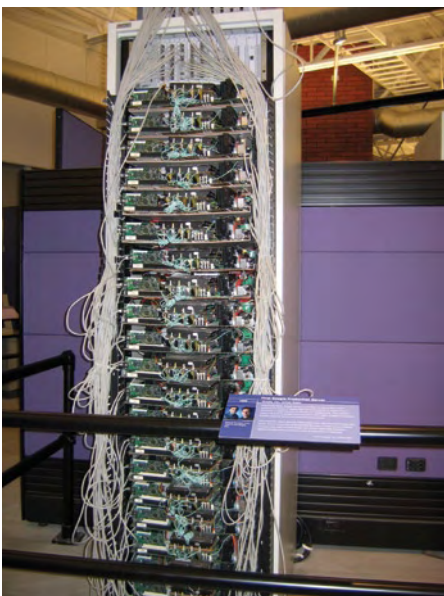
1995

Pierre Omidyar founds an on-line auction website then known as Auctionweb in Campbell. A year later they changed name to become eBay. The original building at the intersection of Hamilton and Bascom is still in use by eBay although its headquarters have now moved to North First Street in San Jose.

1996



Larry page and Sergei Brin develop a data sorting and indexing algorithm as students of computer science at Stanford



University. In 1998 they would incorporate Google that would go on to become the world's no. 1 search engine.

From its humble beginnings in a garage in Menlo Park they soon moved in to the now empty buildings of Silicon Graphics in Mountain View. The first Google server is on display in the Computer Museum.

1999

At the same time that Agilent technologies is spun out of Hewlett Packard the new corporation sets up a partnership with Philips Lighting to further develop the LED technology that the former semiconductor group from Hewlett-Packard developed. This culminated in the Luxeon series high power LED's. Eventually the company spun off from Agilent and became Philips Lumileds Corporation. It is located off of First Street in San Jose.

2000

PayPal is founded as a merger between two leading online payment companies. The companies were located on University Avenue in Palo Alto. In 2002 PayPal was acquired by eBay and moved to the big eBay campus at North First Street in San Jose.

2002

Nanosolar Corporation is incorporated in San Jose. The company has a unique technology in the sense that it can screen print the solar panels, thus sidestepping the expensive silicon based panel technology. They use a special kind of 'ink' that contains copper indium gallium deselenide.

This material achieves an average 15% efficiency and can be printed using an ink-jet-like technology on a backing material. Its plant cranks out enough solar panels a year to produce 430 Megawatts. This plant tripled the annual solar cell productions of the entire US in one shot. A second factory is planned in Germany.

2004

Martin Eberhard, Marc Tarpenning and Ian Wright incorporate Tesla Motors, the world's first manufacturer of high performance all-electric vehicles. A mass produc-



tion plant is being constructed in San Jose. The main showroom of Tesla Motors resides in Palo Alto.



2005

Stanford University's 'Stanley' would become the first fully robotized, driverless car, to finish a 136-mile dash across a desert obstacle course, snatching up the 2 million dollar from the DARPA research grant.

Besides the locations mentioned here it is also worth stopping at the truly incredible Computer History Museum in Mountain View which besides fantastic 'live' and 'interactive' equipment restoration demos, has an early Elektor computer adjunct on display, and the Intel Museum in Santa Clara where you can look at a 4004, 8008 and experience the joys of wearing a clean room suit. Check out their websites for opening hours and locations. Admission is free!

(090776-1)

Hexadoku

Puzzle with an electronics touch

Towards the final pages of this November 2009 issue we again print Hexadoku, your monthly dose of puzzle entertainment. Find the lounge chair, concentrate and put an effort into solving what looks like a maze of numbers and letters. Send the numbers in the grey boxes to Elektor and enter a prize draw for an E-blocks Starter Kit Professional and three Elektor Shop vouchers. Have fun!

The instructions for this puzzle are straightforward. In the diagram composed of 16 × 16 boxes, enter numbers such that **all** hexadecimal numbers 0 through F (that's 0-9 and A-F) occur once only in each row, once in each column and in each of the 4×4 boxes (marked by the thicker black lines). A number of clues are given in the puzzle

and these determine the start situation.

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 the Elektor USA website.

Solve Hexadoku and win!

Correct solutions received from the entire Elektor readership automatically enter a prize draw for an

E-blocks Starter Kit Professional worth US\$425.00 and

three Elektor Electronics SHOP Vouchers worth US\$55.00 each.

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

Participate!

Please send your solution (the numbers in the grey boxes) by email to hexadoku@elektor-usa.com – Subject: **hexadoku 11-2009** (please copy exactly). Include with your solution: full name and street address.

Alternatively, by fax or post to: Elektor Hexadoku
PO Box 876 – Peterborough NH 03458-0876 – USA.
Fax 603-924-9467

The closing date is 1 December 2009.

Prize winners

The solution of the September 2009 Hexadoku is: **10965**.

The E-blocks Starter Kit Professional goes to: Torsten Clever (Germany).

An Elektor SHOP voucher goes to: J. Kartman (Netherlands), Matthias Rummel (Germany), Pierre Chareyron (France).

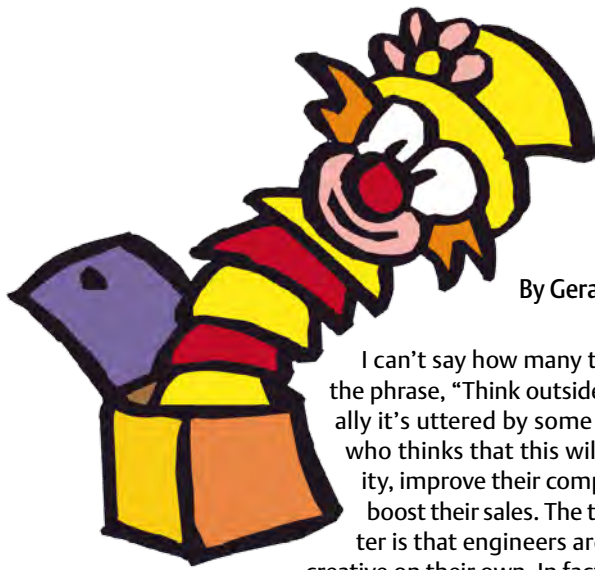
Congratulations everybody!

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By Gerard Fonte (USA)

Outside the Box

I can't say how many times I've heard the phrase, "Think outside the box." Usually it's uttered by some manager or VP who thinks that this will foster creativity, improve their company's image or boost their sales. The truth of the matter is that engineers are usually pretty creative on their own. In fact, the real problem lies with management's inability to recognize and understand the implications of their request.

Don't Fence Me In

Management's problem is that they want risk-free, revolutionary ideas. Obviously, there is no such thing. All new ideas force a change in the status-quo — by definition. Any change in the existing state will require an investment in time and money and will entail some degree of risk. This is true in difficult financial times, too, like now. The result is that companies become more conservative, while, at the same time, insisting on new ideas for better profits. Generally, "Thinking Outside the Box" is an oxymoron.

Then there is the problem with management's ability to recognize the potential of a new idea. Sometimes their approach is simply irrational. They will go full throttle on some wildly novel idea that is clearly silly and doomed to failure. For example, in 1958 Ford seriously considered building a nuclear powered car. They actually had a design and built prototypes (without the plutonium reactor). Then there was the "New Coke" debacle in 1985 when Coca Cola changed its secret formula after 100 years of huge and steady profits. Alternatively, they are often incapable of seeing the benefits of relatively small changes. For example, I tried to introduce the new surface-mount technology (SMT) to my company (with 2000 employees) in the late 1980's. I showed how a relatively small investment of about \$100,000 could repay itself in a few months with reduced labor costs and improved reliability. I even built non-functional copies of our major product using SMT. My boss "wasn't impressed." Unfortunately, new ideas that are not glamorous or easily understandable are often panned by management.

Fundamentally, it's not a matter of stupidity, but one of ignorance. Managers and executives often lack the training and experience to understand technical issues and applications. They must rely on others to guide them. This direction may or may not be competent, knowledgeable or unbiased.

Leading a Horse to Water

So how can somebody present an "Outside the box" idea (that is supposedly craved) without getting shot down? The first thing you need is credibility. If you're a newbie just out of college and want to re-design your company's cash cow, you have little chance. Why

should anyone listen to you? What have you done to show your mettle? Without credibility, few people will listen. First you have to put in time and effort, and demonstrate that you can excel.

Next you must have an attentive audience. Your boss and his boss must be truly willing to listen to a new idea (regardless of what they say). You should have a good idea of how your boss will react. Often you can just ask him how his boss will respond. This inquiry has the subtle effect of priming them that something is in the works. This is good. It's much better to be slow and deliberate than to spring an unconventional concept upon them unexpectedly. The typical first response to an unusual idea is to reject it. And someone can always find a way to show why it won't work.

Your idea must fit the business and your situation. If your company designs braking systems for rail cars, a concept for a new web-based voting system isn't going to fly. However, if you can show how to improve brake reliability, decrease production costs, reduce parts count or even lower shipping expenses, you will have a good chance. (These are the "Out of the Box" ideas that management is really referring to. And as you can see, they aren't really out of the box at all.) If your idea is to replace the current friction-type brakes with magnetic brakes, you are in for a hard sell. This is too far out of the box. There is too much infrastructure already in place for the friction brakes. Manufacturing, marketing and engineering would all have to transition. In short, the whole company would have to change. You can see why this is not likely to happen.

Lastly, it cannot be overstated that HOW you present your idea is critical to its success. Droning on and on about minutiae while your audience falls asleep is not useful. Providing a paper with complex technical equations on every page is not likely to be understood or read by management. Usually these details are not necessary to understand the idea. If they are necessary to support the idea, present them in an appendix.

Start your presentation with an introduction that explains the idea in general terms and shows clear and precise benefits. The body should expand on the concepts mentioned in the introduction. Quite often the conclusion is just a restatement of the introduction. Don't make the report into a mystery where the reader has to figure out what's going on. Don't save the best for last or have a 'surprise' ending. This is not English composition. Start by giving the reader reasons to finish. Write so you can't be misunderstood.

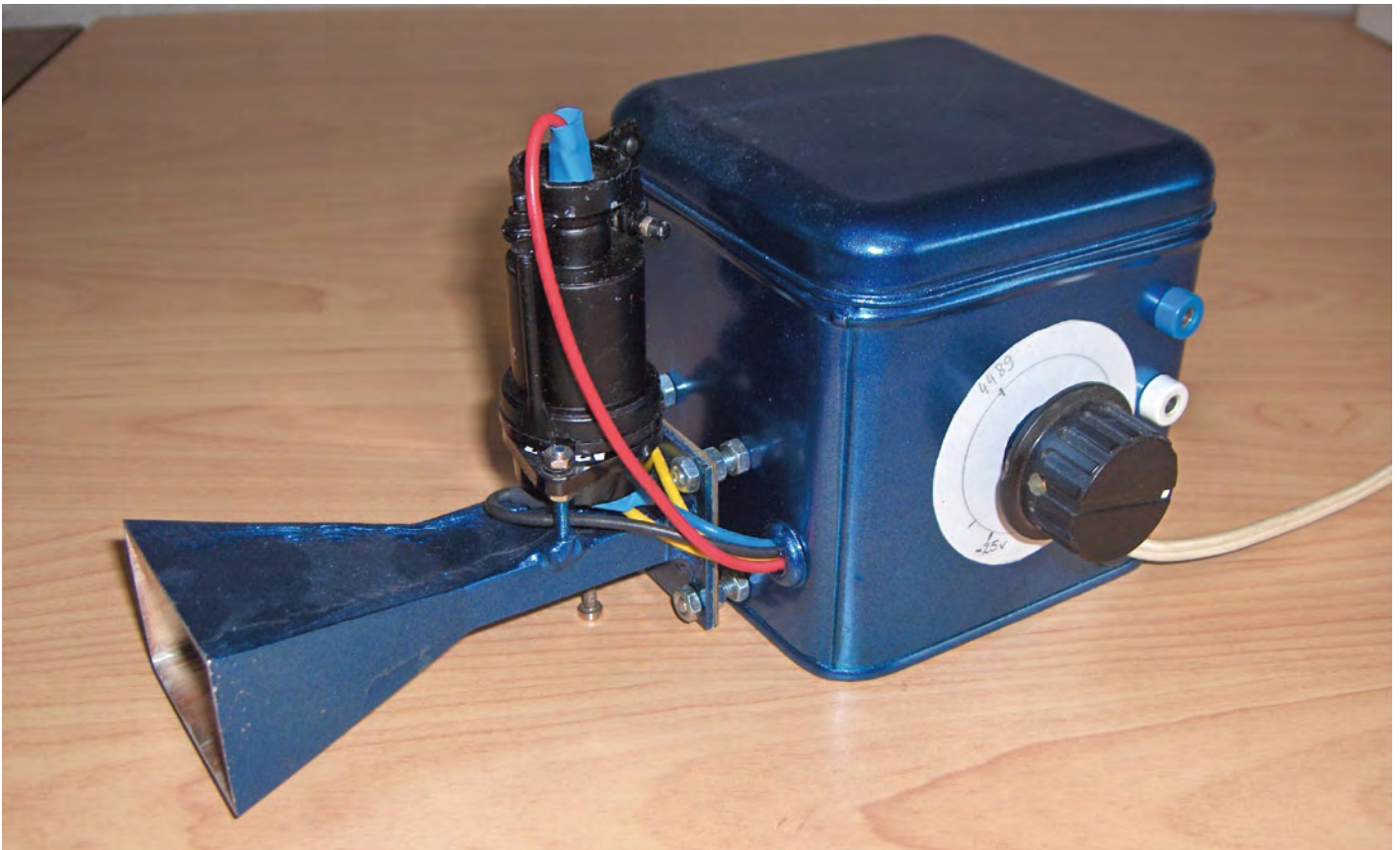
Teaching the Horse to Sing

But what about your magnetic brake idea? You know it's good. You know there's a big market for it. You know that it's cheaper to manufacture and performs better than the friction brake.

If you truly believe in your idea and are willing to really work hard to make it real then the answer is pretty clear. Find someone in marketing/sales that agrees with you and start your own company. This is how new companies get born. Look at National Semiconductor, Intel, Xilinx, Apple, Hewlett/Packard and on and on. These are the brainchildren of people who really do think "Out of the Box".

(090811-1)

Klystrons type 2K25 and 2K56



By Jean Herman (Belgium)

The klystron was invented, and a first prototype constructed, by the brothers Sigurd and Russel Varian working at Stanford University (CA) in 1937. After a paper on the new device appeared in *Journal of Applied Physics* in 1939, radar experts were soon upon the brothers and not surprisingly the klystron was embraced big time by the US military. The klystron's heyday was to last, well, about 50 years.

Several types of klystron exist; one model has two or more cavities centred on an electron beam focused by magnets; the first cavity receives the signal from a local oscillator, it modulates the beam, it acts as a sort of control grid, the second cavity close to a collector (anode) where the signal appears highly amplified. These klystrons exist for all the UHF and microwave bands and all powers, right up to 1 MW and esoteric components as they might appear to the non-initiated, you may have been enjoying its practical use for more hours than you realize simply by watching TV between 1960 and 1995 (roughly).

Another type of klystron is known as 'reflex' (**Figure 1**); this is an oscillator, it only has one cavity centred on the electron beam. The volume of the cavity is slightly adjustable, and hence the resonant frequency too.

It could be thought of as a little like a whistle, except that here the flow tangential to the lips of the cavity is a beam of electrons instead of air.

The speed of the electrons is close (and adjustable) to the variation in the alternating voltage on the two lips of the cavity. With the help of a reflector, the electrons pass and then pass again a second time across the lips of the cavity. When the reflector voltage is just right, the electrons exchange energy with the cavity twice (each time they pass). They finish up on the outside of the cavity or on the metal of the valve envelope.

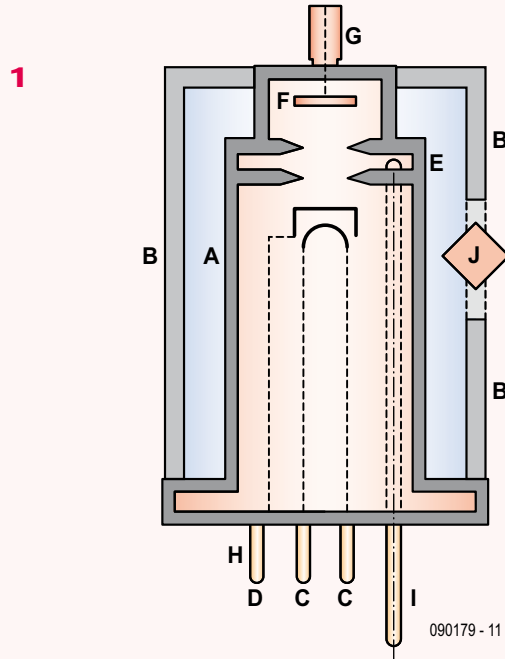
In an accelerated electron beam, the spectrum of the speed of the electrons is wide. Hence it is important that the median speed is centered on the cavity's resonant frequency. In this way, faster or slower electrons will form distinct packets that will be speeded up or slowed down at the lips of the cavity – in other words, they exchange energy with the cavity. Out of chaos, harmony (and RF power) is born!

I've had a type 2K56 reflex klystron for 50 odd years. It came from a WW2 bomber radar unit. Getting hold of the specifications [1] was very troublesome, although its sibling the 2K25 is very common. The '56 and the '25 are pin compatible, but their resonant frequencies are very different: the 2K56 oscillates at 4400 MHz (3840–4460 MHz); while the 2K25 oscillates at 9050 MHz (8500–9660 MHz).

Over 30 years ago, I ventured out to build a circuit 'around' the 2K56. In fact it boiled down to a fairly complex power supply for this tube, which was fitted onto a piece of RG52/U waveguide (1" × 0.5"). What a mistake, it should have been fitted to a length of

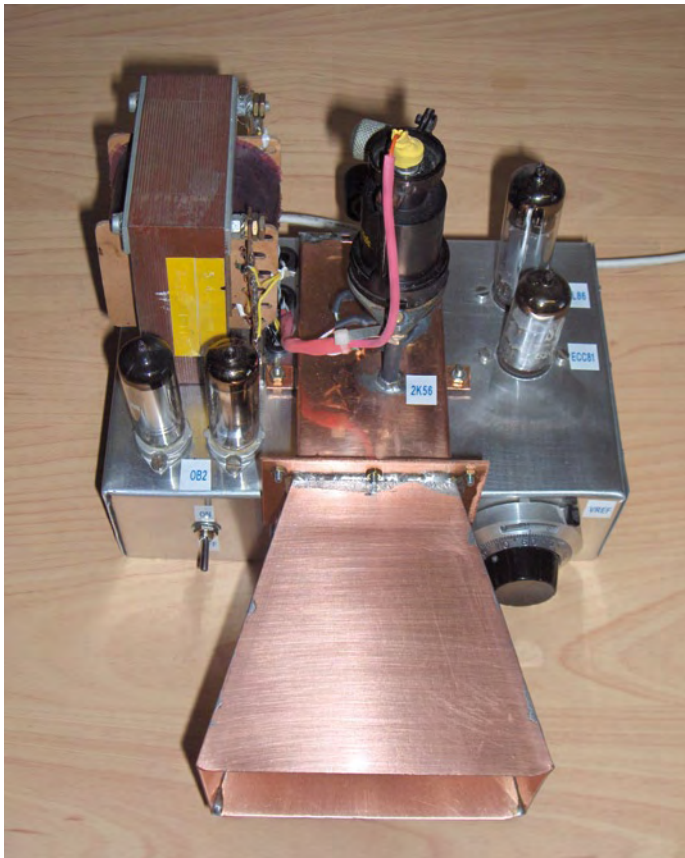
Specifications of the 2K25 and 2K56 klystrons

- Nominal cathode/cavity voltage: + 300 V
- Cavity/cathode current: approx. 22 mA
- Reflector/cathode voltage variable from -24V to -180V
- Reflector current: < 7 μ A
- Reflector resistance must be < 100 k Ω
- Heater voltage: 6.3 V @ 0.44 A.



Cutaway representation of a klystron.

A: envelope (anode); B: cavity tuning pillars; C: heater filament terminal; D: cathode terminal; E: RF coupling loop; F: reflector; G: reflector voltage terminal; H: filament and cathode pins; I: antenna; J: frequency adjustment screw.



RG49/U waveguide (2" x 1")! However, when tested, a weak microwave signal was detected; measuring its frequency, I realized that it was too low for this type of waveguide. I then had the idea of fitting a dielectric into the waveguide. Experimenting with a stick of Perspex soon resulted in recovery of about 50 mW of gigahertz RF power from the klystron.

The 2K25 is an old favorite with radio amateurs who command our respect for having pioneered much of today's microwave communication infrastructures (taken for granted by millions of cellphone users unaware of the SHF link systems carrying their conversations). With a few judiciously applied dents in the cavity, an ex-army 2K25 is easily pulled into the 10 GHz (3 cm) amateur radio band.

If you think that the 'cantenna' was invented during the WiFi and WLAN age, you are mistaken. One of the finest and most appealing applications developed for surplus klystrons and widely published by the ARRL in the 1960s was the 'Klystron Polaplexer' [2]. Two suitably tuned Polaplexer units using (US size!) bean cans were capable of covering line-of-sight links of tens of miles with just a few milliwatts of RF power in the 9 cm (3.4 GHz) band. Full-duplex (!) wideband FM communication 'on a shoestring' was achieved using a portable VHF

FM radio as the final converter and demodulator. Borrowing a term from today's world of microcontrollers, the Polaplexer/Cantenna design was "easily migrated" to the 3 cm (10 GHz) "platform" simply by fitting the klystron on a piece of WG16 waveguide and adapting the antenna shape and dimensions.

Finally, 2K25 klystrons are by no means difficult obtain, for example, through Ebay.

(090179-1)

Editor's note: the author has developed both a tube-based and a transistorized power supply unit (PSU) for the klystrons described here. Scans of his original circuit diagrams may be downloaded free from the Elektor website [3].

Internet Links

- [1] www.pmllett.com/tubedata/HB-3/Transmitting_Tubes/2K56.pdf
- [2] www.ham-radio.com/sbms/sd/ppxrdsgn.htm
- [3] www.elektor-usa.com/090179

Retronics is a monthly column covering vintage electronics including legendary Elektor designs. Contributions, suggestions and requests are welcomed; please send an email to editor@elektor-usa.com

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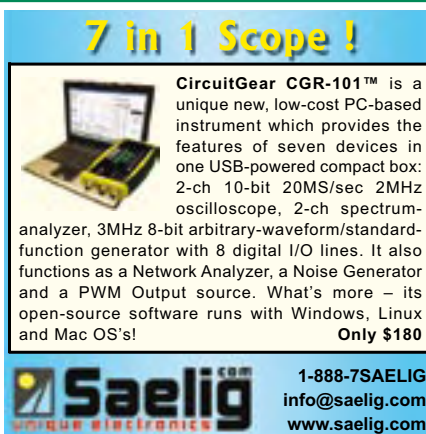
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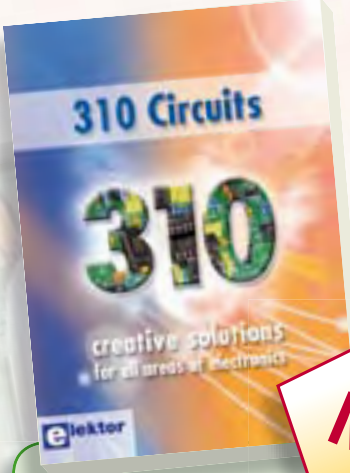
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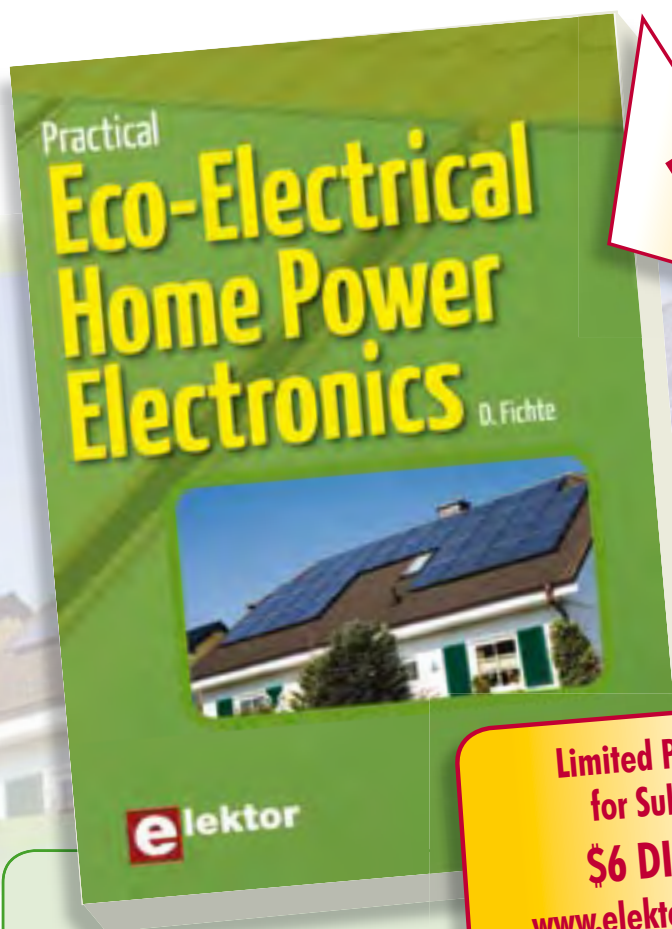
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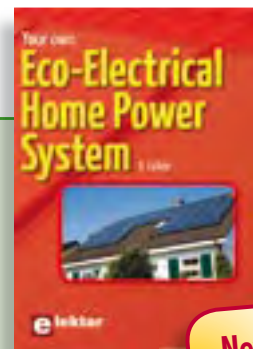
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Look into the electronics of eco-power

Practical Eco-Electrical Home Power Electronics

This book "opens the hood" and looks into the electronics of eco-power. Explained from circuit diagrams of commercially-available products are the electronics of affordable eco-electrical power components such as solar chargers, battery inverters, and off-line chargers. Not only are circuits analysed in detail, design modifications are presented, and basic design principles applied so that you can do your own improvements and achieve high performance at low cost. The effects of various kinds of loads on the power distribution lines reveal potential problems and insights. Included are power circuits useful to homesteaders, such as LED and fluorescent lamp drivers, optimal wind converters, and improved system-level architecture for eco-power. The book ends with an alternative solar power technique based on thermal instead of photovoltaic conversion, using thermoelectric modules, and storing energy in a tank instead of batteries.

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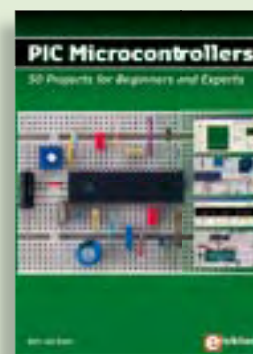
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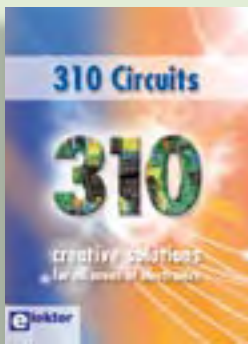


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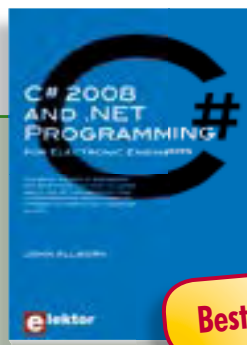


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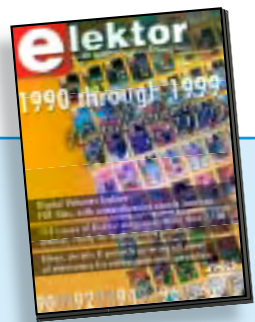
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The program package consists of eight databanks covering ICs, germanium and silicon transistors, FETs, diodes, thyristors, triacs and optocouplers. A further eleven applications cover the calculation of, for example, LED series droppers, zener diode series resistors, voltage regulators and AMVs. A colour band decoder is included for determining resistor and inductor values. ECD 5 gives instant access to data on more than 69,000 components. All databank applications are fully interactive, allowing the user to add, edit and complete component data. This CD-ROM is a must-have for all electronics enthusiasts.

ISBN 978-90-5381-159-7 • \$39.50



Embedded USB Know How

USB Toolbox

This CD-ROM contains all the essential information a designer needs to start working with the USB interface. It includes a large collection of data sheets for specific USB components from a wide range of manufacturers. USB Toolbox provides information on all ICs suitable for different applications. A sub-division has been made in controllers, hubs, microcontrollers and others. What is perhaps more interesting for many designers however, is the extremely extensive software collection which contains drivers, tools and components for Windows, Delphi and various microcontroller families. Of course, none of the Elektor articles on the subject of USB are missing on this CD-ROM.

ISBN 978-90-5381-212-9 • \$39.00



Bestseller!

OBD2 Analyser NG

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

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

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Experimenting with the MSP430

All the big electronics manufacturers supply microcontrollers offering a wide range of functions. Texas Instruments supplies handy USB evaluation sticks with related software for its low-cost MSP430 controllers. Unfortunately the I/O facilities are somewhat limited. These can be substantially enhanced with the help of the Elektor MSP430 board.

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Software Defined Radio

SD radio receivers use a bare minimum of hardware, relying instead on their software capabilities. The Elektor SDR project (by Burkhard Kainka) demonstrates what's achievable, in this case a multi-purpose receiver covering all bands from 150 kHz to 30 MHz. It's been optimised for receiving DRM and AM broadcasts but is also suitable for listening in to the world of amateur transmissions. The designer's aim for this project was to create a receiver displaying high linearity and phase accuracy. Development was focussed on the characteristics that were most important for a top-notch DRM receiver and the end result is a receiver with remarkable interference rejection characteristics!

Ready-populated and tested board

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Automotive CAN controller

Since cars contain an ever increasing amount of electronics, students learning about motor vehicle technology also need to know more about electronics and microcontrollers. In collaboration with the Timloto o.s. Foundation in the Netherlands, Elektor designed a special controller PCB, which will be used in schools in several countries for teaching students about automotive technologies. But it can also be used for other applications, of course. The heart of this board is an Atmel AT90CAN32 with a fast RISC core.

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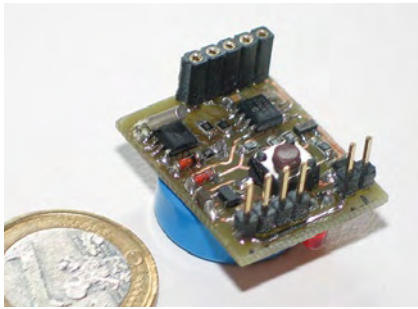
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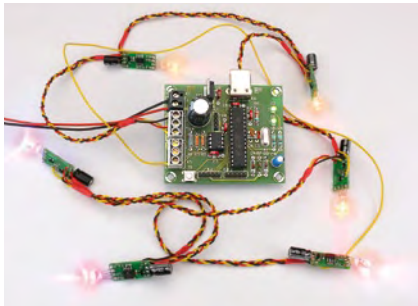


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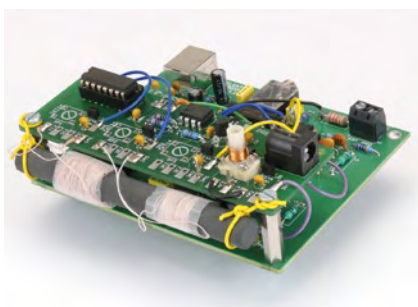
Cutting down on Energy Consumption

It's not too difficult to trace equipment that's wasteful of electrical energy — in fact we've shown how it can be done in an earlier issue of Elektor. But what to do if you are faced with 6 watts power consumption, compliments of the WiFi router? Pulling the plug if you are not online is unworkable, so let's think up some realistic measures to cut down on electricity wasted on standby power. In the same article we present an ingenious mini switching clock based on a PIC microcontroller, which allows the DC supply of equipment to be switched on and off at user defined times.



Colorful Party Lights

In time for the Festive Season you can get cracking with this lights pendulum that's sure to provide super light effects. The project consists of 63 modules with RGB LEDs, and a master unit. The LEDs are driven via a 3-wire serial bus, which is fed back to the master to enable it to determine the number of LEDs connected up! The light patterns can be changed by adapting the PIC source code.



Active Antenna and Preselector for Elektor SDR

The vastly popular Elektor Software Defined Radio (SDR) from the May 2007 issue works quite well with just a ferrite rod or an indoor tuned loop for an antenna. In the December issue we present a small PCB comprising an active antenna and a preselector for up to four LC circuits, each of which is tuned by software and varicap diodes. The control of the DAC supplying the tuning voltage is carried out via the I²C bus already present on the Elektor SDR board.

Article titles and magazine contents subject to change, please check 'Magazine' on www.elektor-usa.com
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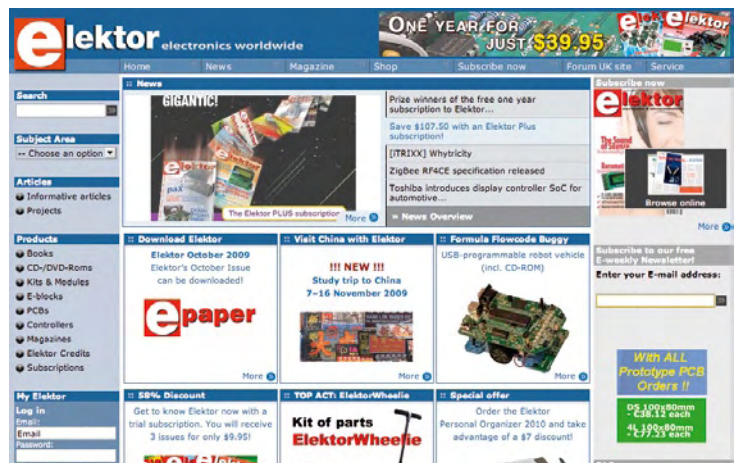
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First take two electric motors, two rechargeable batteries and two sensors, then add two micro-controllers, and the ElektorWheelie is ready to transport you in style to your destination.



Demo video on
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- Automatic power off on dismount
- Maximum speed approx. 11 mph (18 km/h)
- Range approximately 5 miles (8 km)
- Weight approximately 35 kg

The kit comprises two 500-watt DC drive motors, two 12-V lead-acid AGM batteries, two 16-inch ABS wheels, casing, control lever and assembled and tested control board with sensor board fitted on top.

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