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elektor

electro

revolutionary audio amplifier
paX

DigiButler – a Coldfire home automation server
Sweep Generator – with a Parallax SX28 micro
ATM18 AVR Board – ATmega88 building block

Radio has come a long way

Elektor Internet Radio

CAPSENSE WEB RADIO AVR BOARD OPEN SOURCE GAME CONTROLLER

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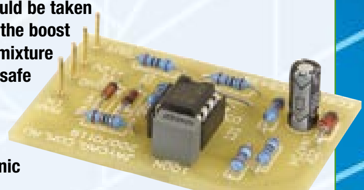
Note: Care should be taken to ensure that the boost level and fuel mixture don't reach unsafe levels. Kit includes PCB with overlay, and all electronic components.



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Jaycar Electronics

Spring time!

New initiatives at Elektor

I do hope spring is in the air when you read this, because at the time of writing I can only see hail and sleet from the windows of Elektor House, and the wind is howling in the chimneys. Elektor staff, including myself, has just returned from the Embedded 2008 show in Nuremberg, Germany. We were happy to see not only representatives of small, large and would-be companies active in the microcontroller arena, but also a good many readers of our publications. Long time subscribers, occasional newsstand buyers, newcomers… thanks for dropping by and letting us know what you like (and hate) about Elektor. Remarkably, none of our direct competitors had a presence at the Embedded show, and even the Circuit Cellar booth was empty. Although the ATM18 and DigiButler projects published in this issue were developed well before the Embedded 2008 show, it was good to meet up with our contact persons at the companies behind the initiatives and discuss the progress. In the case of the ATM18, a working quadrocopter could be seen in action at the Elektor booth (video on YouTube soon). DigiButler, our open-source Coldfire home automation server, was demonstrated on the impressive Freescale stand.

It's difficult if not impossible to pinpoint a single trend from this year's Embedded show, but the buzzwords are definitely C-to-hardware, open-source, development kits, CAN, fabless companies, core licensing and fun applications. Unfortunately, there was also a lot of vapourware around.

Back to the world of discrete components and (mostly) analogue design, I guess publishing an audio power amplifier using error correction can also be called an initiative on our part, if only because the high-end audio scene seems to have regurgitated conventional feedback concepts for more years than I care to remember. Elektor having a fine reputation for high-end audio designs that can be built at home, it's time for a fresh, audacious, approach!

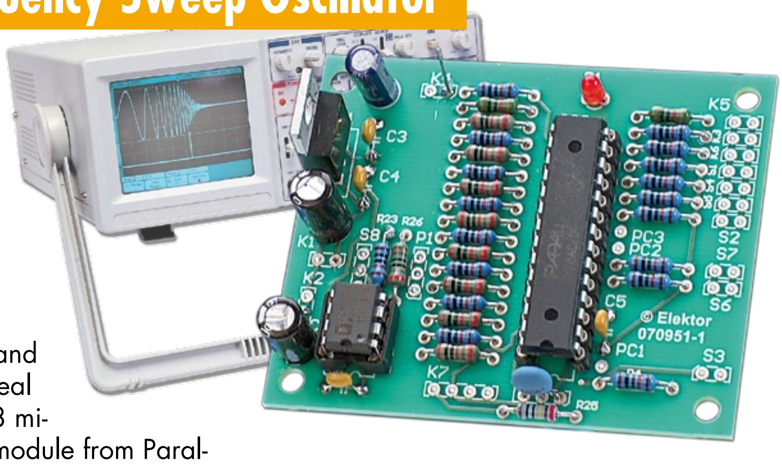
The concept of i-TRIXX — simple circuits from the Elektor labs combined with 'geeks & gadgets' stuff supplied through a free weekly newsletter — has proved very successful in Germany and The Netherlands over the past year or so, and you may have seen a crop of i-TRIXX circuits already in our December 2006 and 2007 issues. The English language version of i-TRIXX was launched on 5 March — have a look at www.i-trixx.com and play the quiz — I did badly.

Jan Buiting
Editor

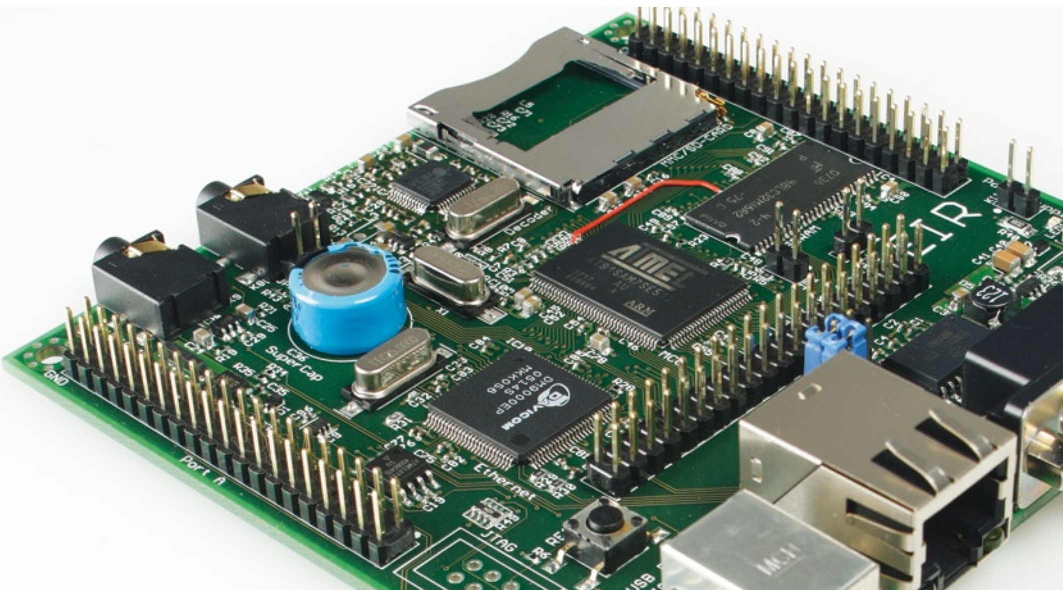
Most solid state power amplifiers employ some form of global negative feedback to reduce non-linearities and output impedance. In some cases, designers exploit alternatives like feedforward to circumvent perceived disadvantages of global negative feedback. The present design uses error correction as (re)defined by Malcolm Hawksford around 1984.

24 paX
a Power Amplifier w

56 Frequency Sweep Oscillator



This project found its origins in a need to see and measure the frequency response of audio filters, tone controls and amplifiers in real time. An SX28 microcontroller module from Parallax turned out to be a really good means of implementing the circuit.



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a Coldfire 32-bit home automation server (1)
Here's advanced, all open-source hardware and PC software that allows remote switching of electrical loads across networks including the biggest we know – the Internet. The ingredients from the Freescale/Elektor kitchen: 32-bit embedded technology, free software, a low-cost kit for the hardware and free software tools.

16 Elektor Internet Radio (EIR)

Nowadays you can access every Internet radio programme in the world by receiving, buffering and decompressing IP packages. This is all very easy with the state-of-the-art hardware described in this article. All open-source!

elektor international media

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

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Early experiments with a radio and U-series valves

At the age of a secondary-school student (15), I received a radio from my grandparents. It had an attractive brown Bakelite case with a loudspeaker at the rear and a small grille covered with cloth. It was a fairly lightweight set, without a heavy built-in mains transformer. The Bakelite case could be removed easily by loosening two screws at the rear. There were lamps inside: U-series valves with thin steel pins fitted in valve sockets. I can still remember that one of them was a type UCH21.

If I interchanged the positions of the valves, the radio stopped working. Evidently they were different types of valves… The filaments of all the valves were connected in series, as I quickly discovered. If I pulled out one of the valves, the filaments of the other valves went dark. The high voltage was taken directly from the (then 220 V) AC mains, and it was connected directly to the chassis. Safety was apparently not an issue! With a bit of experimenting, at that time I already found out that rectifying 220 V AC produces a much higher DC voltage than 220 V! Only much later did I really understand why.

With further experimenting, I also noticed that the chassis was sometimes 'live'. That proved to be related to which way the power plug was plugged in. With nail polish borrowed from my sister, I painted a small line on the AC plug and socket. Then I could work 'safely' as long as the plug was the 'right way round' in the socket (*Ed.*: older AC wall outlets in The Netherlands did not have plug polarisation).

By twiddling the trimmers, I managed to shift and stretch the medium-wave band so much that I could receive Scheveningen Radio coastguard. After that it was impossible to make the tuning scale correct again, but that didn't bother me.

The radio set proved to cause interference to the radio in the sitting room. By experimenting, I found a sensitive point in the radio. If you touched one of the components, a whistling sound came from the other radio. Later I managed to connect a crystal headphone to the radio and use it as a microphone. The result could be heard a block away: the pirate transmitter 'Grannie' was born! However, the neighbours were not at all pleased, and the local policeman was equally unhappy.

However, this problem was sorted out quite quickly. I often experimented with the set while it was connected to the AC mains. This involved operating the radio while it was upside down on the table. At a certain point I dropped a component in the radio, and without thinking I tried to grab it. I received an enormous electric shock, and my hand tore the wiring to pieces. Most likely my muscles contracted due to the current that flowed through my hand. The short circuit in the radio caused the fuse to blow. That wasn't anything special for my parents – my father knew how to repair fuses with bit of wire on the outside of the porcelain cartridge.

Looking back on this adventure, I realise how lucky you can be with electricity. But I still keep saying, 'Don't try to do it yourself this way!'

Kees de Groot (Netherlands)

This bit of electronics nostalgia will no doubt bring back fond memories for many of our readers

E-blocks for vocational secondary schools

Dear Editor — we want to have students at a vocational secondary school learn a programming language that they can ultimately use to control devices or equipment via a PC and an I/O module (possibly separate).

We formerly used Pascal for this, but it is now too old.

We presently have your Flowcode, E-blocks, Visual Basic, etc. What would you recommend?

Edward Ransbury (UK)

The E-blocks and ECIO units available from us are without question a convenient and fun way to let students get acquainted with programming by using Flowcode.

As E-blocks is a modular system, you can always expand it in order to provide your students with a constant stream of new challenges and let them discover new areas of interest.

A large number of schools all over Europe have now discovered the benefits of the E-blocks system for educational purposes and are already using it.

Enclosure and heat sinks for the Mugen final amp

Dear Elektor — how can I obtain the heat sinks for the Mugen hybrid amplifier described in your October 207 issue?

Carl Hamlin (USA)

The enclosure used by the author has integrated heat sinks on the sides.

This enclosure comes from an Italian company and can be ordered here: www.modushop.biz/ecommerce/cat079_l2.php?n=1

Description: Pesante dissipante 03/300N 3U 10mm BLACK

The German company Schuro can also supply a similar enclosure that can be used with this design. Have a look at: www.schuro.de/preisl-gehaeuse.htm

Mac programs

Dear Editor — in response to your answer in the Mailbox section of the February 2008issue of *Elektor*, I would like to comment that the statement that software for programming microcontrollers is not available for Mac OS X is simply not true.

It is perfectly possible to program AVR microcontrollers under Mac OS X. There is a lot of software available in the open-source world, and as Mac OS X is a Unix-based system, in many cases it can be used without modification. I personally use the USBprog, which was featured recently in your magazine (October 2007), with my MacBook Pro to program a variety of AVR systems (AT2323, ATmega16 and ATmega32).

The required software consists of an assembler (AVRA) and a programmer (avrdude), along with a C complier, etc. as necessary.

You can find all of them, ready for direct use with Mac OS X, at http://www.osx-avr.org.

There are various packages of this sort in available, but I use the above-mentioned programs almost every day.

Finally, with regard to your suggestion to install Windows using Bootcamp, it is much less expensive and more convenient to install a Linux distribution (such as Ubuntu) on your Bootcamp partition. Windows XP is expensive, and it is not popular among Mac users for relatively irrational reasons. Naturally, software such as avrdude and avra can also be used just as well under Linux.

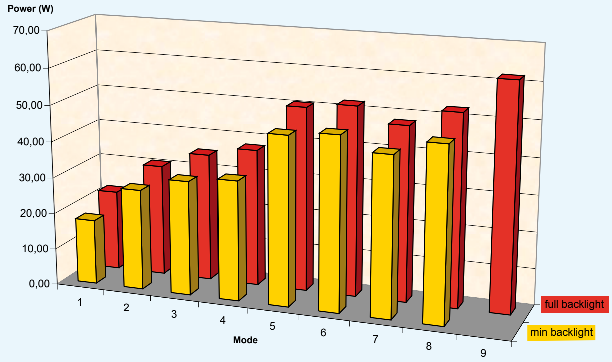
Paul Boven (The Netherlands)

Some programs don't work right out of the box, but in many cases there are pre-built images available with good installation guides. Although you may not always have a nice GUI environment for the microprocessor, it is often possible to configure Eclipse

Intel 'unplugged' challenge

Dear Jan — I am a member of the group of students at the Technical University of Delft in the Netherlands that participated in the Intel Challenge. And I am proud to say that we received the Innovation Award, which you may have already heard. Now I am busy writing a scientific paper on this.
In the November 2007 issue of *Elektor*, I saw that your had also established a competition for the Intel Challenge. The article in that issue included a table of measurements for the energy profile of a laptop computer. We also performed similar measurements, and for this reason I find the table interesting for checking and comparison with our measurements for the paper.
I would like to ask you exactly how these measurements were made. The article includes all the usual information about the configuration and specifications of the laptop, but I would like to know where in the electrical path the measurements were actually made. Were they made directly at the input to the laptop, or ahead of the adapter? And was the battery installed in the laptop, and if so, was it fully charged?
Ivo Roos (The Netherlands)

Antoine Authier, the head of our Elektor lab, is the best person to answer this question:
To start with, my sincere congratulations to you for winning the competition!
In order to measure the energy profile of the laptop computer made available to us by Intel, we measured the voltage and the current drawn by the laptop directly at the power connector of the laptop (i.e. after the AC mains adapter). The battery was not installed in the laptop for these measurements.
For your information, I should also say that:
- The computer hardware allows the backlight of the TFT screen to be set to 8 different brightness levels, but we only made measurements at the minimum and maximum levels.
- We used glxgear to activate and load the 3D GPU.
- Audio output via the built-in speakers was also active during the measurements. We used three levels here: off (mute), half of maximum volume, and maximum volume. The current consumption only increased when signals with a strong bass content were being reproduced.
- The basic application load consisted of running Open Office and the GIMP on the laptop.
- The standard network application load consisted of constantly sending a file (using the SCP protocol).
- Full CPU loading was achieved by reading a DVD and DivX encoding.



(possibly with plugins) for the microcontroller you want to program, which means that you do not have to create any make files. In addition, much of the tooling is open-source and is maintained quite well by an enthusiastic user community (which can also provide a lot of support).
Best wishes from a programming OS X user!
Niels Langendorff (Germany)

Dear Elektor — I have been a Mac user for a long time now, and I speak from experience when I say that there is a lot of software available for programming microcontrollers under Mac OS X.
This software supports the 8051, Microchip, R8C, AVR and ARM devices. If you Google 'avr usb osx', you will find the following links:
http://ccrma.stanford.edu/~matt/avr-osx.htm
http://www.eecs.berkeley.edu/~mseeman/resources/macmicro.html
http://chris.dwan.org/robot/

We are happy to pass these comments on to Mr Pantott, who asked the question last month, and of course to all other readers who use Mac systems.

MailBox Terms

- Publication of reader's orrespondence is at the discretion of the Editor.
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Corrections & Updates

TV Surround Light
February 2008, p. 24-29, ref. 070487-I
In the parts list, the designations IC3 and IC4 should be interchanged. This does not affect the PCB or the circuit diagram.
All passive SMD parts are rectangular shape, footprint SMD1206.
Of the ADC1175JM and ADC1175TC mentioned in the article, only the –JM version is a discontinued part. The PCB has been designed to accept both versions.
LED light bars are available from, among others, www.reichelt.de (e.g. # LED 13,5RGB 3W).
Contrary to what is stated in the article text on page 28, ready-built boards are not available through the Elektor Shop.

Digital Inspector
September 2007, p. 38-41, ref. 060092-I.
The circuit diagram erroneously shows X1 as a 20 MHz crystal. This should be 10 MHz as stated in the parts list.

MUGEN — a Hybrid Audio Amplifier
October 2007, p. 20-29, ref. 070069-I.
In the parts list, resistor R11 should be 18 kΩ, not 18 Ω. This does not affect the circuit diagram, which shows the correct value.
In the power supply schematic (Figure 3), the type code of transformer T2 should be 78057, not 78075.

Fanless System with Core Duo processor

New from BVM is the WPC-763, an innovative I/O-rich fanless micro computer designed for applications such as digital signage, POS terminals, kiosks, ATM, thin servers, in-vehicle displays, outdoor entertainment, gaming, multimedia system and building automation; anywhere where 24/7 operation, low noise and protection from dust are critical requirements.
Based on the Intel 945 GM and ICH7M chipset, two versions are available, either the Core Duo 2 GHz or Celeron M 1.86GHz low power processors. The systems fully support Vista in addition to Window XP and XP Embedded. With six COM ports, a GPIO port for data collection and unit management, two USB 2.0 ports and an LPT port, the I/O-rich unit is ready-configured to accept the barcode scanners, photo sensors, card readers, limit switches, printer and other peripherals required in POS and kiosk applications without having to install additional cards.

Power input is 12-28 VDC with robust on-board voltage conversions that isolate the unit from voltage spikes and current surges likely to be encountered in automotive applications; an anti-vibration drive bay provides protection from shock and vibration. The watchdog timer function automatically resets in the event of a software crash to maximise system up-time in embedded public applications.

www.bvmltd.co.uk

(071168-IV)

RF amplifiers From AR offer unique impedance-matching capabilities

Most RF amplifiers have a nominal internal impedance of 50 ohms, which is fine for most RF applications. But since more and more low to mid-frequency RF applications are now characterized by impedances other than the usual 50 ohms, AR RF/Microwave Instrumentation has created a family of RF power amplifiers that can incorporate a variable output impedance.

The A3 amplifiers feature an internal impedance transformer with selectable output impedance values of 12.5, 25, 50, 100, 200 and 400 ohms. An external impedance transformer is also available for applications requiring an extended range from 8 – 2000 ohms.

The A3 family presently includes three amplifiers: Model 800A3 (800 watts), Model 1500A3 (1500 watts), and Model 5000A3 (5000 watts). Each of the amplifiers covers the 10 kHz to 3 MHz frequency range.

The unique impedance-matching capabilities along with the excellent mismatch tolerance makes the A3 series amplifiers extremely well suited to the ever-changing requirements of research & development applications as well as general purpose lab use.
A3 amplifiers are currently being used in applications for fluorescent lighting, ultrasound, plasma generation and testing, mass spectrometers, piezoelectric crystals, EMC, and a variety of low to mid-frequency RF applications.
For other applications and more information on impedance matching, please see AR RF/Microwave Application Note #47 – available in the Application Notes section of AR Information Resource Center on the company's web site.

www.arww-rfmicro.com
www.emv.nl

(071168-I)

PicoScope 6 update

Pico Technology has released the latest version of PicoScope 6. This version is the first to support Pico's entire range of USB PC Oscilloscopes, and has a number of new features.

Owners of the high-performance 5000 Series scopes are already familiar with the improved layout and advanced triggering options of PicoScope 6. From now on, it will support all Pico oscilloscopes from the entry-level 2000 Series, through the general-purpose and high-precision scopes of the 3000 Series, up to the high-performance 5000 Series with 1 GS/s real-time sampling rate.
The most exciting new feature in PicoScope 6 is resolution enhancement. This filtering algorithm adds up to four bits to the effective resolution of a scope. For example, it can boost the effective resolution of a PicoScope 5203 or 5204 from 8 bits to 12 bits, and the 12-bit PicoScope 3224 and 3424 high-resolution scopes can now deliver up to 16 effective bits. The resolution enhancement is selectable in increments of 0.5 bit.

PicoScope 6 now has independent horizontal zoom, using a new control that is easily accessed from the toolbar to give precise control over timebase magnification. The familiar windowed zoom tool is still there to allow quick inspection of waveform details.
Finally, the text file export feature has been improved so that text-format data files up to 1 million samples long can now be exported.
PicoScope 6.0.12 is available for download now, free of charge, from the Pico Technology website

www.picotech.com

(071168-II)

QVGA for Microchip PIC24F/H micros

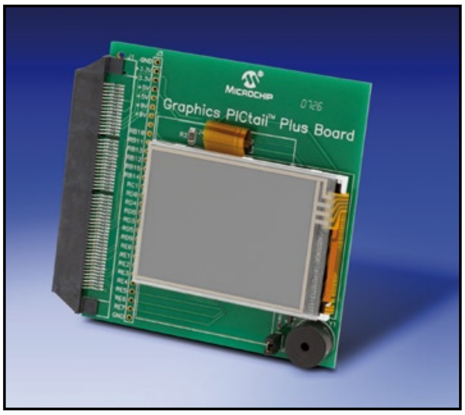
Microchip announces a QVGA Graphics Solution for implementing graphics display and control in cost-sensitive applications. The new, easy-to-use solution for PIC24 16-bit microcontrollers includes a free, highly optimized graphics library with source code; third-party library support; and the new Graphics PICtail™ Plus daughter board.

The free Microchip graphics library supports rapid, low-risk development using two- and three-dimensional objects, including text, circles, rectangles, buttons, meters, windows, progress bars and more, along with images, animation, and touch screen capabilities. In addition, Microchip's third-party partners, Segger (www.segger.com) and Ramtex (www.ramtex.dk), offer compatible graphics libraries to provide even greater flexibility.

Microchip's new Graphics PICtail Plus daughter board is designed to plug into the (Elektor) Explorer-16 development board and includes a Thin Film Transistor (TFT) LCD module that supports 320x240 (quarter VGA) graphic resolution and 65,000 colours along with touch-screen operation.

The new QVGA Graphics Solution supports any of Microchip's existing PIC24F 16-bit microcontrollers, and will offer support for future PIC24H 16-bit microcontrollers, 16-bit dsPIC® digital signal controllers, and the new 32-bit PIC32MX microcontrollers.

The PIC24F family of devices provide a parallel master port interface, 4–8 kB of RAM and 16-128 kB of Flash program memory, offering maximum flexibility in supporting different LCD panel options. For example, using a 28-pin PIC24F microcontroller can enable high system performance, an extremely small footprint and reduced total system cost.



The graphics library, application notes and additional design resources are all available from Microchip's website today, and the Graphics PICtail Plus daughter board can be purchased from www.microchipdirect.com. For further information visit Microchip's website below.

www.microchip.com/graphics

(080073-I)

Compact 5.7-inch VGA TFT display with LED backlight

Hitachi Display Products Group recently launched the TX14D14VM1BAB that brings VGA resolution and a 40,000 hour LED backlight to the existing range of compact 5.7 inch LCD TFT displays. The 640(w) x 480(h) VGA resolution display delivers 262,000 colours while a contrast ratio of 350:1 and typical brightness of 350cd/m2 ensure clear, bright images for all lighting conditions and environments.

With module dimensions of (w)131.0mm x (h)102.2mm x (d)10.9mm the TX14D14VM1BAB form factor is compatible with the other compact displays in the 5.7 inch range and features an active matrix, transmissive TFT LCD display. A touchpanel version of the display, the TX14D14VM1BPB, is also available, making this product ideal for a huge range of embedded industrial solutions from handheld data loggers to human-machine interfaces.

Both product versions are available immediately via Hitachi Display Product Group's distribution partners across Europe. Hitachi Display Products Group is also able to design and develop customised display modules for specific customer requirements.

www.hitachi-displays-eu.com

(071168-VII)

IP68 rated temperature sensors

One of the main problems with temperature sensors is the ingress of moisture which can seriously affect the sensor performance — the weakest point often being the lead/sensor interface.

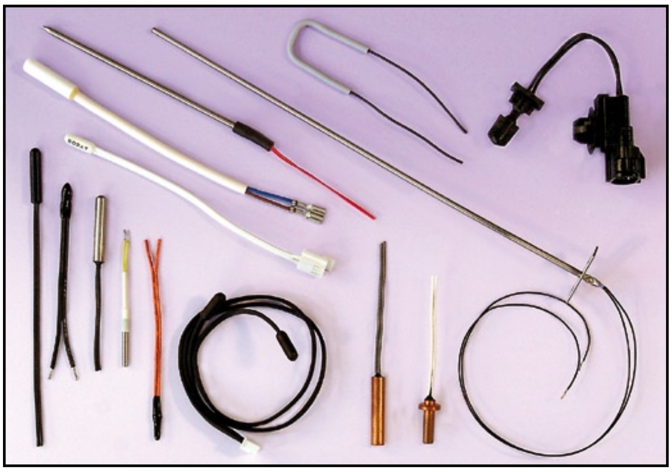
So ATC Semitec have developed a range of TPE encapsulated sensors where the leads and sensor are made from the same material. This creates a waterproof barrier which is rated to IP68 and can operate up to 105 °C.

These cost-effective sensors ensure absolute integrity when used in outdoor locations (e.g. solar panels) as well as in under-floor heating and other HVAC applications. There are also other options such as stiff lead versions and a high temperature variant rated to150 °C.

Double-insulated and rated to 4 kV, these IP68 sensors offer complete peace of mind in applications where moisture ingress has previously been a problem.

http://www.atcsemitec.co.uk/

(080073-VI)

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Other robot kits available based on 68HC11, 8051, AVR, BASIC Stamp and PIC, plus large range of accessories.
Test Equipment
The PoScope features a logic analyser with serial bus decoding, oscilloscope, pattern generator, spectrum analyser, chart recorder and square-wave/PWM generator in one low-cost instrument from £79.
New range of high-specification logic analysers from ZeroPlus now also available.
Control Systems
The PICPLC16B makes an ideal platform for developing and implementing automation applications with its 16 relay outputs, 16 opto-isolated inputs and Ethernet controller for £99.
A wide range of microcontroller and PC-based control boards and add-ons are also available.
Educational Products
Designed specifically for teaching about 8051 microcontrollers, the NX-51 V2 incorporates a useful range of I/O devices and comes complete with detailed example programs for £99.
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The IDL-800 is a low-cost digital circuit lab incorporating a large solderless breadboard, DC power supply, function generator, volt meter and useful switches and displays for £199.
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New PicoScope 2000 series scopes

Each new model in the PicoScope 2000 series is an oscilloscope, spectrum analyser, signal generator and arbitrary waveform generator (AWG) all in one unit, making it extremely versatile and economical. Unbeaten for functionality and price, with bandwidths up to 25 MHz and sampling rates up to 200 MS/s, the new scopes have a compact footprint of 100 mm x 135 mm (3.93 in x 5.31 in), small enough to fit easily into a laptop or travel bag.

The new PicoScope 2000 series scopes have two BNC input channels, a third BNC for a signal generator and arbitrary waveform generator output, and a USB port. Power is taken directly from the PC, and the scopes use the full USB 2.0 bandwidth of 480 Mbps to achieve rapid display updates without compromising accuracy and detail.

All PicoScope PC Oscilloscopes are supported by the same fully functional version of PicoScope 6 for Windows, which makes the most of the PC's processing power, storage, graphics and communications. The familiar Windows interface and controls make the software easy to learn and operate, and convenient for everyday use. PicoScope owners can download software updates, feature extensions and improvements that will remain free of charge for the lifetime of the product. They can also contact Pico's technical specialists for support by web, email, phone or Skype, at no extra charge.

PicoScope 6 can save data in a range of formats including CSV text, PNG and BMP images and MATLAB binary files. Drivers and examples are included for LabVIEW, C, C++, Delphi and Visual Basic for integration into custom applications.

The new PicoScope 2203, 2204 and 2205 PC Oscilloscopes are available from local distributors, or direct from Pico Technology, priced from £159 to £300 + VAT and delivery.

www.picotech.com

(080073-II)

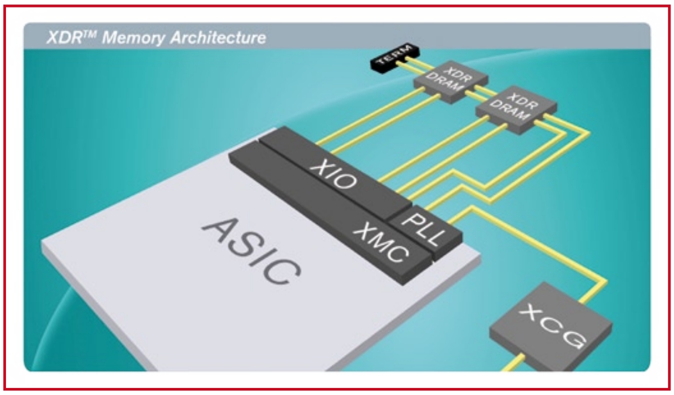
Rambus xdr(tm) memory architecture named 2008 Designvision winner

The International Engineering Consortium (IEC) has chosen the Rambus XDR(tm) memory architecture as the winner in the 2008 DesignVision Awards category for Semiconductors and ICs (IP). The IEC DesignVision Awards recognize technologies, applications, products, and services judged to be the most unique and beneficial to the industry.

Rambus recently announced that Toshiba has taken a license for the XDR memory architecture for its next-generation HDTV chipsets. In addition, Qimonda has begun shipping its first samples of XDR DRAM, and Elpida has begun shipping 4.8 GHz XDR memory, the world's fastest production DRAM.

Key components enabling the breakthrough performance of the XDR memory architecture are:

- The XDR DRAM, a high-speed memory IC that turbo-charges standard CMOS DRAM cores with a high-speed interface capable of 4.0 GHz data rates providing up to 8 GB/s of bandwidth with a single device.
- The XIO controller IO cell providing the same high-speed signaling capability found on the DRAM, but adding additional enhancements like FlexPhase(tm) technology that optimizes timing and eliminates the need for trace length matching.
- The XMC memory controller, a fully synthesizable logical memory controller that is optimized to take advantage of innovations like Dynamic Point-to-Point which provides for capacity expansion while delivering the signal integrity benefits of point-to-point signaling.
- The XCG clock generator providing the system clocks with four programmable outputs, guaranteed to meet the clocking requirements for the XIO and XDR DRAM devices.



www.rambus.com

(080073-IV)

SMS Electronics wins major deal

Nottingham based SMS Electronics Ltd have secured a multi year / multimillion pound deal with Siemens Enterprise Communications Limited to provide a range of services including Field Repair Unit support, Second user equipment refurbishment, Recycling (WEEE) and logistics. Under the terms of the deal SMS will acquire the Siemens Enterprise Communications Limited current operations based in Beeston Nottingham which will be transferred to a new company SMS Product Services Ltd.

SMS Product Services Ltd will be located in 40,000 sq ft building adjacent to the SMS Electronics Ltd current facility and increases the manufacturing floor space available to SMS to a total of 110,000 sq ft. The additional capacity is also required to cater for higher volumes from its existing customer base and recent contract wins.

SMS Electronics Ltd. have a long and successful relationship with Siemens and have also secured a further 5 year extension to their current Manufacturing agreement with Siemens Enterprise Communications Ltd.

www.smselectronics.co.uk

(080073-VIII)

Quarter-brick DC-DC converters

The Bel Power division of Bel Fuse Inc. announced the 0RQB-C0U Series of open-frame isolated DC-DC converters. Housed in the industry standard ¼ brick (2.28" L x 1.45" W) package, the low-cost series provides up to 100 W of output power from a nominal 48 V input. Notably featuring a 4-to-1 input voltage range to accommodate both a 24 V and 48 V standard input voltage in the same module, it is moreover engineered with built-in input and output filtering to further minimize part counts. The highly reliable devices operate at efficiencies up to 91% over an ultra wide range of output voltages extending from 1.2 V to 12 V.

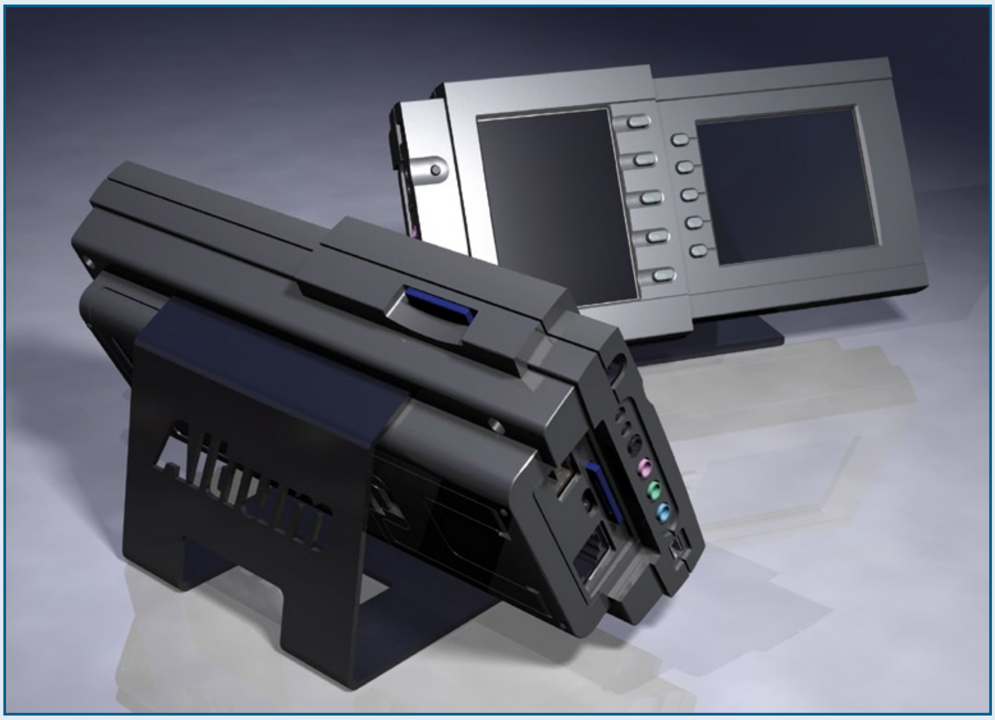
Bel's newest UL/cUL 60950-1 approved series may be confidently specified for employment in a broad array of distributed power architecture applications where space is limited, and overall weight is a factor. Among the most common uses for these high power density parts are in wireless networks, optical and access networks, as well as in industrial networks and equipment. Additionally, their open-frame construction makes them ideally suited for convection-cooled environments.

The isolated DC-DC converters offer a full complement of control and protection features that include differential remote on/off, positive/negative remote sense, input over-/under-voltage lockout, and over-temperature protection. Parts also offer output voltage trim, current limit, and short circuit protection. These devices switch at a fixed frequency (285 kHz) and have an operating temperature range of –40 to +85 degrees C.

www.belfuse.com

(080073-III)

NanoBoards open up new hardware possibilities



Altium Limited has previewed its extended range of deployment NanoBoards at DesignCon 2008 and will showcase the new solution in Europe at Embedded World 2008.

Altium's new deployment NanoBoards are standard, off-the-shelf design solutions that offer greater design flexibility for electronics designers. They can customize these cases to their own requirements. And by using Altium's Innovation Station electronics designers can develop and test device intelligence and transfer that design into the deployment NanoBoards for a complete and marketable product.

Electronics designers can now, regardless of background or expertise, deploy a design into final hardware making the end product immediately available.

The extended range of deployment NanoBoards features the same mother board and choice of daughter and peripheral boards as the Altium Desktop NanoBoard. Designers will have the choice of using a deployment NanoBoard as a final product, or integrating their deployment NanoBoards into larger systems such as mechanical devices. They will also be able to do semi-custom hardware design using the templates included with the Altium Designer software.

The Modular Commercial Enclosure system comprises basic units available in two sizes, a 1.0 and a 0.5 module. They can be configured by designers and come with a range of interchangeable components for an array of installation options.

The system is designed to support the pluggable NanoBoard hardware deployment platform and includes all of the templates, mounting details and graphics specifications required to produce a fully customised application. The standard enclosures accommodate a mother board with a choice of FPGA daughter boards and a 3.5 inch touch screen display. The standard 0.5 module provides for a maximum of two peripheral boards while the 1.0 module supports up to four peripheral boards.

Altium's range of deployment NanoBoards will be available later in 2008.

www.altium.com/Products/NanoBoard/

(080073-V)

Elektor Internet Rad

Listening to radio programmes with the

Harald Kipp and Dr Thomas Scherer

In the good old days, you had to modulate audio signals onto an RF carrier so they could be received and demodulated to produce something more or less audible. Nowadays things are different: audio signals are compressed and put into IP packets that are 'streamed', and you can access every Internet radio programme in the world by receiving, buffering and decompressing these packages. This is all very easy with the state-of-the-art hardware described in this article.

Internet radio is something quite special: even the most sensitive shortwave receiver cannot come close to providing such a broad range of programmes, and the sound quality is simply not comparable. As the 'Internet broadcasters' that provide these programmes do not have to pump several hundred kilowatts of RF energy in the air (with the resulting 'electrosmog'), this type of broadcasting operation is also quite economical for relatively small target audiences.
We could say a lot more about the advantages of this new sort of radio (see inset), but what's more important is to answer the question posed in the next section.

Why not use a pure software solution?

First of all, we have to say that there are several programs (WinAmp, iTunes, VLC, etc.) that are available entirely free of charge for all possible operating systems and can be used to listen to Internet radio. Every true 21st-century person has a PC, Mac or Linux machine available somewhere, so why should you spend money on a non-virtual, physical device, and on top of that build it yourself?
Well, for one thing the hardware platform for a software radio consumes electricity, and quite a lot for this purpose. Anyone who spends a good deal of time listening to radio programmes with a PC is engaged in a very environmentally unfriendly activity. The solution proposed here manages to do the job with a power consumption of only 1 watt. If you use it 10 hours a day, the savings in electricity costs alone (relative to using a gamer PC as a radio) are enough to repay you investment within six months.

For another thing, there are applications for which a PC is not such a clever solution, such as connection to a stereo system. A DIY Internet radio based on Open Source technology is easy to extend and adapt to special requirements – and last but not least, the EIR keeps on working when your PC hangs or crashes .

Operating principle

As the EIR is a complex project that uses state-of-the-art hardware, it is impossible to deal adequately with all relevant topics in a single article. For this reason, the main objective of this article is to describe the hardware and tell you how to assemble it and put it into service. You can find additional information in documents on the Elektor website (www.elektor.com) and the project website [1], and there will be additional articles on this subject in future issues.

As you probably already realise, an Internet radio must receive, buffer and decode data streams. This means that one of its basic ingredients must be a reasonable microcontroller. As already mentioned in the last issue of Elektor [3], an ARM7 MCU [4] can provide the necessary processing power.
The basic architecture is shown in Figure 1. The MCU is shown in the upper middle of the diagram, and it has access to a healthy 64 MB of SDRAM – which is sufficient for the buffer and quite a few 'extras'. The MCU has room for the firmware, and there is also 4 MB of flash memory available for non-volatile data storage. A real-time clock backed up by a Supercap allows the circuit to be used to implement an alarm radio or other applications that depend on knowing the current time. To avoid having to exploit the full capacity of the ARM7 MCU, audio decoding is handled by a VS1053 IC [5], which is specifically designed for this purpose.
The EIR also provides a comfortable selection of interfaces: beside the mandatory Ethernet port (since the EIR has to access the Internet somehow), there is a USB programming interface for downloading new firmware, a serial port and a JTAG port (useful for debugging), and three useful expansion connectors at the port level.
To allow you to record broadcasts if you so desire, there is also a slot for an MMC/SD memory card.

General aspects

The incoming data streams are normally compressed to such an extent that they can handle sampled stereo data, which typically has a resolution of

io (EIR)

latest ICs

16 bits and a sampling rate of 44.1 kHz, using a data transmission rate as low as 192 kbit/s (or even less) instead of the normal rate of around 1.4 Mbit/s. This means that a buffer with a capacity of approximately 10 seconds can be implemented with around 256 KB of RAM. This may not sound like much nowadays, but it is still quite a hefty chunk of memory for a microcontroller. If you want to be on the safe side and also want to have room for Internet niceties and other 'extras', you can quikkly end up with 512 kB or more. The ARM7 MCU selected for this design supports SDRAM, so the EIR with its 64 MB of RAM does not suffer from any shortage of memory.

We chose Nut/OS as the operating system. It is quite accommodating in comparison with Linux and can manage with less than 40 kB of memory. All in all, the software needs around 200 kB of memory. A capacity of 1 MB is ample for data storage. As the MCU already has 512 kB of flash memory on board for program data as well as an abundance of RAM, there are no bottlenecks. All of the software is Open Source, except for the flash programming software from Atmel.

Incidentally, the microcontroller has sufficient processing power to allow a second audio stream to be recorded on the SD card while another stream is playing. It will certainly not take very long for the Open Source community to devise upgrades that support this capability and other conceivable features.

In order to avoid constraining the form of any possible extensions, no user interface components (such as buttons or a display) are incorporated in the board. However, they can easily be connected via the expansion connectors. The EIR is intended to form the basis for user-designed expansions, and the firmware that comes with the board is thus designed to be used via an integrated website. However, the firmware is completely open, so other options are always possible.

Details

As you can see immediately from looking at the schematic diagram in **Figure 2**, this is a complex design. For this reason, the following description is based on the functional blocks.

• Ethernet

Access to the Internet is via an Ethernet connector with an integrated transformer and two LEDs. The green LED lights up when data is being transferred, while the yellow LED indicates that a connection is present. The Ethernet traffic is handled by a specialised IC (IC10, a DM9000E). Buffer IC9

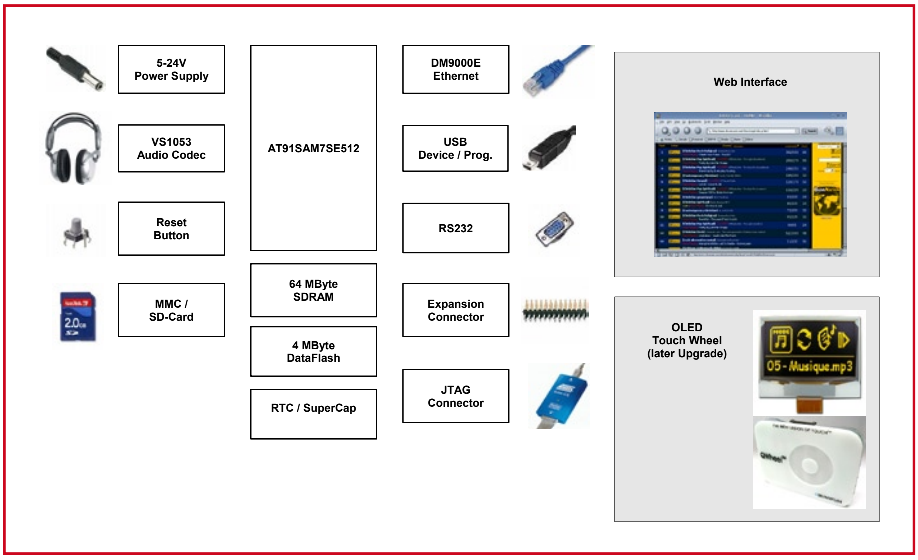


Figure 1. Block diagram of the Elektor Internet Radio.

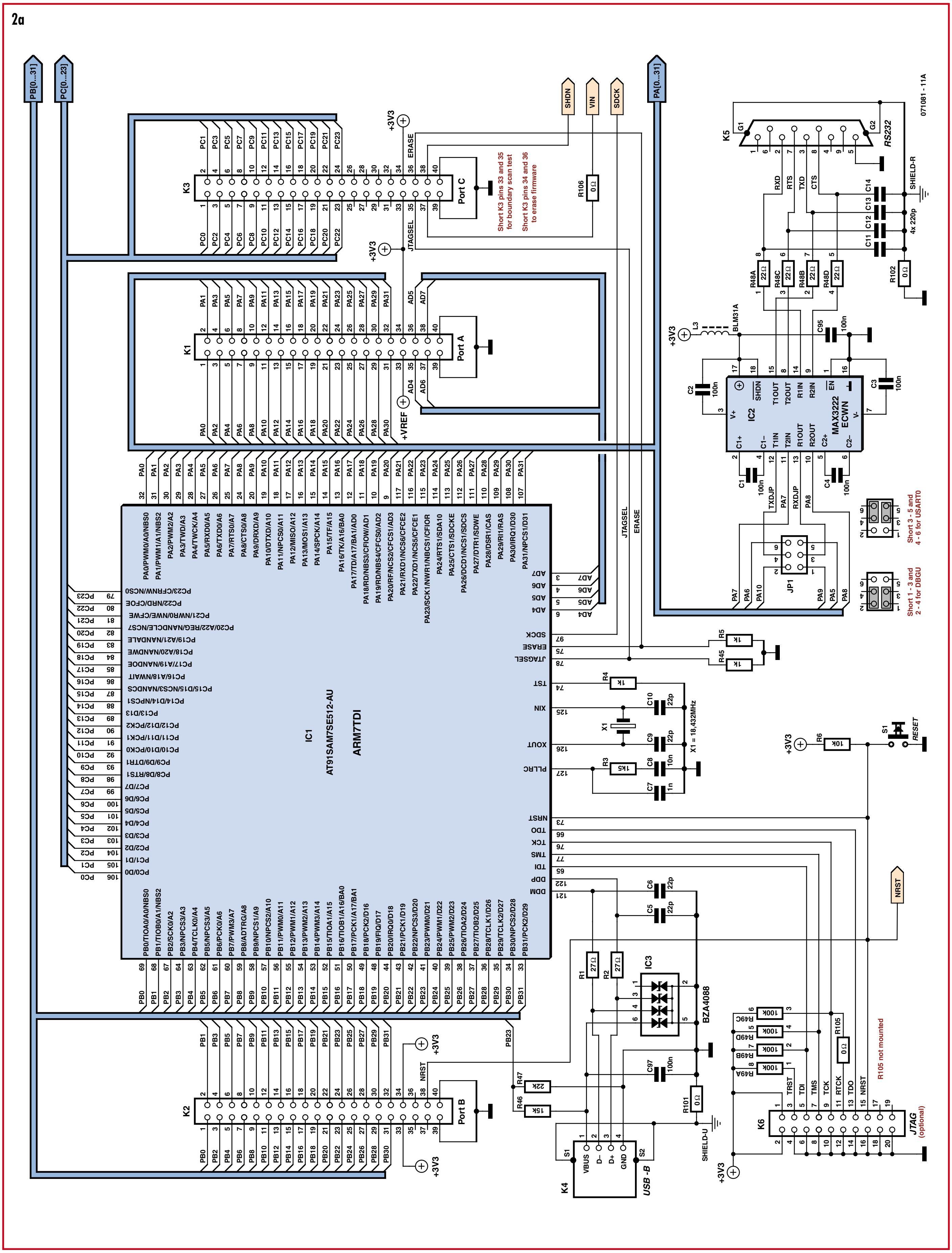
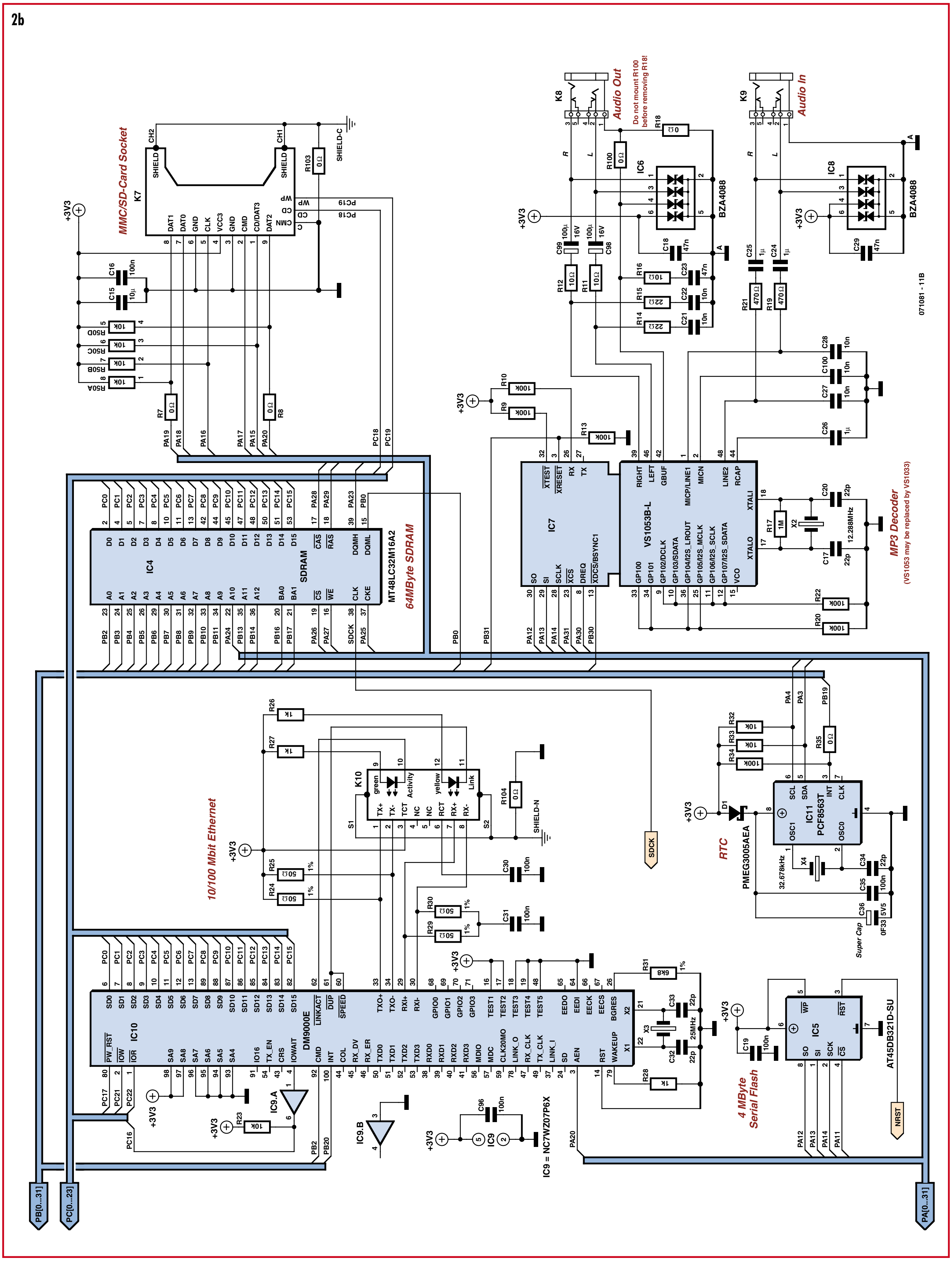
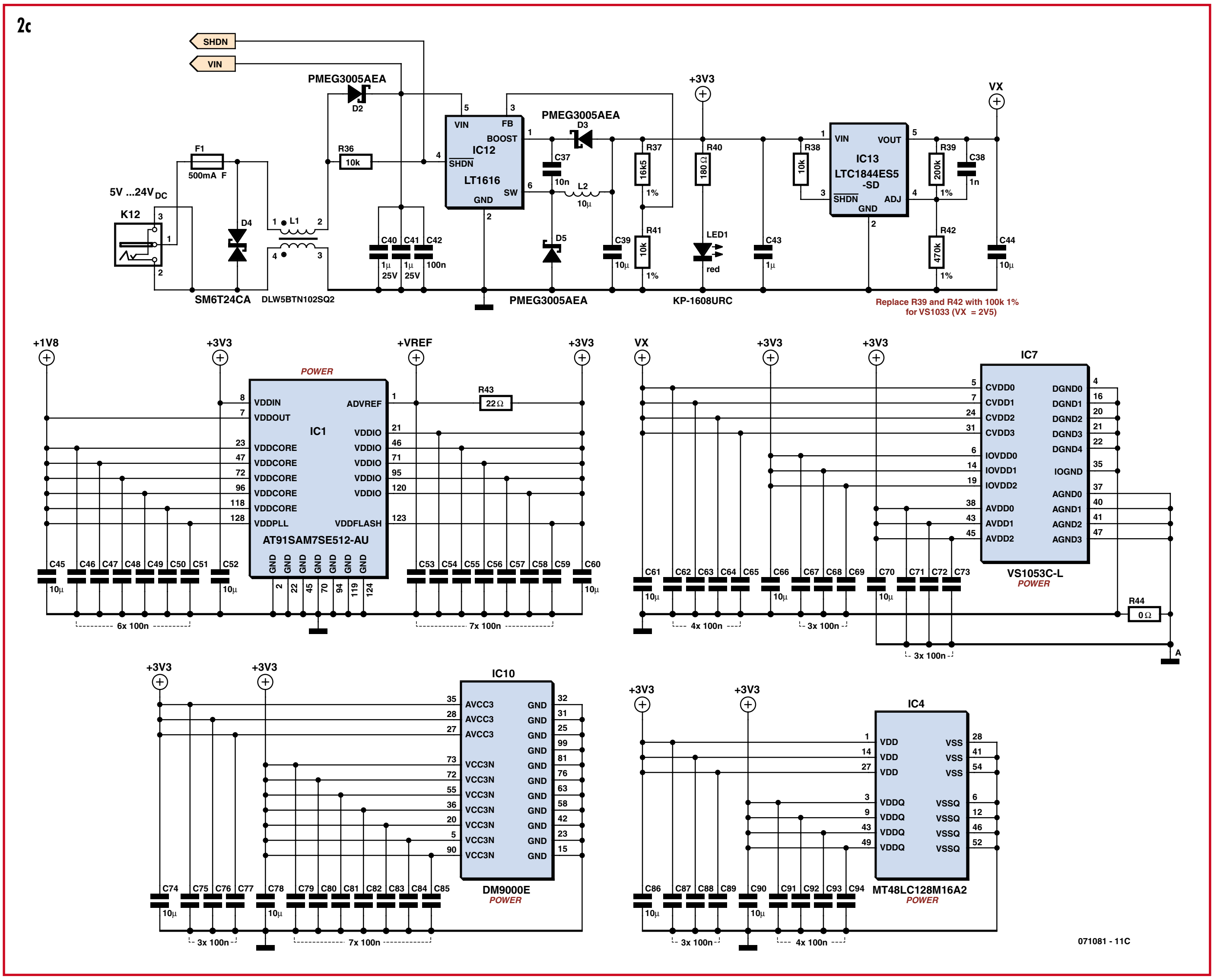


Figure 2. As you can see immediately from the schematic diagram of the EIR, this is a sophisticated project.



2b
MMC/SD-Card Socket
K7
64MByte SDRAM
IC4
MT48LC32M16A2
10/100 Mbit Ethernet
K10
IC10
DM9000E
IC9 = NC7WZ07P6X
Audio Out
Do not mount R100 before removing R18!
K8
IC6
BZA4088
Audio In
K9
IC8
MP3 Decoder
(VS1053 may be replaced by VS1033)
IC7
VS1053B-L
RTC
IC11
PCF8563T
PMEG3005AEA
4 MByte Serial Flash
IC5
AT45DB321D-SU
071081 - 11B



allows the Wait input of the MCU to be used by expansion circuitry.

• Audio decoder

Although the ARM7 would just be able to handle decoding of MP3 or AAC data in software, a dedicated IC such as IC7 considerably reduces the load on the MCU, and it is specifically designed to handle HE-AAC and even Ogg-Vorbis data in addition to the usual MP3 versions. Logically enough, this also simplifies the application software. We used a pre-production sample from VLSI in the prototypes. If you have trouble obtaining this IC, you can use the VS1033 version (without Ogg Vorbis capability) instead. Although the MCU has a 1.8-V output for powering peripheral devices, a separate 1.8-V voltage regulator is provided for IC7 for reasons of stability. If you use the VS1033, R39 and R42 must be changed to 100 kΩ because it needs a 2.5-V supply voltage.

• Supplementary flash memory

It is necessary to store a large number of operational settings for the radio, and they must remain available even after a power outage (especially the station list). The internal flash memory of the MCU could be used for this purpose, but writing data to it is cumbersome. To simplify the process, a serial flash memory (IC5) is included in the design. With a capacity of 4 MB, it has room for extensive station lists and even more.

• Power supply

To keep the power consumption of the EIR as low as possible, it is powered by a switch-mode supply built around IC12. It provides around 5 watts of power at 3.3 V with an input voltage in the range of 5–24 V. As the EIR takes only 1 W for its own use, there is enough left over for DIY hardware extensions.

• Soldering

The EIR is built on a densely populated multilayer PCB with lots of tiny SMD components (see **Figures 3** and **4**), with some of the IC pins spaced only 0.5 mm apart. To avoid problems with DIY assembly, Elektor can supply a pre-assembled board with all SMDs already fitted (with the VS1053). All you have to do is to fit the relatively large components, which helps you avoid pernicious assembly errors. For the diehards, it is of course possible to build the board yourself using the layout artwork.

Functional test

For initial testing of the power supply, the load on the 3.3-V side should be at least several millampères (do not use it with no load). The voltage regulator should start working with at input voltage of at least 4 V and draw 50 to

150 mA, depending on the load. This will drop to 30–50 mA at 24 V. If everything is OK, LED1 will light up. After the ICs are fitted, you can use an oscilloscope to check that the crystal is working. If X1 is oscillating, the MCU should be ready for action.

The MCU comes with an on-board boot loader that supports communication from and to the RAM and with the flash memory as well as downloading new firmware. The AT91-ISP.exe file available from Atmel (see reference [6]) installs the program SAM-BA, which runs under Windows. After installing this program, connect the EIR to your PC via the USB port. After the power is switched on, Windows should select the appropriate driver automatically. Now you can start SAM-BA. Select 'USB' as the connection type and 'AT-91SAM7SE512-EK' as the device (this is largely compatible with the EIR).

You can download a simple testing firmware program from the Elektor website. With this firmware and an operational MCU and serial interface, you can check the other components, such as the Ethernet port and the audio decoder. After downloading the firmware to the MCU, you have to tell the EIR

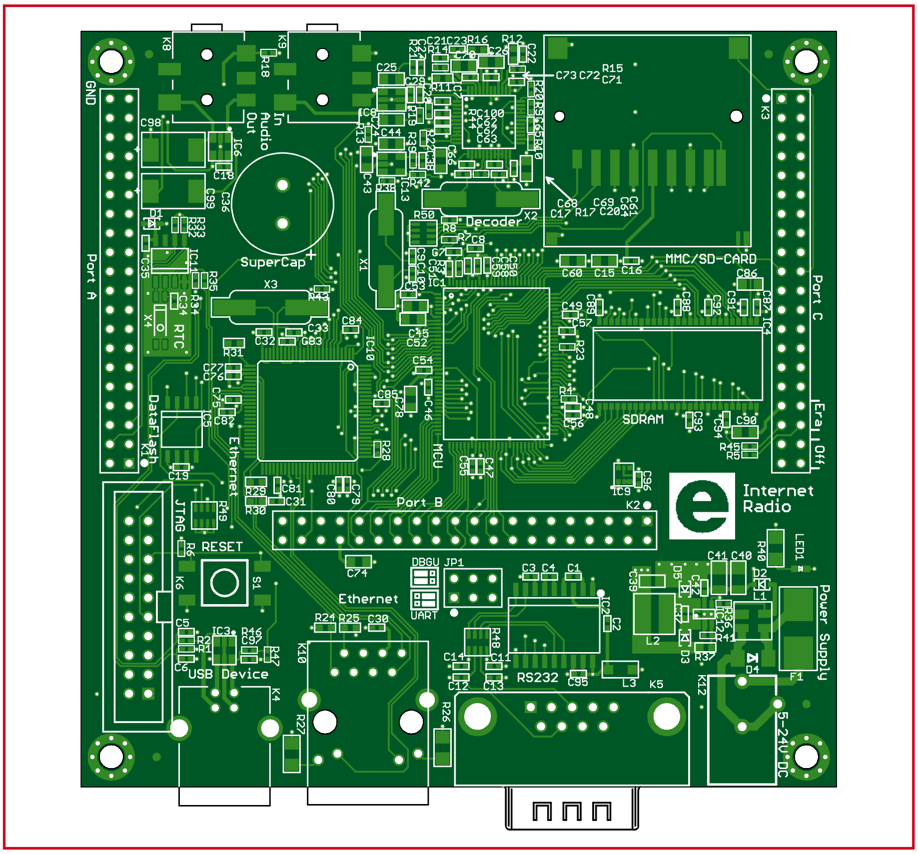


Figure 3. The component layout of the EIR. To avoid assembly problems, a board with prefitted SMD components is available.

COMPONENT LIST

Resistors

R1,R2 = 27Ω, SMD 0402
R3 = 1kΩ5, SMD 0402
R4,R5,R28,R45 = 1kΩ, SMD 0402
R6,R23,R32,R33,R36,R38 = 10kΩ, SMD 0402
R7,R8,R18,R35,R44 = 0Ω, SMD 0402
R9,R10,R13,R20,R22,R34 = 100kΩ, SMD 0402
R11,R12,R16 = 10Ω, SMD 0603
R14,R15,R43 = 22Ω, SMD 0402
R17 = 1MΩ, SMD 0402
R19,R21 = 470Ω, SMD 0402
R24,R25,R29,R30 = 50Ω 1%, SMD 0402
R26,R27 = 1kΩ, SMD 1206
R31 = 6kΩ8 1%, SMD 0603
R37 = 16kΩ5 1%, SMD 0603
R39 = 200kΩ* 1%, SMD 0402
R40 = 180Ω, SMD 1206
R41 = 10kΩ 1%, SMD 0402
R42 = 470kΩ* 1%, SMD 0402
R46 = 15kΩ, SMD 0402
R47 = 22kΩ, SMD 0402
R48 = 22Ω, array, CAY16
R49 = 100kΩ, array, CAY16
R50 = 10kΩ, array, CAY16
R100-R106 = 0Ω*, SMD 1206 (not required)
* see text

Capacitors

(SMD ceramic 6.3V unless otherwise indicated
C1-C4,C16,C19,C30,C31,C35,C42, C46-C51,C53-C59,C62-C65,C67,C68,C69,C71,C72,C73, C75,C76,C77,C79-C85,C87,C88,C89,C91-C97 = 100nF, SMD 0402
C5,C6,C9,C10,C17,C20,C32,C33,C34 = 22pF, SMD 0402
C7,C38 = 1nF, SMD 0402
C8,C21,C22,C27,C28,C37,C100 = 10nF, SMD 0402
C11-C14 = 220pF, SMD 0402
C15,C39,C44,C45,C52,C60,C61,C66,C70,C74,C78,C86,C90 = 10μF, SMD 0805
C18,C23,C29 = 47nF, SMD 0402
C24,C25,C26,C43 = 1μF, SMD 0805
C36 = 0.1F, Double Layer Cap FG0H104Z135
C40,C41 = 1μF 25V, SMD 1206
C98,C99 = 100μF 16V tantalum, SMD

Inductors

L1 = DLW5BTN102SQ2 (Murata)
L2 = 10μH, MSS5131 (Coilcraft)
L3 = BLM31A (Murata)

Semiconductors

D1,D2,D3,D5 = PMEG3005AEA (Philips)
D4 = SM6T24CA (STM)
IC1 = AT91SAM7SE512-AU (Atmel)
IC2 = MAX3222ECWN (Maxim)
IC3, IC6, IC8 = BZA408B diode array
IC4 = MT48LC32M16A2
IC5 = AT45DB321D-SU (Atmel)
IC7 = VS1053C-L (VLSI)*
IC9 = NC7WZ07P6X (Fairchild)
IC10 = DM9000E (Davicom)
IC11 = PCF8563T (Philips)
IC12 = LT1616 (Linear Technology)
IC13 = LTC1844ES5-SD (Linear Technology)
LED1 = KP-1608URC, red, SMD 0603 (Kingbright)

Miscellaneous

X1 = 18.432 MHz quartz crystal, SMD HC49SM
X2 = 12.288 MHz quartz crystal, SMD HC49SM
X3 = 25.000 MHz quartz crystal, SMD HC49SM
X4 = 32.678 kHz quartz crystal, SMD MC-146
F1 = fuse, 0.5A, fast, with holder, SMD OMNI-BLOK (Littelfuse)
K1,K2,K3 = 40-way SIL pinheader, lead pitch 2.54mm
K4 = USB-B socket, AMP-787780
K5 = 9-way sub-D plug, angled pins, US standard
K6 = 20-way boxheader, 2.54mm lead pitch
K7 = SD-card socket, SMD, FPS009-2700 (Yamaichi)
K8,K9 = 3.5-mm stereo jack socket, SMD, SJ1-3515 (CUI)
K10 = RJ-45 socket with Ethernet transformer and LEDs, SMD, RJLD-043TC (Taimag)
K12 = DC adaptor socket with 2-mm pin, TDC-002-3
JP1 = 6-way 2-row pinheader with 2 jumpers, 2.54mm lead pitch
S1 = pushbutton, SMD, LSH (Schurter)
PCB with pre-mounted SMD parts, Elektor Shop # 071081-1
Project software, archive 071081-11.zip; free downloads from www.elektor.com

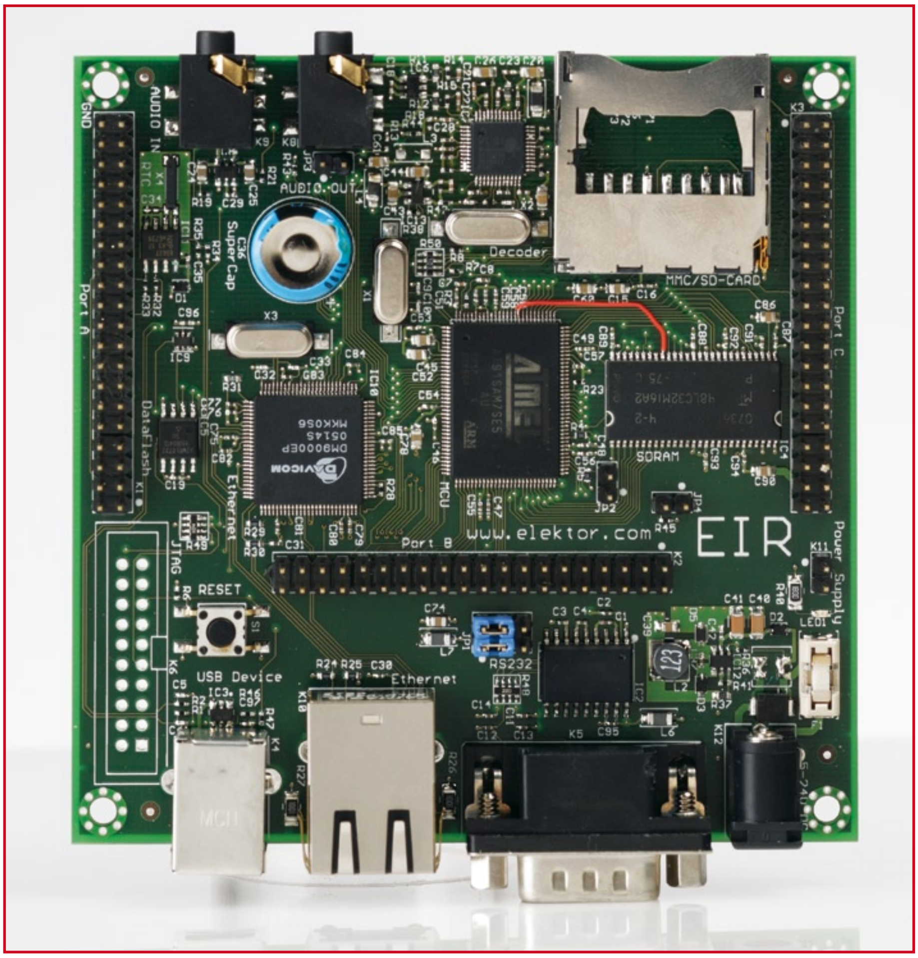


Figure 4. As you can see from the fully assembled prototype, DIY soldering isn't so easy here.

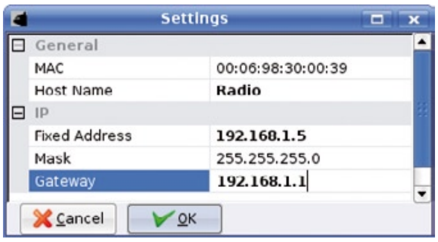


Figure 5. Screen shot of SAM-BA running under Windows 2000.

that it should boot from this firmware when it restarts. To do so, select the routine 'Boot from Flash (GPNVM2)' under 'Scripts' and click 'Execute'.

Then close SAM-BA and press the Reset button. Now the EIR can communicate with the PC via the serial interface and a null-modem cable (pin 2 & 3 leads swapped), and you can use a terminal emulator to send commands to the EIR (we recommend TeraTerm [7] for Windows or Miniterm for Linux, and Macs have a built-in terminal utility).

Listening to the radio

Before you can start listening to the radio, you have to delete the test firmware from the EIR and install the radio firmware. To allow new firmware to be loaded, first connect pins 34 and 36 of connector K3 with a jumper, then press Reset, and finally remove the jumper. After this, the EIR will start up again with the boot loader, and you can use SAM-BA to download the radio firmware.

Now connect the EIR to your local network via the Ethernet port (using a hub, a switch, or an Internet router with several ports) and connect the audio output to a headphone or an amplifier.

If the LAN or the router you are using has an active DHCP server, the EIR will fetch a valid address and start playing the programme from the default station. If you prefer to use fixed IP addresses, proceed as follows. When you install Nut/OS, a small utility called 'Discover' is installed on the PC, and you can always use it to find the EIR (see **Figure 6**) and then configure the desired IP address. Enter the router address under 'Gateway', as illustrated in **Figure 7**. After this, you should be able to listen to the radio (**Figure 8**) with fixed IP addresses.

Prospects

As already mentioned several times, the EIR is a completely open-ended concept. The software and hardware (via the ex-

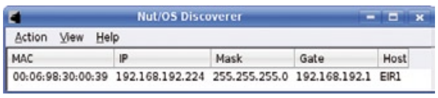


Figure 6. You can use this program (here running under Linux KDF) to find the EIR even if its IP address is unknown.

Table 1. Expansion connector K1

Pin	Signal	Use	Pin	Signal	Use
1	PA0	Free	2	PA1	Free
3	PA2	Free	4	PA3	TWI SDA
5	PA4	TWI SCL	6	PA5	UART0 RxD via JP1
7	PA6	UART0 TxD via JP1	8	PA7	UART0 RTS
9	PA8	UART0 CTS	10	PA9	DBUG RxD via JP1
11	PA10	DBUG TxD via JP1	12	PA11	Data Flash Chip Select
13	PA12	SPI MISO	14	PA13	SPI MOSI
15	PA14	SPI SPCK	16	PA15	MMC Chip Select
17	PA16	MMC Clock	18	PA17	MMC Command
19	PA18	MMC DAT0	20	PA19	MMC DAT1 via R7
21	PA20	MMC DAT2 via R8	22	PA21	Free
23	PA22	Free	24	PA23	SDRAM DQMH
25	PA24	SDRAM A10	26	PA25	SDRAM CKE
27	PA26	SDRAM Chip Select	28	PA27	SDRAM WE
29	PA28	SDRAM CAS	30	PA29	SDRAM RAS
31	PA30	IRQ1, MP3 Interrupt	32	PA31	MP3 Command Select
33	Vref	ADC Reference	34	3.3V	Power
35	AD4	Analogue input (free)	36	AD5	Analogue input (free)
37	AD6	Analogue input (free)	38	AD7	Analogue input (free)
39	GND	Ground	40	GND	Ground

Table 2. Expansion connector K2					
Pin	**Signal**	**Use**	**Pin**	**Signal**	**Use**
1	PB0	SDRAM DQML	2	PB1	Free
3	PB2	Address Bus A2	4	PB3	Address Bus A3
5	PB4	Address Bus A4	6	PB5	Address Bus A5
7	PB6	Address Bus A6	8	PB7	Address Bus A7
9	PB8	Address Bus A8	10	PB9	Address Bus A9
11	PB10	Address Bus A10	12	PB11	Address Bus A11
13	PB12	Free	14	PB13	Address Bus A13
15	PB14	Address Bus A14	16	PB15	Free
17	PB16	SDRAM BA0	18	PB17	SDRAM BA1
19	PB18	Free	20	PB19	FIQ, RTC Interrupt
21	PB20	IRQ0, Ethernet Interrupt	22	PB21	Free
23	PB22	DataFlash Chip Select	24	PB23	USB Monitor
25	PB24	Free	26	PB25	Free
27	PB26	Free	28	PB27	Free
29	PB28	Free	30	PB29	Free
31	PB30	MP3 Data Select	32	PB31	MP3 Hardware Reset
33	3.3 V	Power	34	3.3 V	Power
35		Not used	36		Not used
37		Not used	38	NRST	Hardware Reset
39	GND	Ground	40	GND	Ground

pansion connectors) can be extended as desired, and you can certainly look forward to seeing several articles on this subject in future issues of *Elektor*.

With regard to software tools, source code and further developments, you should occasionally check the egnite project website [1] to see what's new. There you will find source code and installation files for Windows, Linux and OS X. You will also find links to development environments and other Open Source projects.

There are lots of possibilities. An obvious enhancement would be to add a few buttons and an LCD display so the EIR can be used as a convenient standalone device instead of only via a Web browser. And the memory card slot almost cries to be used for a supplementary MP3 player application.

(071081-1)

Internet radio

If you take a look on the Web, you'll be astounded to see that Google presently finds more than 21 million hits for 'Internet radio', so it's obviously a hot topic. The first experiments with packet-based 'broadcasts' were carried out as early as 1993, at around the same time as the first usable browser (NCSA Mosaic) and thus the dawn of the commercial Internet era. Quite early on, 'real' radio stations started broadcasting their programmes via Internet streaming in addition to conventional radio waves. Today you can receive tens of thousands of radio programmes with an ordinary Internet connection. In addition to a plethora of highly diverse niche programmes, you can now access nearly all public and commercial broadcasters.

The term 'streaming', which covers near-real-time transmission of time-referenced data such as audio or video content, refers to data streams that are as continuous as possible and require the originator to transmit a separate stream for each client, which can generate an enormous traffic volume and thus be a costly proposition if there are a lot of listeners. To keep the data rates within acceptable bounds, a lossy compression is usually used to compress the data before transmission, and the data is subsequently decompressed by the receiver. This means that an Internet radio receiver must incorporate a commonly used streaming decoder, such as MP3, Ogg Vorbis or Real Audio, regardless of whether it is purely software-based or uses dedicated hardware.

As it is not possible to guarantee a constant propagation delay for individual data packets with the HTTP and FTP protocols normally used on the Internet, the receiver must also have a data buffer with sufficient capacity, which delays reception by a few seconds and means that it is only 'quasi live'. This makes fast zapping between stations impossible. However, thanks to digitalisation this drawback is offset by stable audio quality, extreme (worldwide!) range, and a truly fathomless diversity of programmes. It is also possible to receive previously recorded programmes (missed broadcasts) by means of 'audio on demand', which no conventional radio station can offer.

Table 3. Expansion connector K3					
Pin	**Signal**	**Use**	**Pin**	**Signal**	**Use**
1	PC0	Data Bus D0	2	PC1	Data Bus D1
3	PC2	Data Bus D2	4	PC3	Data Bus D3
5	PC4	Data Bus D4	6	PC5	Data Bus D5
7	PC6	Data Bus D6	8	PC7	Data Bus D7
9	PC8	Data Bus D8	10	PC9	Data Bus D9
11	PC10	Data Bus D10	12	PC11	Data Bus D11
13	PC12	Data Bus D12	14	PC13	Data Bus D13
15	PC14	Data Bus D14	16	PC15	Data Bus D15
17	PC16	Bus NWAIT, Open Collector	18	PC17	Ethernet Hardware Reset
19	PC18	MMC Card Detect	20	PC19	MMC Write Protect
21	PC20	Free	22	PC21	Address/Data Bus NWE
23	PC22	Address/Data Bus NRD	24	PC23	Ethernet Chip Select
25		Not used	26		Not used
27		Not used	28		Not used
29		Not used	30		Not used
31		Not used	32		Not used
33	3.3 V	Power	34	3.3 V	Power
35	JTAGSEL	Boundary Scan Enable	36	ERASE	Firmware Erase
37	VIN	Unregulated 5–24 V via R106	38	SHDN	Power Shutdown
39	GND	Ground	40	GND	Ground

References and web links

[1] egnite project website:
www.ethernut.de/de/hardware/eir/

[2] Wikipedia article:
en.wikipedia.org/wiki/Internet_radio

[3] Ethernut and the Kipp Family:
Elektor, March 2008, pp 18–21.

[4] ARM7 MCU data:
www.atmel.com/products/at91/

[5] VS1053 data:
www.vlsi.fi/products/vs1053.html

[6] Link for AT91-ISP.exe:
www.atmel.com/dyn/resources/prod_documents/Install%20AT91-ISP%20v1.10.exe

[7] Windows terminal emulator:
ttssh2.sourceforge.jp/

paX – a Power Amplif with Error Correction

Part 1: EC and the output stage

Jan Didden

Most solid state power amplifiers employ some form of global negative feedback to reduce non-linearities and output impedance. In some cases, designers exploit alternatives like feedforward to circumvent perceived disadvantages of global negative feedback. The present design uses error correction as (re)defined by Malcolm Hawksford around 1984 [1].

In part 1 of this article the author discusses error correction for audio amplifiers and presents an audio output stage based on error correction. Part 2 will extend the principle to the voltage amplifier stage and present a complete error correction power amplifier. In a separate article next month the protection circuitry is discussed in more detail.

Negative feedback is not negative

This is not an article against negative feedback (nfb). Negative feedback, as a general principle, is one of the most powerful tools available to the designer to build amplifiers that are transparent to the signal they amplify. With that I mean that they do not add anything to, or subtract from, the input signal. In reality, circuits are never ideal, but the changes to the signal can be made so small that inaudibility of the change is pretty much guaranteed.
Negative feedback is also fully understood, and although bad-sounding feedback amplifiers are still being sold, it is totally unnecessary. So, you may ask, why bother with error correction (ec)? For one thing, it is different; and different roads to the same goal are often enjoyable to travel and explore. Secondly, although we will see that ec is in many respects another face of nfb, with similar advantages and disadvantages, there are some interesting differences and different challenges leading to better understanding of the processes inside any feedback amplifier.

What the H.ec?

Let's start by narrowing down what we mean by ec in the context of this article. I refer specifically to Malcolm Hawksford's paper referenced above. I will use the term 'H.ec' to refer to Mr. Hawksford topology, and 'ec' to refer in general to error correction.
Figure 1 is the basic topology from that paper. We see an amplifier block N, on which the error correction will be ap-

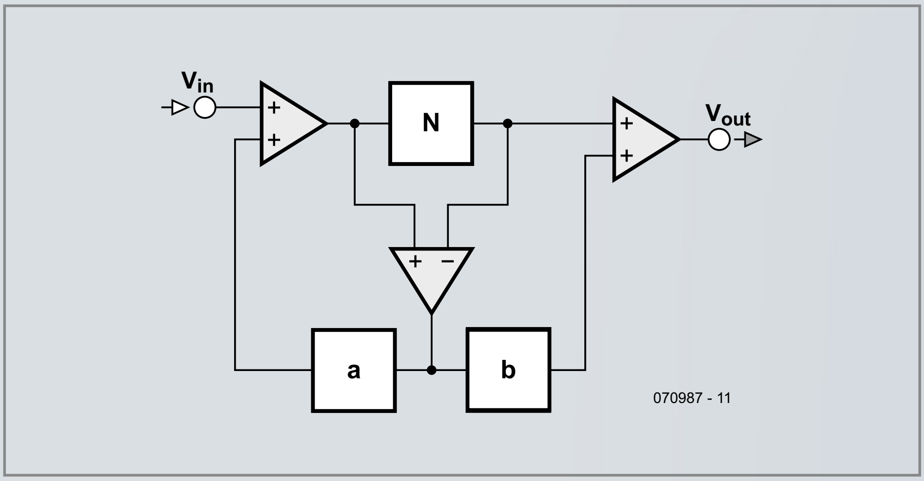


Figure 1. Hawksford's general feedback/feedforward/error correction structure.

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plied. The difference between the input and output of that amplifier is either added to the input via block 'a' (error feedback), or to the output via block 'b' (error feedforward). All the summing and differencing blocks have unity gain (1×). Of course it is important that the error correction signal is added in just the right proportion to cancel the original error. In this design I use the correction via block 'a', added to the input.

We will further assume that the amplifier block 'N' is an output stage from an audio power amplifier with a gain only just below 1. The object here is to make this gain exactly 1, independent of output load, frequency and signal level. If we succeed, we will have an ideal output stage. Of course we won't get that far, but as we will see, we can get pretty close.

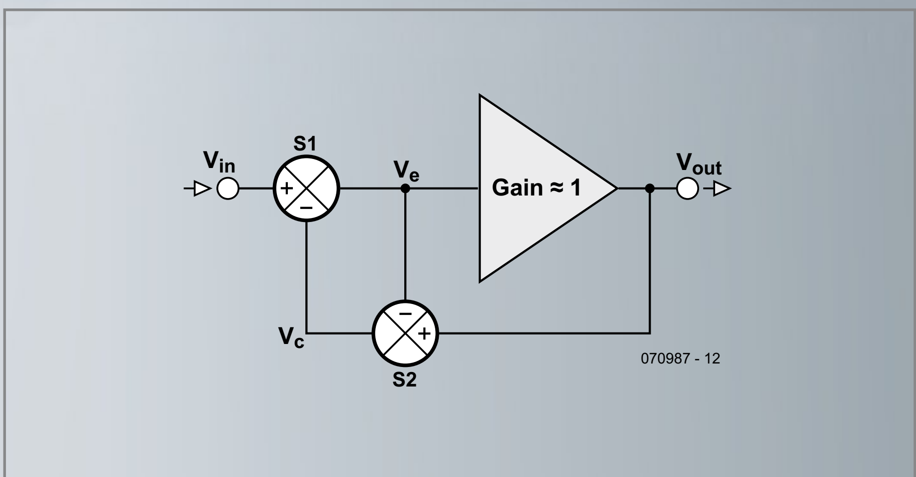


Figure 2. Error correction concept.

We now get to our conceptual circuit in **Figure 2**. The output stage we want to linearise is 'A', with a gain of 'about 1'. In practice, most output stage gains are anywhere between 0.92 and 0.98 depending on the topology, loading, signal frequency etcetera. We see immediately that V_c, the signal that is fed back to the input, is $V_{out} - V_e$, where V_e is the effective input signal to the output stage. We can now calculate V_e as

$$V_e = V_{in} - (V_{out} - V_e).$$

We also know that $V_e = V_{out}/A$, and if we plug that into the former equation and rearrange terms, we get: $V_{out} = V_{in}$.

What is significant here is that the actual amplifier gain *A* is no longer part of the equation. Whatever the shortcomings, non-linearities or errors of *A*, we got rid of all of those. This is our ideal output stage!

If you are familiar with practical audio amplifiers, you probably are feeling a bit uneasy now. An ideal power stage? That would be the first one ever! And you are right — in reality, we can't make that ideal.

The reason is that we assumed that the summers in Figure 2 are ideal summers, without flaws. That cannot be. Those summers consist of passive and (most probably) active devices that have their own non-linearities, so the basic accuracy will not be ideal. Their characteristics will also vary with frequency, so the correction accuracy will vary with frequency. As the output stage gain will also vary with frequency and load, the amount of correction required will vary with frequency and load, meaning that signal levels in the summers vary with frequency and load as well. This further leads to accuracy limitations.

Nevertheless, it is possible to greatly improve the performance of the output stage with relative simple means, as we will see.

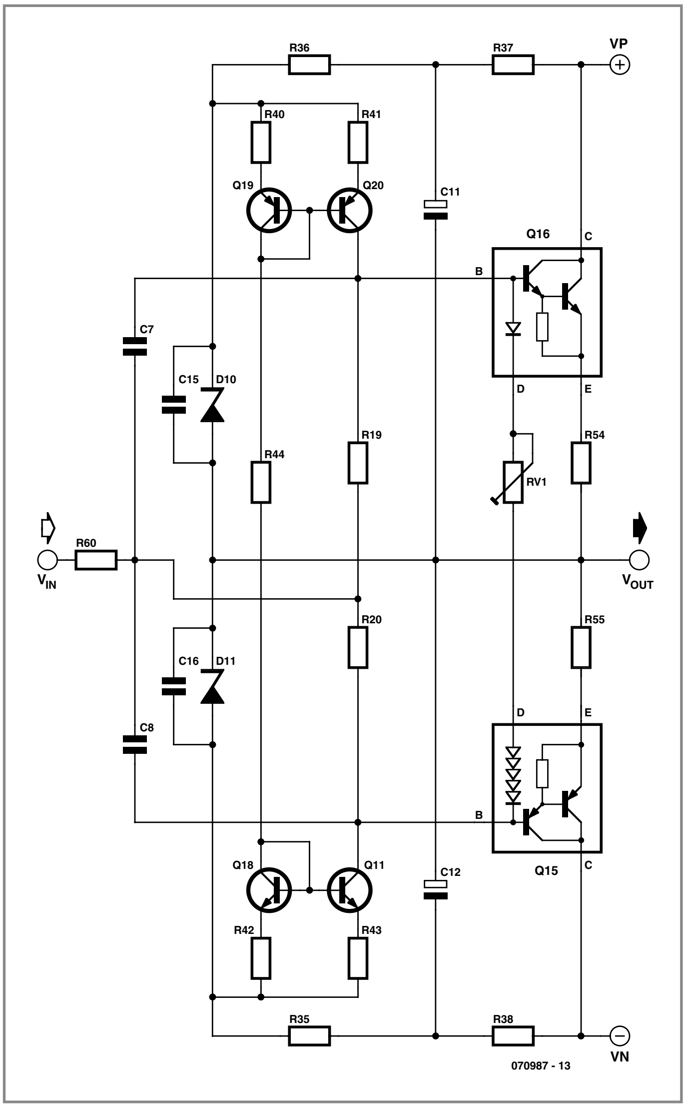


Figure 3. Basic paX output stage.

Thermal memories

There was one other goal I had with this amplifier. In most power amplifiers, the thermal bias compensation is obtained by mounting a transistor in the bias circuit on the same heatsink as the output devices. In that way, if the output devices heat up and start to draw more current, the bias transistor also heats up. That causes the bias voltage to decrease, and the object is to dimension this thermal feedback loop such that the bias current in the output devices remains stable with temperature. But because it takes time for the heatsink to heat and cool and transfer this changing temperature to the bias transistor, this loop reacts relatively slowly at several seconds or more.

The first time I read about this was in an article by a French audio (not fashion) designer authoring under the pseudonym Hephaïstos [2]. He realized that the dissipation levels in the output and driver devices vary with signal output levels, related to music level variations, and that they are much faster than the reaction time of the thermal bias compensation circuit. When a high level signal burst appears, the devices' biasing point would shift, and would return to the earlier state only seconds after the high level burst had disappeared. Such a burst is too short for the thermal feedback to adjust the bias. A smaller signal after the burst would thus be processed with different operating conditions than before. He called this 'thermal distortion'.

In my design I wanted to get rid of this problem as well. Therefore I selected Sanken STD03N and STD03P devices for the output stage. These are Darlingtons, with a bias diode integrated on the transistor chip. By using this diode in the bias circuit, it can track thermal cycles in the output devices instantaneously, thus hopefully eliminating thermal distortion. Because it is a Darlington, any (pre) driver dissipation would also be low enough to avoid memory distortion.

There's one catch: the on-chip sense diodes need to be run with a specific current to make their thermal bias changes in millivolts per degree, equal to the V_{be} changes of the driver and output devices in millivolts per degree. This requires a different bias circuit from the usual V_{be} multiplier.

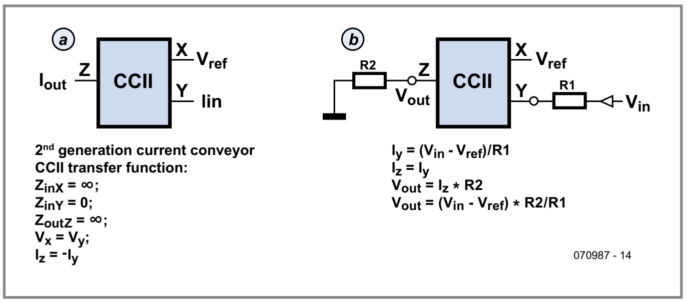


Figure 4. Current Conveyor basics.

Error correction basics

Figure 3 shows the basic topology of the output stage without error correction. You will notice the integrated bias diodes in the output devices. To get a precise matching between these diodes and the output Darlington's b-e junctions, Sanken's engineers used a string of five Schottky diodes in the P-device and a single silicon diode in the N-device.

The datasheet specifies a bias current of 2.5 mA through the diodes, and this current is set by the current mirror formed by Q19-Q20 and Q18-Q11. The current is set with R44 and mirrored into the diodes. To keep this current stable, the supply voltage for the current mirrors is regulated by zener diodes D10-D11 to 15 V. The bias for the zeners is coming from the main supply via R36-R37 and R35-R38. To keep exactly that supply stable, the junction between those resistors is bootstrapped from the output via C11-C12. The result is that with varying output signal levels, the zener diodes can always provide a constant supply voltage for the current mirrors.

The datasheet for the output devices also specifies a quiescent current of 40 mA through the output Darlingtons for best thermal tracking. Although the diodes track the changes in the Darlington V_{be} quite well, the absolute value of the diode threshold values varies from unit to unit. Thus, it is necessary to be able to adjust it, and that is the purpose of RV1. So, we should set RV1 for 40 mA through the output stage.
OK, so now we have a nice and stable output stage, but we need to drive it with a signal. That is done through R60 to the junction of R19-R20. Suppose that the input signal goes positive: the junction of R19-R20 goes positive so there will be less current through R19. Since the current coming out of the collector of Q20 is fixed, there will be more current into the base of the Darlington and the output signal will also go positive, following the input signal. In this case there will also be more current through R20 so less from the base of the P-device.

This will work quite well for DC and low frequencies and nominal, resistive (8 ohms) loads, where the Darlingtons have a very high gain and the current mirrors are almost perfect. However, with increasing frequency and increasing load currents, the Darlingtons need more input current, so capacitors C7 and C8 are added to bypass R19-R20 so the input source can directly drive the output devices.

This output stage is quite simple, reasonably linear and satisfies the requirement for accurate temperature tracking of the instantaneous output device dissipation.
The next step is to wrap error correction around it. Because the stage has no excess gain, you cannot use a global nfb loop around it. The nfb loop that normally includes the output stage of a feedback amplifier of course relies on the excess gain in the voltage amplifying stage to work its distortion-reduction trick.

The Current Conveyor

For ec we need to derive the difference between the input and output signal, and add that difference to the input signal, as shown in Figure 2.
Subtracting two signals that are of similar level, and adding two signals that are of similar level is trivial with opamp circuits. We can use one opamp (S2) to subtract V_{out} from V_e, and another (S1) to add the resulting V_c to V_{in}. But in the spirit of ec I didn't want to use an obvious high global feedback element in this circuit.

After a lot of head scratching and many Internet searches, I came up with the idea to use a current conveyor [3]. The basic circuit is shown in **Figure 4a**. This is a very interesting circuit: basically, whatever you send into the Y terminal comes out in opposite direction from the Z terminal, which works as a current source.
Hence the name *current conveyor*: the current at the input is conveyed to the output. This particular type is called a second-generation conveyor, generally shown as a 'CCII'. Terminal X is a reference terminal for the current input, and the voltage at Y will be kept the same as that at X.

What is this good for? As an example (**Figure 4b**), if you connect a signal to Y via a resistor, you know that the current into that resistor will be the signal minus V_x (remember, $V_Y = V_X$). So the current into Y is this voltage across the resistor divided by the resistance. That same current comes out of Z, so you have now converted a signal level to a current that can be converted back to a signal via another resistor.

If the second resistor on Z is twice the input resistor on Y, you have a gain of 2, without a feedback loop. You can set the gain of this circuit with just two resistor ratios, as shown in Figure 4b. The nice thing here is that we can accurately set a gain (or attenuation, if that would be required) without having to resort to nfb.

How H.ec differs from Global Negative Feedback - or not.

Error correction works by feeding back (part of) the output signal to the input of the amplifier. It has many similarities to a classical negative feedback loop. But how is it different?

Two sides of the same medal. Figure 1a is the basic H.ec topology. You can identify two feedback loops: one positive feedback loop via V_e to V_c and back to V_e; and a negative feedback loop from the amplifier output to V_c. That particular arrangement makes H.ec so interesting. Let's assume that the output stage 'A' is ideal and has a perfect gain of 1. In that case, the correction signal at V_c is 0, because there is no difference between V_e and V_{out}. We could just throw away the whole error correction part. But if the gain A is just below 1, V_c is a negative signal which is subtracted from V_{in} and the effect is that V_e increases. This works as a positive feedback loop. In the case where the gain A would be larger than 1, the signal at V_c is a positive signal, which will be subtracted from V_{in} to decrease V_e. In this case, the system works as a negative feedback loop. So, what you see is a combined feedback loop that can act either as a positive or negative feedback loop, or not at all, depending on the error of the main amplifier block. It looks as if the phase and level of the loop adjusts itself as needed. The validity of treating a combined feedback loop by 'summing' the individual loop contributions has been established by several researchers in the past. Gerald Graeme, at the time analogue IC development manager of Burr-Brown, wrote several articles about it [1].

How does this differ from a 'classical' negative feedback loop? We can take the two feedback loops in H.ec apart as in ***Figure 1b***. Error correction can be seen as a classical global nfb loop with a positive feedback loop embedded. For comparison, ***Figure 1c*** shows the global nfb topology for a unity-gain amplifier.

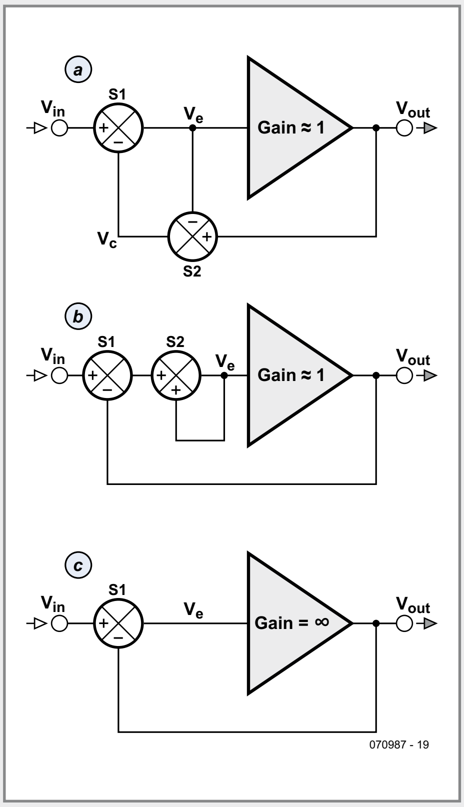


Figure 1a, top, is the basic error correction topology. In Figure 1b, middle, the two feedback loops are separated. The two figures are equivalent. Figure 1c, bottom, is a classical global nfb amplifier.

Less complexity is better. In the classical case, the high loop gain, necessary for negative feedback to reduce distortion, is obtained by means of a high-gain (ideally infinite-gain) forward amplifier block. In the case of H.ec, this high forward gain is obtained by a positive feedback loop, and the forward amplifier block can have any open-loop gain. To keep the task of a practical error correction circuit as small as possible (and therefore optimise the ec circuit linearity), the error signals should be minimal. For this, an open-loop gain equal to the required closed-loop gain is best. That means that with H.ec, similar results as with classical feedback can be reached with a much simpler amplifier. In the case of a unity gain amplifier, just an emitter follower would be sufficient, while in the classical case, even if we wanted a closed-loop gain of 1, we would still need a very high-gain amplifier block. If nothing else, this leads to the practical advantage that the forward amplifier can be much simpler. Of course, there is no such thing as a free lunch (TANSTAFL): we have diverted some of the complexity to the two summers that must be precise circuits to make it all work. As always in audio engineering, the final advantage depends on how smart you are at implementing the various circuit parts.

Less gain is better. There is another advantage to H.ec. When a negative feedback amplifier clips, the feedback loop tries to make the output following the input by increasing the input signal more and more. But that output cannot increase beyond clipping, and as a result the amplifier is overdriven. This can be quite drastic: consider an amp with a 1 V input signal and an open-loop gain of 60 dB (1000 times) and a closed-loop gain of 30 dB (30 times) that clips at 30 V_{out}. If the output signal is 30 V, ***the effective input signal*** to the 60 dB gain amplifier ($V_{in} – V_{feedback}$) is 30 V divided by the open-loop gain, or about 30 mV. If we overdrive this amplifier by doubling the input signal to 2 V, the feedback signal cannot increase due to clipping. So the effective input signal to the 60 dB gain amplifier jumps from 30 mV to 1 V! (2 V input – 1 V feedback). The clipping will become very hard, and the output wave looks as a sine wave with the tops sheared off. There is a danger of heavy internal stage overdrive, and it is possible that it takes some time, after the clipping ends, until all internal stages are returned to their stable operation point. Many amplifiers will have measures to try to avoid these conditions but it does add to the complexity. With an H.ec amplifier, the mechanism is similar. The error correction signal will increase and the input signal to the amplifier block is increased in an attempt to enable the output to follow the input. But now the amplifier block is a low-gain block, typically having a gain of only the closed-loop gain, for example only 30 dB, instead of the very high open-loop gain of 60 dB of the negative feedback amplifier. As a result, clipping and internal overdrive is not as hard. In my opinion, this is an important advantage, which is shared with valve amplifiers. Valved amps of moderate power output can sound quite pleasant, despite relatively high distortion factors, which is to a large extend caused by their soft clipping characteristics. It is also one of the reasons why very high power (300 W or more) solid state amplifiers sound better than 50 W amps with the same distortion: the high power amp clips far less than the low power amp, so the hard clipping, which can make the sound so harsh, is greatly reduced.

[1] "Generalized opamp model simplifies analysis of complex feedback schemes" – Gerald G. Graeme, EDN, 15 April 1993, pp. 175.

The current conveyer does not use global feedback; it is an open-loop circuit. As an aside, current conveyors consist internally mainly of current mirrors; and it can be argued that current mirrors use 100% local feedback. But we won't get into that discussion here!

There is our summer circuit: we will use equal resistors for unity gain (1). V_c back to V_e is realized with the connection of Z to X in Figure 5.

So, at this point, we need to get practical: where do we find this CCII thing? There are CCII's around, often designed in low-voltage CMOS IC technology, and mostly used in laboratories in academic surroundings. They might as well be made from 'unobtanium'.

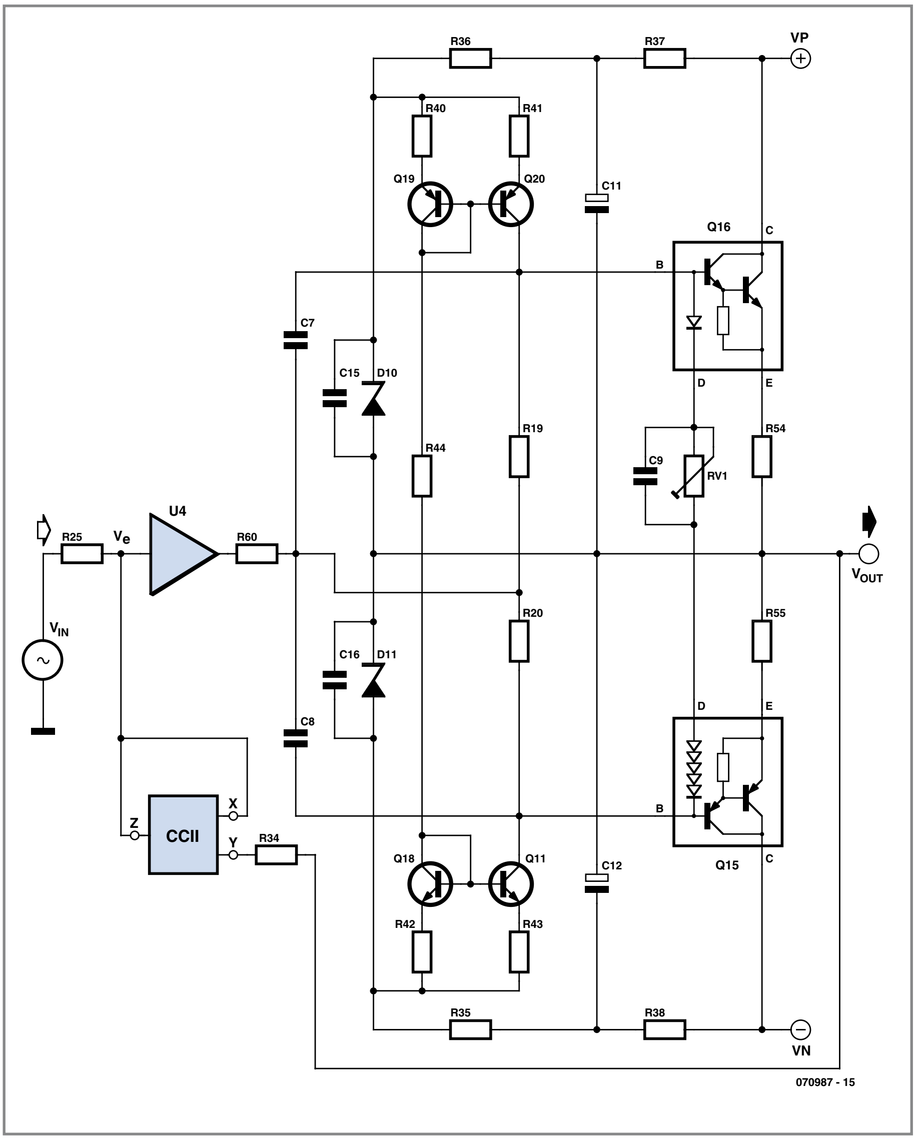


Figure 5. Output stage with error correction.

The error correction loop around my output stage is shown in **Figure 5**. The error between the input and the output appears across R34 and develops a current that is 'conveyed' to R25. This adds the correction signal to the V_{in} to make the H.ec work as we discussed before in Figure 2. The positive feedback loop in Figure 2 from V_e through

But, interestingly, CCII's are part and parcel of current feedback opamps and so-called 'diamond transistors'.

Figure 6 shows the simplified diagram of the internals of an AD844 current feedback opamp. We recognise the CCII terminals: pin 3 is the high-impedance X terminal, pin 2 the low-

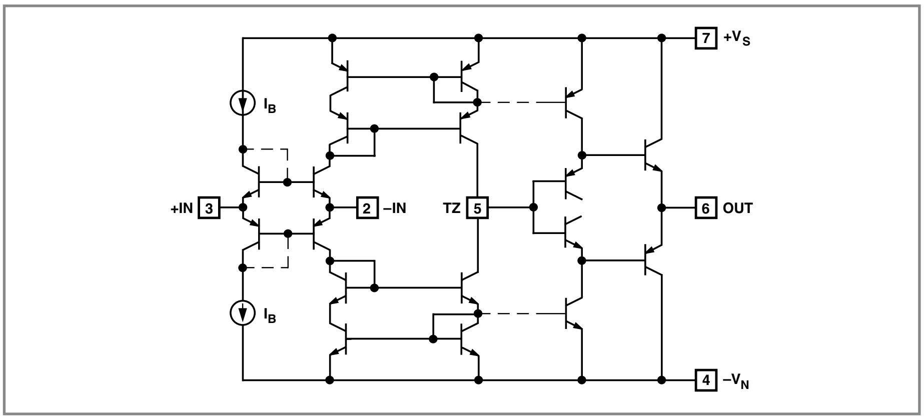


Figure 6. Basic AD844 CCII diagram plus output buffer.

impedance current input Y and pin 5 labelled Tz is the current source output Z. It is readily seen that whatever current is injected into pin 2 (Y) comes out at pin 5 (Z) but in opposite direction. It seems this part has been custom designed for us! Other similar parts are Maxim's MAX435 and MAX436 (now obsolete) and TI's OPA860, which superseded the OPA660 and OPA2660.

We can use the input stage for the CCII function, and the buffer to drive the output stage to isolate the input summer from the output stage's non-linear input impedance. We see that the current output terminal is already internally connected to the buffer input, again, just what we need!

Figure 7 shows the full output stage circuit, with component values. **Note**

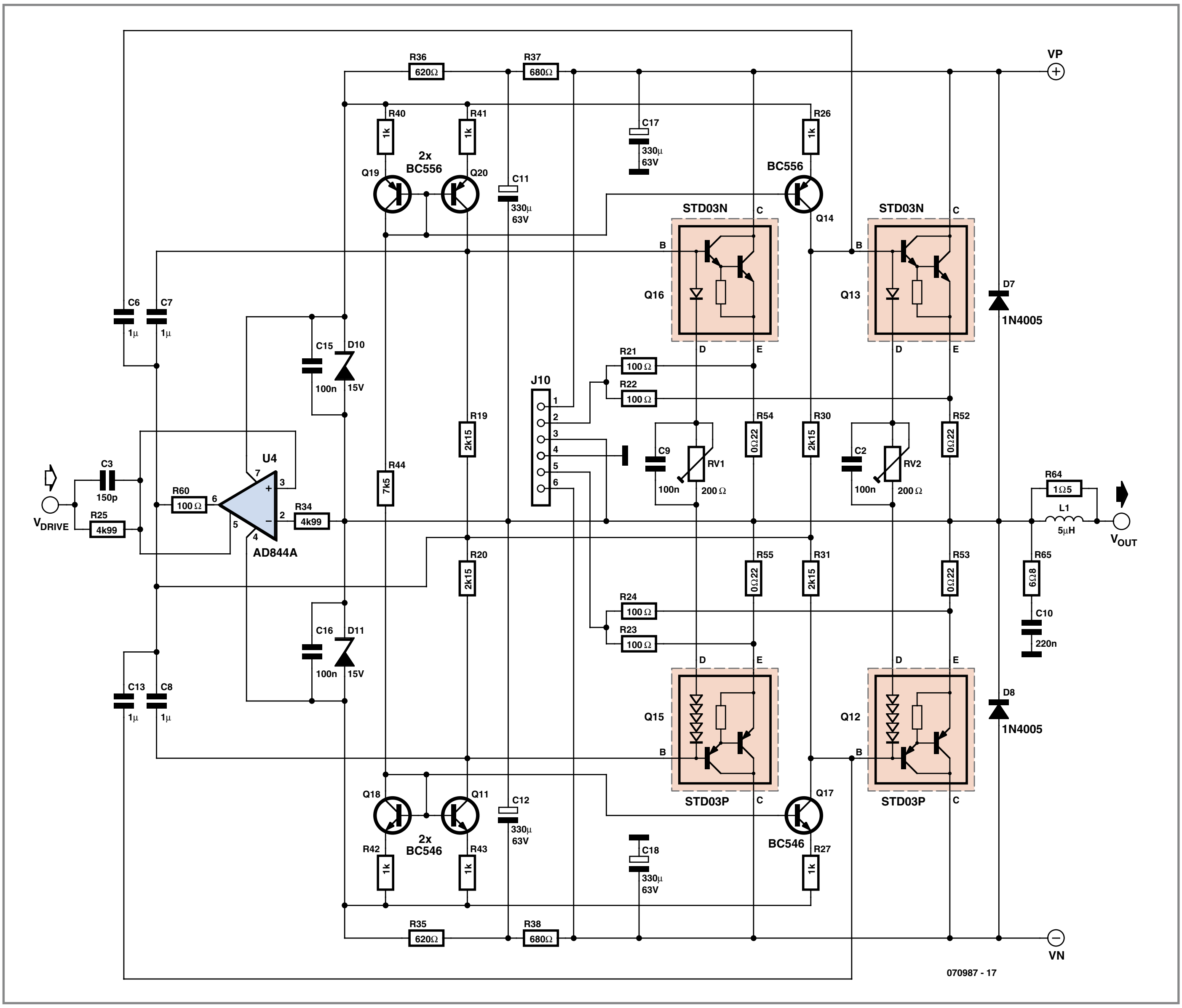


Figure 7. Full unity-gain output stage with Hawksford error correction.

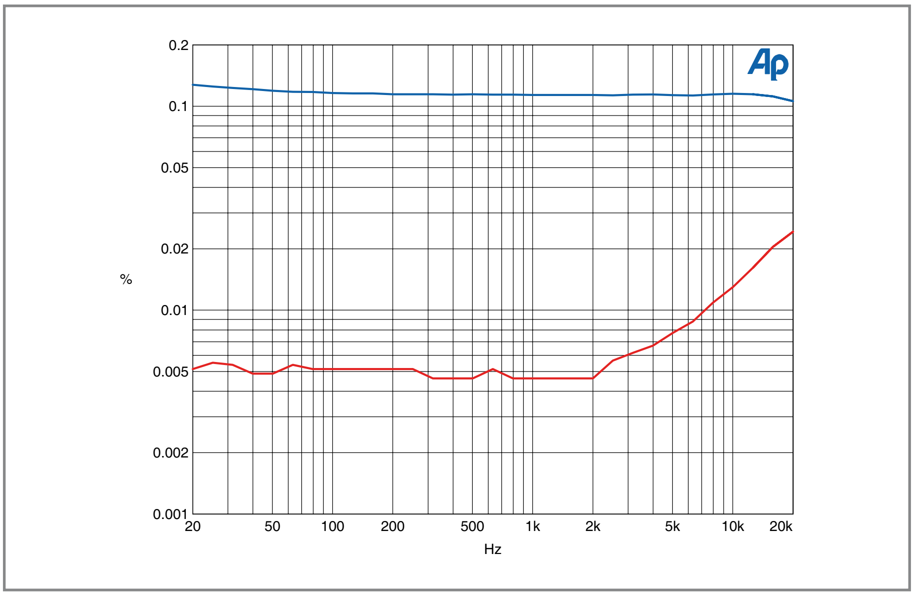


Figure 8. Output stage distortion curve without (top) and with (bottom) error correction. P_{out} = 50 W into 8 Ω.

that the amplifier input is at pin 5 of the AD844, not at pin 2 or pin 3 as we would expect in a classical opamp circuit. This is NOT an opamp circuit, but I'm sure a lot of people will be confused by this...

Putting it all together

This output stage has two pairs of output devices. The design goal was 100 watts in 8 Ω and 200 watts in 4 Ω. For a pure resistive load, one pair of devices would have been sufficient. However, speakers are not purely resistive; depending on the signal frequency they can act capacitive or inductive, especially if there is a complex cross-over filter. This leads to phase shifts between the output voltage and output current, so you can get the situation that the output voltage is negative,

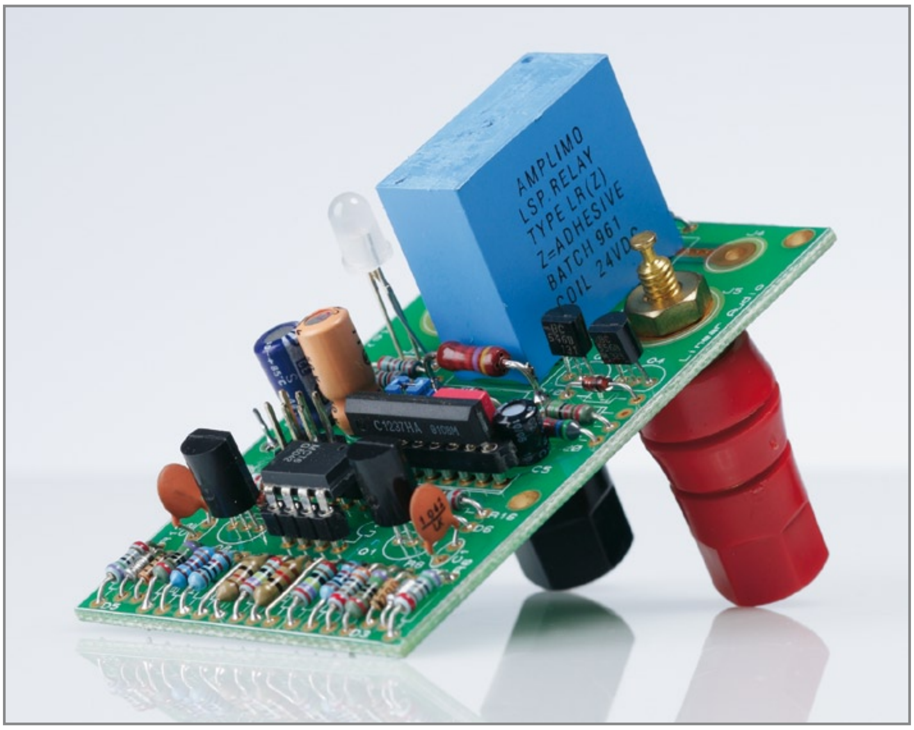
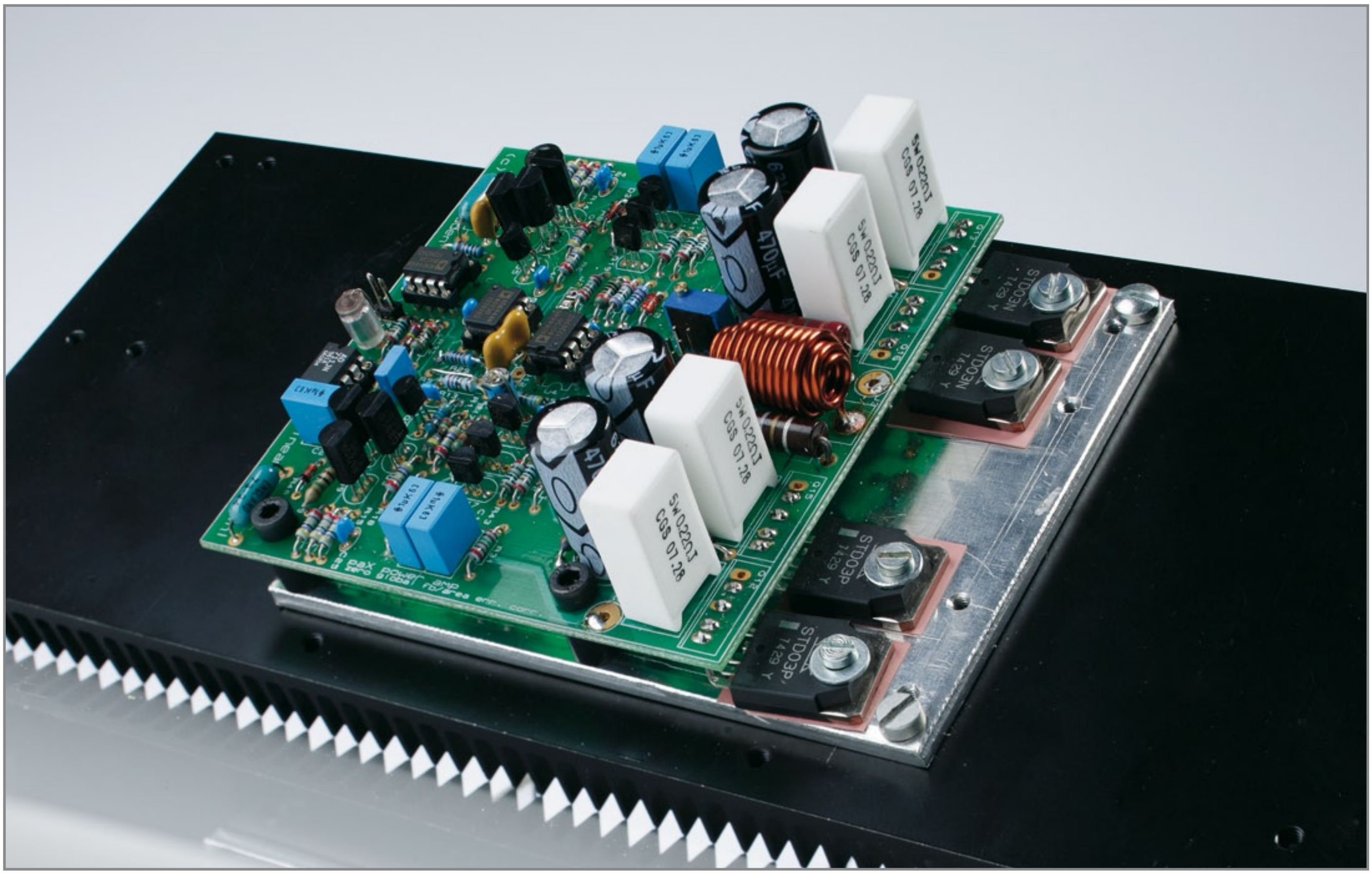


Figure 9. Prototype amplifier module and output/protection board.

but that the current is coming from the positive side (the N-device). The N-device will have a quite large V_{ce}, and the current it is allowed to source is much smaller with a large V_{ce} than what you would think from the allowable dissipation.

Further details about the safe operation area of the output devices will be given in a separate article next month. Anyway, because of the dual output devices, there is also an additional current source to bias the thermal tracking diodes, as well as an extra bias adjust trimmer.



Figuur 10. De opgebouwde versterker-module op z'n koellichaam.

There are a few extra components in the circuit which we haven't mentioned before.

R60 is a small resistor in series with the AD844 buffer output stage. A large part of the output drive goes via the two capacitors C2 and C4 to bypass the current mirrors. R60 isolates the buffer output from capacitive loads ensuring stability.

Another capacitor, C3, is placed across R25. As the frequency increases, the loop through the output stage as well as the current conveyor will exhibit phase shift. In a 'classical' feedback amplifier, if the phase shift becomes too large, it will turn the nfb into pfb which, as we all know, will lead to instability and even oscillations. In H.ec this is also the case of course (it shares many attributes with a feedback amplifier), so we need to roll off the loop gain for higher frequencies, just as in a classical nfb amplifier. C3 does just that by decreasing the effective correction impedance (R25//C3) with increasing frequency.

Also remember that this stage needs to be driven from a low impedance source, because the source output impedance forms part of the ec scaling resistor R25.

Finally, there is the 6-pin connector J10 and some associated resistors. This is the connection to the protection board which we will discuss separately. It provides the V_{ce} and I_c related information of the output devices to the protection circuitry.

This output stage is pretty linear as attested by the curves in **Figure 8**. The output stage can perfectly stand on its own when driven by a suitable voltage amplifier (Vas) stage. So, let's take a break here; we'll attack that Vas, and the power supply, in the next instalment and develop a full-fledged, high quality audio power amp. Stay tuned.

(070987-I)

Literature and note

[1] Hawksford, M.J., 'Distortion correction in audio power amplifiers', JAES, Vol. 29, No.1/2. pp. 27-30, Jan/Feb 1981.

[2] Hephaïstos, 'Thermal Distortion – it exists, I've seen it', L'Audiophile, no. 32, May 1984. (Ed.: Hephaistos was the Greek god of fire, metalworking, stonemasonry and the art of sculpture)

[3] In the early 90's, an IC designer, Doug Wadsworth, designed a current conveyor for audio on his own money (PA630). The chip, the 'Swift Current' chip, eventually found its way into Wadia DACs. It is no longer available for other parties, but I had bought some from him and knew they were a well kept secret for hi-end audio.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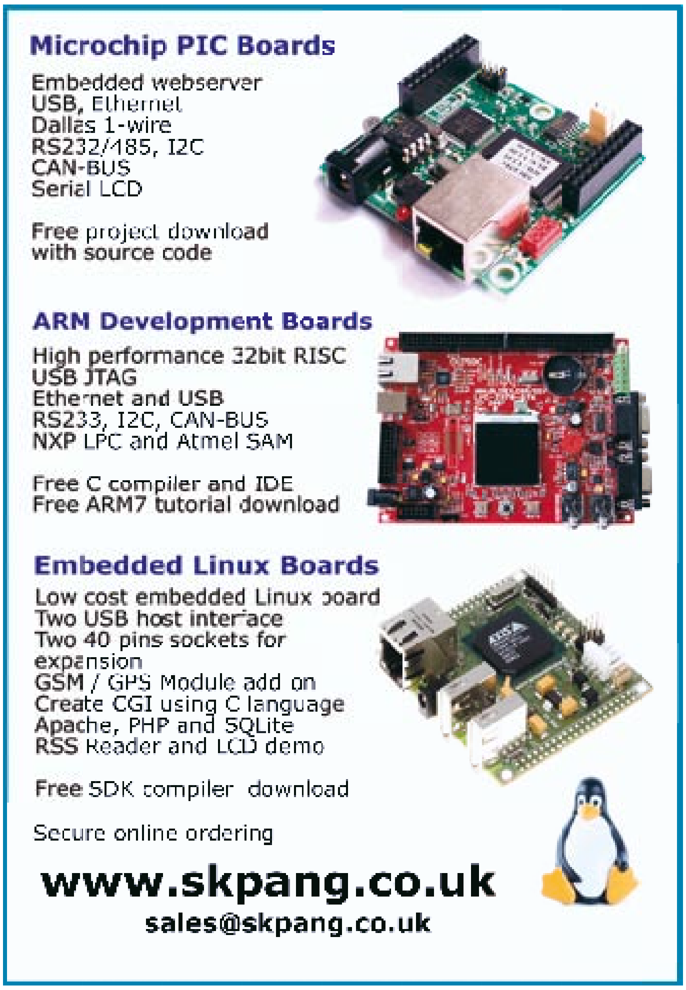
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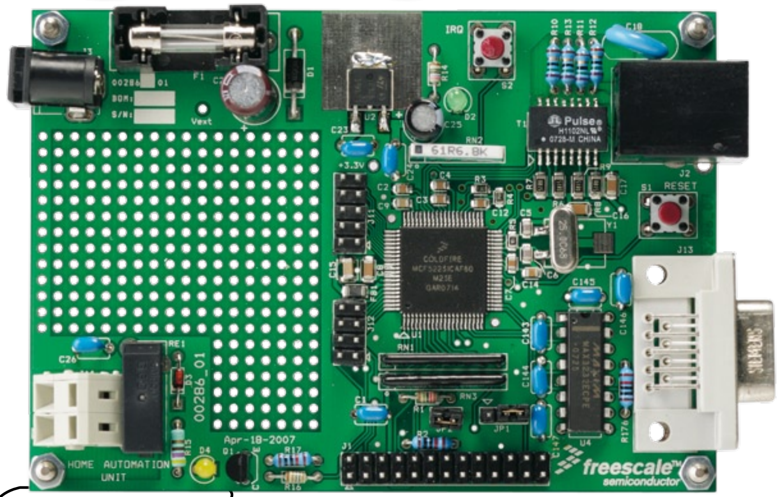
DigiButler



A Coldfire 32-bit home automation server

Part 1: introduction and circuit descriptions

Richard Sumka (Freescale Semiconductor Inc.),
Luc Lemmens & Jan Buiting (Elektor)

This project employs a Freescale Coldfire micro and associated PC software that allows remote switching of electrical loads across networks including the biggest we know – the Internet. The ingredients from the Freescale/Elektor kitchen: 32-bit embedded technology, free software, a low-cost kit for the hardware and free tools to expand the functionality of the server to your own liking.In the first instalment we describe the general structure of the server and the optional Turbo BDM programmer for Coldfire devices.

Out for the night and forgotten to switch off the lights at home, or the heating? This project could be the solution, providing the ability to control equipment remotely over the Internet using a web browser or WAP enabled phone.
Sure, that application alone may look trivial considering the sheer power of the microcontroller used but that's also the crux of the project: it's expandable and totally geared to open-source development as we have made sure that

all resources are available either free (software) or at low cost (hardware).

Networked home automation server

Connecting applications together is fast becoming a necessity rather than an option, especially where Ethernet networking is concerned. This home automation server using a Freescale 32-bit Coldfire device and Freescale software allows remote switching of loads across Ethernet networks and the Internet. And with some ingenuity, simple modifications allow the server to be used for remote sensing and monitoring.

Crossing the internet (and WAP gateways)

Web pages are transferred across the Internet using HyperText Transport Protocol (HTTP). HTTP is a request-response protocol and can be used to send any type of data including binary data. The client – a web browser – requests a web page from a web server and the web server responds with the web page contents. Simple as that may sound, there's a lot of technology behind it all!

As illustrated in **Figure 1**, DigiButler is a mini web server that will happily sit behind an Internet connected router. Alternatively, it may be connected to a local network or directly to a PC. For most of this article we will describe the connection as though it were behind a router.

The unit will accept commands from, and return data to, any Internet-connected PC or WAP telephone that has DigiButler's IP number. Password protection is also provided by the client software.

About the MCF52231

The Freescale Coldfire MCF52231CAF60 in its LQFP80 case is a member of the MCF5223x family of 32-bit connectivity microcontrollers. Its architecture is shown in **Figure 2**. The two key features of the family are the integrated 10/100 Mbit/s Fast Ethernet Controller (FEC) and Ethernet Physical Layer (EPHY); in brief, everything needed to get a single chip application onto an Ethernet network. If you want to delve really deep into this, there's a must-read article available from Eric Gregory [1].

This device also has a CAN 2.0B controller. CAN is commonly used as an

Main specifications

- 32-bit Coldfire MCF52231 microcontroller
- Open-source project
- C source code
- Free CodeWarrior software development platform
- Doubles as a low-cost Coldfire development system
- Connectivity: Ethernet (RJ45), RS232, BDM, analogue, I²C, timers
- 1 relay (on board) suitable for mains loads up to 2 A
- Accessible through Internet or WAP
- Client software with password and username protection
- TCP/IP and RTOS stack with HTTP, DHCP, UDP, ICMP, ARP support
- Easy IP setup
- Ideal for web-driven remote sensing and control
- Kit of parts available from Elektor Shop

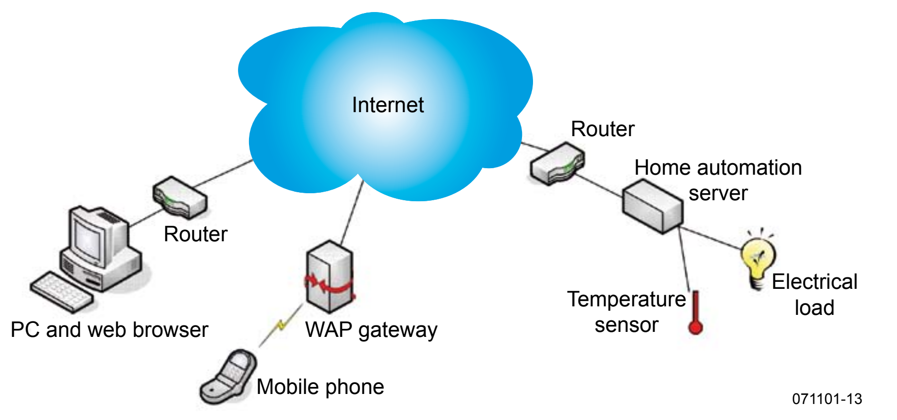


Figure 1. DigiButler gets its commands from any PC connected to the Internet, or a WAP telephone.

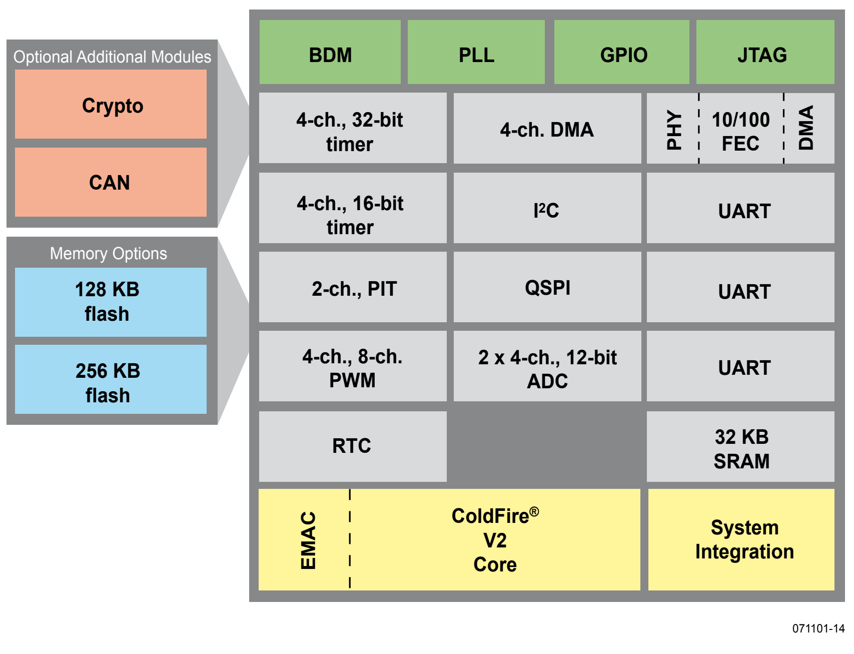


Figure 2. MCF52231 'Coldfire' architecture (courtesy Freescale).

MCF52231 – bits to remember

- 128 kB of embedded Flash memory
- 32 kB of SRAM
- 60 MHz Coldfire V2 32-bit CPU
- Up to 56 bits of general purpose I/O
- Three UARTs
- Serial peripheral interface (QSPI)
- I²C bus interface
- Four 32-bit timer channels with DMA capability
- 4-channel, 16-bit timer for capture, compare and PWM
- 2-channel periodic interrupt timer
- 4-channel, 16-bit or 8-channel, 8-bit PWM generator
- Two 4-channel, 12-bit analogue-to-digital converters
- 4-channel DMA controller
- Up to 73 general-purpose I/Os
- PLL, watchdog, real time clock, range of reset sensors
- On chip background debug module (BDM)
- Single 3.3-volt supply

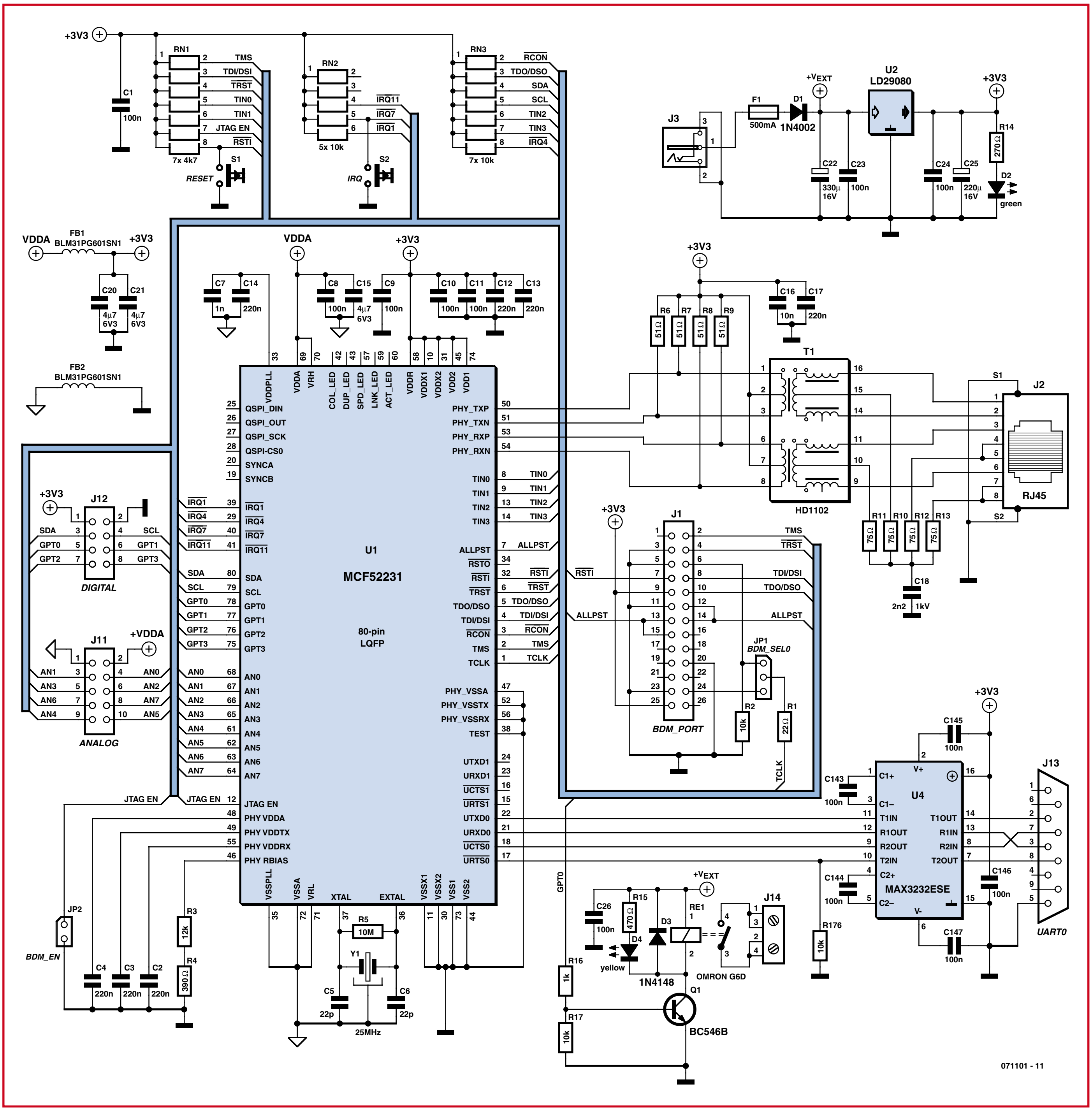


Figure 3. Schematic of the home automation server. The circuit has been designed for expandability — in fact it makes a great development system for Coldfire 32-bit microcontrollers.

industrial control serial data bus because of its suitability for use in real-time communication environments and its reliable operation in conditions of harsh EMI. The MCF52231's bigger brother the MCF52235 also has Cryptographic Acceleration Unit and random number generator for secure hardware encryption. Some of the other important features of the MCF52231 are listed in the **inset**.

Everyone's encouraged to improve & extend the DigiButler C code and let us know the results

Electronics

If we include the transistor and the voltage regulator, there are four active components in the circuit diagram in **Figure 3**. Let's take a tour of the schematic.

At the heart of the circuit sits the Freescale MCF52231 Coldfire device (U1). The 10 or 100 Mbit/s 802.3 ready Ethernet interface is provided by isolation transformer T1 and the physical RJ45 Ethernet connector J2.

Crystal Y1 (25 MHz) sets the clock frequency of the Coldfire microcontroller. This is multiplied up by the device's internal PLL to give a core clock frequency of 60 MHz.

Eight 12-bit analogue inputs are available on connector J11. These are routed directly to the ADC pins of the Coldfire. A further six of the Coldfire's digital input/outputs are available on J12. All can be used as general-purpose I/O and two may be configured to connect to the I²C module in the microprocessor. The two I²C lines, SDA and SCL, are fitted with 10 kΩ pull-up resistors. The I²C can operate at up to 100 kbps with maximum I²C bus loading and timing, and even faster if the bus loading is reduced.

J1 is the BDM (Background Debug Mode) interface, allowing in-circuit debugging of the application code and Coldfire Flash memory erasing and programming. The associated programmer (for optional use) is described further on.

RS232 port J13 is driven by the internal UART of the Coldfire and voltage level translation is provided by U4, the familiar MAX232. A regular RS232 cable should be used to connect the port to a PC, i.e. not a null-modem cable.

Pushbutton S1 is the main Reset and its activation will restart the application code. S2 is directly connected to pin IRQ7 of the Coldfire, with a pull-up to the +3.3 V supply. acts as a general purpose pushbutton input. If you want to 'program it in', feel free to do so!

Jumpers JP1 and JP2 on the board are for programming purposes and will be discussed in part 2.

It's not shown in the circuit diagram, but a large prototyping area on the board gives the user lots of room for experimentation and to expand the board's functionality.

Any low-cost regulated or unregulated power adapter with an output voltage of 5-8V DC at about 500 mA is suitable for powering the circuit. This input minus the drop across D1 is used to supply relay RE1, which has a maximum coil voltage rating of 8 V. As would be expected for such a design, there is reverse polarity (D1) and over-current protection (F1), and an LED (D2) to indicate power on.

Voltage regulator U2 steps the input voltage down to provide the Coldfire device with a stable 3.3 V, which is further decoupled by lots of 100 nF and 220 nF SMD capacitors in key positions. The VDDA supply for U1 is also derived from the +3.3 V line and has additional filtering by ferrite bead FB1 and a pair of low-voltage SMD 4.7 µF capacitors, C20 and C21. Clean as whistle!

Relay control

A key feature of the home automation board is its capacity to control hardware remotely via the Internet. The ability to control mains voltage equipment is especially interesting but requires special precautions. As with any life threatening voltages, safety is paramount and there must be electrical isolation between the low voltage of the board and any mains voltage. Isolation is provided by relay RE1 whose contacts can switch a 250 VAC, 2 A load, the current capacity being limited by the width of the PCB tracks from RE1 to connector J14. Yellow LED D4 shows the relay on/off status.

DigiButler software

The project firmware is a modified version of the Coldfire Lite HTTP server software available free from Freescale and described in Application notes AN3455 [2] and AN3470 [3]. A wealth of information covering the software operation and including training presentations can be found at [4] and [5]. In this project, modifications have been made to the Freescale software to pro-

freescale™ & elektor electronics worldwide

Elektor is again proud and glad to work together with Freescale Semiconductor Inc. for the benefit of its readership. After the great success of the 8-bit MC9S08 SpYder and Accelerometer articles in March and April 2007 we now take a giant leap to a 32-bit embedded system we hope will challenge and inspire the thousands of microcontroller fans among you. The effort is boosted by a kit of parts we're selling at a low price for the DigiButler project.

Historically Freescale has successfully concentrated on the automotive market for its microcontrollers and as a result has held a leadership position there for many years. More recently however, there has been a real push to significantly increase support to the markets served by the distribution network. This increase for the mass market also extends to students and enthusiasts and has led Freescale to work with Elektor.

Interestingly, Freescale has also been asked by some of their largest OEM customers to work with Elektor so that graduates coming into industry are familiar with their products when they start their careers.

Yes, Milord

- The project is open-source with all C code available free for everyone to alter, recompile and flash
- The hardware and software are designed for expansion and experimenting
- You are working with real 32-bit embedded technology
- The project has been designed and tested in close cooperation with Elektor labs
- The PCB in the kit comes with the micro programmed and SMD parts pre-soldered
- The hardware is fun to build on a high-quality board with SMDs pre-stuffed
- There is a large community of knowledgeable Freescale microcontroller users
- The CodeWarrior programming suite is free and easy to use
- East Kilbride is a wet & windy place
- There may well be several Coldfire micros in your new car

vide authentication using username and password and to allow access from WAP enabled phones and web browsers. There are a large number of code modules in the project and all are written in 'C'. As the microcontroller is operating at a whopping 60 MHz there is no need for any assembly language code. In the project settings, 81 kB of Flash memory has been reserved for code space and 45 kB of it for web content. If code optimization Level 1 is used when building the project then only 58 kB of code space is used — give it a try!

The board implements an HTTP web server using a free TCP/IP and real time operating system stack from Freescale. The term 'stack' is used as the software is designed as one protocol stack on top of another, as shown in **Figure 4**. For those interested in the internal workings of the stack, a browse through the project source code will show that the stack supports DHCP, UDP, ICMP and ARP protocols in addition to TCP/IP and HTTP.

Thanks to lots of free information being available on Coldfire TCP/IP stack programming, very little knowledge of the code operation is needed to modify web pages and access the board hardware across the Internet or a WAP phone.

TBLCF: open-source and optional

It's heartening to see that many Freescale micros have been adopted with great enthusiasm by the 'embedded' underground community. Some members have actually developed low-cost alternatives to Freescale's proprietary programming and debugging systems for various microcontroller families, including the high-end ones! In all cases, the concept of BDM is used to access the micros. SpYder [6] is a BDM for MC9S08 micros.

TBLCF is optional, open-source, has USB and costs less than $10 to build

A "Turbo BDM Light Coldfire Interface" (TBLCF) for use with CodeWarrior was developed by Daniel Malik. It is found on the Freescale *68K/Coldfire Processors* forum [7]. In good community spirit Daniel released all relevant material on his design into the freeware domain. If you master the art of 'judicious sampling', TBLCF should not cost more than a tenner for parts.

An important point to mention is that **TBLCF is optional for the present project**. The DigiButler board in the kit supplied by Elektor contains a ready-programmed MCF52231 micro that will not normally require re-programming or debugging. So, TBLCF is for advanced users wishing to modify the DigiButler firmware — everyone is encouraged to do so and show the results.

Daniel Malik's description of TBLCF is exhaustive and eminently presented in free documents and even artwork to make the PCB. There's an associated DLL and a step-by-step software installation guide. Here, we will limit ourselves to a condensed circuit description referring to **Figure 5**, courtesy Daniel.

TBLCF has USB connectivity to the PC. The hardware has two main parts: the MC68HC908JB16 MCU and the BDM interface driver based on a 74VHC14 buffer. The 'VHC14 is used to achieve low-cost translation of BDM signals with voltages anywhere between 3.3 V and 5 V to the 5 V logic of the MCU. The VHC logic accepts overvoltage on inputs, however the output voltage swing is limited by the power rail voltages. When the 74VHC14 is powered by a 3.3 V source, resistors R3 and R4 would not be able to pull the signals above the 3.3 V rail and would only inject current into the power rail of the 74VHC14. Alas, 3.3V is below the minimum High level input voltage of the MC68HC908JB16 and the circuit would not be guaranteed to work. Diodes D2 and D3 have

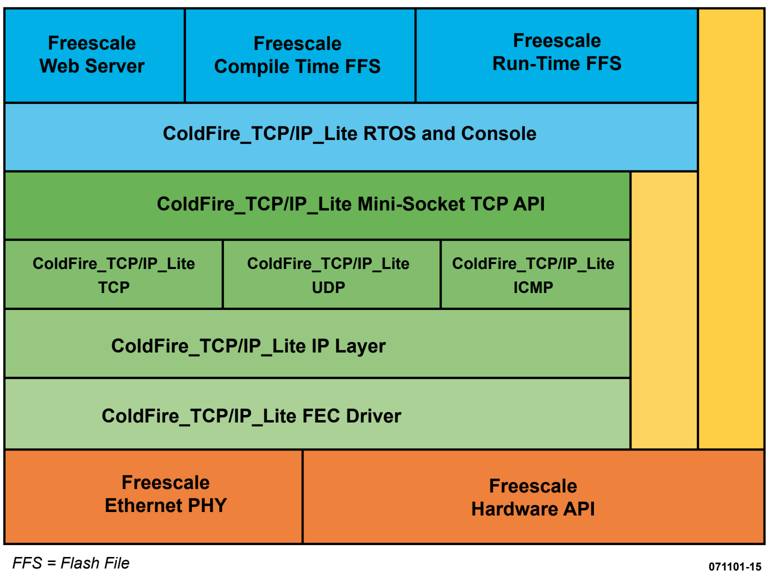


Figure 4. TCP/IP and RTOS stack implemented on the Coldfire micro.

been added to increase the high level voltages. The better alternative, two N-channel MOSFET transistors, would increase the cost and complicate the PCB layout.

The RSTO signal is brought to two different pins of the MCU. This is strictly speaking not needed and a connection to pin PTE1 would be sufficient. However connecting the signal to PTA6 as well simplified the PCB design!

The ColdFire BDM connector has been here for a long time. In the past, boards usually contained a lot of components and were fairly large. A 26-way connector with 0.1" spacing was therefore of a reasonable size. Size of boards is however shrinking and the connector is becoming too large for smaller applications. Two **optional** enhancements have been made to the standard BDM connector:

1. Where the 26-way connector is too large you can use a 10-way subset of the connector (pins 1 through 10). The only signal which is then missing is TA (Transfer Acknowledge) on pin 26, but this is only needed in systems with external memory bus where the debugger is configured incorrectly and accesses an area for which a TA is not generated (neither internally nor externally). So, the probability that it will be needed is quite low and the absence of the signal can be compensated for by a careful use of the debugger.
2. The RSTO signal has been added to pin 1 of the connector, which was so far unused. This enables the interface to detect resets of the microcontroller caused by, for example, the COP/watchdog circuit or a user RESET button.

Note that the above enhancements are suggestions only and the interface will happily operate even with the original 26-way connector. Pins 11 and 12 of the 26-way connector can be removed to make the interface compatible with both the 10-way and 26-way ribbon cables.

Next month

It is planned to have kits for the DigiButler project available with the publication of the May 2008 issue of Elektor. We then finish the article by discussing hardware assembly and test, network connection, Ethernet setup and creating and uploading web pages. For advanced users, CodeWarrior-driven compilation and reflashing of the MPU is also discussed.

(071101-1)

References and Internet Links

Note: documents also available from the project web page:
www.elektor.com/digibutler_en

[1] ColdFire Ethernet, by Eric Gregori.

[2] www.freescale.com/files/microcontrollers/doc/app_note/AN3455.pdf

[3] www.freescale.com/files/microcontrollers/doc/app_note/AN3470.pdf

[4] www.freescale.com/webapp/sps/site/homepage.jsp?nodeId=0162468rH3YTLC

[5] www.emgware.com/

[6] Attack of the SpYder, Elektor Electronics March 2007.

[7] http://forums.freescale.com/freescale/board/message?board.id=CFCOMM&thread.id=624

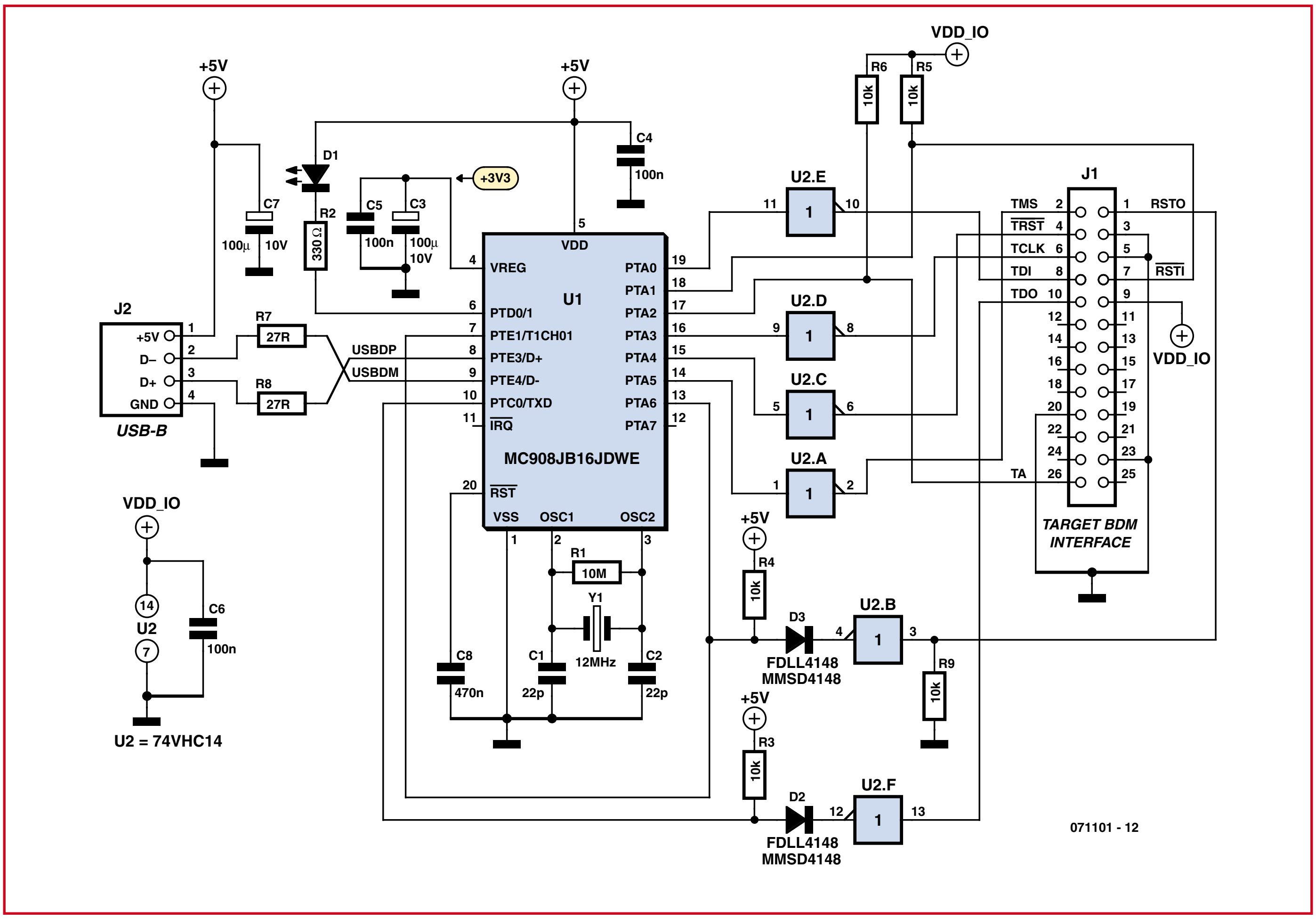
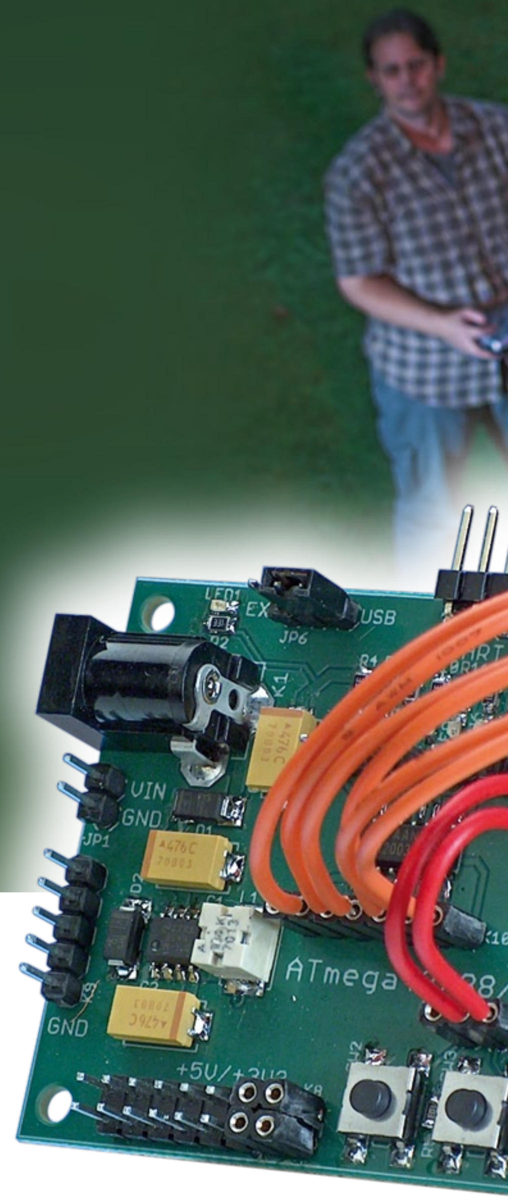


Figure 5. Circuit diagram of TBLCF, the open-source, optional debugger/programmer for Coldfire micros. TBLCF should not cost you more than $10 to build.

ATM18 AVR Board

Small but perfectly formed

Udo Jürss and Wolfgang Rudolph



This new series of articles presents a tiny processor module based on an ATmega88 microcontroller, ideal for use at the heart of any number of different projects. We begin with a reaction time tester and quickly move on to more advanced projects such as a precision weather station and a 3D magnetometer. Our most ambitious and final project will use the ATmega to provide autonomous control to a four-motor aircraft. Each application example provides an easy-to-understand demonstration of how to work with AVR microcontrollers.

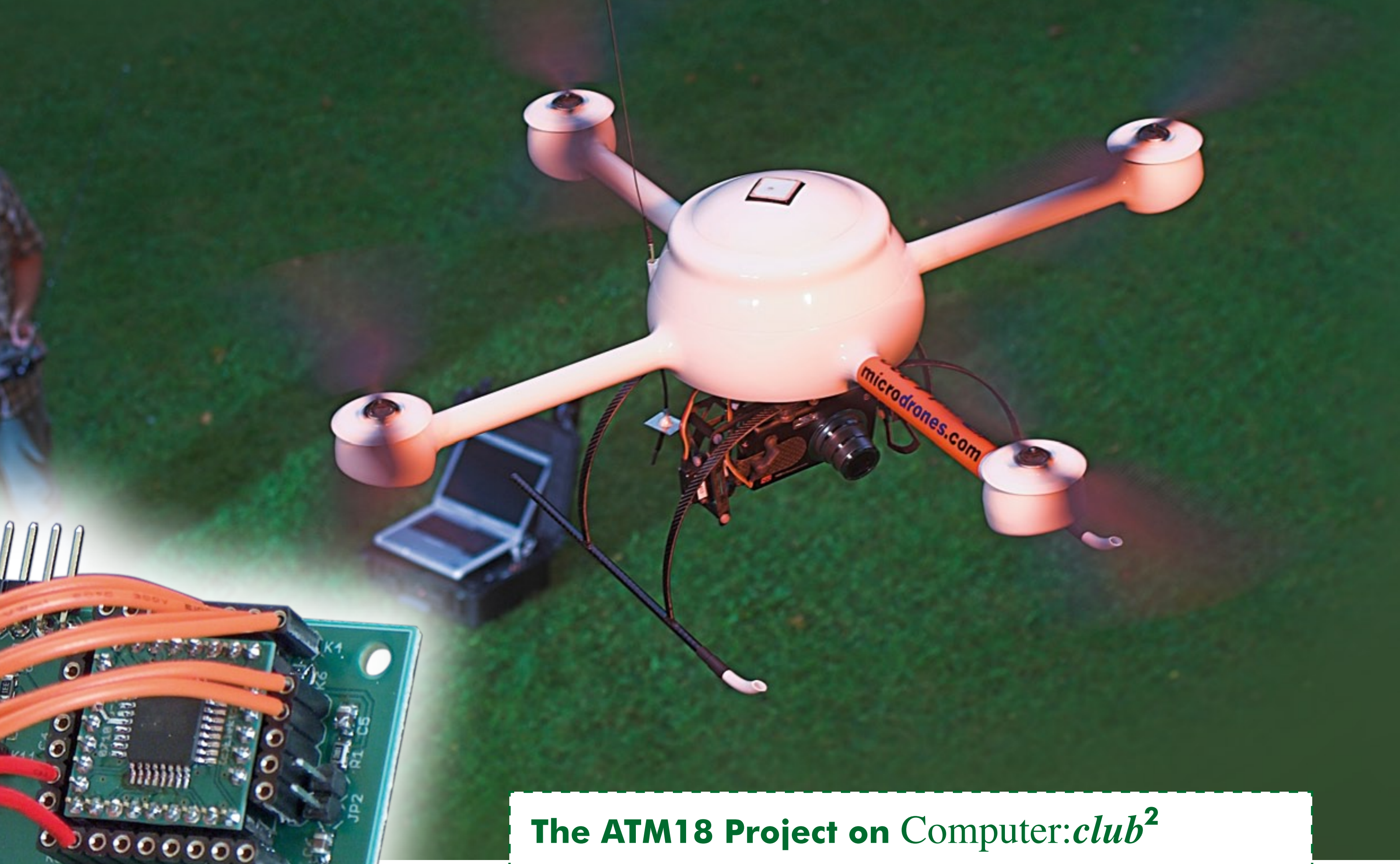
Elektor readers will already have seen the ATmega8, ATmega16 and ATmega32 used in real-world applications. In this series we will be using the ATmega88, which is a small, lightweight and powerful microcontroller (see text box). In comparison to the ATmega8, which is the same physical size, the device offers a higher clock rate, up to six PWM outputs, and many other extras to make life easier for developers.

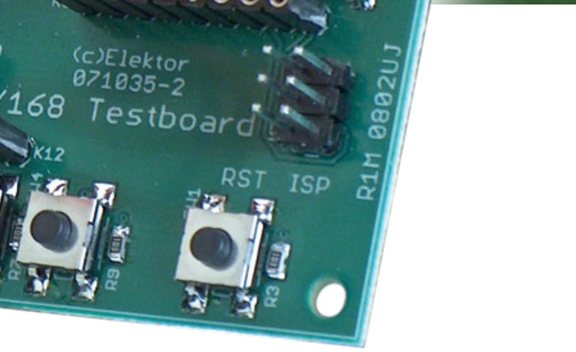
Our AVR projects centre around an ATM18 microcontroller module fitted with an ATmega88. To make the unit universally useful, it has been designed to be as small and lightweight as possible. The printed circuit board is tried and (thoroughly) tested: it is based on a design that has been used successfully for years in autonomous aircraft made by Microdrones in Germany, adapted to suit our particular needs. Anyone who has seen one of these four-propeller aircraft in operation (for example, at Embedded World 2008) will appreciate how important it is to pack as much computing power as possible into a tiny volume.

The project essentially consists of two printed circuit boards. The first is the ATM18 microcontroller module, measuring 18 mm square; the second is the ATM18 test board, which sports a wide range of interfaces and which is intended to be used to help with development. Of course, surface-mount technology is inevitable in a project like this, and so manually populating the boards is somewhat tricky. However, *Elektor* comes to the rescue with ready-made modules and test boards: only the connectors need to be soldered manually. This has the advantage that the connectors not required for a particular application need not be fitted. In some applications it is appropriate to connect the microcontroller module directly to other printed circuit boards or sensors, and so the module is also available as a separate item so that you can use a single test board to develop a range of different projects based on the module.

The ATM18 microcontroller module

The module takes the form of a carrier board, similar in style to that featured in the R8C project which will be familiar to *Elektor* readers. We have used a special thin material for the printed circuit board to keep the weight and overall size of the module to a minimum.





The ATM18 Project on Computer:*club*²

ATM18 was developed jointly by Elektor and Computer:club² (*www.cczwei.de*) with contributions from Udo Jürss, the main developer of *www.microdrones.de*. Elektor is pleased to support the project through articles in the magazine, ready-stuffed boards supplied through the Elektor Shop, supplementary information, software downloads and the forum at *www.elektor.com*.

Each month, the latest deveopments and applications of the ATM18 system are presented by Wolfgang Rudolph of Computer:club² in a TV broadcast on the German NRW-TV network. The boards and example programs from this article instalment can be seen in ***Broadcast #9*** of CC²-tv on ***20 March 2008.*** Some understanding of German required!

CC²-tv is also broadcast as a Livestream on the Internet at *www.nrw.tv/home/cc2*.

CC²-tv Podcasts are available from *www.cczwei.de* and – a few days later – from *sevenload.de*.

The TQFP32 version of the ATmega88 is used (the device is also available in a 28-pin DIL package). Also featuring on the board is a 16 MHz crystal and the necessary SMD capacitors, and two resistors. Measuring just 18 mm square the unit is smaller than a postage stamp, and, once programmed, it forms a self-contained autonomous unit. For reasons of space, the header connectors are laid out on a 2 mm pitch; in very space-critical applications the headers can be replaced with a cable soldered directly to the board. Headers with a 2 mm pitch are reasonably widely available since they have long been in common use in Japan. Unfortunately, we cannot use standard perforated board with the module, but of course we can use the test board, which brings the signals out to 2.54 mm (0.1 inch) pitch box headers. Experiments can then be performed very simply using insulated wire (0.8 mm) to connect the various inputs and buttons.

Figure 1 shows the pinout of the ATmega88 and **Figure 2** shows the pinout of the module: the similarities (and the differences) should be evident. A total of 32 pins is reduced to 29, as the GND and VCC connections are repeated on the TQFP package. The connections required for in-system programming (ISP) are made available in a single row to simplify connection to a programmer.

The crystal and a couple of capacitors are located on the reverse of the module (see **Figure 3**). This is all that is needed to get the microcontroller running: see the circuit diagram in **Figure 4**. The analogue supply voltage AVCC is derived from the main supply via a filter comprising R1 and C3, and there is a 10 kΩ pull-up resistor (R2) on the reset input.

The printed circuit board layout is shown in **Figure 5**, with the 2 mm pitch pin headers on all four sides clearly visible. When these are fitted to the board, they mate perfectly with the corresponding sockets on the test board.

When soldering these headers it is important to ensure that they are mounted exactly vertically: it is possible to use the test board as a jig to simplify the job: mate the pin headers with their corresponding sockets on the test board and then place the microcontroller module on top. This

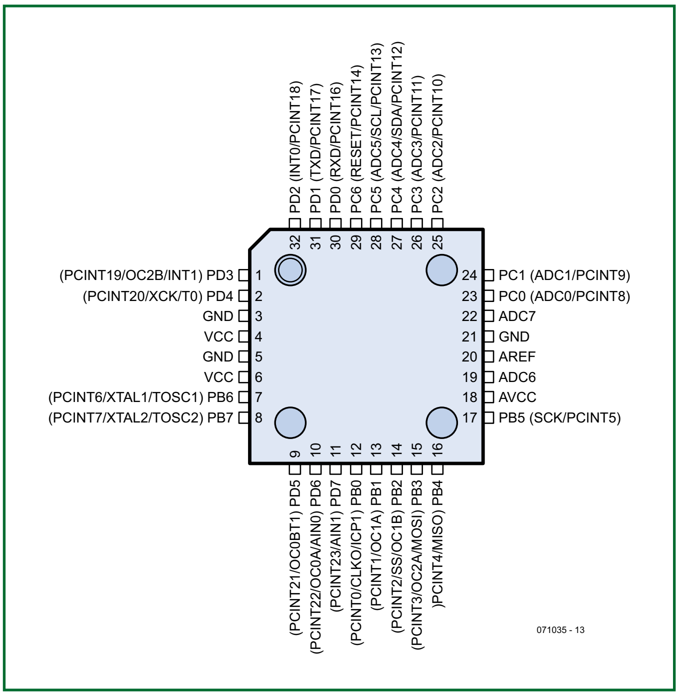


Figure 1. The pinout of the ATmega88 in a TQFP package.

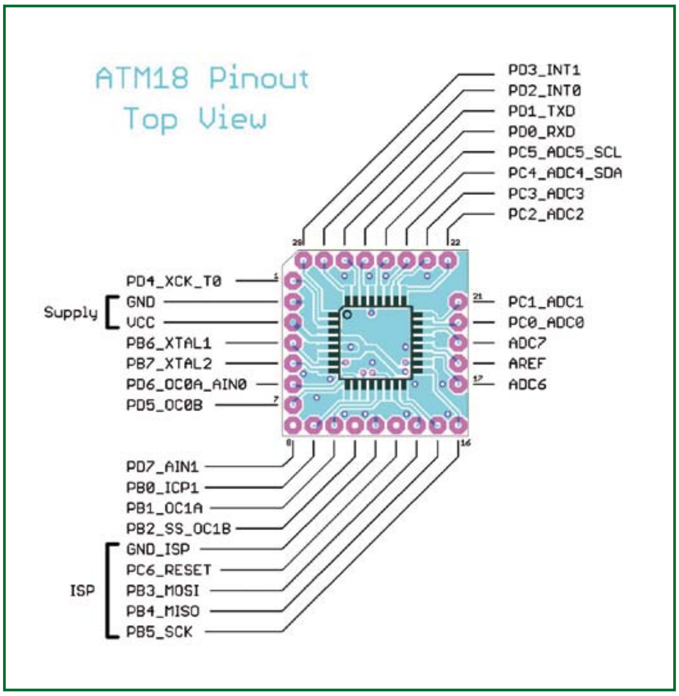


Figure 2. Pinout of the ATM18 microcontroller module.

will keep everything at the correct angle while soldering. Do a single pin on each connector first, and then make a thorough visual inspection, adjusting the positions of the connectors if necessary. When everything is in order the remaining pins can be soldered.

ATM18 micro-controller module

Quick data

Microcontroller: ATmega88

Operating voltage: 2.7 V to 5 V

Processor clock: 0 Hz to 20 MHz (typically 16.0 MHz)

Current consumption: approximately 18 mA (at 5 V and 16 MHz)

Hardware features

Two 8-bit counter/timers (Timer0, Timer2)

One 16-bit counter/timer (Timer1)

One synchronous serial interface (SPI)

One asynchronous serial interface (UART)

One two-wire interface (I^2C)

One 10-bit A/D converter with 8 inputs (ADC0 to ADC7)

One analogue comparator

Up to 23 digital I/O lines

The test board

This printed circuit board is of course rather larger. It provides a wide range of external interfaces as well as a power supply for the ATM18, providing an easy way to experiment with the module and connect extra hardware, sensors, actuators and other bits and pieces. The board measures 80 mm by 50 mm and the mounting holes are spaced at 72 mm and 44 mm.

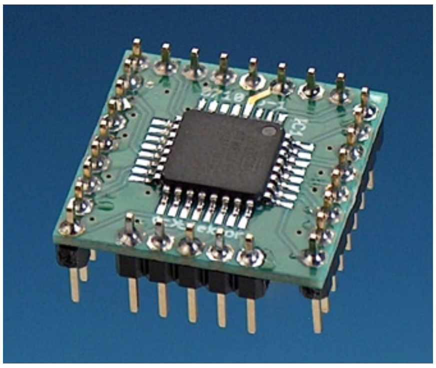


Figure 3. Top and bottom views of the ATM18 microcontroller module.

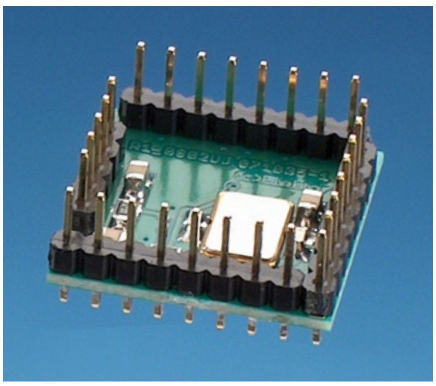


Figure 6 is the circuit diagram of the test board. IC1 is a type LM2594-5.0 step-down converter, which provides a regulated supply voltage of 5 V for the microcontroller and peripherals from an input supply (on connector K1) of between 7 V and 16 V without dissipating large amounts of power as heat. Current demand is low, and a simple mains adaptor can be used. Battery power, using rechargeable or dry cells, is also feasible. Diode D1 protects against accidental reverse polarity connection of the power supply: a Schottky diode is used as it has a lower forward voltage drop. The regulated voltage, EXT+5 V, is used as the supply for the board if jumper JP6 is set to 'EXT', bridging pins 1 and 2. If JP6 is set to bridge pins 2 and 3 ('USB'), the supply is obtained from K2, the connector for the TTL-level serial interface. If an FTDI TTL-232R adaptor [1] is connected to K2, the 5 V supply will be taken from the connected PC via its USB port. The adapter will be available from the *Elektor* shop in the near future. There is also a 3.3 V version of the adaptor, which can equally well be used. The selected supply voltage is available on eight pins of connector K8. There are

AVR, ATtiny and ATmega

It was decided to use an Atmel ATmega microcontroller for this project. This comprises an entire family of devices, with the main difference between individual devices being in their processing power. The design is particularly flexible and modern and ideal for low-cost implementations. The original AVR design was produced at the Norwegian Institute of Technology in Trondheim before being bought by Atmel. The AVR core is particularly small and can be implemented in as few as 4000 gates. Atmel, the only manufacturer of processors using this core, produces two series of devices: the ATtiny series and the ATmega series. The AVR has a RISC (reduced instruction set computer) architecture; traditional CISC (complex instruction set computer) architectures offer more powerful and sophisticated instructions, but decoding such an instruction takes considerably longer than does the decoding of a RISC instruction. Furthermore, a CISC processor generally takes longer to respond to an interrupt request than a RISC processor, impairing real-time performance.

All ICs in the AVR family are structured in essentially the same way, differing only in the quantity of memory available and the number and types of timers provided. Some also feature an A/D converter or a UART (universal asynchronous receiver/transmitter) to provide a serial interface on the chip.

The AVR was designed with the efficient execution of programs written in high-level languages in mind. From the point of view of both price and performance a RISC microcontroller of this type makes the ideal basis for our projects.

also a further eight ground pins, giving a total of eight points from which a supply can be obtained to power external devices. Six more ground pins are available at K9.

Jumper JP2 is also concerned with power supply options. If it is fitted, the +5 V supply is used as the reference voltage for the A/D converters in the microcontroller. A low-pass filter is used here to smooth the reference voltage in the same way as the analogue supply is filtered on the module board. Together these filters ensure that the reference used for A/D conversions is stable and free of interference.

The TXD and RXD signals on K2 are compatible with TTL levels and are not inverted. If proper RS-232 levels are required, an external interface device (such as a MAX232) must be used. The interface is designed for direct connection to an FTDI TTL-232R USB-to-serial converter.

There is a total of four pushbuttons on the test board (**Figure 7**). Switch SW1 is the reset button, allowing the microcontroller program to be restarted at any time. SW2, SW3 and SW4 are general-purpose buttons connected to K12. They can be connected to the microcontroller's I/O ports so that their state can be determined by a suitably-written program.

The test board also provides outputs, a ULN2003 power output driver giving seven high-current outputs on K11. Each open-collector output can sink up to 500 mA, and so is capable of driv-

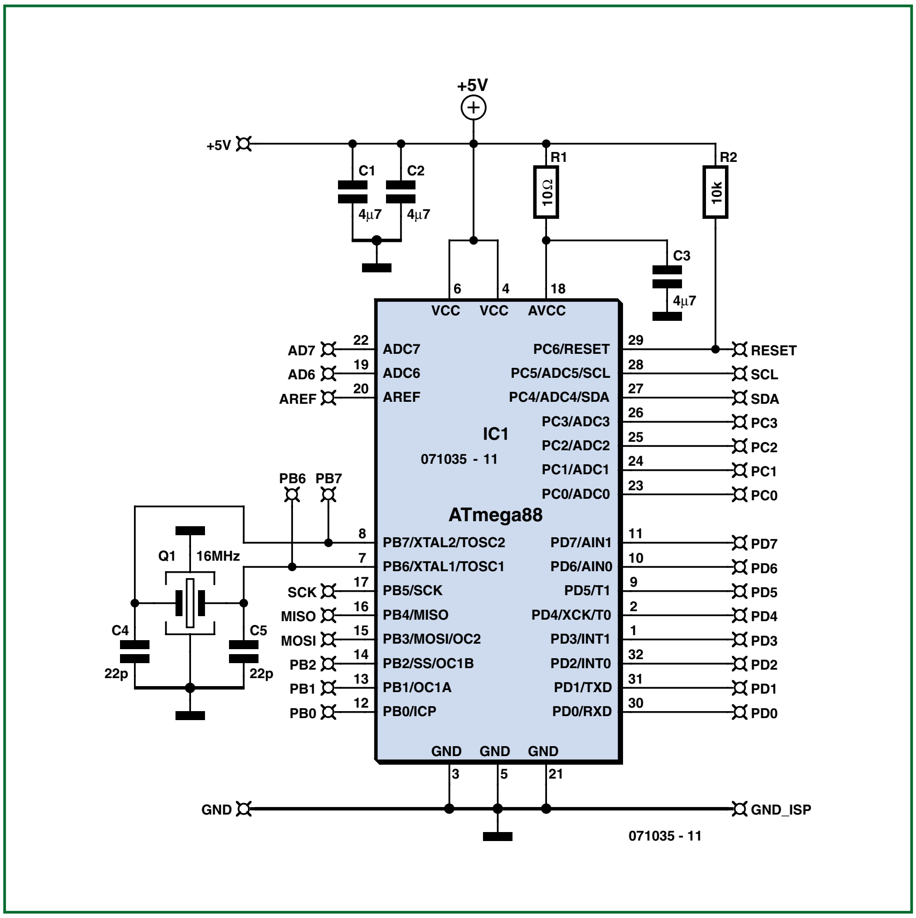


Figure 4. Circuit diagram of the ATM18 microcontroller module.

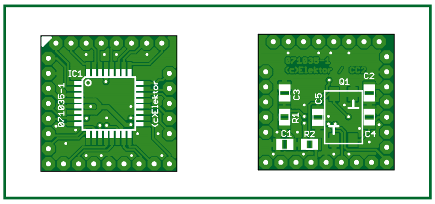


Figure 5. Printed circuit board for the ATM18 microcontroller module.

COMPONENTS LIST

ATM18 controller module

Resistors (SMD 805)
R1 = 10Ω
R2 = 10kΩ

Capacitors (SMD 805)
C1,C2,C3 = 4µF7 6.3 V (Farnell # 922-7857)
C4,C5 = 22pF

Semiconductors
IC1 = ATmega88 (TQFP32 case), Atmel)

Miscellaneous
Q1 = 16MHz quartz crystal, SMD (7mm x 5mm)
3x 8-way pinheader, 2mm lead pitch
1x 5-way pinheader, 2mm lead pitch
PCB, ref. 071035-1 (track layouts free download from www.elektor.com)
PCB, ready populated with SMDs, tested, including pinheaders, Elektor-Shop # **071035-91**

ing motors and relays directly. Seven LEDs (with current-limiting resistors) are provided to show the states of the output signals. The inputs to the power driver IC are available on K10, allowing them to be connected to any desired port on the microcontroller as required by the user or programmer.

One of the most important interfaces on the board is ISP connector K7, used for connection to a programmer. The pinout is compatible with the six-pin ISP connector on the STK500 as well as Atmel's ISP mkII. A less expensive option is the *Elektor* USB AVR programmer, compatible with the ISP mkII. This design will appear in next month's issue, but the unit is already available in conjunction with the ATM18 test board. The USB AVR programmer is based on the popular general-purpose USBprog programmer published in the October 2007 issue of *Elektor*. Another alternative is to make a simple PonyProg compatible connection directly to the connector on the processor module board.

The power supply and interface options are summarised in the accompanying text boxes.

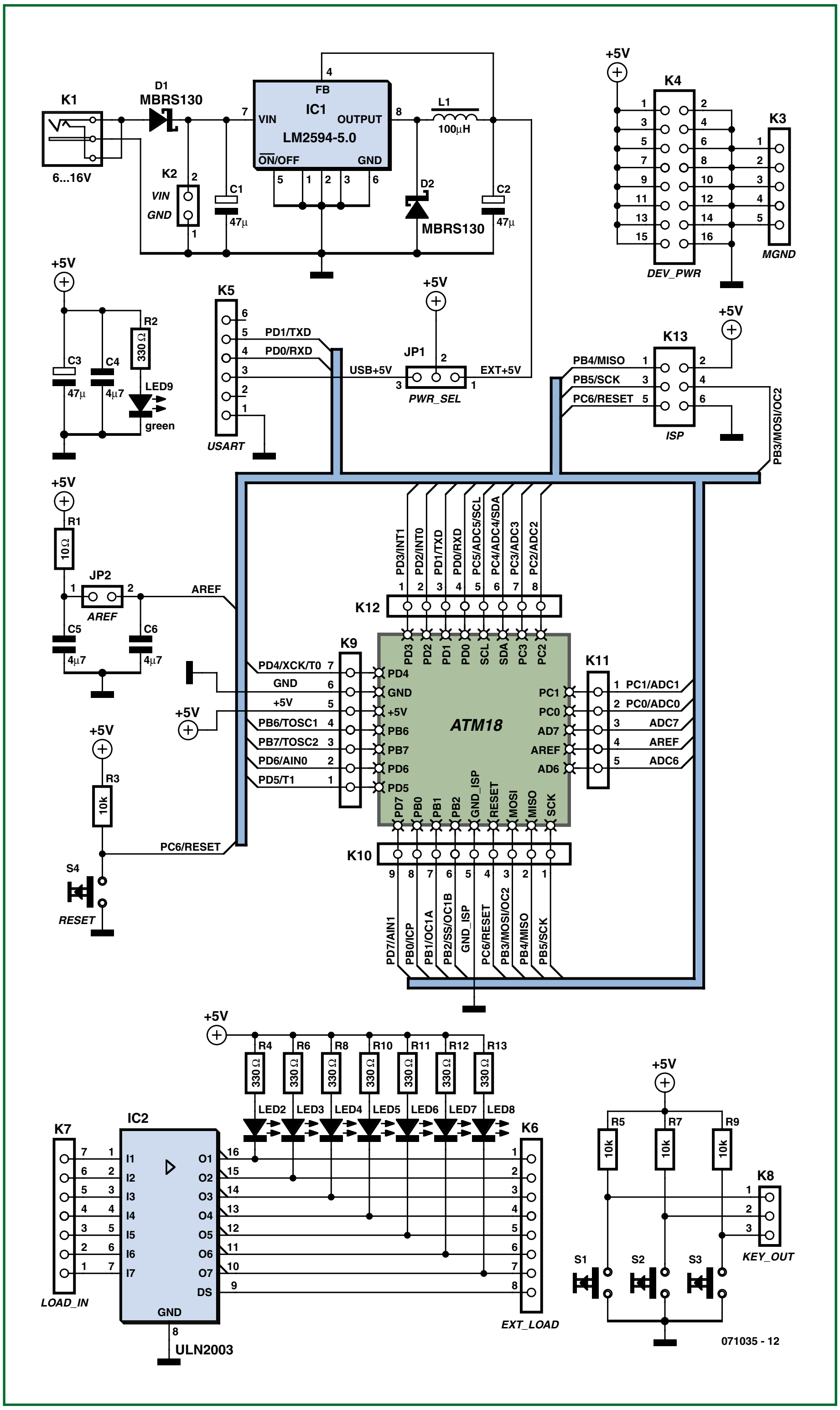


Figure 6. Circuit diagram of the ATM18 test board.

Rapid prototype

The ATM18 test board is fitted with a large number of 2.54 mm pitch connectors. These can be connected without the need for a soldering iron: any desired configuration can be realised quickly and simply using lengths of insulated wire with stripped ends. Wire with a gauge of 0.8 mm is ideal: with a few 8 cm lengths of such wire to hand the necessary connections can be made and changed as needed for any desired application or experiment (**Figure 8**). If connections to external modules or devices are needed, a pin header can be used along with a suitable length of ribbon cable.

Software

Udo Jürss [2], the designer of the ATM18 system, is a professional engineer and normally uses professional software tools. For the applications we will be looking at, the IAR C compiler fits the bill: it provides a powerful development environment offering almost every conceivable feature. As is so often the case with such powerful tools, it is not always easy to use at first, and there is a degree of 'running in' as the programmer learns how to use the compiler to the desired effect. Time- or memory-limited demonstration versions of the compiler are available from the IAR website download area [3]. The latter version is adequate for many applications. The 'Kickstart Edition' of IAR Embedded Workbench for the Atmel microcontroller is not time limited, but can only generate code up to a maximum of 4 kbytes. A number of questions must be answered on the website before the software download can begin. We have arranged for a project file to be available for readers to download from the *Elektor* website: this greatly simplifies configuring the IAR compiler. All programs that feature in this series are also available for download as hex object files.

Power supply

Overview of the ATM18 test board

- External supply from 7 V to 16 V DC (K1).
- Reverse polarity protection (D1).
- Select between external and USB power (PWR_SEL, JP6).
- Selectable A/D converter (AREF, JP2).
- Low-loss 5 V switching voltage regulator (IC1).
- Eight connections for powering external modules (DEV_PWR, K8).
- Auxiliary connection point for external power (VIN, JP1).
- LED power indicator (LED1).
- Additional ground reference (MGND, K9).
- Current consumption: 9 mA at 12 V without ATM18 module, 27 mA with ATM18 module.

Users who prefer not to use C and a sophisticated development environment can work with assembler or BASCOM. BASCOM-AVR is a very efficient high-level language for the AVR microcontroller, broadly comparable to QBasic. Programs are very clear and straightforward to write as complex commands save the programmer a great deal of work. The demonstration version of BASCOM can be downloaded for free from the Internet [4]; again, there is a 4 kByte code size limit, but there are no functional limitations and the system is perfectly adequate for our applications. BASCOM-AVR runs under Windows 95, 98, NT and XP and, with minor restrictions, under the Wine emulator on Linux platforms.

LED running light in BASCOM

Our first programming example with BASCOM-AVR is the now classic first test of a new microcontroller system, a LED running light. Note that the program (**Listing 1**) must specify the file m88def.dat; alternatively, the microcontroller type can be specified in the options. The crystal frequency (16 MHz) is given here in units of Hz; the value is needed so that the delays in the program have the correct timing. We have chosen to drive the LEDs from port C, which is therefore configured as an output. Finally a byte variable 'Leds' is declared, initialised to the value 1 (corresponding to just the first LED being lit).

In the infinite loop (from 'Do' to 'Loop') this single set bit is shifted left one place at a time: this corresponds to a repeated multiplication of the variable by two: 1 becomes 2, 2 becomes 4 and so on. In this way the program drives

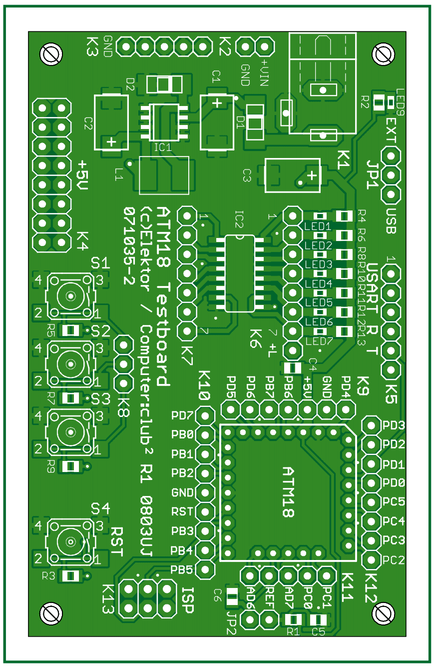


Figure 7. Printed circuit board for the ATM18 test board.

COMPONENTS LIST

ATM18 test board

Resistors (SMD 805)

R1 = 10Ω
R2,R4,R6,R8,R10-R13 = 330Ω
R3,R5,R7,R9 = 10kΩ

Capacitors

C1,C2,C3 = 47µF 16V (SMD7343-43, Farnell # 498-762)
C4,C5,C6 = 4µF7 6.3 V (SMD 805, Farnell # 922-7857)

Inductors

L1 = 100µH (SMD2220, Epcos # B82442A1104K)

Semiconductors

D1,D2 = MBRS130 (BYS10), DO214-AC (Farnell # 995587)
LED1 = SMD0603-LED, green (Farnell # 852-9833)
LED2-LED8 = SMD0603 LED, red (Farnell # 852-9868)
IC1 = LM2594-5.0, SO8 (National Semiconductor)
IC2 = ULN2003AD, SO16

Miscellaneous

K1 = mains adapter socket, PCB mount, Lumberg NEB21R (Farnell # 1217037)
K2 = SIL pinheader, 6-way, angled pins
K3 = SIL socket pinstrip, 7-way
K4 = SIL socket pinstrip, 8-way
K5 = SIL socket pinstrip, 9-way
K6 = SIL socket pinstrip, 5-way
K7 = double-row pinheader, 6-way,
K8 = double -row pinheader, 16-way
K9 = SIL pinheader, 5-way
K10 = SIL socket pinstrip, 7-way
K11 = SIL pinheader, 7-way
K12 = socket pinstrip, 3-way
JP1, JP2 = pinheader, 2-way
JP6 = pinheader, 3-way
SW1-SW4 = pushbutton, SPNO-B3S series, Omron (Farnell # 118-1016)
PCB, ref. 071035-2, track layouts free download from www.elektor.com
SMD-populated board and all parts, # **071035-92** from the Elektor Shop

Interfaces

Overview of ATM18 test board:

- ISP programming adaptor (ISP, K7).
- USART for FTDI USB-serial converter or TTL-level serial interface (USART, K2).
- Three uncommitted pushbuttons that can be connected as required (SW1, SW2, SW3, K12).
- Seven LEDs that can be connected as required (LED2 to LED8, K10).
- Seven power outputs (maximum 500 mA) that can be connected as required (K11).
- Reset button (SW1).
- Socket for ATM18 microcontroller module (K3, K4, K5, K6).

the outputs high one after the other. After each change there is a delay of 100 ms.

To test the program we first have to connect port C (six pins) to the inputs of the ULN2003 LED driver (seven pins). The lower six bits, PC0 to PC5, are used, and the seventh input to the ULN2003 is left unconnected. If desired, a bit from another port could be used, or port D, which has eight pins, could be used instead of port C.

Next we must flash the code into the microcontroller. For this we need a suitable programmer such as the STK500 [5] or the *Elektor* USB AVR programmer mentioned above. If you wish (and provided your PC has a parallel port) you can also use a simple parallel port programmer described in a free bonus article available from the *Elektor* website. An AVR ISP programming adaptor for the PC serial port was described in the 'Mini ATMega Board' article in the May 2006 issue of *Elektor*.

Programming is carried out using the AVR tools, within which the programmer itself is called up. It is essential to select the correct device (ATmega88) and to specify the generated hex object file (LED1.hex): see **Figure 9**.

The device must be programmed not only with the desired code, but also with the desired fuse settings. Particularly important is the configuration to allow use of the crystal as clock source: as delivered by the manufacturer the device is configured to use its internal oscillator with a divide-by-8 prescaler. **Figure 10** shows the correct fuse settings (again using the STK500).

If the programming procedure has been carried out correctly, the result is exactly what one would expect from a quick glance at the Basic program: the LEDs light in turn from right to left at the rate of one step every 100 ms.

A further example BASCOM program is available for free from the project page on the *Elektor* website, as is the C project for the reaction time tester mentioned at the start of this article, which requires the IAR compiler.

(071035-1)

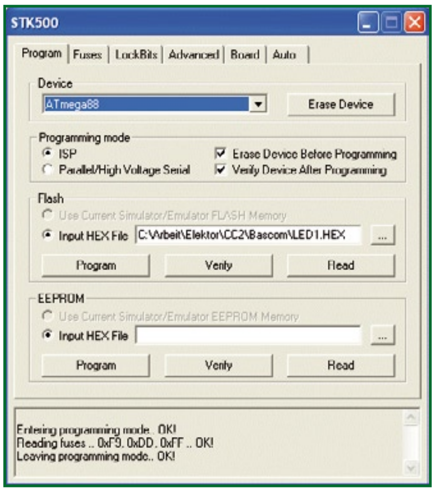


Figure 9. Programming the flash memory.

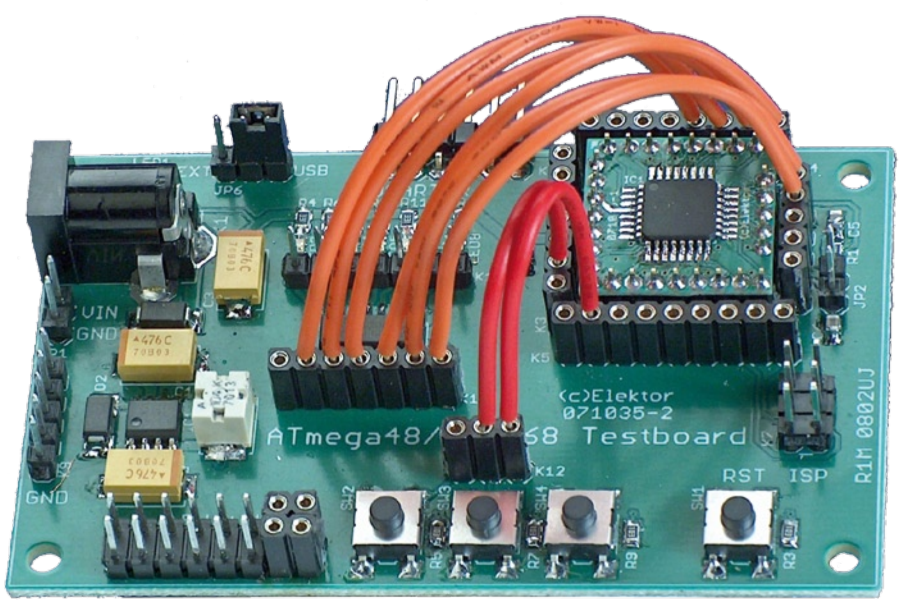


Figure 8. Test board wired up ready for an experiment.

Web Links

[1] http://www.ftdichip.com/Products/EvaluationKits/USB-Serial.htm

[2] http://www.microdrones.de

[3] http://www.iar.com

[4] http://www.mcselec.com/elektor.htm

[5] http://www.atmel.com

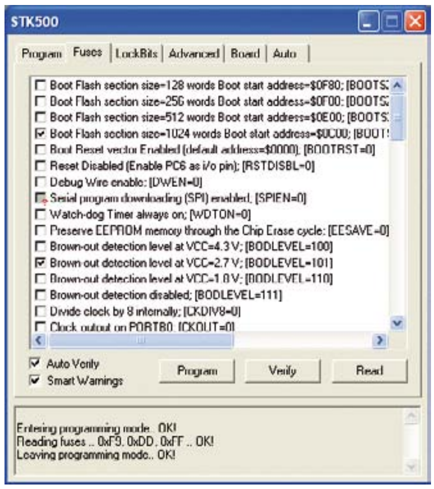
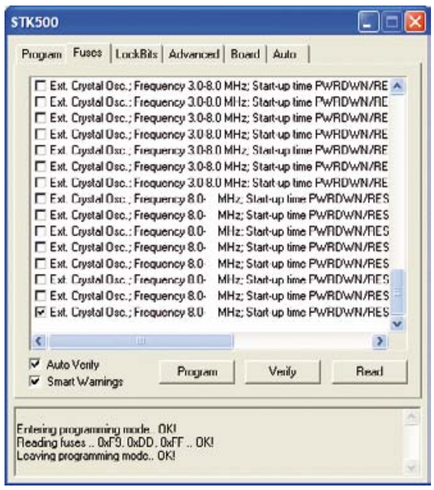


Figure 10. Configuring the AVR fuses.



Listing 1

Running light (LED1.hex)

```
'7 LEDs on PortD

$regfile = "m88def.dat"
$crystal = 16000000
Config Portd = Output
Dim Leds As Byte
Leds = 1

Do
  Leds = Leds * 2
  If Leds > 64 Then Leds = 1
  Portd = Leds
  Waitms 100
Loop
```

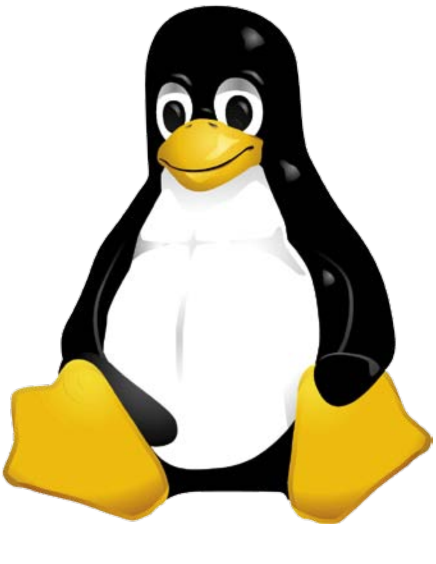
Free, Open, Lice

...the liberties of Open Innovation

Antoine Authier

The boom in the Internet and rapid evolution of communication techniques and tools have made diffusion of knowledge and projects possible on a massive scale, and allowed work and discussion communities to be created on a global level. New ways of publishing and distributing artistic or technical creations, and contributing to collective projects or works have appeared. When these activities take place within a framework of openness and exchange, we talk about Open Innovation.

This is the case with projects like GNU, Linux, Mozilla, Apache, The GIMP, MySQL, Amarok, OpenOffice, YAMPP, or more recently OpenMoko – all referred to as Open Source software or electronic designs.
Artists too are taking advantage of this wave and these collaborative tools. Take a look at the Wallpaper project started by Alex Ciccius and The Sambuki Social Crew: 100 artists are creating a 100' (approximately 32 m) long banner that can be viewed on *www.thespacejockeys.com/wallpaper*.



The vast quantity of information available on this subject on the Internet is not very user-friendly and is difficult to summarize. The intention of this article is to first give a few historical landmarks and describe open innovation. Then we'll take a look at a few examples of the different modes of distribution and their viabilities.

We will of course highlight the special character of electronic hardware and describe the development process.
There's no question here of patents or copyright laws, so unfortunately we won't have the opportunity to discuss the problematic local implementations of EUCD (European Union Copyright Directive). Maybe some other time…

Open Source

The Open Source movement arose in the late seventies at Berkeley University in California, in a development project for an operating system compatible with Unix, called BSD (Berkeley Software Distribution). The publication of the source code, with no restrictions and for the purpose of sharing, allowed this project to develop in a collaborative manner. In the event of collaboration on major projects, many contributors may be involved without their necessarily having known each other at the outset. They work with the same aim in different locations around the globe, and they occasionally organize meetings to define the development plan.
A little later, in 1983, Richard Stallman created the Free Software Foundation to provide a framework for the development of GNU (famously explained as 'GNU is Not Unix'). Then he drew up the GPL (General Public Licence) in order to distribute the fruits of this labour, ensure its durability, and launch free software. The use of the ambiguous word 'free' has caused a lot of misunderstandings. **A piece of 'free' software isn't necessarily 'free of charge'**; it may be sold, though this is generally not the case.
The co-operative development of the Linux core, launched by a Finnish student, then its incorporation into GNU (whose operating system was slow in coming), laid the foundations for this form of open innovation. When it involves mainly software, we talk about open source.

There is no definitive definition of open source, nor does it correspond to a particular software licence either. The term 'open source' doesn't even have any inherent legal value in itself.
We should also dispel once and for all the confusion between 'free' software and 'open source' software often perpetrated by the press.

ntious...

Principal licences

The information published in this inset has no legal value. The sheer amount of information in the licence documents is such that we have to content ourselves with merely extracting a few relevant passages just to give a taste of the subject. We have concentrated on the principal licences used for distributing source code or electronics projects. Readers interested in one particular licence or another will need to look up the corresponding complete document. You will find the texts of these various licences in their many revisions on the Internet via the links available at http://www.elektor.com/UK_open-innovation or directly from the FSF website.

● BSD licence (Berkeley Software Distribution) allows the document it protects to be re-used, in whole or in part and without restriction, in a public or proprietary work.

Unlike the public domain, it does however present a few constraints to be respected when redistributing the document.

It also protects the names of the authors in derivative publications, and releases them from any problems that might arise out of the use of the work.

It is one of the least restrictive.

● GNU GPL licence (GNU General Public License) is certainly the most stringent. It makes the publication of modifications obligatory to the distribution of the software. It is based on the Copyleft principle, which relinquishes reproduction rights to the community (as distinct from Copyright).

However, a document published under GPL belongs in a very real sense to its author, who will decide the appropriate licence for the distribution of later versions of the document, thereby enabling them to change licences.

It has a viral character, as it contaminates (closed) projects in which it is used.

A project published under GPL must be GPL as a whole.

This is certainly the oldest and most popular licence for free software.

● GNU LGPL licence (GNU Lesser General Public License), a toned-down version of the previous one, allows association of code under a GNU GPL licence that is totally free with a resource that is not. In this way, it allows a piece of proprietary software to be written including free resources. It applies principally to software libraries. It's only really of very limited interest.

● MPL licence (Mozilla Public License) allows combining both proprietary source code (normally unpublished) with free source code within a single project. It then guarantees the openness of the code specified as free. By virtue of its non-viral character, it is regarded by many as freer than the GPL licence. It guarantees the authors that the open character of their work will be preserved, without constraining other contributors (current or future) to doing the same.

● Chronodegradable licences

The free distribution of the source code takes place in a delayed fashion after marketing of the software – in principle when a new commercial version is published. This is the case with ID Software, famous for the success of 'Doom', its first 3D game, whose source code it decided to publish at the end of its software's lifetime, thereby benefiting from external contributions to the storyline.

● IBMPL licence (IBM Public Licence) – used by IBM for distributing certain of its source codes that are regarded as non-strategic – recognized by the OSI.

It differs from the GPL in the way it handles managing and distributing patents. It makes the software publisher and distributor responsible, rather than the contributors.

● SCSL licence (Sun Community Source Licence) is the licence originally used by SUN Microsystems for distributing its JAVA language.

It does not allow the opening up of the JAVA source code and so is not regarded as 'open'. However, it does allow, on the one hand, acquisition, use, and free redistribution of the JAVA virtual machine (without which it wouldn't be possible to interpret the code you write), and on the other hand, distribution of free libraries, software, and tools written in JAVA. Since 2005 SUN has introduced new licences in order to increase its openness, though still without publishing its sources.

● Shared Source licence, set up by Microsoft in response to pressure from the free software world, constitutes several licence contracts and is reserved for Microsoft's largest commercial partners and certain influential institutions (universities, Chinese government, etc.) It mainly lets them consult the source code and allows debugging. Very few have the right to modify.

● Creative Commons licence is flexible and customizable. It offers four distribution options: paternity, no commercial use, no modification, share-alike of the original conditions, which can be combined to create a specific distribution licence.

A refreshing, novel concept that is really starting to take off.

The OSI (open source initiative) open source movement was created in 1998 to respond to the economic and technical realities and defend the freedom of access to software source codes. In a few points, it defined the conditions for a piece of software to be described as open source; what's more, it has become the official certification body for open source and its diverse publication licences.

Advantages and disadvantages

In his document entitled 'The Open Source Dynamic', Robert Visseur lists the advantages and disadvantages of open source. We thought it worthwhile to sum these up here.

● Quality: the stability and performance of open source software like Linux or FreeBSD.
● Reactivity: e.g. updates to software

like Apache or Linux appear very quickly.

- Durability: e.g. loyal users have reprogrammed old operating systems like MS-DOS or CP/M.
- Cost.
- Freedom: independence from the developers
- Competition: impossible for a monopoly to take place, by virtue of the source code and communication standards. Stimulates competition between companies, as well as between nations!

With open source code, the software can breathe freely and benefits from the support of the entire community. This goes hand-in-hand with the writing and development of real, open, reliable standards where everyone can cast a critical eye.

- Protection of intellectual property: the principal complaint of open source's adversaries is that secrecy and fierce competition are vital to sustain innovation. To which open source partisans argue that the mixing of ideas and mutual and cross-fertilization favour innovation much more than the fact of appropriation.
- Finish: interfaces have a reputation for being rustic
- Risk of divergence: e.g. BSD gradually split into three projects: FreeBSD (the most widespread and the most user-friendly, favouring performance), OpenBSD (favouring security) and the original branch, NetBSD (which favours adaptation to hardware).
- Brand image: Linux is often poorly-regarded by the hierarchy for professional use.
- Support: Documentation is sometimes lacking. The Wiki script, which came out in the mid-90s and has been made popular recently by the free encyclopædia Wikipedia, is attempting to make up for some of these shortcomings. It offers readers the opportunity to contribute to documentation on line.

English is obligatory, despite some laudable translation efforts.

Contributing to a project

Nothing could be simpler than contributing to an open source project. Contact its author by e-mail or IM, express yourself in the project forum, give your opinion, add a page of documentation or advice to the Wiki.

You can contribute on several levels, from simple encouragement to a small donation. Your general remarks on features or the interface will be appreciated, a bug report, comment, or the review of the source code will be welcomed. And if you have a literary bent, don't hesitate to participate in the project documentation. If you want to program, prove yourself by sending patches (corrections, improvements) and it won't be long before you obtain write access to the version manager (CVS, sub version, and so on).

Launching a project

Launching a project is hardly any more complicated. You have an idea, you think it may be useful to a community, you want to share it. If you aren't a natural webmaster, open an account at www.sourceforge.net and publish your project, distribute your sources and your work. If you want to keep control of it and host your project website yourself, while benefiting from certain collaborative development tools, create

your community space with the help of gforce. If not, then a simple website will do…

Distributing a project

How can the author of free software earn a living, or at least some money from it? Prior to distributing the fruits of your labours on the Internet or simply opening it up to the world, and in order to be able to do so, it's important to define the legal framework for it that will allow you to be recognized, to protect yourself against possible abusive use, and to share it or not.

Distributing code, circuits, drawings, photos, art, etc. freely and free of charge, while still retaining paternity, can be done by means of a licence (for example, Creative Commons). The **inset** should help you choose a licence appropriate to your needs, from the fairly stringent open source (free software) licence to the shared source one, via various intermediate nuances.

If your aim is to make money, you'll need to conform, to a greater or lesser extent, to the economic models, strategy, and marketing that are usual practice in our societies. The OSI is working towards an economy for software with no user licences but based on the sale of services, hardware, and the support needed for rapid deployment. Several thousands of engineers in Europe are employed by way of this economic model.

Open Hardware

The concept of open source hardware, or 'open hardware', is not all that different. However, it is much easier to copy a piece of software than to reproduce hardware, which requires more advanced skills and knowledge.

Although the open source concept is still quite fuzzy, it is however clearly defined by its licences. The concept of open source hardware, on the other hand, still does not have a definition that is recognized around the world, nor totally accepted.

In an article published in 'Linux Today' in 1999, Richard Stallman, founder of the FSF (Free Software Foundation) and author of the GPL (General Public Licence), stated that the GPL licence was not suitable for electronic circuits, as they are difficult to modify or copy. Most of the people involved consider that the same applies to embedded software (firmware), generally stored in Flash memory, but in any event not at all comparable with the volatility of software in a computer's RAM, at best stored on hard disk.

Users of open source hardware must be able to modify the hardware and distribute it freely. This necessitates making available all the circuits, along with the source code of the components, in particular the HDL (Hardware Description Language) sources of the hardware and the firmware (most often written in C and assembler).

In an Elektor interview with Harald Kipp in Elektor March 2008, the father of the Ethernut said, rather tongue-in-cheek, that “for many people, open source is like communism, in the sense that everyone can take from the community without paying anything.” Kipp added that certain developers also regard open source as like communism, but because they perceive the hierarchy as a dictatorship!

Indeed, we might be tempted to imagine that anarchy reigns in open source, but that’s far from being the case. The organization of open source projects is built on a solid framework, indeed highly hierarchical, most of the time with the owner of the project as incontestable master at the top of the structure.

If he doesn’t like a contribution, he can withdraw it without asking anyone’s opinion. If it’s a developer he doesn’t like, he can send them packing without any other form of trial, and refuse any contribution from them.

For small-scale projects, it’s also the owner who decides when and which version will be published.

Source codes are (in general) freely redistributable, i.e. anybody can proclaim themselves a distributor of free software (as long as the licence conditions are obeyed). If part of the community, or an isolated (and frustrated) developer, thinks they can do better, they are free to take up the source code and branch off into a new project. This branching process is called ‘fork’ (from the name of the instruction in the POSIX standard for duplicating a process in C).

Openness of minds

It’s important for a company to gather malfunction (bug) reports from its users. It may go even further and deploy a public forum where all users can express themselves, criticize any deficiencies in the architecture, or sing its praises. This initiative can turn out to be an uncomfortable one. Allowing anyone to freely study the quality of the source code and the hardware design in order to discuss it openly takes a degree of courage, a lot of getting used to, perseverance, and even a thick skin, such is the extent to which the criticism may turn out to be caustic.

The more judicious criticisms are vital to enable projects to evolve efficiently. Without the pressure of a critical external viewpoint, most design defects will survive the various states, will become entrenched, and before long an initially elegant concept can turn into a huge, labyrinthine system like MS W****.

Throughout the project, whether in soft- and/or hardware, you must be careful to stay legal and avoid infringing – intentionally or not – this or that patent. Difficult as such infringements are to detect in a ‘closed’ project, they will come to light all the quicker in an open project because the size and diversity of the community. So you’ll need to take appropriate measures to ensure the validity of the copyright for each of the various contributions – no small task!
The community spirit of open projects occasionally forces developers to spot such infringements and to take immediate action.

At the present time, most open hardware and firmware projects are distributed under a BSD licence – less restrictive than the GPL licence – which allows, in particular, distribution of improved firmware without distribution of the corresponding source code. In this way, companies retain control over the publication of certain improvements, while keeping others secret, to protect the added value of the product.

Commercial contribution

So where is the interest for a company in contributing to an open source project, when this is not constrained by a licence? Why would it run the risk of one of its competitors possibly profiting from its work? Doubtless to benefit from the improvements of other contributors, but also because it judges that before its competitors catch up, the benefits of openness will have enabled it to establish a convincing lead, thanks to better products, better services, and quality that it knows is superior – even if all the competitors are using the same software.

Certain companies will also make ‘late contributions’, initially keeping their improvements secret and only publishing them once their product is well launched (see an example of a chrono-degradable licence in the **inset**).

We would like to thank Harald Kipp for the interview he granted us.
To discover this fascinating world in greater depth, come and have a browse at the following address:

www.elektor.com/UK_open-innovation

To your keyboards – happy surfing, and happy development!

 We are keen to open up the source code of our publications, and do so whenever possible. Certain of our authors are still reluctant and unfortunately won’t give us their permission. It’s often a hard choice for Elektor between refusing a very interesting but closed publication, and publishing it anyhow, to allow as many people as possible to benefit from it – but without the pleasure of sharing the source. In the long term, openness pays.

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Web links

www.elektor.com/UK_open-innovation

www.fsf.org

www.fsf.org/campaigns

www.opensource.org

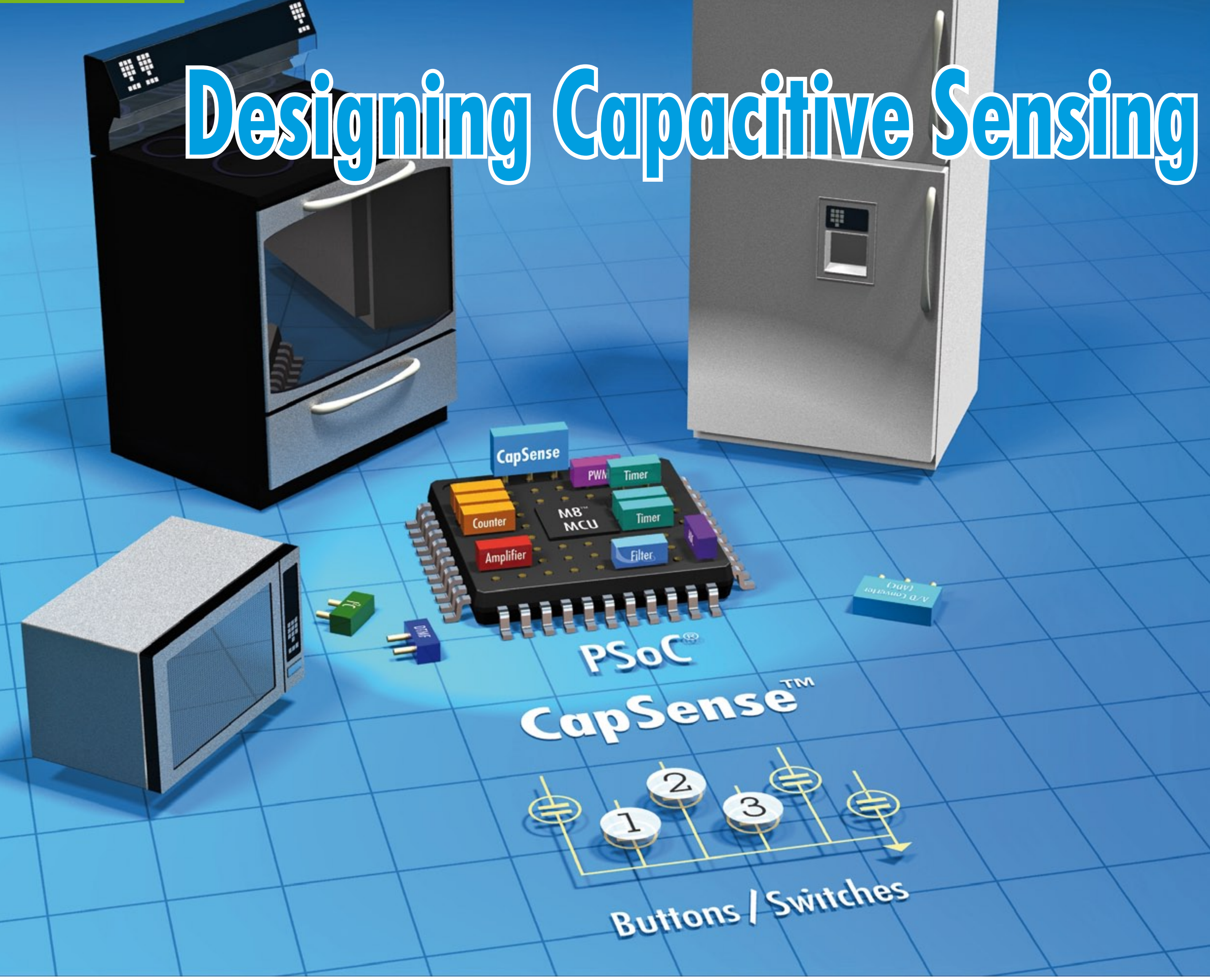
http://opencollector.org/Whyfree/

http://opencollector.org/Whyfree/vilbrandt.html

www.presence-pc.com/tests/Le-Hardware-Open-Source-112

http://features.linuxtoday.com/news_story.php3?ltsn=1999-06-22-005-05-NW-LF

Designing Capacitive Sensing



Ryan Seguine (Cypress Semiconductor Corp.)

With all the excitement about capacitive sensing in the portable media player, laptop PC and mobile handset markets, it is easy to forget that such interface technologies have been actively designed into White Goods applications for years. Significant improvements in sensing algorithms and control circuitry have expanded the suite of applications in which the technology can be implemented.

Designers are seeing the value of capacitive sensing as a mechanical button and membrane switch replacement as well as discovering new, exciting applications such as touchscreens and proximity sensors.

A capacitive sensor is constructed of a conductive pad, the surrounding ground, and its connection to a controller. In most applications, the conductive pad is a large copper footprint and the surrounding ground is a poured fill. As illustrated in **Figure 1**, a native (parasitic) capacitance, C_P, exists between these two objects. When a third conductive object, such as a human finger, is brought into proximity with the sensor, the capacitance of the system is increased by the capacitance of that object, C_F.

Methods to use

There are several methods for detecting the increase in capacitance caused by the addition of C_F.

Field-effect measurement uses an AC voltage divider between a sensor capacitor and a local reference capacitor. Finger detection is achieved by monitoring the change

Interfaces for Home Appliances
The end of the switch as we know it?

in voltage on this divider. Field-effect sensing is a highly-sensitive technique and robust with regard to environmental conditions, however it is implemented with a single ASIC per sensor and does not provide analogue functions.

Charge transfer uses a switched capacitor circuit and a reference bus capacitance with repeated charge transfer steps from the smaller sensor capacitor to the larger bus capacitor. The voltage on the bus capacitor is proportional to the sensor capacitance. The capacitance can be determined by measuring the voltage after a fixed number of steps or by counting the number of steps necessary to reach a threshold voltage. Charge transfer is a low impedance sensing method giving it good noise immunity and is capable or supporting analogue features in capacitive sensors. The direct connection to V_{DD} requires a high-quality, dedicated voltage regulator for the sensor controller.

A **relaxation oscillator** is a charge time measurement where the charging ramp is determined by the current source (usually fixed) and the sensor capacitance value. Larger sensor capacitors yield longer ramp times, usually measured with a PWM and a timer. The relaxation oscillator is highly flexible and can be implemented in many standard microcontrollers, however the high-impedance inputs can make it susceptible to noise sources without firmware or hardware modifications to filter out such interference.

Successive Approximation

The Successive Approximation method (patents applied for by Cypress Semiconductor) implemented with the PSoC device uses a capacitance to voltage converter and single-slope ADC. The capacitance measurement is achieved by converting the capacitance to a voltage, storing this voltage on a capacitor, and then by measuring the stored voltage using an adjustable current source. The low-impedance technique has high immunity to interference and greater sensitivity and analogue characteristics. The current source and the connection scheme allow for more tolerance in voltage regulator quality.
The capacitance-to-voltage converter shown in **Figure 2** is implemented with switched capacitor technology. The circuitry brings the sensor capacitor to a voltage relative to the capacitance of the sensor. The switched capacitor is clocked by the PSoC's internal main oscillator.
The sensor capacitor is connected to the analogue MUX bus and is charged via a programmable current output digital-to-analogue converter (iDAC) also connected to the bus. The charge on each bus is given by $q = CV$. Switch SW2 is opened and SW1 closed to bring the potential across C_X to zero and reducing the charge on the bus by a value proportional to capacitance of the sensor capacitor. This charge-discharge process is repeated so that the sensor capacitor is a current load on the bus.
With the switched capacitor circuit running, the iDAC uses a binary search to determine the value at which the voltage on the bus remains constant. This voltage is a factor of the switching frequency, the sensor capacitance and the iDAC value (current). The bus also functions as a bypass capacitor, stabilizing the resulting voltage. Additional capacitors can be added to the bus and affect performance and timing of the circuit.

The following equations apply:

$$V_x = [1 / (f_{osc} \times C_x)] \times I_{DAC}$$

$$V_{BUS} = V_{REF} - V_x$$

The calculated iDAC value is then used to charge the bus again and the time required to take the bus from an initial voltage to the comparator threshold is measured. The initial voltage with no finger present and therefore the charge time is known. A finger on the sensor increases the value of C_X, decreasing the initial voltage and increasing the charge time measurement — see **Figure 3**.

Building a Sensor: the options

Capacitive sensors have diverse forms and functions and they can use a variety of media. Their implementation ranges from simple to complex. Also, application requirements determine sensor construction and implementation details.

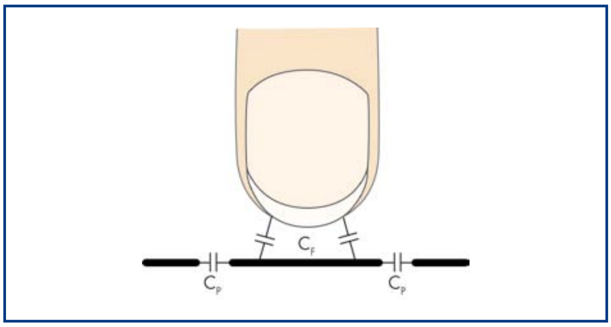


Figure 1.
Graphical representation of the elementary capacitances involved.

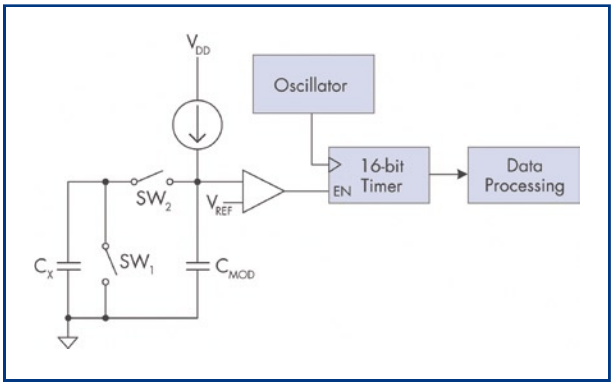


Figure 2.
Basic circuitry to implement capacitive sensing based on successive approximation.

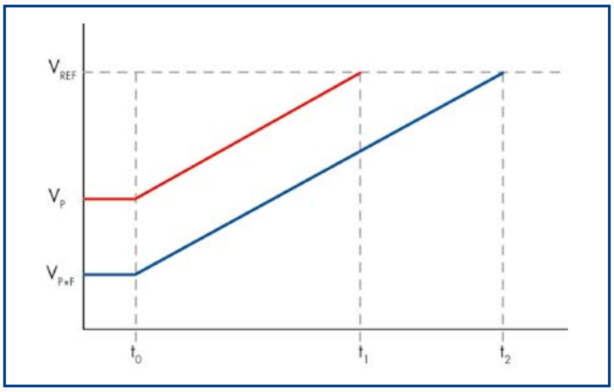


Figure 3.
Charge time measurement.

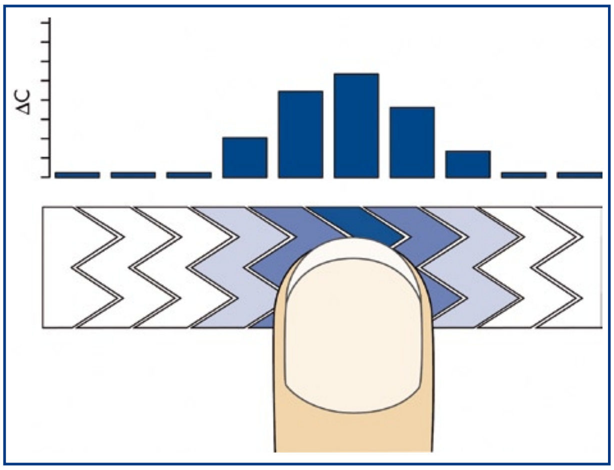


Figure 4.
A slider control employing capacitive sensing.

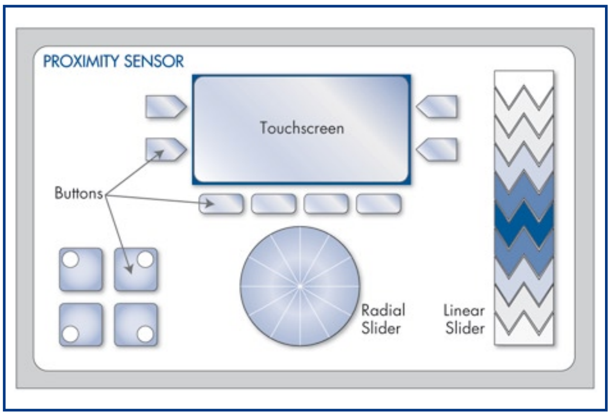


Figure 5.
Capacitive and other sensors in various forms can be used to implement lots of user controls on electronic equipment.

Buttons and sliders are most common. Buttons are large conductive pads connected to the controller. Capacitance is measured and compared against a series of thresholds. Decisions can be made as digital outputs or with more analogue characteristics for activation pressure or finger size. Sliders are linear or radial arrays of conductive pads. Centre-of-mass algorithms determine the position of activation to a resolution far greater than the number of pins used to sense. Most often, simple capacitive sensors like buttons and sliders are deposited onto a printed circuit board using copper (**Figure 4**). Other substrates and deposition media such as silver ink can be used, however.

Dynamic user interfaces use buttons or activation regions that reconfigure in response to the display itself. These displays are moving the user experience forward by promoting more seamless and intuitive interaction. The construction of these systems is somewhat more complex that simple buttons or sliders. Projected capacitance touchscreens use transparent conductive materials over a display. The conductive surface is deposited onto a substrate such as glass or PET film and connected to the control circuitry. The substrate is then adhered to the overlay between the overlay and the display. The position of the activation is determined in the same way as a slider. Two sliders, one for each axis are intertwined to provide complete coverage of the display area. Activation is detected on both axes and the position exported as *x*- and *y*-data. Because a projected capacitance touchscreen is behind an overlay, it is protected from impact, flexion, and environmental factors that plague traditional resistive touchscreens.

Proximity sensors are essentially large buttons. The object of a proximity sensor is not to detect the exact position of a conductive object; rather the presence. Since the device does not need to know exact position, the response time may be slower (3-4 ms vs. 250 µs). The sensitivity of a proximity sensor is much greater; 30 cm can be achieved in a well constructed design. Since proximity sensors do not need to be associated with any display graphic, their placement on the device is more flexible. A copper ring around the outside of the control circuit board or a wire behind the overlay allow very basic, cost-effective construction of a proximity sensor.

Home appliances and white goods

Usage of capacitive sensors is expanding. The sensors described have created new opportunities for designers to work with such flexible, durable and elegant design elements. Buttons are still used for basic menu navigation and activation. However, analogue characteristics of buttons that are not expensive potentiometers allow easier and less expensive implementation of increased functionality and safety features.

LG's model LA-N131DR Air Cleaner (**Figure 6**) uses five capacitive sensors for front panel display menu navigation buttons. These buttons have allowed the designers to implement a seamless chassis design while still realizing the user interface. The capacitive buttons detect the presence of a human finger through four millimetres of glass. The control circuitry is located on the non-sensor side of a two-layer printed circuit board. LG uses the PSoC Mixed-Signal Array to control the sensors and output status to the main device processor.

Proximity sensors allow for reactive backlighting for night-time operation or for safety features requiring a larger activating element such as an adult hand or metal pot to engage the range-top controls. **Figure 5** shows how proximity sensors, buttons, sliders and even touchscreens can be controlled by a single processor using PSoC. Firmware routines allow changes in state based on user inputs or host commands.

Putting It All Together

The PSoC Mixed-Signal Array allows designers to implement buttons, sliders, touchpads, touchscreens, proximity sensors and any combination of all these in a single chip. The pre-defined firmware development modules, reference code and calibration tools make designing a capacitive sensing application fast, easy and effective.

Pre-defined firmware development tools include device interconnects, I/O drive modes and APIs. These are created with only a few clicks of the mouse in the PSoC Designer or PSoC Express development tools. Reference code provides a starting point with basic functionality, but the open-source

nature of the PSoC solution allows for customization and optimization for any project. Calibration tools accelerate development by providing real-time feedback for capacitive inputs. Adjust parameters, increase sensitivity, and calibrate sensors individually through the calibration tool.
PSoC devices are more than just capacitive sensors. Analogue and digital resources are available for a myriad of other applications [1]. Basic digital control is available on all PSoC devices. Drive LEDs, communicate through I²C, SPI and other media, and control a simple 8-bit PWM. Higher-function devices are capable of more digital functions as well as basic analogue. A single PSoC can be configured as a capacitive sensing and a temperature meter or a voltage meter.

Create your capacitive sensing application

The PSoC Mixed Signal Array is a configurable array of digital and analogue resources, flash memory and RAM, an 8-bit microcontroller, and several other features. These features allow PSoC to implement innovative capacitive sensing techniques in its CapSense portfolio. Use PSoC's intuitive development environment to configure and reconfigure the device to meet design specifications and specification changes. New sensing technologies exhibit improved sensitivity and noise immunity, reduced power consumption, and increased update rate.

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Web Links

[1] PSoC CapSense: www.cypress.com/capsense.

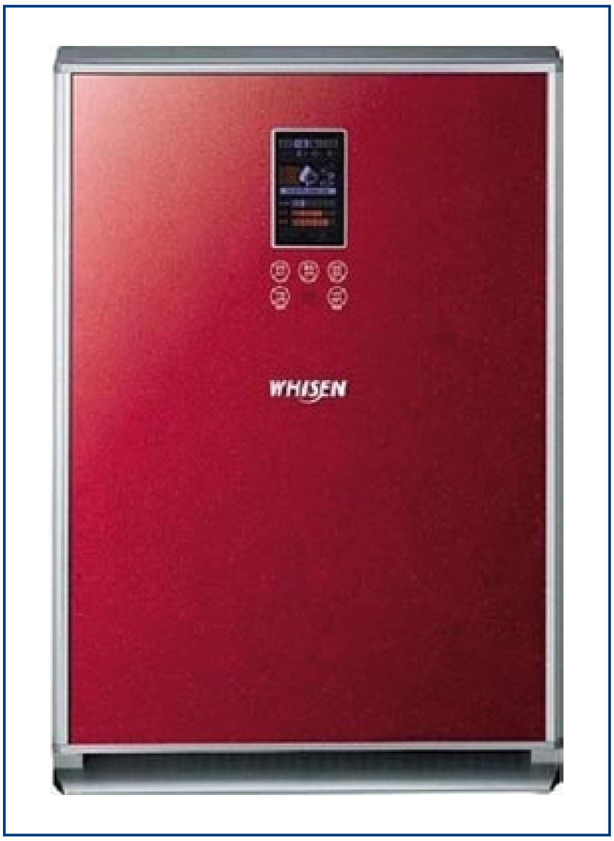


Figure 6.
Capsense is expected to become an established technology in home appliances and 'white goods' like this (conspicuously red) air cleaner from LG.

Frequency Response Sweep Oscillator

Jeremy Crook

50 Hz – 100 kHz range using the Parallax SX28 micro

This project found its origins in a need to see and measure the frequency response of audio filters, tone controls and amplifiers in real time. An SX28 microcontroller module from Parallax turned out to be a really good means of implementing the circuit.

The standard way of measuring frequency response is to use a frequency generator with an oscilloscope or (fast) AC voltmeter and then plot the results on logarithmic graph paper.

This is time consuming especially when dealing with voltage controlled filters which vary their frequency response with a control voltage.

The author developed this circuit as a means of displaying the frequency response of a circuit on a standard oscilloscope. The firmware for the microcontroller core of the test instrument is written in assembly language.

Pluses and specs

There are a number of benefits to using this design:

1. The oscillator has two frequency ranges:

- 100 Hz to 100 kHz. This allows for the

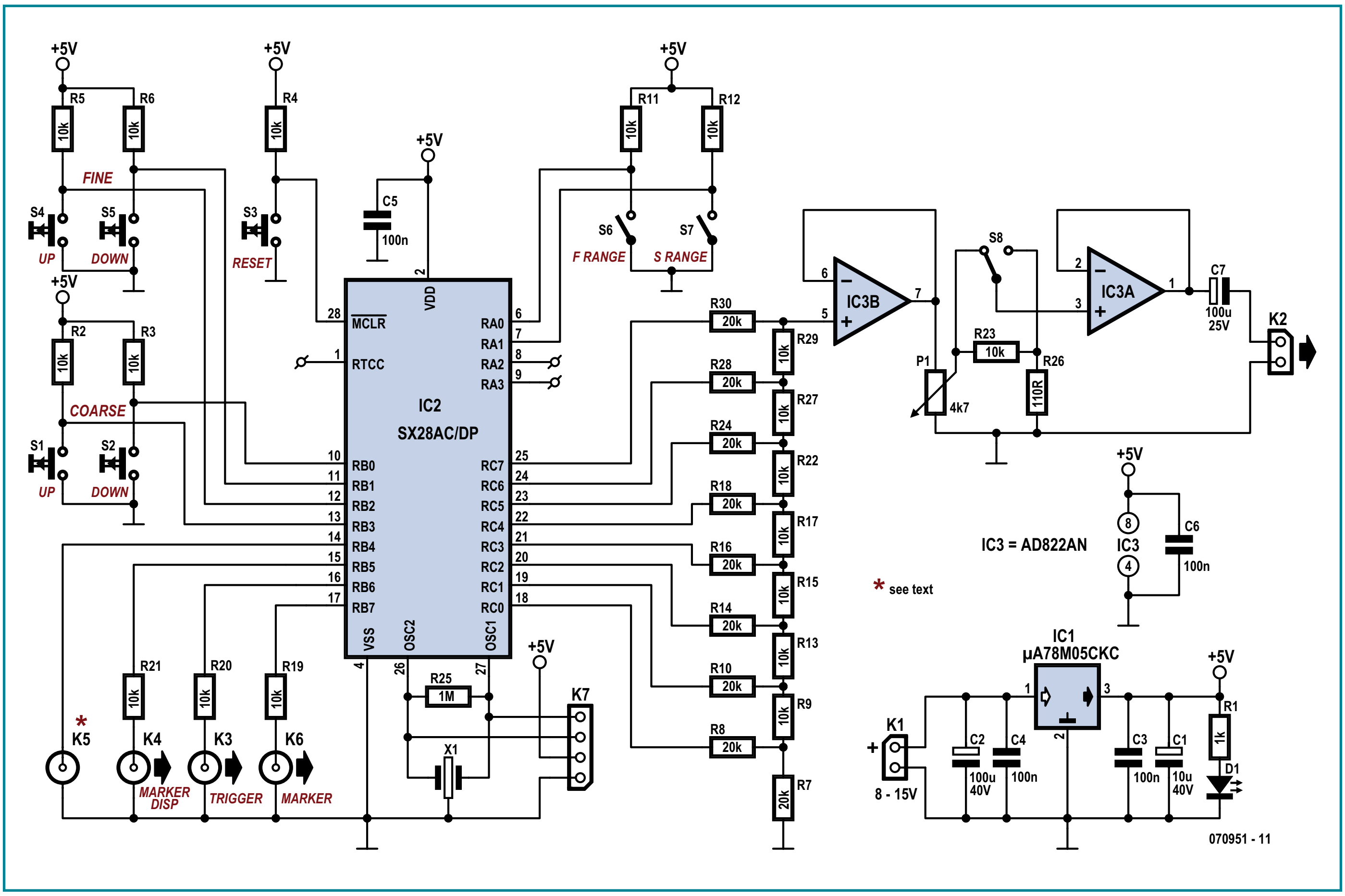


Figure 1. Circuit diagram of the sweep oscillator. The heart of the circuit is a Parallax SX28AC/DP microcontroller module.

testing of audio, ultrasonic and infrared communication circuits.

- 50 Hz to 15 kHz. Primarily for higher resolution audio testing.

2. As component values in the circuit under test are changed, the change in frequency response is instantly observable on an oscilloscope screen. This makes it easier to show the difference in frequency response between various types of filter such as low-pass, high pass, bandpass and notch filters. You can even see the difference between filters with Butterworth and Chebychev responses.

3. The display on the scope shows a true logarithmic response and as such volts per decade/octave measurement can be taken directly from the display.

4. There is a facility to show a frequency marker on a second channel of the oscilloscope. A frequency counter (a digital multimeter with a frequency range is adequate) connected to the Marker Frequency Output will then show the frequency at that point, the marker can be moved to any point on the display. This enables the easy measurement of the –3 dB roll off points and Q (quality factor) of any filter.

5. There is a facility for switching between two different frequency sweeps and altering the amplitude of the output signal.

6. The output of the circuit is buffered so that it will not affect the response of the circuit under test. This means that both passive and active (amplifying) circuits can be tested.

Circuit operation

The circuit is very straightforward, see the schematic in **Figure 1**. The microcontroller (IC2) generates the 8-bit values that are then sent to the *R*/2*R*-based ADC (analogue to digital converter) made from precision (1%) resistors R7 through R30. A dual precision operational amplifier type AD822AN (IC3) provides the buffering needed in the circuit. A pot (P1) and a changeover switch (S8) allow the output signal level of the sweep oscillator to be attenuated as required to match the sensitivity of the circuit under test if it's 'active'. The swept-frequency signal fed to the input of the filter or circuit under test is available on connector K2.

The SX28AC/DP micro is clocked at 50 MHz using ceramic oscillator X1. The oscillator pins of the micro also serve to program the device and that's done via K7, which also provides the necessary ground and +5 V connections.

The micro may be reset by pressing and releasing pushbutton S3.
The power supply is conventional, based on a 78M05 regulator (IC1) with its usual set of decoupling capacitors for noise suppression on the supply rails. The unstabilised DC input voltage may be between 8 V and about 15 V from a mains adaptor with 300 mA or so current capacity.
The microcontroller reads five pushbutton switches (S1 through S5) and

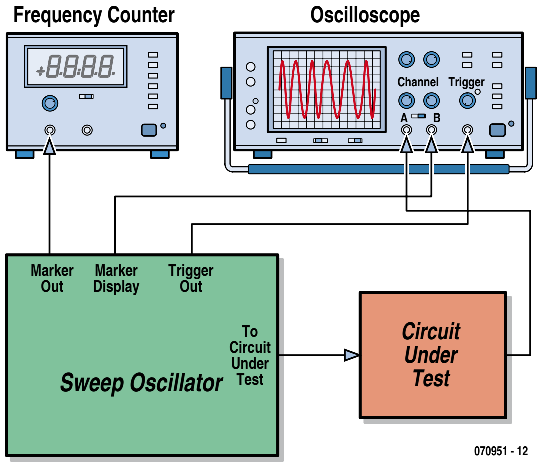


Figure 2. How to connect the sweep oscillator to the oscilloscope, the filter and the frequency counter.

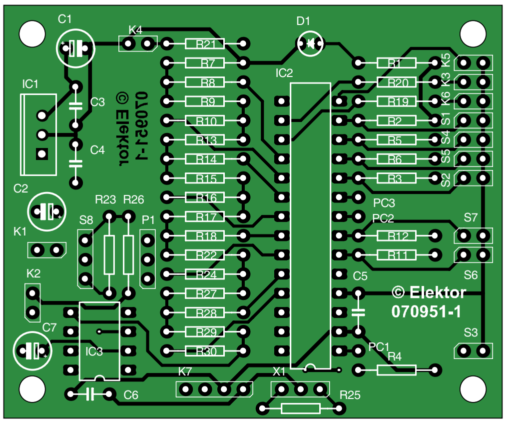
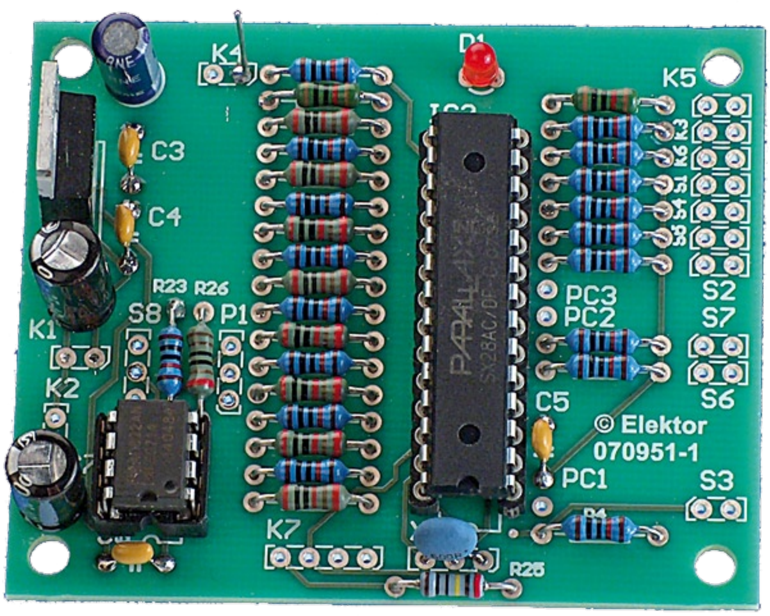


Figure 3. Component mounting plan of the sweep oscillator board. True-scale copper track layout available as a free download from www.elektor.com.



two on/off switches (S6 and S7) to determine the operation and settings of the sweep oscillator. The switches are read on microcontroller port lines RB0-RB3 and RA0/RA1.
The instrument supplies signals to the oscilloscope and the frequency meter via RB5/K4, RB6/K3 and RB7/K6 with 10 kΩ resistors inserted to protect the micro against short circuits. RB4/K5 is provided for experimental purposes and future expansion. The same applies to SX28 port pins RA2 and RA3.

Let's get connected

The functional connections to the circuit are shown in **Figure 2** mainly for those who have never used a sweep oscillator. Although some experienced users will be able to do without it and derive everything from the scope image, the frequency counter is extremely useful as it allows you to see the marker frequency instantly.

Software & hardware development

All the hard work is done by the program ('firmware') running within the SX28AC, a microcontroller developed by Parallax Inc. and available direct from them or through authorized distributors [1]. Like so many other Parallax products (including their renowned Basic Stamps and recently the Propeller), the SX28 enjoys wide support from Internet communities. The SX28 is cheap by any standard, and lots of free software and documentation is available on the web. Datasheets, compilers, programming examples, simulators, you name it and it can be found — see [2] 'for starters'.

In terms of hardware development tools, the author used Parallax's SX-Key™ Rev. F (now an 'End of Life' product, to be replaced soon by a USB equivalent). The software developed for the project was written using SX-Key V3.10, also from Parallax. The source code may be obtained as a free download from the Elektor website, the archive file number is **070951-11.zip**. We suggest you open it to be able to follow the discussion below.

The main loop of the program outputs a continuous sine wave using a direct digital synthesis (DDS) algorithm to access values in a sinewave lookup table. This is a pretty standard method for creating a sinewave. The clever part comes by using an interrupt service routine to alter the value which determines the frequency in the DDS routine. A piece of the routine is shown in **Listing 1**. There is a facility in this program for two sweep tables. An external switch is read by the program which then changes between the two sets of tables.

Again, SX28 micros come as ‘blank’ ICs so you have to do your own programming. Fortunately, that’s easy using the information found on the Parallax website. If you want to delve into the intricacies of SX28 programming, the publications [3] and [4] are sure to get you hooked on the device. Best of all, Al Williams’s writings on assembly code programming are a free download!

Construction

Elektor Labs have designed a quality printed circuit board for the project. The component layout is shown in **Figure 3**. The copper track layout is available separately as a free download from the Elektor website. It’s a pdf at true scale you can print directly to a laser printer to make an acetate transparent or ‘direct to copper’ transfer for PCB production on a budget.

IC sockets should be used for the SX-28AC micro and the AD822 opamp. The SX28AC micro should be programmed, of course, before it can be used in this circuit (yes there are readers out there inserting blank micros in Elektor circuits and complaining *it don’t work*). Populating the board should not present problems as the layout is generous and no esoteric or extremely small parts are used. Everyone with a keen eye for detail, some patience and reasonable soldering skills should be able to pull this one off.

BNC sockets should be used for the sweep oscillator analogue output (K2), the Trigger output (K3), Marker Display (K4) and Marker (K6). The BNC sockets are connected to the pinheaders on the PCB using short pieces of thin coax like RG174. The braid of the coax cable goes to Ground!

Operation

The operation of the device is straightforward. Connect up the circuit as shown in Figure 2. Before switching on the power to the sweep oscillator and circuit under test, set the output amplitude pot and the attenuator switch to

COMPONENTS LIST

Resistors
R1 = 1kΩ
R2-R6,R9,R11,R12,R13,R15,R17,R19,R20-R23,R27,R29 = 10kΩ 1%
R7,R8,R10,R14,R16,R18,R24,R28,R30 = 20kΩ 1%
R25 = 1MΩ
R26 = 110Ω
P1 = 4k7 potentiometer

Capacitors
C1 = 10µF 40V radial
C2 = 100µF 40V radial
C3-C6 = 100nF
C7 = 100µF 25V radial

Semiconductors
D1 = LED, 3mm, low current
IC1 = 7805
IC2 = SX28AC/DP (Parallax), programmed, Elektor Shop # **070951-41**
IC3 = AD822AN

Miscellaneous
S1-S5 = pushbutton, 1 make contact
S6,S7 = on/off switch, 1 contact
S8 = switch, 1 changeover contact
K2-K6 = BNC socket
K7 = 4-way SIL pinheader
X1 = 50MHz ceramic resonator
SX28 source and hex files, free download # **070951-11.zip** from www.elektor.com
PCB, ref. # 070951-I from www.thepcbshop.com

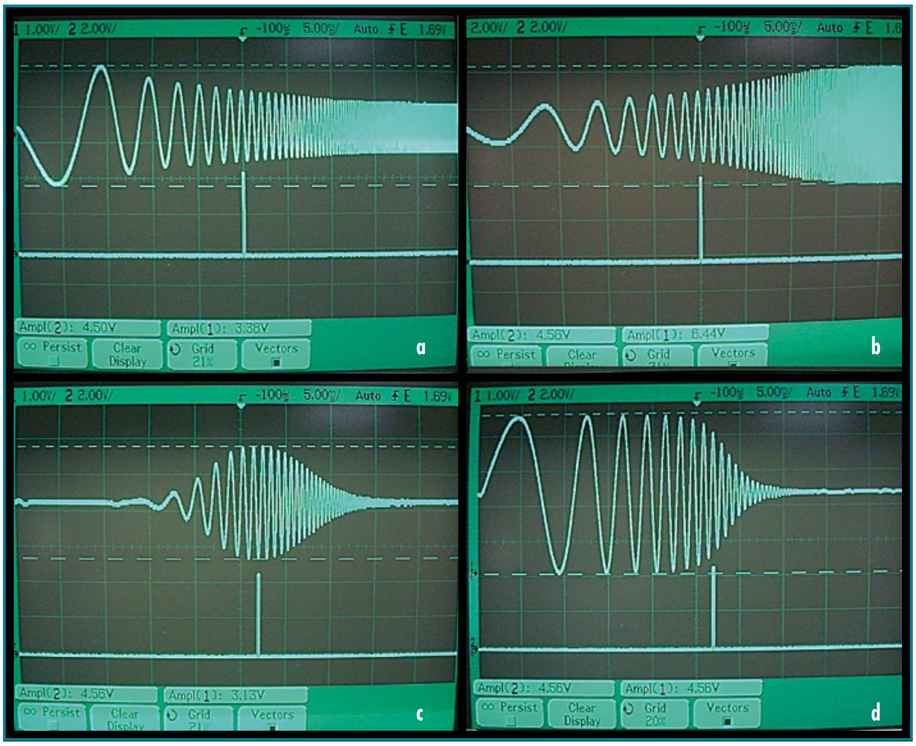


Figure 4. ‘Scoped results obtained with the instrument. (a) active tone control circuit with bass boost switched on. (b) The same, with treble boost switched on. (c) band pass filter. (d) low-pass filter.

Listing 1. DDS frequency control

```
;-----------------start of 0.2ms interrupt routine--------------------
;
;  MODE register points to sine table on entry
;  Mode register must point to sine table on exit
;
;  ()Value fetched from table is added to frequency register
;    This increases the frequency produced by the main output routine.
;    At end of sweep everything is reset.
;  ()Marker Buttons are read
;  ()Marker frequency is updated
;  ()Marker pointer is updated
;  ()Trigger is generated
;
;--------------------------------------------------------------------

Interrupt
```

their lowest levels, set the frequency range switch (S6) to the desired position (100 kHz or 15 kHz) and the scope time base selection switch to the 5 ms position.

The oscilloscope controls have to be set to the following positions

- timebase: 5 ms per division;
- external trigger on falling (negative-going) edge.

Connect the power to the circuit under test (CUT) first and then switch on the power to the sweep oscillator. Increase the output amplitude level to provide a usable display on the oscilloscope screen without any clipping of the signal. You should also see the output of the marker display on the second channel ('2' or 'B'). Adjusting the position of this marker using the four pushbutton switches allows you to measure the frequency at this position on the screen using a frequency meter connected to the marker output connector.

Should there be any problems getting the output of the circuit under test to display on the oscilloscope screen (faulty CUT, faulty connections etc.) then connect the output of the sweep oscillator directly to channel 1 (or 'A') of the oscilloscope to check that everything is working properly.

There is an option for altering the timebase setting for the 15 kHz frequency range on the sweep oscillator but this is best left switched to the 5 ms setting.

(070951-I)

Web Links and Literature

[1] www.parallax.com

[2] www.parallax.com/ProductInfo/Microcontrollers/SXProductDownloads/tabid/460/Default.aspx

[3] Programming the SX Microcontroller: A Complete Guide. Günther Daubach, published by Parallax.

[4] Beginning Assembly Language for the SX Microcontroller. Al Williams (free download from Parallax website)


```
;(not shown here: check frequency range switch; Fetch low and high frequen-
   cy word; start of button reading routine; end of button reading routine)

;------start of marker frequency output routine on rb.7---------------
;:fetch current marker value
        mov     M,Table_pntr_L          ;1:Fetch low word
        mov     W,MFreqT_Pntr           ;

        iread                           ;

;M now contains lower nibble of FreqM and W contains FreqL

        mov     MFreqL,W        ;
        mov     MFreqM,M        ;

        mov     M,Table_pntr_H          ;1:Fetch high word
        mov     W,MFreqT_Pntr           ;

        iread                           ;

;M now contains FreqH and W now contains Higher nibble of FreqM

        or      MFreqM,W        ;
        mov     MFreqH,M        ;

;:marker frequency value now in MFreqH.MfreqM.MfreqL

;------------------end of frequency marker output routine---------------

;-----start of frequency marker display rb.5 (ch2 on oscilloscope)------
;bttn_flgs.4=0 no marker being displayed so test counter
;bttn_flgs.4=1 marker displayed so clear marker


        sb      Bttn_Flgs.4
        jmp     tst_cntr                ;bttn_flgs.4=0
        clrb    bttn_Flgs.4             ;bttn_flgs.4=1
        clrb    rb.5
        jmp     F_M_end
tst_cntr
        stc
        mov     W, M_Cntr               ;is M_Cntr=MFreqT_Pntr
        mov     W,MFreqT_Pntr-W
        sz
        jmp     F_M_end                 ;no
        setb    rb.5                    ;yes
        setb    bttn_flgs.4
F_M_end
        inc     M_Cntr

;--------------end of frequency marker display------------------------



;----------------start of trigger section. Output on rb.6---------------
; toggle trigger output based on state of FreqT_Pntr.7

        sb      FreqT_Pntr.7            ;
        clrb    rb.6                    ;
        snb     FreqT_Pntr.7            ;
        setb    rb.6                    ;

;---------------------end of trigger section--------------------------

        mov     M,#sine>>8              ;point M to Sine table
        mov     W,#%10000110            ;set RTCC interrupt
        mov     !OPTION,W               ;

;---------------------check delay switch----------------------------

        sb      ra.1                    ;select  time delay
        jmp     :td_sel_0
        mov     Time_dly,#delay_1               ;ra.1 is 1
        jmp     :td_sel_e
:td_sel_0       mov     Time_dly,#delay_2                       ;ra.1 is 0
:td_sel_e

..............(end of fragment)
```

Keyboard goes Game C

Abraham Vreugdenhil

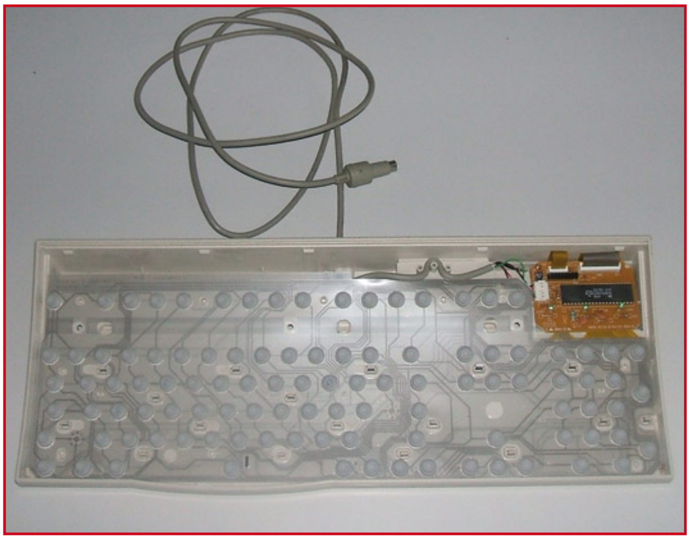
As a hobbyist you may often be designing a game or an application for your computer. When you're demonstrating your program or game at a computer fair it seems a shame that people have to use a standard keyboard. It would be much better if their attention was drawn to your creation rather than the computer.

There are various reasons for wanting a Custom Input Device (CID). We can think of the following two examples.
What about a pinball game on your computer? When you've created a great table or game using Visual Pinball [1], there is nothing so annoying as having to use the keyboard for the plunger and flippers. You want to put your hands on the sides of the table when using the flippers and pull a plunger to launch the ball. A computer keyboard is obviously not suitable for this.
Then there is the game of Rock, Paper, Scissors [2], where two players have to use their hands to show each other a symbol for a rock, paper or a pair of scissors. A rock beats a pair of scissors because the rock blunts the scissors. The scissors beat the paper because the scissors cut the paper. And the paper beats the rock because the paper can wrap round the rock. Instead of playing against another person you can also play against the computer. In that case it's down to the computer program to 'guess' what its human opponent will do. From the Elektor website [3] you can download this game. You can use the following keys for your selection: [r] for rock, [s] for scissors and [p] for paper. This isn't much fun, however. It would be much more enjoyable if you had a real rock, scissors and paper that you had to hit to make your choice. But how can we turn this bash on a rock or a flipper button into a computer signal? Read on!

Keyboard

To build your own Custom Input Device we propose the following method. We'll use a type of input that is well known and used by everybody: the keyboard. Inside each keyboard is some electronics that converts a key-matrix into a serial signal that can be

Get hold of an old keyboard with either a PS2 or USB connector.



Open it up to get at the internal electronics.

ontroller

Build your own Custom Input Device

PS2 or USB?

In principle there is no difference between the operation of PS2 and USB keyboards when they're used to make a Custom Input Device. What could make a difference is if you connect a PS2 keyboard via a PS2 to USB converter to your PC or laptop. In games where timing is important, such as pinball games, you may notice when a short delay occurs in the operation of the Custom Input Device. The question is if the delay is caused by the PS2 to USB converter, the Visual Pinball program; or simply the PC you're working with or its graphics card.

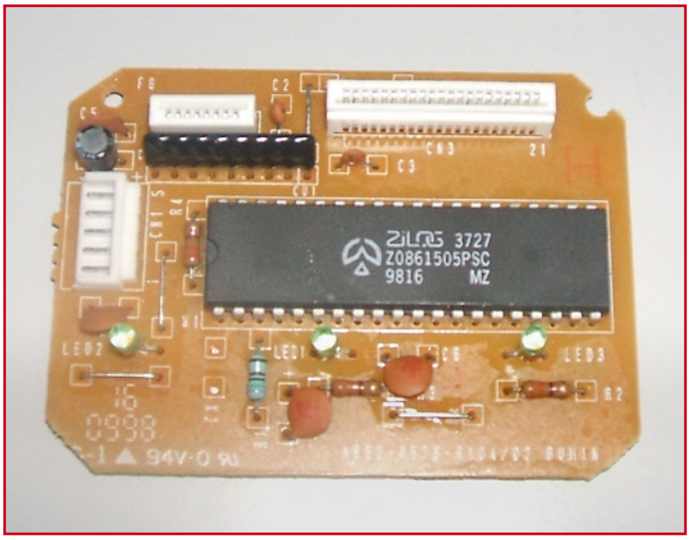
It has to be said that the author has never found any delay to be a hindrance. The nice thing about USB is that you can connect more than one device at the same time. So you can connect a standard keyboard for normal use, as well as your Custom Input Device. In theory you could connect up to 127 devices to your computer via USB. The PS2 to USB converters will come in very handy here.

used by a computer. Instead of the more than 100 keys that are in a typical keyboard we'll only use those that are required by the game and connect those to the electronics. In our example for Rock, Paper, Scissors it will only be the [r], [p] and [s] keys.

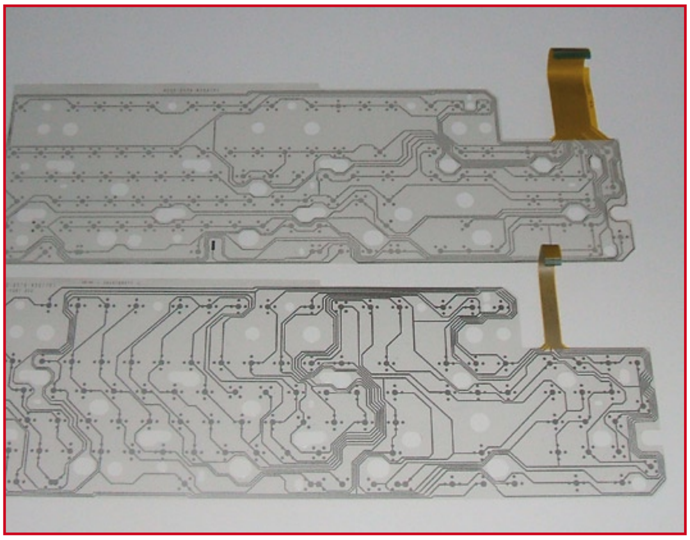
First you need to find an old, surplus keyboard and take it apart. After removing the screws from the underside we can prise the two halves apart. This exposes a membrane that consists of three layers. The outer layers have tracks on them and the middle layer keeps them apart. The top and bottom layers are connected to a small board of about 10 by 6 cm. This board also has a cable with a PS2 or USB connector at the end. The board should be carefully removed from the keyboard, with a note being made of the connections to the membrane. The two connectors on the board for the membrane connections usually consist of a smaller one with about 8 pins and a larger one with about 21 pins.

Key choices

Now we have to determine which connections are used by a particular key. We place the top of the keyboard onto the membrane and look which contacts are underneath the required key. Next we can find out in two ways which connections are used by this key. The simplest is to follow the tracks from the key to the connector. You'll have to look carefully and hope that you don't make a mistake. The second method is more reliable from a technical point of view. Use a multimeter, (who can do without one these days) and put it to its resistance setting. Put one probe on the membrane contact underneath the key and with the other test each of the contacts that connect to the board. When you see a low resistance



Behold the (simple) electronics (this can obviously look different if you have a different keyboard).



The two layers that make up the key matrix are used to determine the correct connections.

of about 60 to 120 Ohm you'll know you've found the right contact. All the other contacts should return an infinite resistance.
Once we've determined which connection is used by the key on the layer with the small connector, we have to do the same thing for the layer with the large connector. We've then found the point in the matrix for that particular key.
Next we connect two wires to the connections we've just found and connect the other ends to our switch. With the keyboard circuit connected to the computer, a press of the switch causes the appropriate keystroke to be detected by the computer.

CID for Rock, Paper, Scissors

For the game of Rock, Paper, Scissors we choose the [r], [p] and [s] keys and connected them to some cables. The other ends were connected to three switches that were mounted inside three wooden discs. The discs are mounted on springs and can be pressed down. When that happens a switch closes. On top of the discs we've placed images of a rock, paper and scissors. The keyboard electronics are actually fairly attractive to look at. There is a real 40-pin Zilog processor with a few peripheral parts. It would be a pity to hide this circuit out of sight. We've therefore put this board in a hollow wooden disc and put a clear plastic panel over the top. In that way everybody can admire the simplicity of the keyboard circuit and our Custom Input Device.

CID voor Visual Pinball

In the program for Visual Pinball we can specify which keys operate the flippers and which key launches the ball. We can also interrupt the game with the Esc key. We could use the 1 or 3 key to start a new game, for example. There is also a facility to assign keys to nudge the table in various directions.
For all functions that we want to make use of we determine the switch connections on the keyboard circuit and connect them to small switches. We've used a sturdy, bash-proof plastic box measuring 40 by 30 by 12 cm for our Visual Pinball CID. When it's placed sideways on the table it feels comfortable with your hands on it. The two pushbuttons that operate the flippers are mounted on the sides of the case to give a more realistic feel of a pinball table.
The plunger is made from a wooden knob mounted on the end of a 6mm diameter metal rod. On this rod we mount a ring that is normally pulled against a switch (by an elastic band for example), keeping it opened. When we pull the plunger (to launch the ball) the switch closes. And when we let go of the plunger the switch opens again and the ball is launched. In Visual Pinball the time that the switch is closed corresponds to the power of the launch. A short time gives less power and a long time gives more power.
This type of interaction between your CID and the program adds a lot to the enjoyment. If we use a projector to display our Visual Pinball game on a large screen and put the CID some distance away we can imagine that we're standing in front of a giant pinball machine. The show can begin!

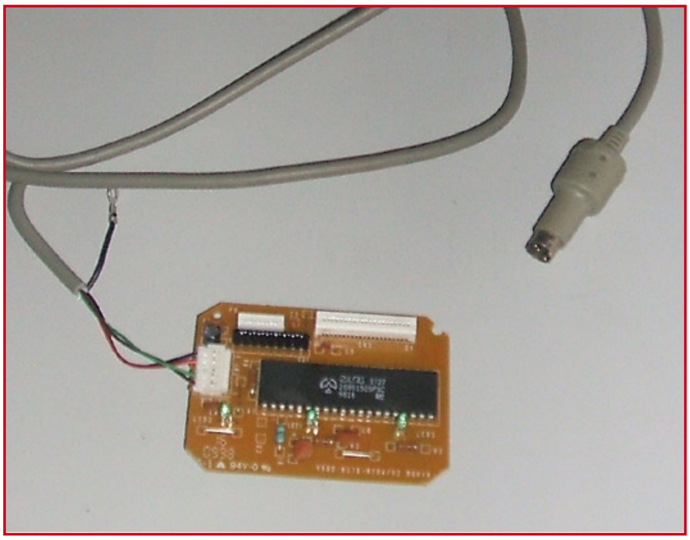
(070724-I)

Web Links

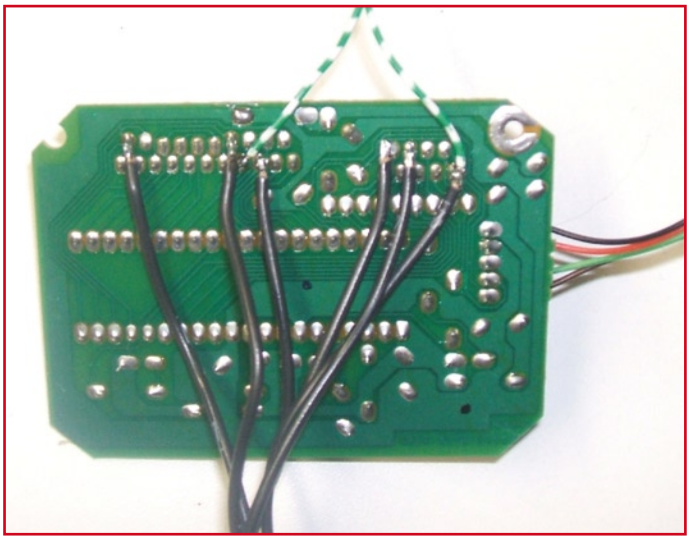
[1] www.pinballnirvana.com/index.php?name=UpDownload

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

[3] www.elektor.com



This is all we'll use from the keyboard: the board with a cable and plug.



You only need a few switches to make a functional CID.

Keyboard electronics or microcontroller

Instead of using the electronics from a keyboard to build a CID you could also build all of the hardware and software yourself. We take an AVR processor made by Atmel and use the BASCOM-AVR compiler, for example. This compiler includes the commands to simulate a serial PS2 keyboard. When we connect the switches of our CID to the inputs of the microcontroller then the rest of the electronics can be designed as we wish. Next we assign a particular ‘key value’ to each contact and use the microcontroller to send it to the computer. This key value is used in our program to perform a certain action.

There are advantages and disadvantages in designing and building the hardware and software yourself. The advantage in building a system yourself with e.g. an AVR microprocessor is that you can make it very small. On an 8-pin microcontroller there are five pins available for I/O, but three are required for the PS2 connection, leaving two for switches.

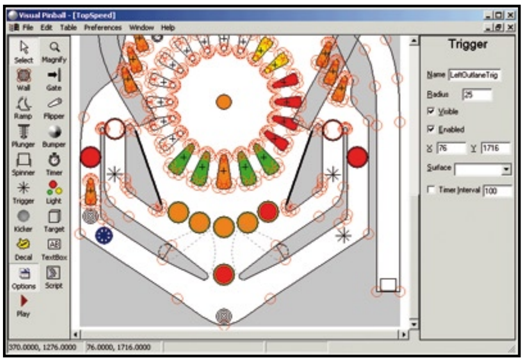
If we use a 20-pin controller then we have 15 I/O pins available. Taking away the connections required for PS2 leaves us with 12 pins for the switches. Even with a 20-pin IC the circuit can be made very compact.

The disadvantages of building the circuit yourself are the costs and time required. An AVR microcontroller still costs a few pounds and it will easily take up a few evenings before everything works. On top of that you need a cable with a PS2 connector, so you would probably have to take that from an old keyboard anyway. In that case you might as well use the internal electronics of the keyboard at the same time.

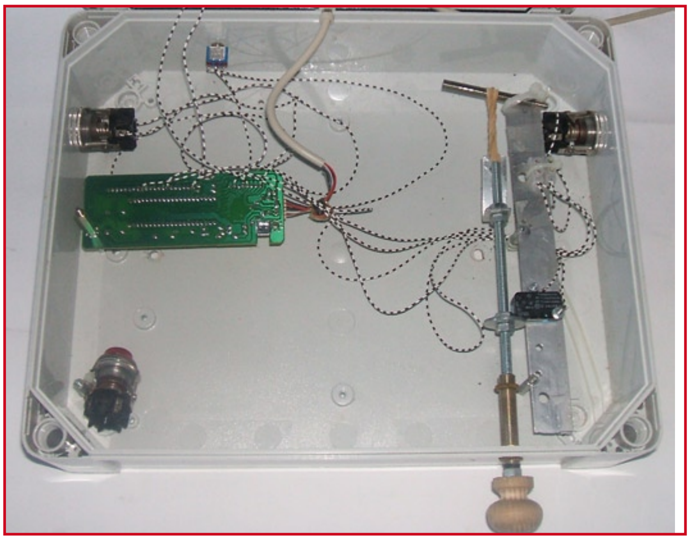
The only reason to build the electronics and software for a CID yourself is when it needs to be very small or in a particular shape. This will only be the case when the look and size of your CID is very important to you.

Visual Pinball

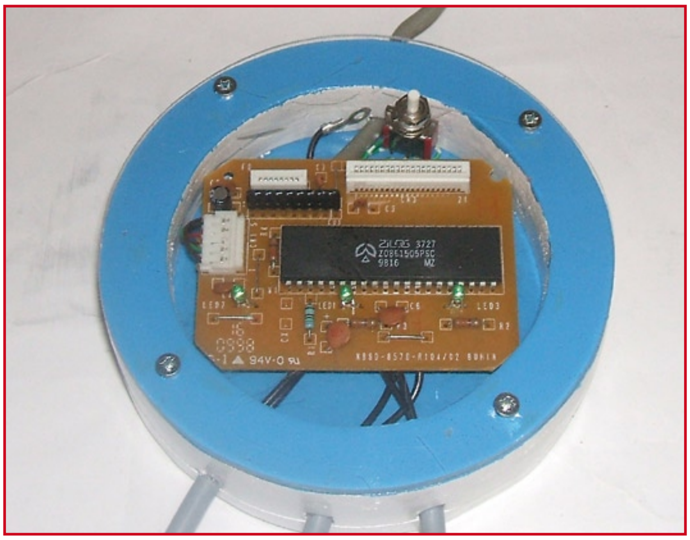
Visual Pinball is a Visual Basic toolkit to create a pinball game on your computer. In the program are many objects, such as bumpers, flippers or rollovers that have unique properties and can react to various events. The method of programming, such as the code for an event, is very similar to Visual Basic. For example, when a ball goes across a rollover you could increase a counter (get points) or play a wav file. You can display images on the table or the backbox, etc. You could use it to build a table based on a real pinball game, but you could also design a futuristic game that in reality could never be built.



A unique game, adapted for a particular theme or activity such as a Fancy Fair, can be made to look very interesting with the help of Visual Pinball. On the Internet you can find a wealth of information. A good place to start is this link [1]. From here you can also download Visual Pinball 7.



With a few innovations (elastic band and positioning of the switches) the CID for the pinball table is like the real thing.



The ‘controller’ for the Rock, Paper, Scissors game is exposed to the world in all its glory.

µC Goes Analogue

Cypress PSoC development kit

Paul Goossens

Your average embedded system will be primarily composed of digital components. However, analogue components are also necessary for filtering and amplifying signals, among other things. Cypress PSoCs combine a microcontroller with analogue functional blocks. A development kit such as the CY3270 forms a good starting point for rapid familiarisation with these ICs.

You can buy the CY3270: PSoC First Touch' starter kit for around £15 (25 euros). It provides a convenient way to discover for yourself what the Cypress PSoCs have to offer.

This development kit consists of two hardware modules, a mini-CD, a *Quick Start Guide*, and a piece of wire (!). All of this is packaged in a plastic box, which you can later use as a handy storage container. The only thing that's missing is a USB cable – otherwise the kit is complete and ready to use.

What is PSoC?

The abbreviation PSoC stands for 'programmable system on chip'. A variety of IC makers use this designation. It usually refers to a microcontroller with a large amount of memory and peripheral functions. At Cypress, this name is used for a rather different kind of IC. Beside the microcontroller and some peripheral functions, the Cypress PSoC incorporates several analogue components.

These analogue components are configurable. You can thus use them to build a wide variety of analogue amplifiers, filters, modulators, and the like directly in the chip. These blocks allow analogue circuits to be incorporated in an embedded system along with the microcontroller, all in a single chip. This reduces the total number of components required for a given design.

The inputs and outputs of these analogue blocks can be connected to any desired pins of the IC. This also holds true for the digital peripheral components of the chip. This makes designing the PCB layout a lot easier.

Hardware

The hardware in this kit consists of two parts. The first part is the 'FTPC bridge', while the second part is the expansion board.

The expansion board holds the PSoC – a CY21434 – that is used to test the provided examples. In addition, this board has an RGB LED, a small speaker, and a thermistor.

The PCB also has a pair of copper strips and a connector for inserting the wire included in the kit. The copper strips can be used to make a touch button in combination with the PSoC. The included wire, which extends as a sort of antenna, can be used to build a proximity sensing circuit.

The FTPC bridge provides the communication link between the expansion board and a PC. The USB interface on this board makes connection to a PC easy. This allows the PSoC on the expansion board to be programmed from the PC. In addition, it acts as a USB to I²C bridge and as a USB to SPI bridge. This simplifies debugging of applications that use these interfaces.

Software

The included CD-ROM contains another important part of the kit: the development software and programmer. Incidentally, this software also runs under Windows Vista without any problems. Unfortunately, the programming software included on the CD does not work under Windows Vista. However, a new version that does work with Vista is available on the Cypress website.

The microcontroller can be programmed in C with this software. There is also a built-in simulator. The special feature of this software is the capability of configuring the analogue blocks in the PSoC.

Witt this software, connecting various types of sensors is very easy. The software also includes a large number of predefined blocks that can be used to connect a wide variety of sensors directly to the IC. The associated C routines for reading these sensors are also included. You can even display typical schematics for the various sensors on the screen.
Constructing a circuit effectively amounts to dragging the necessary analogue functions to the design. The properties of these blocks can be adjusted as necessary with a few mouse clicks.

Sample applications

The software is complemented by four sample applications for the expansion card. Using these examples, you can quickly understand how to make a touch sensor that operates on the capacitance principle. Using a piece of wire as a proximity detector is also quite easy, and it's fun to experiment with adaptations of this design.
The light sensor and temperature sensor are also used in the other two examples.

Assessment

The Cypress CY3270 development kit provides a lot of value for relatively little money. The hardware is simple but functional, and the FTPC bridge can be used afterwards as a programming interface for your own projects.
Experimenting on the basis of the supplied examples is a pleasant way to spend your time, and it's bound to inspire you to develop your own creative uses for these PSoCs. The easy-to-use development software, along with the library of handy routines and ready-made sensor interfaces, is especially convenient.

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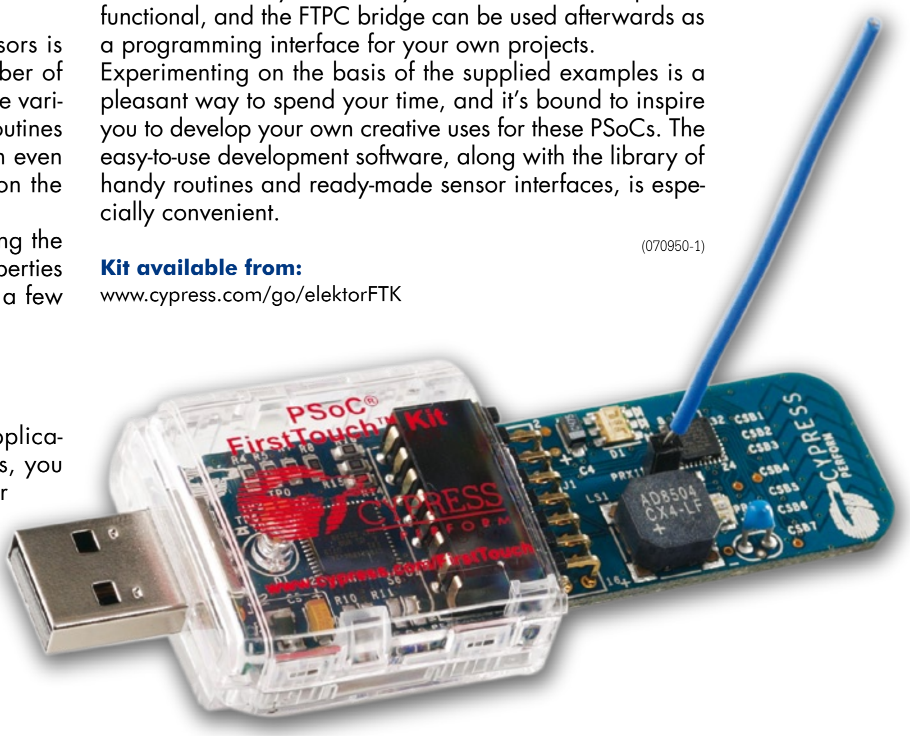
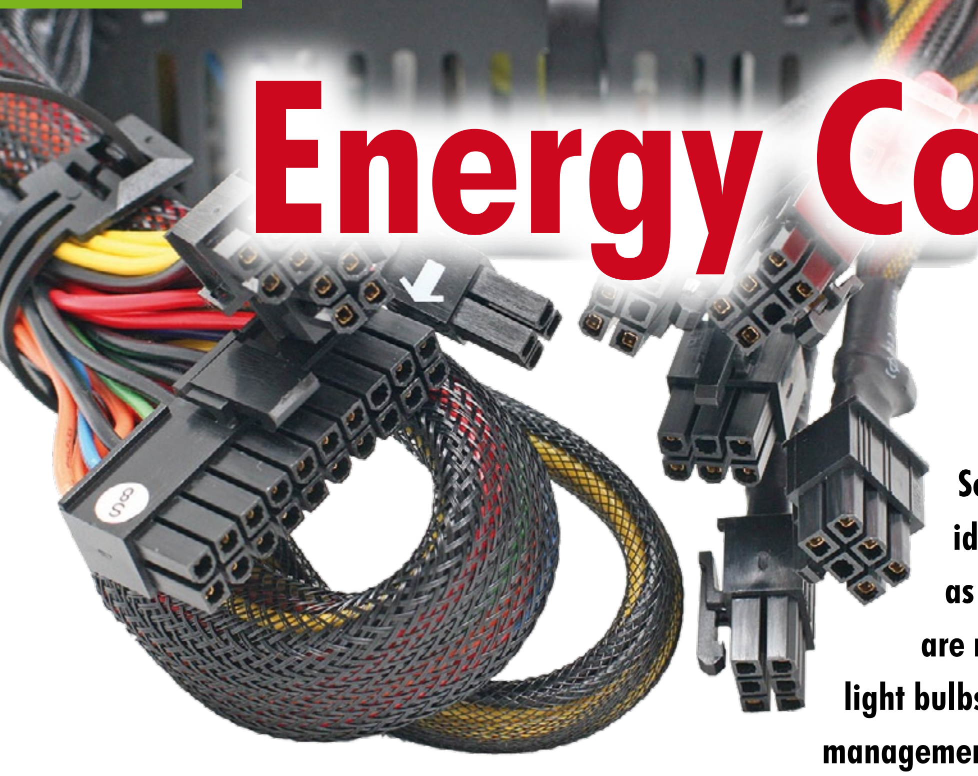
Kit available from:
www.cypress.com/go/elektorFTK





Energy Conscious

Kaj Schulten

Sensible energy usage is always a good idea. It is better for the environment as well as your wallet. Standby settings are now frowned upon and low-energy light bulbs are becoming more popular. Power management inside the PC is also becoming more important. Certainly those heavy-duty game systems that can consume over 500W can do with a critical look at power saving possibilities.

In the early days of the personal computer the system could really only be in one of two states: on or off. Putting the machine into standby so it could be restarted more quickly was still unheard of then. There was also the fact that the operating systems in use at that time (DOS and later OS/2 and Windows) weren't very good at doing several things at the same time. It was better to keep the hardware active all the time (it was well-known that the hard drives in those days didn't like it if they were continuously turned on and off again). But even then the motherboard manufacturers were hard at work implementing the Advanced Power Management (APM).

APM made it possible to enter a power-saving standby mode via a time-out setting in the BIOS or by pressing a Suspend/Resume button. On detecting this signal the hardware switched into a power-saving mode.

transformation

With the advent of newer operating systems such as Windows 95 it became possible to activate this standby mode from within Windows and make better use of it. After all, if the BIOS decides that a device can go into standby mode, but the operating system can't handle that, then the result will be chaos.
As it was, APM could never be used to its full potential. Much of the functionality could only be used from within the BIOS and was not accessible to the operating system. The support left much to be desired and there were numerous problems with Windows 95 and power management that left many users feeling very frustrated.

Progress

The successor to APM is known as the Advanced Configuration and Power Interface (ACPI). With ACPI it is the operating system that makes the decisions regarding the power management. It can put certain parts of the computer into a different state, saving energy. This happens according to the preferences of the user and the programs running at the time. A device that is not used can be turned off or put into an idle state; this is something that can also apply to the whole computer.

The ACPI gives the operating system direct control over the power management and the so-called Plug and Play properties of the computer. You do of course need an operating system that supports the ACPI. Every Windows version from 98SE and NT4 onwards has support for these features.
It was very different as far as the alternative operating systems were concerned. It wasn't that long ago when putting a computer into hibernation would result in a crash and then required thorough check of the hard drive.
Fortunately the open source community doesn't rest and these days most versions of Linux and FreeBSD make it easy to call the ACPI functions. This is actually quite an achievement since the full ACPI specification is in excess of 600 pages. If it had been left to Microsoft it would have been a closed Windows-only specification.

How does it work?

So how does the ACPI work? It would be too much to go through the complete specification, but in a nutshell the ACPI has seven different states, with the power saving varying from none to maximum.

'G0' is the normal state in which the computer operates. The operating system and programs run normally and the processor carries out its instructions. In G0 it is possible to turn of a device temporarily while it isn't required and turn it back on again afterwards. Examples are hard drives and monitors that are turned off after a few minutes if they haven't been used for that period.
'G1' is the sleep state. This state has four sub-states: 'S1' to

Computing

Advanced Power Management

'S4'. They effectively determine how quickly the computer can be brought out of its sleep state.
In S1 the memory cache is cleared, but the processor(s) and the memory remain powered up. The machine can be brought back to its normal state very quickly. This is also called the 'POS' state or Power On Standby.
S2 is almost the same as S1. The only difference is that the processor is powered down. The computer therefore takes a little bit longer to wake up again.

S3 is also called 'Suspend to RAM' in the BIOS. In the various operating systems it's called something different again ('Sleep' in Vista and OS X, for example). The operating system keeps the memory powered up and stores the system state in it. Because of this the user can get back to work quickly, since storing the system status in RAM requires little effort and you can carry on working where you left off. It takes about as long as powering up the monitor again.
S4 is better known as Suspend To Disk, although the various operating systems again use different descriptions. In OS X it's called 'Safe Sleep' and in the assorted Windows versions it's known as 'Hibernate'. In this state the system state is written to the hard drive. The biggest advantage of this is that the computer can be fully turned off once all the information has been written. This is in contrast with S3, where you would lose all the information if there was a loss of power, for example caused by an empty laptop battery.
G2 is also known as S5, but it is not a state that saves more energy than S4, since several parts remain powered up. In this state a press of a key on the keyboard or a signal over the LAN (Wake On LAN) can restart the computer. In this state you wouldn't be able to change parts either. This can only be done safely and without the loss of data in the G3 state.

G3 is the same as the mechanical off state. The operating system and programs have all been fully shut down and the hardware has been turned off, with just the Real Time Clock (RTC) on the motherboard running from a small lithium battery. In this state it is completely safe to add or replace any hardware. The computer will be in this state when there is a loss of power and usually remains in it when power is re-applied. In some BIOSes this can be changed so that a system will automatically return to the G0 state after a power-cut, and restart.
From the G2 and G3 states there obviously has to be a full boot-up procedure before the system becomes operational again.
The success or failure of this functionality obviously depends on the support provided by the underlying hardware. If certain functions are missing it is often impossible for the operating system to implement some power saving functions. When this is the case the state of the system is often called the Legacy mode. The ACPI is not used in this mode and the computer effectively operates in either G0 (on) or G3 (off) mode.

Choices

The preference of the author is to use the S4 state on his laptop, as that works well with both Linux and Windows. The biggest disadvantage is the power up time. When restarting from Suspend To Disk the system first has to go through a complete POST (Power-On Self-Test) and then write back the system state into the memory, which takes a while. But as with many things in life, it's a matter of priorities: do you want to quickly resume with your work or do you want to save energy (from your laptop battery, for example).
Another function of ACPI is used very much in portable computers; running the processor at a lower frequency than it is made for reduces the power consumption, extending the life of batteries. Intel calls this SpeedStep, and AMD uses the terms PowerNow and Cool'n'Quiet.

(070796-I)

Lucky Dip

Design it yourself or copy from the Internet?

Thijs Beckers

Like it or loath it, the Internet offers a treasure trove of information. Countless pages magically appear on your computer screen via this digital connection. You only need to know how to find what you're looking for. But it's not always that easy. For the electronics enthusiast there are of course all sorts of circuits and ideas waiting to be unearthed — the good, the bad and the ugly! We take a grab at what is on offer.

Do-it-yourself single-chip audio amplifiers with a LM3886 or similar, the so-called 'Gainclones' are quite familiar by now. So we won't talk about those. Perhaps a little less well-known, but still a very popular do-it-yourself subject is the modification of CD players manufactured by Marantz, specifically the CD-63 and the practically identical CD-67. These players have now reached quite a respectable age and can easily be obtained second hand. A large group of audio fanatics [1] knows how to improve this player, with a few modifications, to a level approaching that of high-end.

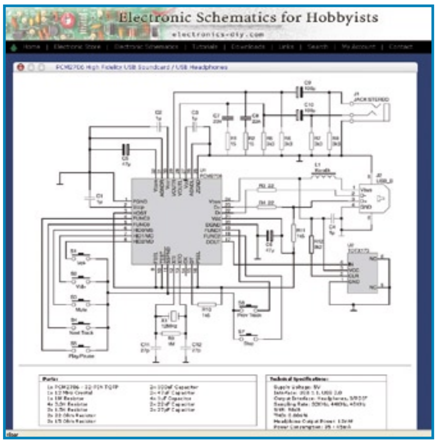


Figure 1. USB sound card.

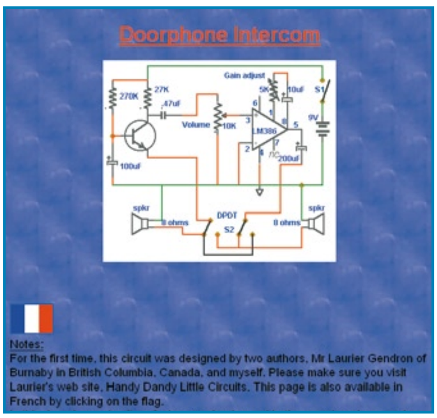


Figure 2. Simple intercom.

Audio

A famous website with all kinds of interesting audio projects is Elliott Sound Products [2]. But this is, of course, not the only source for interesting audio circuits. At [3], for example, we find a nice circuit for a USB sound card (**Figure 1**). Building a simple sound card that connects to the USB port doesn't require a university degree any more. Using an IC such as the PCM2706 from Texas Instruments you immediately have a headphone amplifier, a digital output (S/PDIF) and a hardware control panel for your media player, without the need to install anything at all when used with Windows XP or MacOS X. You can even download a PCB layout for this from this website [3].

For at home...

...there are naturally also a diverse range of interesting circuits to be found. For example, this doorbell intercom [4]. This handy circuit (see **Figure 2**) uses the speaker for reproducing as well as picking up sound. The volume can be adjusted with a potentiometer. A switch (indoors) is used to switch the circuit between listening and talking, so that 2-way communication becomes possible. Very handy, of course.

A somewhat older 'gimmick', but therefore not necessarily less entertaining, is the lightning bulb [5]. With a simple lamp, a piece of aluminium foil and a high voltage power supply, built from a car ignition coil, it appears that there is an electrical storm inside the glass envelope of the lamp (see **Figure 3**). It remains fascinating to see how the electrons work their way from one electrode (the filament) through the gas in the lamp to the other electrode (the aluminium foil). Of course, You need to watch out with these types of projects, because they operate at a dangerously high voltage of several kilovolts.

Another thing that would be nice to have at home is a metal detector. In this instructional video [6] you can see how you can, in a few minutes, turn a radio and a calculator into a simple metal detector that you can use, for example, to find wires or pipes in a wall. The 'circuit' uses the clock frequency of the pocket calculator.

µC

Very popular as well is the Arduino development board [7]. It is targeted at

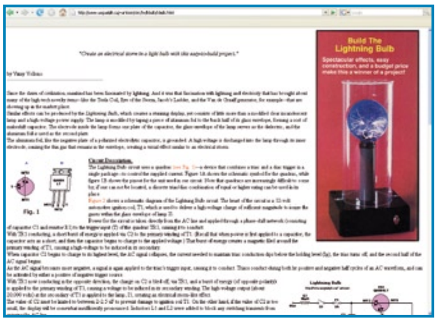


Figure 3. **Lightning bulb.**

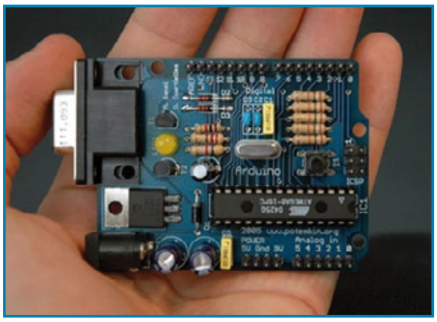


Figure 4. **Arduino board.**

Figure 5. **Midi-drums.**

artists, designers and hobbyists and everyone who is interested in interactive applications. These little boards are usually based on an Atmel ATmega168 microprocessor (see **Figure 4**). There are quite a lot of these open-source applications and the number continues to grow. Examples of projects that have been designed with this mini board are drum pads with a MIDI interface (**Figure 5**), an interactive light system for a bridge and a virtual fish tank.

Microprocessors always need to be programmed of course. One of the many AVR programmers that can be found online is the one from electronics-diy.com [8]. Together with the program called PonyProg [9] it is very straightforward to program hex files in, for example, a 28-pin ATmega8. The circuit is very compact and can be tidily housed inside the shell for the serial connector (see **Figure 6**). Incidentally, on the PonyProg website you will also find a circuit for a programmer that is suitable for connecting to a parallel port.

PC

If you have poor reception of a WiFi signal you will definitely have to watch this video [10]. This explains how you can make a better antenna for just a few pennies. Just roll up your sleeves for five minutes and you're done! "Finally a use for that old Windows 95 laptop", that's how this website [11] announces the circuit (**Figure 7**). With three ICs, a dual opamp and a handful of components you can make an excellent 12-bit data logger for less than £ 10 (€ 14). A simple Qbasic program does the rest. Qbasic.exe is generally on the original Windows 95 CD (usually in the folder 'oldmsdos') or alternatively can be downloaded from [12]. It will probably work with GWbasic as well.

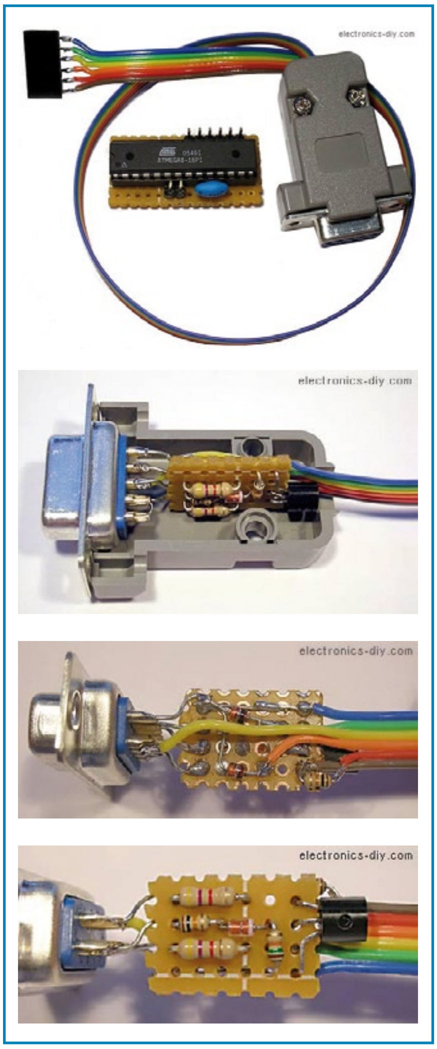


Figure 6. **AVR-programmer.**

Web Links (also on the Elektor website)

[1] www.diyaudio.com

[2] http://sound.westhost.com

[3] http://electronics-diy.com/PCM2706_USB_Soundcard.php

[4] www.mitedu.freeserve.co.uk/Circuits/Audio/doorint.htm

[5] www.uoguelph.ca/~antoon/circ/hv/l-bulb/l-bulb.html

[6] www.instructables.com/id/HomeMade-Metal-Detector

[7] www.arduino.cc

[8] http://electronics-diy.com/avr_programmer.php

[9] www.lancos.com/prog.html

[10] www.metacafe.com/watch/837885/wifi_antenna_hack

[11] www.techlib.com/electronics/serialport.htm

[12] www.fluid.tue.nl/student/colleges/NLS/software.html

[13] www.x-robotics.com/hardware_ing.htm

[14] www.electronics-lab.com/projects/automotive/005/index.html

[15] www.electronics-lab.com

[16] http://home.hccnet.nl/e.vd.logt

[17] www.zen22142.zen.co.uk/Circuits/Power/add-on.html

[18] www.belza.cz/hf/bug.htm

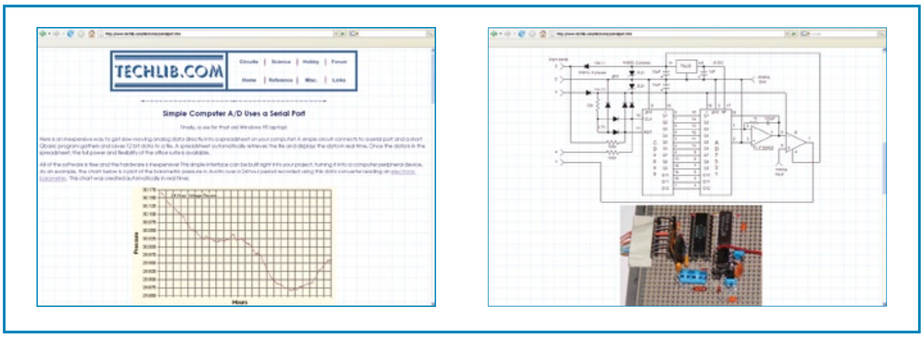


Figure 7. 12-bit ADC.

Robotics

Activating a robot (or something else) with a certain sound signal can be done with this [13] circuit (**Figure 8**). The IC compares the frequency of the input signal with that from its own frequency generator (adjustable with a resistor and capacitor) and switches its output low when they match. So you can for example, by whistling at a certain frequency have the robot carry out a pre-programmed action (make it come towards you, for instance).

Miscellaneous

A simple parking aid which uses an IR LED and IR photo diode is explained here [14]. Via the home page of this website [15] and the accompanying forum many more interesting projects are waiting to be found.

What has brewing beer got to do with electronics? We find the answer here [16]. On this website we can see the building and brewing process of Emile van de Logt. A genuine PID controller and control with PC software are deployed for this brewing process (**Figure 9**).

A handy circuit for limiting the inrush current (**Figure 10**) of, for example, a bench power supply can be found on [17]. Very useful when turning a circuit on for the very first time. The maximum current is determined by 0.7/R2. This can therefore be easily adjusted as required.

With a very small and simple circuit built around a single transistor (**Figure 11**) you can build a spy microphone that can be received with an FM radio. The website [18] is unfortunately in Czech, but it is easy to understand the circuit without the text. There is even a PCB layout available, although it is rather spacious for a spy microphone.

This was just a random selection of the immense number of circuits on offer. We hope that we have given you a few ideas and in the event that your own searches prove to be fruitless, you can always visit the Elektor website for more than 2,000 circuits on stock.

(070955-I)

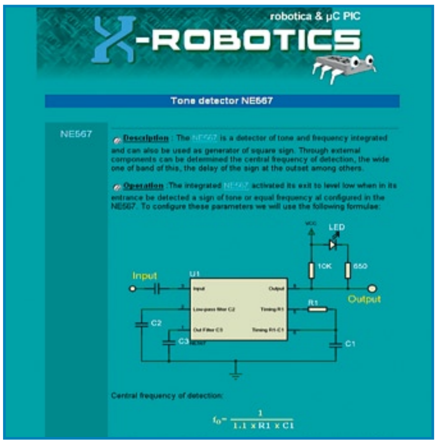


Figure 8. Tone detector.

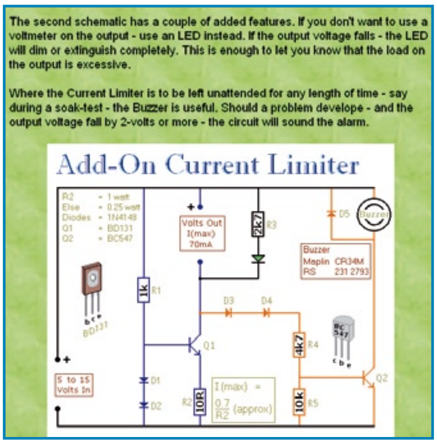


Figure 10. Current limiter.

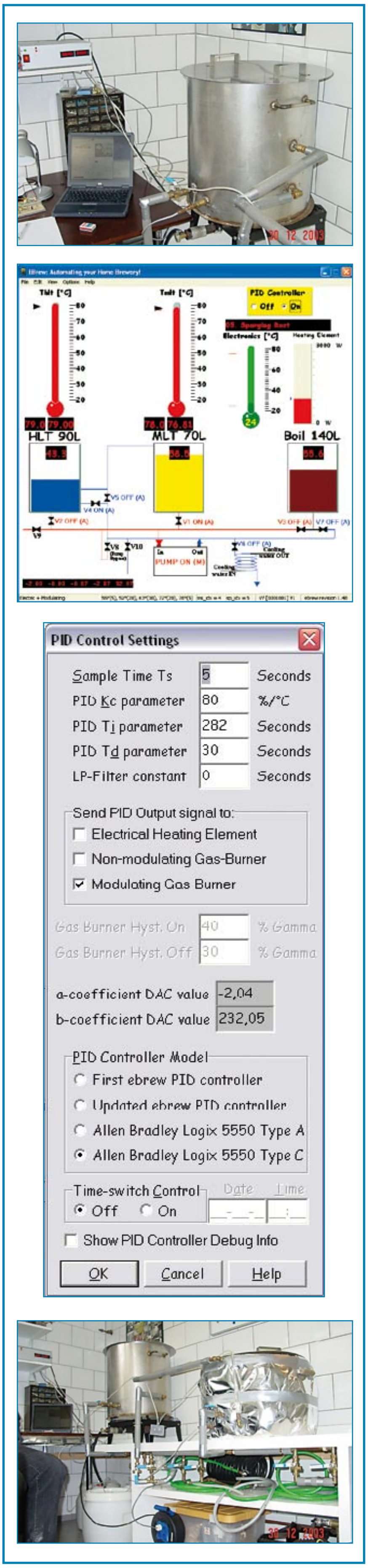
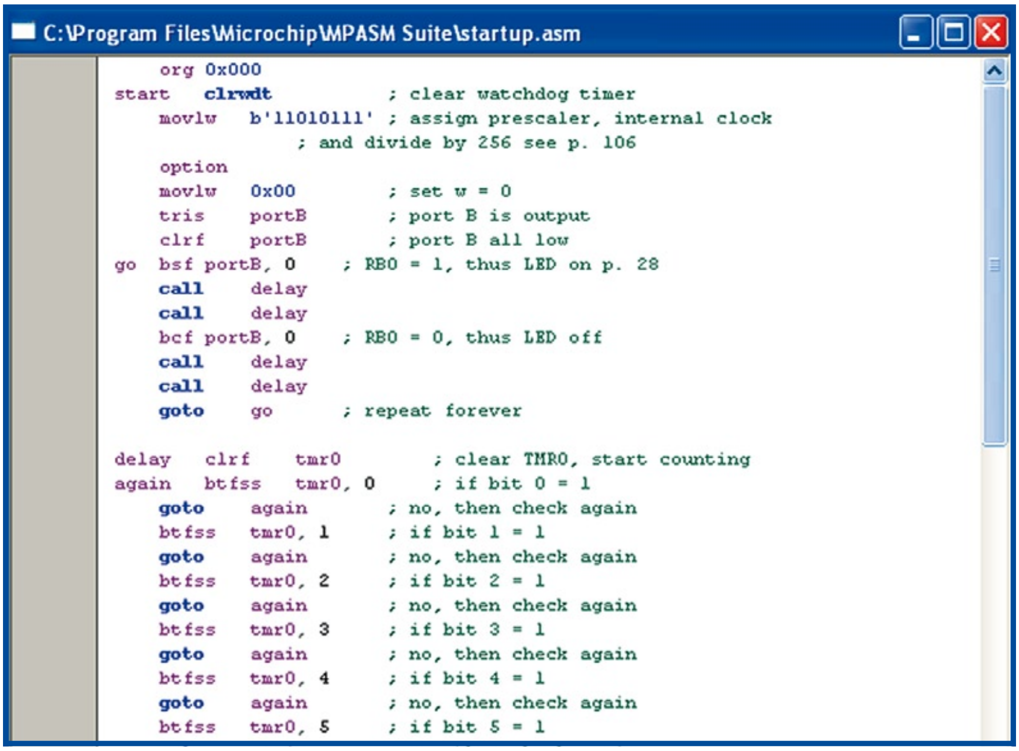


Figure 9. PID controller for brewery.

My microcontroller doesn't go...

It is impossible to imagine modern electronics without microcontrollers. What used to be done with combinational or sequential logic is now done with a single IC that runs a program that does exactly what we want it to do. Or perhaps more accurately: should do exactly what we want it to do.

Luc Lemmens


C:\Program Files\Microchip\MPASM Suite\startup.asm

```
    org 0x000
start   clrwdt          ; clear watchdog timer
    movlw   b'11010111' ; assign prescaler, internal clock
                ; and divide by 256 see p. 106
    option
    movlw   0x00        ; set w = 0
    tris    portB       ; port B is output
    clrf    portB       ; port B all low
go  bsf portB, 0    ; RB0 = 1, thus LED on p. 28
    call    delay
    call    delay
    bcf portB, 0    ; RB0 = 0, thus LED off
    call    delay
    call    delay
    goto    go      ; repeat forever

delay   clrf    tmr0        ; clear TMR0, start counting
again   btfss   tmr0, 0     ; if bit 0 = 1
    goto    again       ; no, then check again
    btfss   tmr0, 1     ; if bit 1 = 1
    goto    again       ; no, then check again
    btfss   tmr0, 2     ; if bit 2 = 1
    goto    again       ; no, then check again
    btfss   tmr0, 3     ; if bit 3 = 1
    goto    again       ; no, then check again
    btfss   tmr0, 4     ; if bit 4 = 1
    goto    again       ; no, then check again
    btfss   tmr0, 5     ; if bit 5 = 1
```

Particularly during the early development phase of the hardware and software, we often run into perplexing problems. The most frustrating of these is when the microcontroller doesn't do anything at all (or appears not to do anything at all). With older microcontrollers that have external program memory an oscilloscope or logic probe could often give an answer. A measurement on the address or data bus would give a quick indication whether the microcontroller was 'awake' or not. But these days all memory is integrated in the IC, in most cases, so only the I/O ports can sometimes provide consolation as to an indication of any sign of life.

Fortunately (?) most controllers still have an external oscillator, so that we at least can check whether the clock is running. However, even this option isn't available with many small microcontrollers that have an internal oscillator.

The simplest method to ensure that the oscillator is running and that the software, in principle, should be able to work, is to insert a short routine at the beginning of the program that toggles one of the port pins a few times. Preferably a port pin that has an LED connected to it, that gives immediate visual feedback and an oscilloscope is not required. Don't make the program wait for some external action (such as a button press, reception of data via the serial link, etc.), but just do 'something' on any pin whatsoever. If there is still no indication of any activity (and assuming that very basic checks like measuring the power supply and whether the reset line is at the desired level have already been done), there is a chance of ten to one that something has gone wrong during programming. The configuration fuses of the microcontroller are the main suspects.

As has been mentioned in an earlier 'LabTalk' article, modern microcontrollers have a number of bits (fuses) that define the behaviour of the IC. In the scope of this article we first have to look at the settings, if there are any, for the oscillator (internal/external, frequency range). If these settings are wrong then in most cases nothing happens at all.
The second suspect is — if present — the watchdog timer (WTD). If this has been turned on when programming and the application does not reset the timer, the microcontroller will repeatedly be reset and often won't even reach the actual program.

Number three is the setting for the reset circuit. For example, the reset signal for some microcontrollers can be selected to be internal or external. Consult the datasheet for the controller and check the remainder of the circuit to determine the correct settings. It can sometimes take a bit of looking around in the programmer software to find where these settings are hidden — as we already discussed in an earlier story — sometimes they have different names than what you would expect. In final desperation you could try all possible combinations of the fuses in the hope that one of them works. This sounds very awkward, but it will unfortunately be necessary at some point! Fortunately, reprogramming of a microcontroller is not such a time consuming job these days.

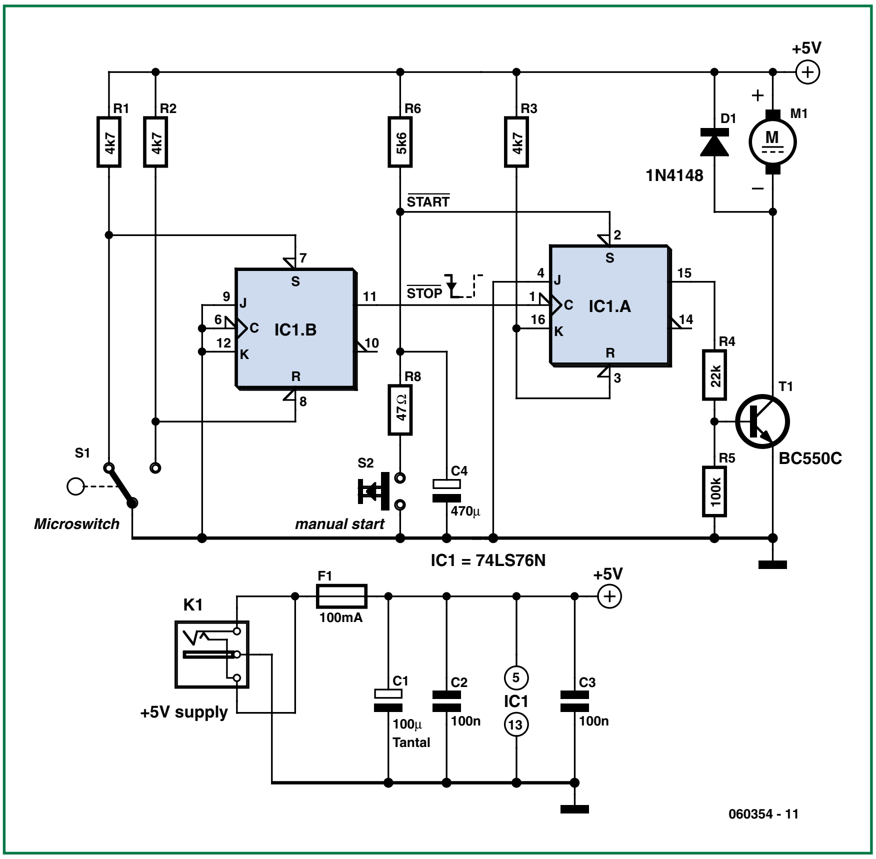
A simple start-up indication built into the application saves a lot of time and frustration — at this point you know that the hardware is functioning and that nothing went wrong when programming the memory and fuses. At a later stage of development, you could remove the start-up routine, but only do that if absolutely necessary.

(070101-I)

Automatic aquarium feeder

Helmut Schaefer

People come in all shapes and sizes and we all have our own character. You probably know people who are at their best first thing in the morning while others can only get things done when they are burning the midnight oil. The feeding habits of different fish species also show variation; some (such as catfish) are nocturnal feeders while others feed during the day. Unless your own body clock is in sync with the fish in your aquarium you will not be providing them with food when they really need it.



The solution described here is an automatic fish food dispenser. On the mechanical side the apparatus consists of an off-the-shelf DC motor and reduction gear driving an external gear train sandwiched between two plates. It is necessary for the spacing between the plates to be greater than the thickness of the fish food pellet (see illustration).
A hole in the upper plate is directly beneath a vertical tube (or magazine) which contains a stack of food pellets. The hole in the lower plate is offset and the pellets will eventually drop through here into the aquarium below. In between these holes is the final cog in the gear train which has a hole made in it between the hub and toothed edge of the wheel. The hole must be slightly bigger than the diameter of the food pellet. When the hole is beneath the column of pellets a single pellet drops down into the hole in the gearwheel. At each feed time the pellet is swept around until it passes over the hole in the lower plate where it drops through and provides a tasty snack to the fish waiting below. The prototype uses a motor/gearbox combination from Conrad Electronics (model catalogue, part no. 242535) which operates on 3 to 6 V and produces an output speed of 11 to 22 rpm. An external set of gears provides a further 10:1 reduction. The final output gear takes around 30 seconds to complete one revolution and the low operating speed helps to avoid the possibility of a pellet becoming jammed in the mechanism. The frequency of feeding is actually controlled by an external mains time-switch which switches a mains adapter powering the whole feeding mechanism. The electronics incorporated into the feeding mechanism ensures that each time the feeder is switched on it only dispenses a single food pellet. Modern time-switches can be programmed to switch several times in every 24hr period and can have an 'on' time of one minute or less. A small cam on the gear train output shaft actuates a micro-switch when a single revolution is completed. This technique of tuning the whole unit off in between switching times means that the standby current (excluding time-switch consumption) is zero. Another advantage is that each time the circuit is powered up it effectively performs a reset so it is not possible for the circuit to lock-up in an undefined state which sometimes occurs in digital circuits as a result of glitches and mains-borne interference.

The central logic element in the circuit is the TTL SN74LS76N J-K flip flop. In addition to the synchronous functions of this chip (store, set, reset and toggle) there are two asynchronous inputs namely 'preset' and 'clear' which are both active-low on this particular version of the flip flop. When power is applied to the circuit the preset input of IC1A is held low by the RC network R6 and C4 which ensures that the flip flop will always be set (Q = 1) at power up. Transistor T1 switches on and the motor begins turning. A feeding cycle can also be initiated by pressing the manual pushbutton. When the output gear wheel has completed one revolution and pushed a pellet over the hole in the lower plate a cam on the output shaft activates a micro-switch. This will ground the 'clear' input of IC1B and produce a negative going signal to the clock input of flip flop IC1A which clocks the state of the J input (0 V) through to the Q output to turn off T1 and the motor. The 'preset' and 'clear' inputs of IC1B are connected directly to the micro-switch output to provide a debounce function ensuring that a single clean clock edge is provided to IC1A. All the other inputs of IC1B related to synchronous operation are unused and tied to ground (logical 0).

Capacitors C2 and C3 should both be ceramic types and although reservoir capacitor C1 is shown as a tantalum a normal electrolytic type can be substituted. The motor together with the circuit draws around 35 mA. A 50 mA fuse (F1) is included in the supply to protect the motor and transistor should a food pellet become jammed in the mechanism and stall the motor. A more powerful motor can be used in the design but in this case it will be necessary to reduce the value of R4 to give a greater drive current and swap T1 for a power transistor. The fuse rating will also need to be beefed-up to handle the increased current.

A tip when drilling the plates is to start by making just two holes through the plates and then fitting two pins or bolts through the holes to fix the plates together before drilling the remaining holes that are common to both plates. This ensures that the holes will be properly aligned.
Although the design was developed for feeding fish it could also be adapted fairly easily for other applications that require a programmable momentary mechanical operation.

(060354-I)

Ultra-responsive peak detector

Stephen Bernhoeft

The peak detector presented here will respond to amplitude changes of the input signal within one-half of a cycle. Because no 'bleed' resistor is required on the output capacitor, droop is only limited by the 'off' resistance of a CMOS switch. Note that circuit is more accurately described as an *amplitude detector*, as the output level is equal to the average of the absolute values of the positive and negative amplitudes. For a sinusoidal input waveform, this corresponds to the peak detect function.

Positive and negative peaks are measured separately. Whilst the positive peak is being acquired, the negative peak is output, or vice versa. At the time a positive-going zero-crossing is detected, the positive peak detector is reset, and similarly for negative signals.

There are two key subcircuits. One is a peak detector, the other is a zero-crossing detector (ZCD). There are two instances of each type, corresponding to the two possible signs of the input signal. Note that all detectors (of both types) give a positive output.

When +ZCD goes high, this causes a brief pulse to reset the positive-peak detector. The reset has no effect on V_{OUT}, since the high level of the +ZCD means that the negative peak detector is connected to V_{OUT} at this time.

During this (positive) half of the input cycle, the +peak detector continuously registers the most positive input signal to date until such a time as it is reset.

Now consider what happens over the negative-going excursion of the input signal. Firstly, +ZCD goes Low, then –ZCD goes High. In the short interval that both are Low, the output capacitor is isolated. When +ZCD goes Low, V_{OUT} is removed from the negative peak detector output, and because –ZCD is high, V_{OUT} is instead connected to the positive peak detector output.

The negative peak detector operates in the same way as described above for the positive one, but because it sees an inverted copy of V_{IN}, it gives a positive (absolute value) output, as required.

The circuit shown is suitable for low frequencies up to a few kHz. The AD8534 is specified as unity-gain stable for capacitive loads of up to 10 nF. Empirically, it was found that even an ordinary opamp such as the LMC6484 gave no problems with ringing at V_{OUT}; possibly the 'on' resistance of the switch in the 74HC4066 helped to isolate the output capacitor.

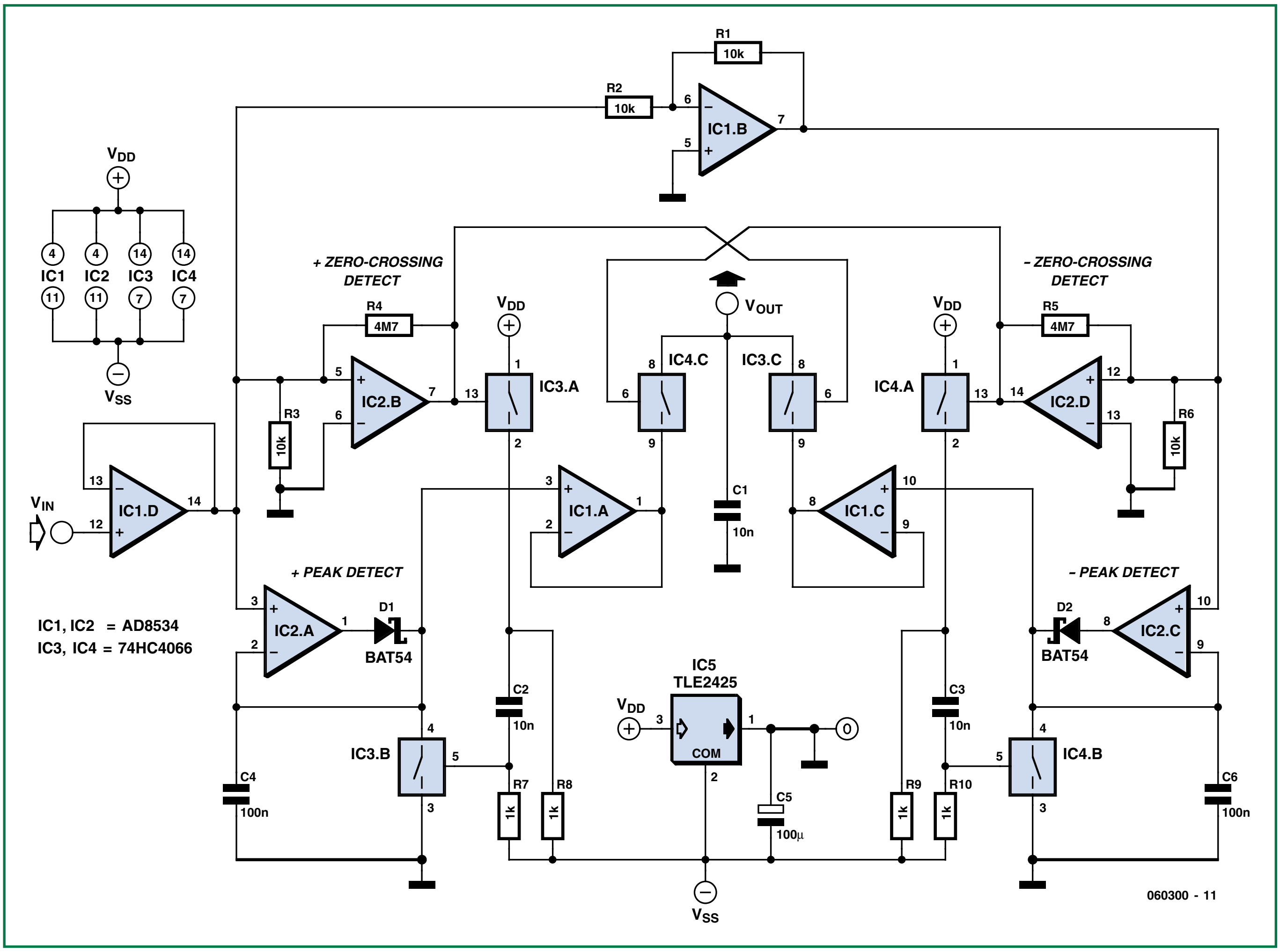
One speed restriction is the width of the reset pulse. It would be possible to use a monostable instead of the RC network. In order to allow short reset times, the MOS switches used here to short the peak detect capacitors could be supplemented with discrete, low $R_{DS(ON)}$ NMOS transistors, such as TN0200K. If necessary, dedicated comparators may be used for the ZCD sections.

Current consumption could also be reduced. Firstly, by swapping the comparator inputs around — the 'working' comparator inputs are high-impedance. If this is done, be sure to invert the BAT54 diodes as well. Of course, now we have an inverted output to the peak detector, i.e.

$$V_{OUT} = -V_{PEAK}$$

Lastly, if desired the inverting opamp stage may be amended to use 100 kΩ resistors.

(060300-I)



Hexadoku

Puzzle with an electronics touch

Despite all new-fangled computer programs the simple pencil & rubber are the preferred tools for solving our monthly Hexadoku puzzle. Add some good brain exercise and win one of the prizes: an E-blocks Starter Kit Professional and three Elektor Shop vouchers.

The instructions for this puzzle are straightforward.

In the diagram composed of 16 x 16 boxes, enter numbers such that **all** hexadecimal numbers 0 through F (that's 0-9 and A-F) occur once only in each row, once in each column and in each of the 4x4 boxes (marked by the thicker black lines).

A number of clues are given in the puzzle and these determine the start situation.

All correct entries received for each month's puzzle go into a draw for a main prize and three lesser prizes. All you need to do is send us the numbers in the grey boxes. The puzzle is also available as a **free download** from our website.

SOLVE HEXADOKU AND WIN!

Correct solutions received enter a prize draw for an

E-blocks Starter Kit Professional

worth **£248.55**

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

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

The competition is not open to employees of Elektor International Media, its business partners and/or associated publishing houses.

PARTICIPATE!

Please send your solution (the numbers in the grey boxes) by email to:

editor@elektor.com - Subject: hexadoku 4-2008 (please copy exactly).

Include with your solution: **full name and street address.**

Alternatively, by fax or post to: **Elektor Hexadoku**
Regus Brentford - 1000 Great West Road - Brentford TW8 9HH
United Kingdom - Fax (+44) 208 2614447

The closing date is **1 May 2008.**

PRIZE WINNERS

The solution of the January 2008 puzzle is: **90467**.

The **E-blocks Starter Kit Professional** goes to: Richard Berends (UK).

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

Jos Hartman (CH), Mehmet Sukuroglu (TR); David Gill (UK).

Congratulations everybody!

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

(c) PZZL.com

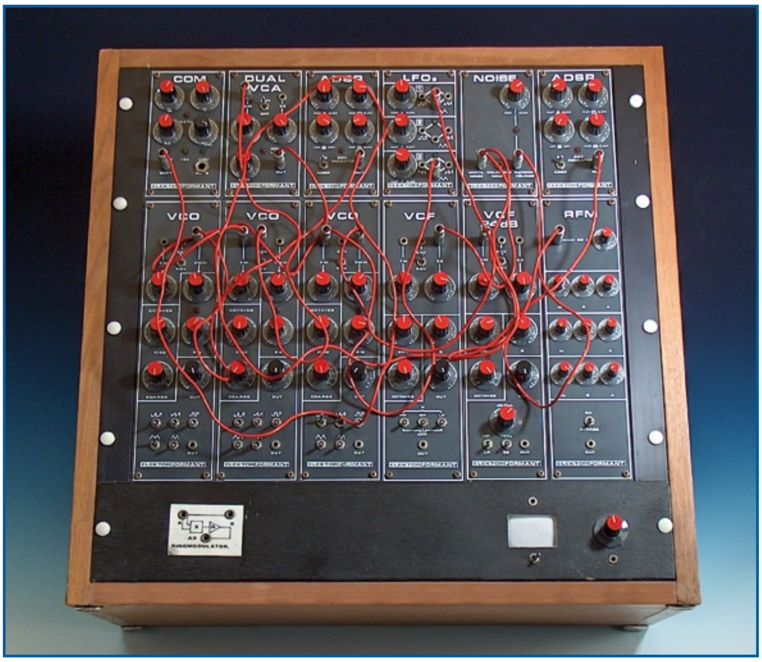
F	6	2	0	A	D	B	4	9	5	E	3	8	7	1	C
3	9	E	7	2	1	5	C	D	8	0	B	A	F	4	6
A	D	4	B	0	E	6	8	F	C	7	1	3	2	5	9
5	C	1	8	7	F	9	3	A	6	2	4	B	D	E	0
9	7	B	C	4	3	E	1	8	F	D	5	0	6	2	A
4	2	F	5	6	9	D	0	3	B	A	C	E	8	7	1
8	1	6	A	F	B	7	5	2	0	9	E	C	3	D	4
E	0	D	3	C	2	8	A	6	1	4	7	F	B	9	5
C	A	3	2	9	0	4	6	7	E	1	8	D	5	F	B
0	8	7	E	B	5	C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

Elektor Formant live performance now on YouTube

Formant synthesizer (1977)

Jan Buiting

'Formant' is without doubt one of the biggest names from the Elektor history. The mega project goes back a good thirty years, was forgotten for about 25, and now hails us through Google and Ebay. Along with Chorosynth, it is one of the vintage instruments presented at the fabulous www.synthmuseum.com [1] website brought to you by Paula Chase and Jay Williston.



The scene: it's 1970 and 'groovy' sounds are heard from Robert A. Moog's synthesizers like the one used by bands like Yes and Emerson, Lake & Palmer.
The Moog synthesizer was the *defacto* standard at the time, with lots of more or less electronically minded musicians (or musically minded electronics fans) adapting and extending it all the time to create their own flavour of sound. The pitch wheel in particular created sound 'bends' that became forever associated with the Hippy age. For a nice history of 'The Moog', see (and hear) [2].

The Elektor Formant was originally designed by C. Chapman and the project saw its first publication in the May 1977 issue of *Elektor*. In an attempt to jump the Moog bandwagon it was announced as "an instrument of advanced specification that bears comparison with many commercially available synthesisers, but at a fraction of the cost". The article series ended with part 10 (!) in the April 1978 issue. Two Elektor editors, now retired, recalled that the publications got immense acclaim but failed to sell significant numbers of the printed circuit boards. That changed dramatically, at first when the Formant article series were bundled into a book (1980), and a bit later (1981-82) when M. Aigner published follow-up articles (and a book) describing what looks like 'Formant mk.II' containing goodies like a Ring Modulator, Sample & Hold, Phase Shifter, Envelope Follower, Mixer, ADSR Controller, VC-LFOs, and other highly desirable sound warping circuitry, some based on Curtis ICs. By contrast, the original Chapman design, although comprehensive by itself, is a conventional Moog-style synth with a classic 1 V/octave characteristic and all the usual modules like VCO, VCF, LFO (made from 3 LFOs), Noise, ADSR, VCA, COM, RFM (not the manual but Resonance Filter Module) and a 24-dB VCF, not forgetting a keyboard and interface and of course a power supply — all DIY, built on Elektor 'EPS' printed circuit boards and taking almost 100 pages to describe in great (albeit dry) detail in the magazine.

Formant was rack-able consisting of circuit boards vertically mounted on a backplane with the controls (pots, switches) in bright colours on the front panel. The instrument pictured here is privately owned by my colleague Jan Visser from the Elektor labs who put it at my disposal for photography and sound checking of course! The wooden case was available at the time from electronics retailers advertising in the magazine. It's an almost fully loaded Formant complete with a keyboard and even a mini-oscilloscope to check the waveforms. With the current revival of seventies things & sounds, I reckon the instrument would fetch some hard cash on Ebay!

The smaller unit pictured here is the Aigner version with a modest complement of dual VCO, VCF, Dual ADSR, LFO and COM. This fine sounding specimen was rescued from the skip and is currently in safe storage at Elektor House. Reportedly the instrument was played 'live' several times at electronics exhibitions and shows in France and Germany during the mid 1980s.

(070937-I)

Retronics free download:
Formant music synthesiser book (2nd edition 1982).
www.elektor.com/retro_formant

Web Links

[1] www.synthmuseum.com/elektor/eleform01.html

[2] www.youtube.com/watch?v=TttYkC3NyjM

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.com

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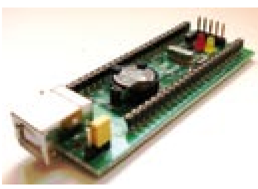

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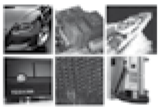

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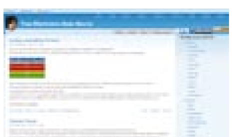

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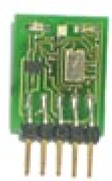

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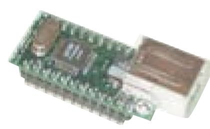

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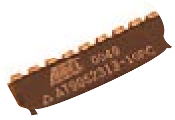

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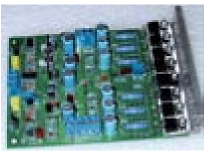

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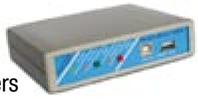

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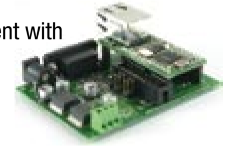

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5.0, 6.0, VBA, .NET, 2005

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Datalogger "deLuxe"

(March 2008)

We have had the pleasure of proposing various data acquisition units over the last few years. This Datalogger "deLuxe" is a nice exercise in product development. It actually utilises an SD card as the media for data storage. The hardware design is compact and that makes the firmware and software features even more interesting.

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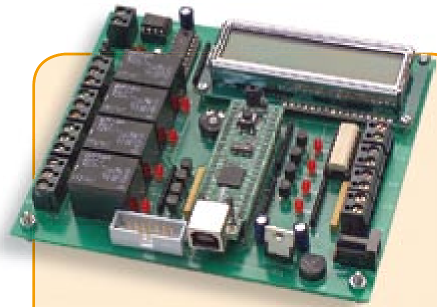

ECIO PLC

(March 2008)

An ECIO acts as the brains of this PLC board that has relays, opto-isolators CAN (!) connectivity and an LCD. All this I/O capacity together with Flowcode allows the board to act as a versatile, powerful PLC for quite complex control and automation projects. The LCD module is used to display ASCII characters to the user as a means of troubleshooting during the software development stage or for monitoring the system.

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(January 2008)

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071035-91 .... PCB, partly populated, ATM18 Controller module	7.30	14.60
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Frequency Response Sweep Oscillator		
070951-41 .... Programmed controller	5.40	10.80
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070745-41 .... Programmed controller	19.90	39.80
070745-71 .... Kit of parts (PCB, programmed controller and display)	71.75	143.50
The Secrets of I2C		
070600-1 ...... PCB, bare	13.60	32.60
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070859-41 .... Programmed controller	4.70	9.40
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LEDBUS System		
070459-1 ...... PCB, power module	www.thePCBshop.com	
070459-2 ...... PCB, central	www.thePCBshop.com	
070459-41 .... PIC12F638-I/SN, programmed (power module)	3.10	6.20
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060201-W ..... Testing & Error Sources Manual	www.elektor.com	
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January 2008 (No. 373)		
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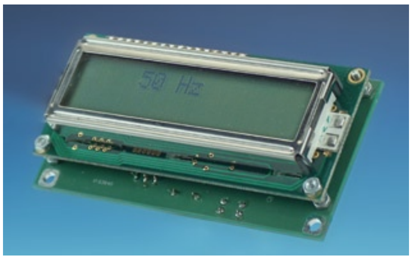
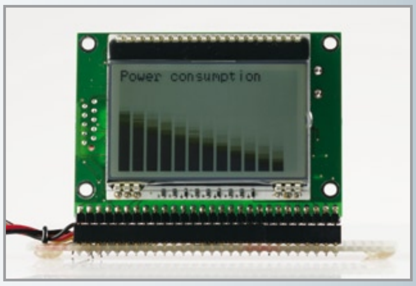
Measure it with the PC and the soundcard

Twenty-odd years ago, PCs were so slow no one dreamed of using them for live measurements. By contrast, today's machines happily run RTA (Real Time Analysis) and FFT (Fast Fourier Transformation) maths as a background task. Obviously the options for measurements depend strongly on the software used and that's why we examined a range of relevant products on the market. Also, the quality of the measurements results returned will be determined to a large extent by the sound card used; well it so happens that an Elektor test was planned for these.



Frequency Counter with ATtiny 2313

Only a few low-cost function generators and signal generators we've seen have a frequency display and an accurate frequency adjustment. The module we propose cancels both shortcomings. The core of the circuit is an ATtiny2313 microcontroller and that's about it for special ICs! Frequencies up to 5 MHz can be measured (without a prescaler!) and the LCD can be switched between MHz, kHz and Hz readout.



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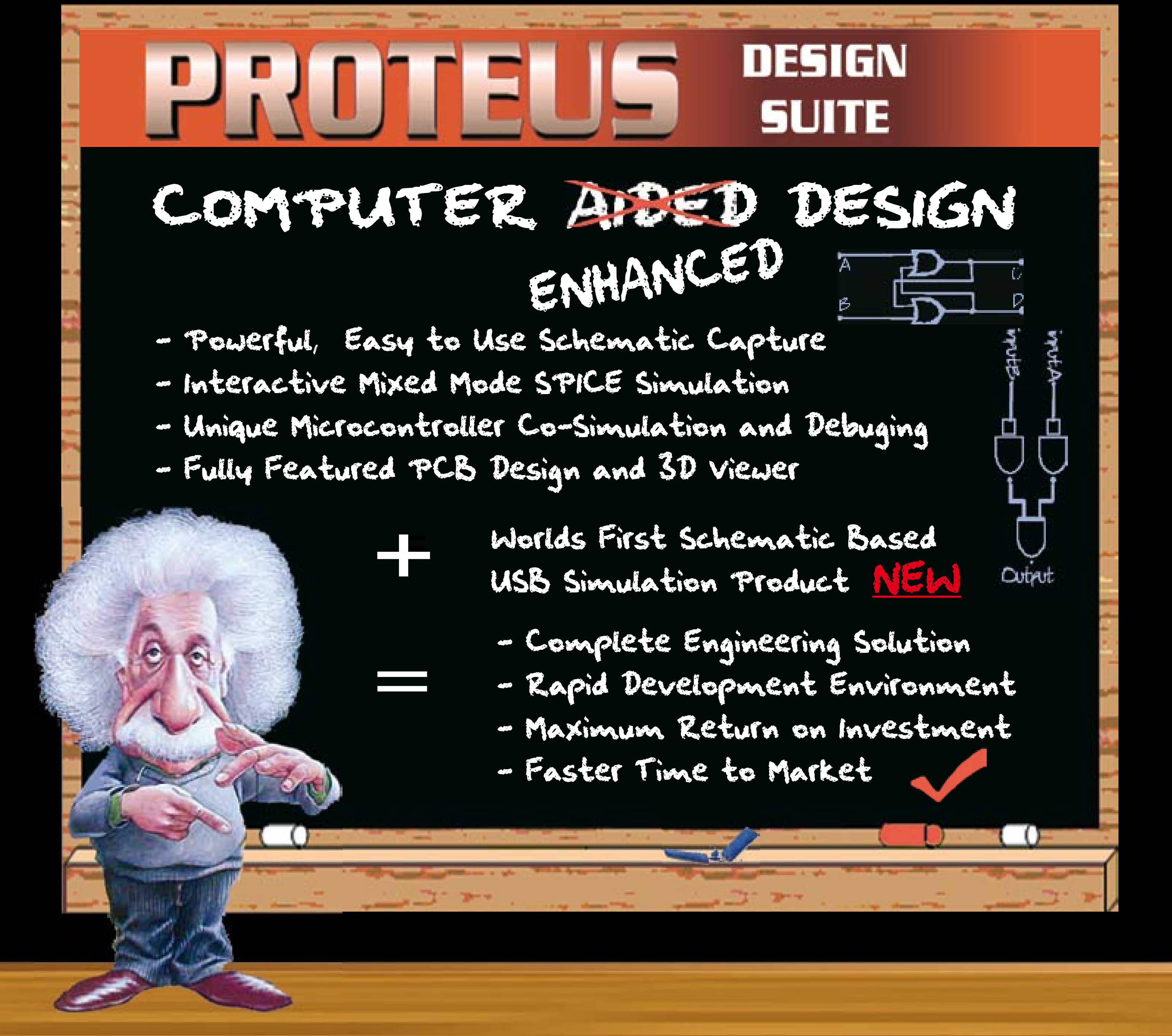
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