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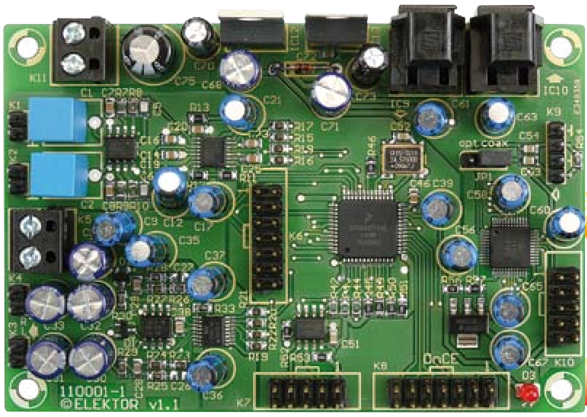
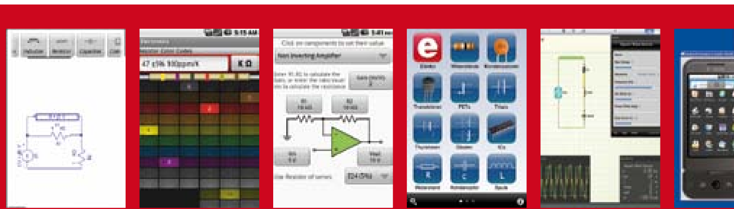


Audio DSP Course

Fast forward in audio signal processing

How useful are electronics apps for tablets and smartphones?



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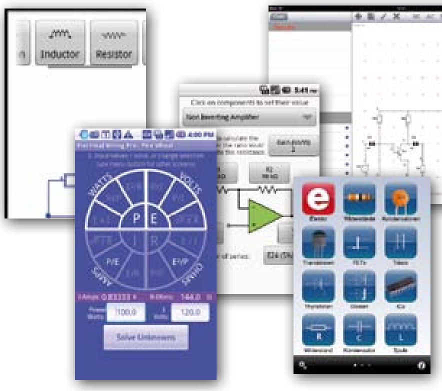
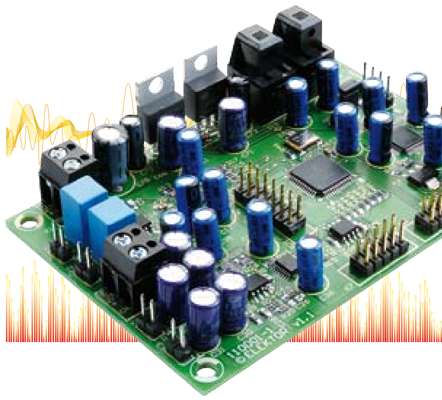
Digital Audio

Before the compact disc (CD) appeared on the market, sound editing involved nothing but analog signals. In essence a tiny alternating voltage from a microphone or a turntable stylus got sent through a number of gain stages before being applied to a tape recorder head, a disc cutter or a loudspeaker drive unit. These days audio editing and recording is considerably more complex, although consumers fail to realize it (excluding of course Elektor readers!). Today even the cheapest MP3 player is sure to contain a microprocessor or a DSP that performs advanced signal processing to enable memory resident data to arrive on your eardrums in analog form.
For sure, today's DSPs are very powerful cores suitable for all kinds (audio) applications, but at the same time they're highly complex beasts to deal with. Consequently it's not at all easy to design a DSP-based circuit and associated software if you're not at home in this area. The DSP course launched in this edition we hope spells the end of fears and ignorance surrounding DSPs. Although we intend to make practical aspects prevail, inevitably some interaction with theory is required considering that everything in this course revolves around real circuits with a DSP inside. Along the course several example projects will be discussed, all of which can be replicated at home or in the lab using a universal DSP board developed by the author in close collaboration with Elektor Labs. Having digested the course in a few months time you should be ready to start developing custom applications for the DSP board. In this edition we kick off the course with some theory you really can't get around before the programming and soldering can commence. So bite the bullet and join our DSP course, it's sure to be fun and educational.

Enjoy reading this edition,
Jan Buiting, Editor





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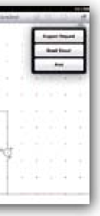

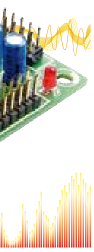

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Elektor International Media provides a multimedia and interactive platform for everyone interested in electronics. From professionals passionate about their work to enthusiasts with professional ambitions. From beginner to diehard, from student to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

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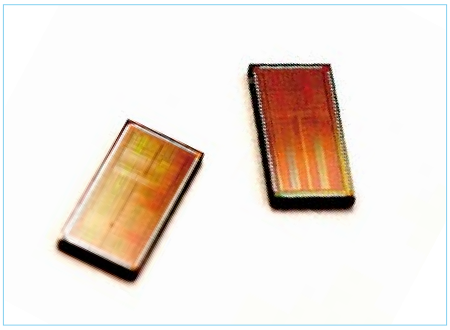
Smart meter reference design harnesses 32-bit Kinesis architecture

Freescale featured a smart meter reference design in its Smart Wall display at the recent Embedded World conference. The reference design provides a high-performance solution for power measurement in single-phase, two-wire installations targeted at the residential metering market.
With the growing consumption of energy worldwide, particularly in the residential market, utility providers need increasingly accurate and cost-effective energy metering solutions. Freescale's MK30X single-phase electricity meter reference design addresses these accuracy and cost needs by providing efficient analog-to-digital converters (ADCs) combined with an embedded programmable gain amplifier (PGA) to increase the accuracy of energy measurement, along with a cost-effective shunt sensing circuit implementation.
The 32-bit Kinetis MK30X256 MCU at the heart of the MK30X reference design is based on the ARM Cortex-M4 core. This powerful core's effective support of 32-bit math enables metering algorithms based on fast Fourier transform (FFT) methods, which calculate metering quantities from basic and harmonic voltage and current readings. Unlike other metering algorithms, this approach yields in precise reactive power measurements.
The MK30X reference design includes a 128-bit unique ID and FlexMemory that gtives every meter an individual identifier and tamper detection. Firmware based on the MQX real-time operating system enables customers to design electricity meters based on their specific requirements and is well suited for use in advanced markets.
Customization is available using the built-in LCD, which provides the standard metering values. Designers can select any of the measured values by clicking the device's built-in buttons. They can also choose from several types of communication interface for remote data acquisition. One option is connection to a ZigBee network via an I²C interface, facilitating easy integration of the meter into a smart grid network. Another option is to use SCI/SPI for "last-mile" connection outside the home.

www.freescale.com/smartenergy (110049-X)

Biomedical signal processor slashes power consumption

At the recent International Solid State Circuit Conference, Imec, the Holst Centre and NXP jointly presented a versatile ultra-low power biomedical signal processor dubbed CoolBioTM, designed to meet the requirements of future wearable biomedical sensor systems. The novel device consumes only 13 pJ/cycle when running a complex ECG algorithm at 1 MHz with an operating voltage of 0.4 V. The C-programmable chip is voltage and performance scalable and supports a clock range of 1 MHz to 100 MHz with an operating voltage of 0.4 to 1.2 V.
Intelligent body area networks (BANs) consisting of wireless sensors nodes which continuously monitor vital body parameters such as heart, muscle and brain activity hold promise for healthcare systems that are more comfortable, more cost-effective and more time-efficient. They allow people to be monitored up at home during their everyday activities. A major challenge in developing BANs is to reduce power consumption to a level where the system can be powered by energy harvesting or a micro-battery with a service life of several months. The CoolBio processor yields a drastic reduction in the operating power of wireless BAN sensor nodes. Processing and compressing data locally at the BAN node limits power-hungry data transmission over the wireless link, while reducing motion artifacts and enabling smart diagnosis.
Imec, Holst Centre and NXP based the design of the special biosensor processor on a standard low power CoolFlux™ DSP baseband core from NXP. The architecture



and circuitry were adapted to operate at near-threshold voltage (0.4 V) at low operating frequencies. Extreme partitioning into different voltage, power, clock and memory domains was implemented to ensure high energy efficiency from standby to 100 M Hz operation. This yields reduced power consumption at low operating frequency while maintaining high performance capability for multi-channel biomedical signal processing.

http://www2.imec.be/be_en/ (110049-V)

Triangle Research rolls embedded PLCs with onboard Ethernet

The FMD88-10 and FMD1616-10 PLCs are Triangle Research International's (TRi) latest Ethernet-equipped programmable logic controllers for OEMs. With the new FMD PLCs, Triangle Research now has a full range of highly integrated "Super PLCs," extending from the compact Nano-10 to the powerhouse F-series. This Super PLC series combines powerful. user-friendly i-TRiLOGI Ladder+BASIC software with a wide array of features, including built-in digital and analog I/O, PWM, PID, encoders, stepping motor control, and on-board communication ports for connecting to other devices.
As the model number implies, the FMD88-10 features 8 digital inputs, 8 digital outputs and 10 analog I/Os, while the FMD1616-10 has 16 digital inputs, 16 digital outputs and 10 analog I/Os. Both models are equipped with an I/O expansion port, an LCD display interface, RS232 and RS485 serial ports, and of course an Ethernet port, which has become increasingly indispensable today.
Triangle Research's iTRILOGI client/server software and support for ModBus TCP/IP protocols not only make the FMD model PLCs remotely accessible for machine monitoring and OEM troubleshooting or repro-

gramming, but also enables them to be easily integrated into mixed-brand PLC environments and networks.
The sub-$300 pricing of the FMD PLCs is rare for full-feature Ethernet PLCs in this popular I/O range, making these PLCs a particularly accessible choice for value-conscious OEMs.
The FMD88-10 and the FMD1616-10 single unit prices are $229 and $295 respectively, and are further discounted with OEM quantity price breaks.

www.tri-plc.com/fmd-ek.htm (110049-VI)

New phosphorescent materials could enhance solid-state lighting

New organic phosphorescent emitters could drastically cut the cost of solid-state lighting panels, according to a team of researchers at the University of Michigan (USA). The team claims to have found the first example of a purely organic compound that can compete with metal-doped emitters in terms of brightness and color tuning capability.
Unlike fluorescent materials, phosphorescent materials do not immediately re-emit the radiation they absorb, but instead continue to glow for up to several hours after the original excitation. Previously this property has been seen only in compounds

doped with metals, called organometallics. However, the new metal-free organic compounds discovered at the University of Michigan, which appear white in visible light, emit blue, green, yellow and orange light after absorbing ultraviolet light.
The novel compounds, called aromatic carbonyls, form strong bonds with halogens in the crystal matrix. This allows the molecules to be tightly packed, which suppresses vibrational and thermal energy losses during recombination and results in strong but nevertheless tunable phosphorescence. The color depends on the precise chemical formula, and quantum yields of approximately 55 percent have been achieved.
Research associate Kangwon Lee discovered the unique properties of aromatic carbonyls, which were developed further by fellow researcher Onas Bolton. Funding was provided by the US National Science Foundation and the National Research Foundation of Korea.

http://ns.umich.edu (110049-VII)

World's smallest JTAG boundary scan controller debuts

Goepel Electronics has launched the PicoTAP, billed as the world's smallest JTAG boundary scan controller with a single test access point (TAP) interface. The new and

extremely handy device is designed for simple boundary scan testing and programming tasks and for cost-critical applications throughout the entire product life cycle.
The PicoTAP boundary scan controller communicates over a USB 2.0 interface and is also powered from the USB port, yielding a convenient and efficient solution. It provides a preconfigured TAP and can be plugged directly into the item under test, with no need for an adapter. For additional convenience, the PicoTAP also provides 5 V auxiliary supply voltage capability switchable at the TAP interface.
Users who wish to upgrade their boundary scan applications at a later point in time benefit from the fact that programs generated with the PicoTAP are cross compatible with all controllers from Goepel Electronics, including their Scanbooster series and the high-performance Scanflex® platform.
According to a Goepel spokesperson, the new low-cost controller was developed in response to increasing customer requests for performing simple or non time-critical testing, debugging and programming with minimal equipment. Furthermore, the PicoTAP provides an convenient entry point for standardized IEEE 1149.x compliant testing by maintaining full compatibility with Goepel's existing hardware and software portfolio.

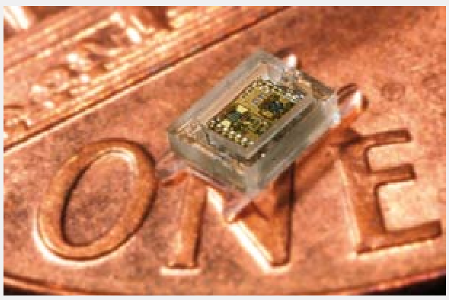
http://www.goepel.com (110049-IX)

mec unveils front end IC for cognitive radio systems

Accelerated deployment of broadband personal communication coupled with rising demand for high data rates leads to increasing spectrum scarcity. Dynamic access to the available spectrum would increase throughput efficiency significantly. For example, in licensed radio bands dynamic spectrum access would allow personal mobile terminals to seamlessly establish and maintain reliable wireless links, while in unlicensed bands it would considerably enhance the utility of devices that rely on uninterrupted connectivity to provide the desired service – such as security, health care, and remote monitoring devices.
Conventional radio architectures are designed to receive a predefined channel and are not suitable for fast, cost-efficient and energy-efficient multi-mode communication and spectrum sensing (frequency scanning), which are essential for next-generation cognitive radio systems that enable dynamic spectrum access. As part of a program aimed at paving the way for effective and energy-efficient cognitive radios and networks, Imec has now developed a digital front end component for low-cost, low-power spectrum sensing. It is designed to provide spectrum sensing functions in collaboration with Imec's analogue reconfigurable radio chip (Scaldio) and programmable digital baseband platform for 4G seamless connectivity (Cobra).
Imec's new DiffS spectrum sensing IC is a versatile digital engine designed to operate in a wide variety of applications scenarios with low cost and low power overhead. The IC, which hosts a dedicated application-specific integrated processor, can perform flexible synchronization and spectrum sensing in diverse environments, including high-throughput WLAN (802.11a-n), mobile telecommunication (including recent 3GPP-LTE systems), and digital broadcasting.

http://www2.imec.be/be_en/ (110049-II)

Researchers develop millimeter-scale computer



Researchers at the University of Michigan have developed what is claimed to be the world's first all-in-one millimeter-sized computer, including everything from solar cells for power to a wireless radio for communications. The novel device was unveiled at the International Solid State Circuits Conference in February.
Designed for implantation inside the eye of glaucoma patients, the tiny all-in-one computer could also be used in wireless sensor networks, remote surveillance, and other applications requiring on-chip trackable intelligence. According to University of Michigan professor Dennis Sylvester, who was assisted in the development by fellow professors David Blaauw and David Wentzloff, the device is the first true millimeter-scale complete computing system. Blaauw noted that millimeter-scale systems open up a wealth of new applications for monitoring human bodies, buildings and the environment, and the associated increase in per-capita system use is a strong driver for the semiconductor industry.
The first application envisaged for the millimeter-scale computer is monitoring the pressure inside the eyes of glaucoma patients to track the progress of the disease. Packaged in a volume of less than one cubic millimeter, the system contains a microprocessor, pressure sensor, memory, thin-film battery, a solar cell for recharging, and a wireless radio and antenna for transmitting stored measurement data.
The current prototype is the third generation of what the researchers call their Phoenix project. According to them, it consumes 10 times less power in active mode and 30,000 times power in standby mode than conventional processors. In the glaucoma monitoring application the device wakes up every 15 minutes to take a measurement and transmit the reading, for an average power consumption of just 5.3 nanowatts. It needs about 1.5 hours of sunlight or 10 hours of indoor light to recharge its battery.

http://ns.umich.edu (110049-VIII)

Credant Technologies releases cloud encryption beta software

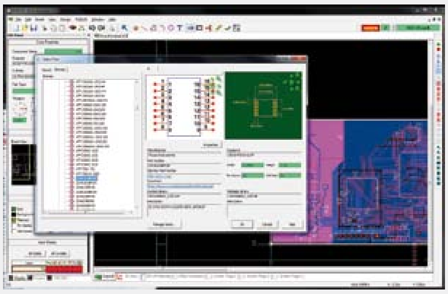
Data protection specialist Credant Technologies has released the beta version of its cloud encryption software for virtual desktop infrastructure (VDI) private cloud infrastructures. The new Credant cloud security platform enables enterprise customers to accelerate adoption of cloud infrastructures by removing the primary roadblock: data security. With this launch, Credant enables organizations to control and enforce security for corporate data located in private, hybrid or public cloud infrastructures. The Credant cloud security platform is claimed to be the only cloud data security approach with support for granular encryption, access control and key management that allows enterprises to protect against insider threats, including from the cloud provider itself.

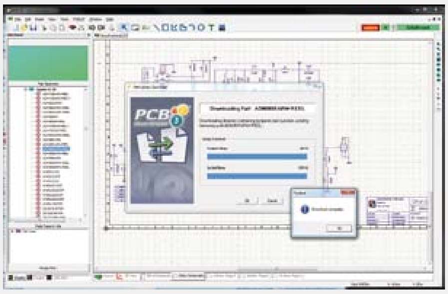
CREDANT® We Protect What Matters

Credant's approach, new to the field of cloud security, is to protect the data instead of specific volumes, drives or devices. According to Credant, their encryption technology is the only automated, centrally managed, policy-based solution on the market, providing real-time protection and peace of mind for enterprise and government customers with sensitive data.
The solution is designed to enable businesses and government organizations to deploy private cloud infrastructures as part of their long-term roadmap to full cloud utilization by putting data security under the control of the enterprise rather than the cloud administrator. The Credant cloud security platform effectively eliminates the risk of insiders (either within the organization or working for an outsourced provider) accessing or stealing sensitive data; gives authorized users granular access to decrypted information while restricting administrators to system access; enables seamless and transparent management of data security in physical infrastructure, mobile devices, removable media, private clouds, VDIs and hybrid/public cloud models; and prevents unprotected data leakage to removable media while enabling secure usage and control of removable storage.

www.credant.com/cloudsecurity (110049-XI)

PCB123 CAD tool gets new, improved schematic editor





PCB prototype solutions provider Sunstone Circuits has enhanced their PCB123® circuit board design software with the addition of a powerful, flexible and intuitive new schematic editor that makes the design process even easier. Sunstone's newest version of their advanced CAD tool now makes the prototyping process faster, easier and more accurate, from project concept to PCB delivery.
In keeping with the strategy defined with the release of PCB123 version 4.0 in September 2010, Sunstone Circuits is constantly enhancing the feature set of their PCB design tool, configuring the software into an even more user-friendly and intuitive resource for design engineers. Version 4.0 introduced data sheet availability, automated bill of materials (BOM) and expanded parts libraries with 500,000 current parts definitions, 2 to 10 times more than available with any other PCB design tool. Now version 4.1 adds seamless synchronization of the layout and schematic views to give engineers even more flexibility and reliability during the PCB design process. This enhanced integration of the design and layout views yields a fully industrial-grade tool in terms of features, performance and mean time between failures (MTBF). Other new features of the CAD software include optimized graphics, which reduce design time and allows engineers to create cleaner drawings.

www.Sunstone.com (110271-I)

Transparent LCD panels utilize ambient light

Samsung commenced mass production of 22-inch transparent LCD panels in March of this year. The panels are available in two versions – monochrome and the color – and have a contrast ratio of 500:1 with WSXGA+ resolution (1680 × 1050 pixels).
Transparent display panels have unlimited potential applications for advertising displays, which can be fitted on store windows, integrated in outdoor billboards, or used in showcases. Businesses and schools can also use the panels as interactive communication devices that allow information to be displayed more effectively.
Unlike conventional LCD panels, which use a backlight unit and have only 5% transparency, Samsung's transparent LCD panels have a transparency of over 20% for the monochrome version and over 15% for the color version. This allows viewers to see through the panel at the same time as they view the displayed imagery. The transparent LCD panels utilizes ambient light, such as sunlight, which reduces overall power consumption by 90% compared with conventional LCD panels with backlighting and reduces the dependence of the display on an external power connection.
Samsung's transparent LCD panels are designed to maximize convenience for both manufacturers and consumers by incorporating HDMI and USB interfaces.

www.samsung.com/us (110271-III)

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www.nxp.com/cortex-m0

Development Tools on the Go

How useful are electronics apps for tablets and smartphones?

A wide and rich variety of software tools is available for electronics development. These engineering aids are no longer confined to the PC: smartphones and tablet computers already have plenty of apps available for them too. So, we decided to find out what programs are available and how usable they are.

By Christopher Rausch
(Elektor Germany Editorial)

PC-based software for designing and simulating electronic circuits is now a common weapon in the engineer's arsenal. Readers will no doubt have heard of products such as Proteus and PSpice. Although these programs are capable of delivering very accurate simulation results [1], they are nevertheless often very expensive and require a PC. However, an internet search will reveal electronics applications not just for PCs, but also for smartphones and tablet computers; these are usually much cheaper and in some cases are even offered for free. The computing power now available in mobile devices is very high, and the devices are almost exclusively operated using a touchscreen. We decided to find out what the apps are capable of and what features they offer the user. What opportunities (and what problems) does the touchscreen interface bring, and how restrictive are the relatively small displays?

To answer these questions, we took a closer look at two apps for smartphones and two for the Apple iPad. In the case of the smartphones we decided to try the free Android operating system. This OS is very widely used and gives software developers more freedom than they have when developing for the iPhone, for example. Whereas Apple developers cannot freely distribute their programs to run on real hardware without obtaining prior approval from the manufacturer, Android developers face no such hurdles. Indeed, Android developers are not even forced to use the official Android application market. For our tests we used the Windows Android emulator (see text box) from the official Android SDK (software development kit) [2].
An overview of some other electronics applications, untested by us, appears in the

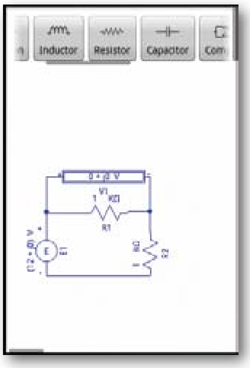


Figure 1. A voltage divider in Droid Tesla.

Figure 2. Col or code decoder in Electronica.

inset towards the end of this article. The selection of smartphone applications is based on a list produced by Android expert Stefan Schwark.

Development tools in your pocket

The palette of electronics applications available for Android smartphones ranges from digital reference works and component value calculators to software for drawing and simulating electronic circuits. Because of the relatively small display, smartphone applications make much greater demands on the user interface in terms of understandability and ease-of-use. On the other hand, the applications make the ideal vademecum for the engineer on the move.

The first application that we will look at more closely is called Droid Tesla [3]. This software (**Figure 1**) is a circuit simulator. The user interface controls (which can be hidden) allow you to construct your circuit and then start the simulation. The simulator can currently cope with devices including resistors, capacitors, inductors and complex impedances as well as voltmeters and ammeters. Voltage and current sources are available to power the circuit. Voltage and current are specified with real and imaginary components, which is relatively unusual. Unfortunately the simulator does not provide a graphical display of its results: the values can only be read from the virtual voltmeters and ammeters. The way that various elements can be hidden on the display is convenient and saves space, though it can often be fiddly to connect components exactly as you want. The relatively small screen area available compared to a PC's monitor also makes it difficult to get a good overview of a large circuit.

The majority of electronics applications for Android smartphones are calculators and reference information for frequently-used components and circuit modules. The standard repertoire includes resistor colour-code decoders, calculators for Ohm's law, potential dividers, resonant circuits and other basic elements of electronic designs. The second application in our test belongs to this category and is called 'Electronica' [4]. It includes a range of calculators, a color code decoder (**Figure 2**) and information about IC and connector pinouts. In terms of the number of different functions offered this program is one of the smaller ones of its kind, but it is easy to use and quickly leads to the required results. The individual tools can be selected using a category menu and are clearly laid out.

Circuit design on the iPad

The iPad is a tablet computer, like a smartphone with a somewhat larger (9.7 inch) display. It is almost exclusively operated using its touchscreen. A wide range of electronics applications is also available for this device. The spectrum ranges from calculator applications and component databases to circuit simulators. Again we meet the question of how successful the touchscreen is as an intuitive interface for the application, and how suitable the iPad software is for practical use. For our test we selected two circuit simulators for the iPad. We managed to construct small circuits with the help of the software; we also managed to call up pre-loaded circuits and simulate them, with the results being displayed graphically.

The first application we will look at is Software Circuit Lab HD [5] (**Figure 3**). As almost invariably with the iPad, the touchscreen is used to enter schematics. First it is necessary to tap the points between which the component is to be connected. Then the desired component is selected from a menu and inserted into the schematic. Compared to a drag-and-drop approach, this method takes some getting used to. The components available include passives such as resistors, capacitors and inductors, as well as semiconductor devices such as diodes, operational amplifiers and bipolar transistors. The component library is thus more than adequate for small analogue circuits. DC and AC voltage and current sources are also available, both

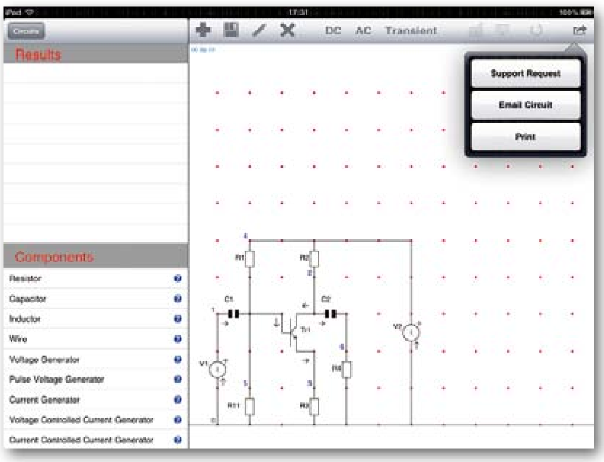
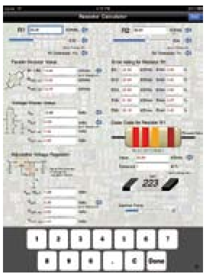
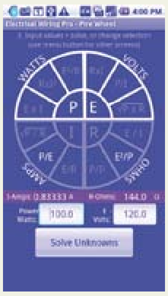
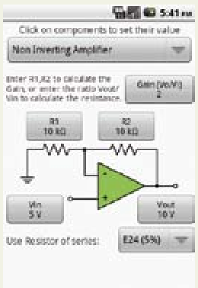


Figure 3. Transistor circuit on the iPad.

More Android and iPad applications

iPad		**DCircuit Lab HD**: This is the companion application to Circuit Lab HD for digital components. According to the maker, combinatorial and sequential circuits can be analyzed either step by step or in one go. *(http://sites.google.com/site/lurvill/dcircuitlabhd)*
		**Elektor Electronic Toolbox**: This tool is a large collection of electronic aids, including many calculators, converters, IC datasheets, circuit diagrams and pinouts for connectors. *(www.elektor.com/news/electronic-toolbox-for-the-iphone.1412874.lynkx)*
		Ohm's Calculator: This is a simple application for performing calculations based on Ohm's law. A special user interface simplifies entering the desired values. *(http://smartchef.org/rantekinc/)*
		**Scientific Electronics Circuit Calculator for iPad**: This is a collection of calculators and formulae for the working electronics engineer. Results are automatically recomputed whenever a component value is changed, so that results are obtained quickly. *(http://www.syclabs.com/CircuitCalciPad.html)*
android		**Elec Ref**: This is a collection of calculator tools for cables, transformers and motors, along with information about various types of cable. *(http://www.trunnion.info/elecref.html)*
		**Electrical Wiring Pro**: This is a collection of information and tools all relating to cables and cabling. A complete feature list can be found on the maker's website. *(http://www.intineo.com/electrical_wiring_pro.html)*
		Audio Test Tone Generator: This application includes a signal generator for sine, triangle, square and sawtooth waves as well as a range of different types of noise, with both graphical and audio output. *(http://www.digitalantics.co.uk/android/audio-test-tone-generator)*
		**ElectroDroid**: ElectroDroid includes a range of calculator tools and information (pinouts of various interface connectors) for electronics engineers. *(http://demisoft.altervista.org/_siti_interni/electrodroid/)*

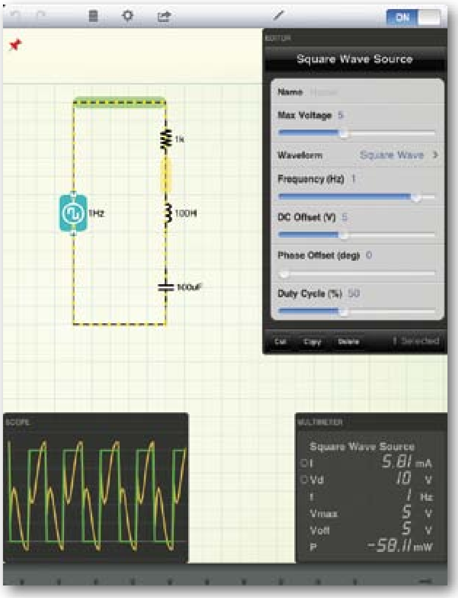
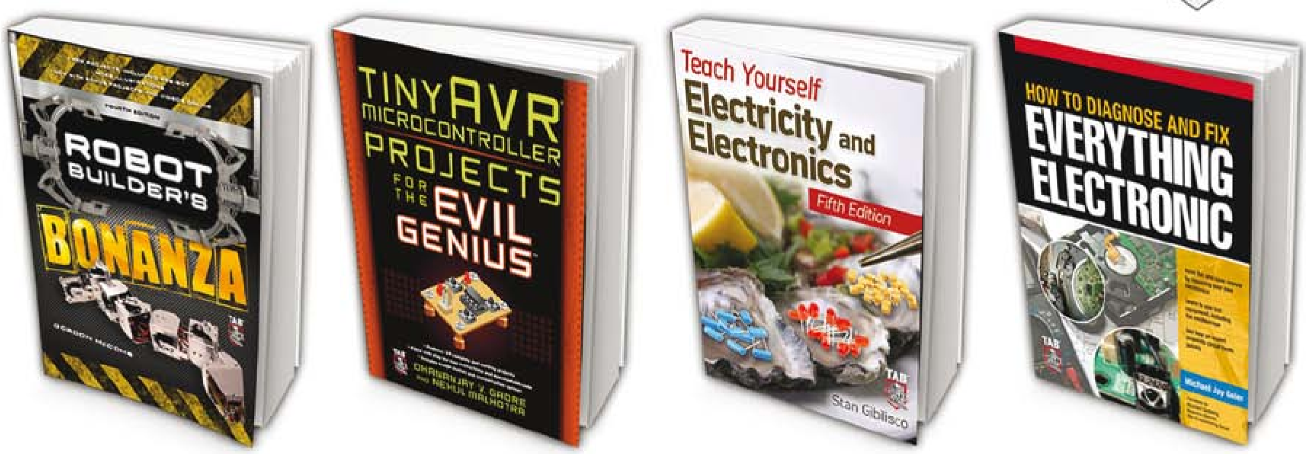


Figure 4. Simulating a circuit using iCircuit.

controllable and fixed. Component values can be entered using the iPad's on-screen keyboard. When the circuit is complete, the user can start the simulation and display the various currents and voltages around the circuit either numerically or graphically. DC, AC and transient (evolution of currents and voltages over a specified time period) simulation are available. When the software presents results graphically, several curves can be overlaid on one graph. Sadly the graphs are presented without scales, which makes interpreting the results difficult and imprecise.

Simulation as a game

Like the application described above, iCircuit [6] is a circuit simulator. However, it gives the user the opportunity to modify the circuit while the simulation is running and observe the effect of these modifications on the live plots produced by the program. Schematics are constructed using a drag-and-drop approach: the components are dragged from the menu to the right place in the schematic using a finger, and wired to one another in a similar fashion. Component values can be entered either by using the on-screen keyboard or by using a slider (**Figure 4**). Changing a component value does not force the simulation to stop, which means that you can interact with the circuit almost like a toy, giving the software an educational feel. A wide range of components is available including standard passives as well as switches, semiconductors including diodes, bipolar transistors and field-effect transistors, A/D and D/A converters and simple logic devices. Visualisation of the simulator results is via virtual oscilloscopes.



Internet Links

[1] www.elektor.com/100359

[2] http://developer.android.com/guide/developing/tools/emulator.html

[3] https://market.android.com/details?id=org.vlada.droidtesla

[4] https://market.android.com/details?id=com.hacsoft.electronica

[5] http://sites.google.com/site/lurvill/circuitlabhd

[6] http://icircuitapp.com/

[7] http://developer.android.com/sdk/index.html

These displays can be hidden and revealed as required. It is also possible to display current magnitude and direction as well as charge distribution on the wires in the schematic.

Conclusion

Developing and simulating larger circuits on smartphones is still rather difficult. The main reason for this is the relatively small size of the display on these mobile devices compared to a PC's monitor, which makes it very easy to lose sight of the overall structure of a larger circuit. The functionality of the applications is also lacking in some respects, although it is worth bearing in mind that in many cases the software is free. The smartphone is better suited to calculator and reference tools. The display is large enough for this kind of application, and it is possible to display all the necessary content in a convenient and comprehensible way. The portability of the device is also a significant plus, making it a handy tool even when out and about.

The iPad applications we looked at are suitable for constructing and simulating small circuits, but do not offer the range of functions that a professional electronics designer would find necessary. This applies both to the range of components that can be used and to the facilities for analysing the simulator output. But again, the application only costs a fraction of what one might pay for a professional piece of PC-based software. The touchscreen is an intuitive interface, but sometimes lacks the precision needed to draw circuits and to wire up components with confidence. For school pupils, students and hobbyists, however, iCircuit is a good choice. The live simulation feature and the ability to visualise current flows within the circuit makes the software a good basis for experimenting and learning.

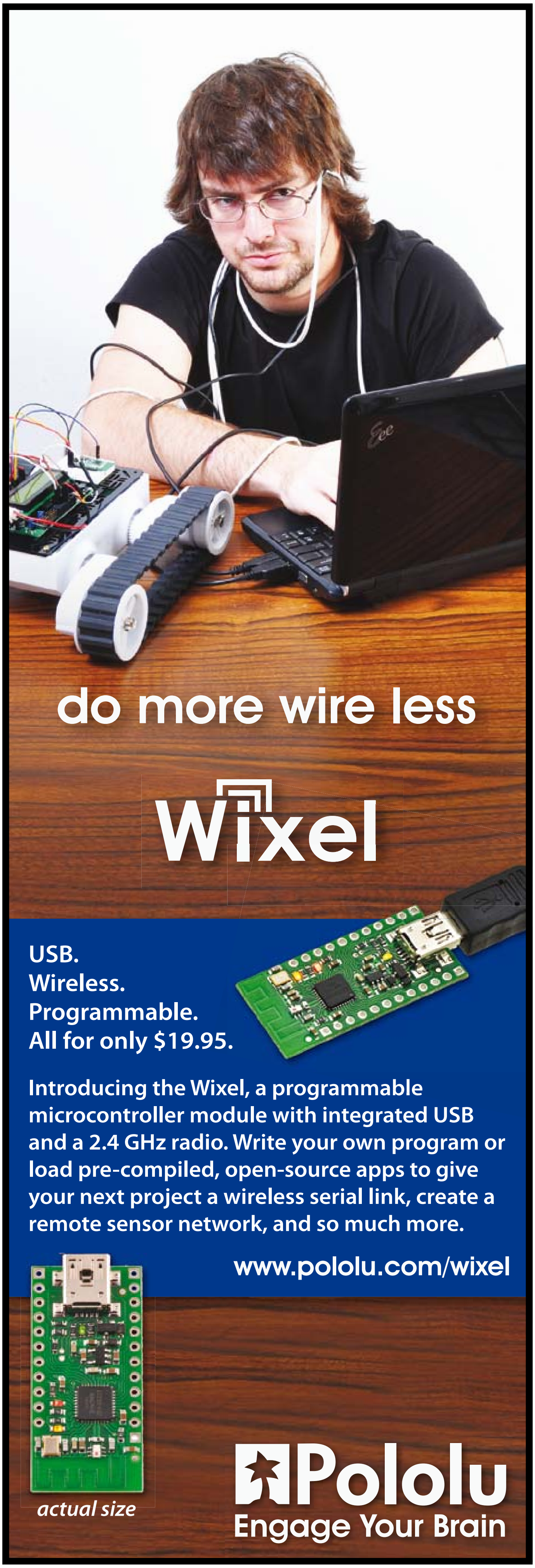
(110230)

About the author

Christopher Rausch is a master's student in Technology and Communications, specialising in electronic engineering, at RWTH Aachen University. He is currently working as an intern with the Elektor Germany editorial team.

Android Emulator

The emulator forms part of the Android software development kit [7] and is able to simulate an Android smartphone on a PC. This is an excellent way for software developers taking their first steps in Android device programming to try out their programs quickly and easily without needing actual hardware. The user can install new applications on the system either by downloading them using a pre-installed browser, or by using a console command and an Android package (APK file) that has been previously-downloaded or built. To take the latter route, the user must (under Windows) open a DOS command window (command.exe) in addition to the emulator, and then, using the familiar DOS commands (such as 'cd <path>') switch to the directory from which the Emulator was started. Installation is then carried out using the command 'adb install <file path>' entered directly at the command window. The full path to the package file is required as a parameter, including the '.apk' suffix. When installation is complete, the new program will be found in the applications menu of the emulated smartphone.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The Nixie Tube

The design and control of Nixie tubes

By Jens Boos (Germany)

There is no doubt Nixie tubes are once again trendy. No other display technology has quite the same character. The fact that we are unlikely ever to see these devices in consumer products (unless production restarts) makes their use in a one-off design special. If you are planning to add the Nixie coolness factor to your next home brew design we give details of their operating principle, power supplies and practical advice on driving the tubes. To inspire you a collection of fascinating reader's projects has been included.

To describe a Nixie tube as an electronic device for displaying numbers or characters is a reasonably good description of its basic function. It does not however give the full picture; a bit like describing a log fire as a type of room heater. Although Nixies are essentially cold-cathode devices many people find their orange glow very appealing, evoking nostalgia and memories of a bygone era. Back in the 1950s to the 1970s before the advent of LEDs, Nixie tubes displays were standard fare on frequency counters, bench timers and most other test equipment, Elektor even featured a project using them [1].
In more recent times we have responded to the revival of interest by publishing the 'Sputnik Clock' in January 2007 [2] and the 'Nixie Tube Thermometer' in January 2011 [3]. In this article we shed some light on their operating principles and give some historical background of the device.

A little history ...

During the course of the 20th century with the rise of digital electronics it became more important for equipment to deal with numeric values and to display values as numbers rather than the using the less precise analog meter or crude indicator lamp. At the beginning of the 1950s the Nixie tube was developed to meet this need. It can display different types of symbols, is free of mechanical wear and consumes very little power. Interestingly a patent was granted for a Nixie-like indicator device back in the 1930s [4] but was never commercially exploited at the time.

There is a certain amount of confusion over which company was the first to produce a functioning 'Nixie-like' display tube. The typical Nixie tube familiar to collectors today was first introduced in 1955 by the Burroughs Corporation who one year later registered it as a trademark [5]. The name Nixie was originally only used internally in Burroughs to stand for 'Numeric Indicator eXperimental no. 1' (**Figure 2**). One year earlier (1954) the company National Union had introduced its own design named the Inditron but this device remains something of a historical curiosity. The tube did not have an anode so required more complex driver electronics and it quickly lost ground to the Nixie when it was introduced.

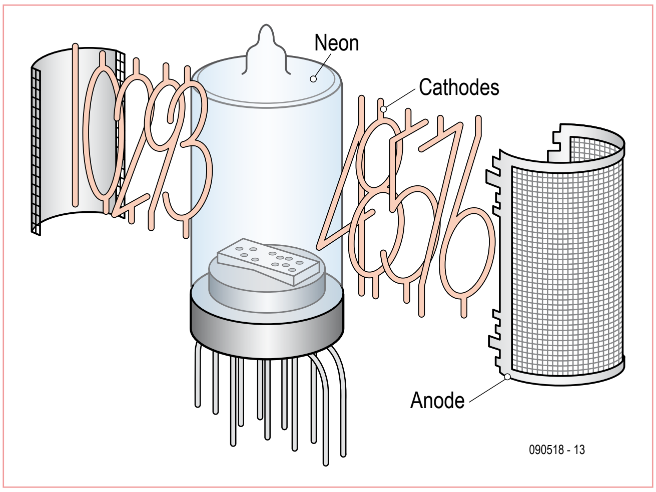


Figure 1. Construction of a typical Nixie tube.

In the following years the Nixie gained acceptance throughout the world and led to the production of the tubes in the UK, Germany, France, Poland, Russia, Japan and China, sometimes under licence to Burroughs.

The last Nixie tubes to be built rolled off the production line in Russia in the early 1990s. The company Richardson Electronics Ltd in the US reputedly still have all the necessary machines to begin production should the need arise [6].

Figure 2. Advertisement for a Nixie (ca 1955).

The complete range of Nixie tubes produced is impressively large. The author has amassed a good selection of tubes over the years some of which are shown in the photo on the first page. A few of these examples are very rare and quite precious [7].

The structure and function

The Nixie tube consists of a sealed glass envelope filled with the noble gas neon or a mixture of neon and argon. Later models also included mercury vapor. Each of the display numbers has been punched from a very thin metal sheet. These are fixed in the glass envelope and wired to individual pins on the tube's base. Each number forms a cathode connection (**Figure 1**) and can be independently controlled. The anode typically consists of a fine wire mesh surrounding the numbers.

A small proportion of the neon-argon gas filling is already ionized due to the influence of the ever-present cosmic radiation. When a DC voltage is applied between the anode (plus) and cathode (minus) the electric field generated accelerates the available free charge carriers (electrons and gas ions) in the glass envelope. When this DC potential exceeds a certain value the speed of the particles (particularly electrons) is sufficient to ionize the neutral gas molecules. A charge-carrier avalanche occurs, causing significant current to flow through the tube. This 'strike voltage' is typically in the range 120 to 150 V.

Figure 3. The Burroughs HB-106 along with the GI-10 from National Union.

A surplus of positive charge carriers (positive space charge region) builds up around the cathode while these gas ions have a much higher mass than the electrons. At this point the voltage gradient and therefore the field strength is increased so that the external voltage can now be reduced to some extent while still maintaining conduction. The lowest voltage necessary to sustain conduction is called the maintaining voltage; and is typically 5 to 10 V below the strike voltage.

When the Nixie is operating at a voltage somewhere between the strike and extinguish voltages (i.e. at the *maintaining voltage*), electrons form the majority of the flow through the tube. Shortly after leaving the cathode their speed is sufficient to excite emission from the noble gas (electrons in the outer shell of the noble gas atoms are moved to a higher energy level and then release a photon as they fall back to a lower energy level). On close inspection it can be seen that the illumination in the tube does not actually occur on the surface of the cathode but a little way out creating a 'glowing tube' effect around the shaped cathode. The electrons must first be accelerated to the necessary energy level.

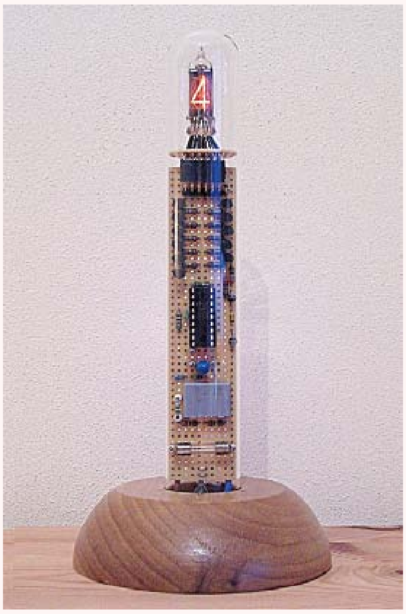
The color of the emission is orange with a gas filling of pure neon, adding some argon to the mix gives the orange a pale violet fringing. Blue effects can be attributed to the addition of mercury vapor.

The series resistor

Current through the Nixie must be limited by using a resistor in series with the power supply. Without the resistor, arcing will occur causing the tube to overheat and be damaged. The series resistor value can be calculated (in the same way you would for an LED) using the formula:

$$R = V / I = (V_s - V_{maint.}) / I_{nom.}$$

A typical value lies in the range from 10 to 80 kΩ. The anode to cathode strike voltage and

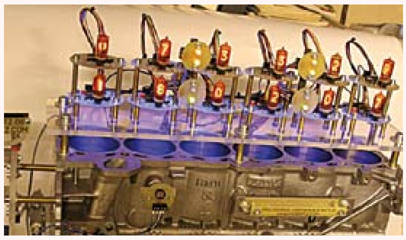


Tube-In-A-Tube

Ronald Dekker has a good selection of Nixie-based projects on his website. One of these is a Nixie clock powered directly from the mains mounted in an inverted test tube. The circuit doesn't require any high voltage transistors or special ICs (www.dos4ever.com/TiT/TiT.html).

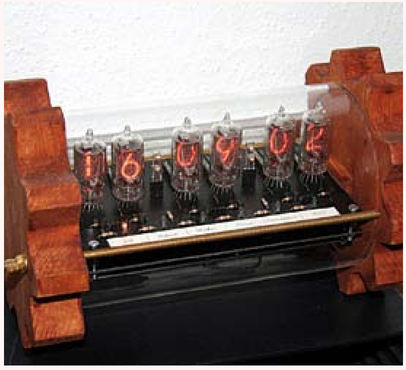
An engine block clock

This is unusual, a DCF clock mounted in a BMW engine block! Steffen Möritz developed this idea in his spare time and has also designed a rev counter with Nixie tube display for his 1961 Mercedes-Benz.



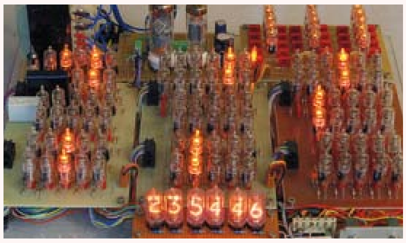
Nixie clock meets Ethernet

Nixie tubes and clock designs belong together. Tobias Krista has designed his with an Ethernet interface. It can request the current time from an NTP server (Network Time Protocol) without the need for a PC. In addition all the functions (Alarm clock, Countdown etc.) can be accessed remotely using a web interface.



A silicon-free clock (display)

This Nixie clock by Michael Pape doesn't use any silicon devices at all. The circuit uses over 100 XC18 type valves. Several ring-counter circuits are used to derive a 1 Hz clock from the AC power frequency.



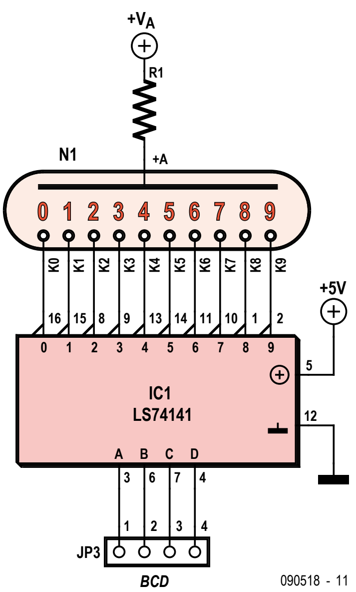


Figure 4. The LS74141 driver IC contains a BCD to decimal decoder and ten transistor drivers.

nominal maintaining current for a particular type of Nixie tube will be given in the corresponding data sheet. Where there is no data sheet available the series resistor value can be ascertained empirically. Using a supply voltage of 180 V identify the common anode pin and cathode pin connected to the displayed character with the minimum surface area (usually the number '1'). Take precautions to ensure that all connections are properly insulated. Connect a high value resistor (a 100 kΩ pot is a good choice here) in series with the supply and tube. Slowly reduce the resistance of the pot until the character starts to glow. When the whole area of the character is glowing uniformly and current through the tube is within spec (1 to 5 mA, or more for larger Nixies) turn off, remove the pot and measure its value. Now select the next highest fixed resistor from the E12 series to use as the series resistor. Larger characters require a smaller resistor (greater area of emission). Take care with the resistor power rating; 2 mA through 100 kΩ will fry a 0.25 W resistor.

Driving the Nixie

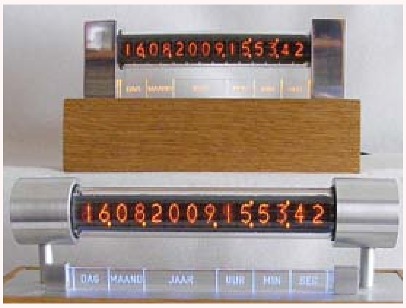
The Nixie tube requires a relatively high supply voltage but not too much current. There have been many different systems to drive the device, some of the more common methods are shown here in chronological order.

Unfortunately it is not possible to use LED driver chips directly because they are not be able to handle the high voltage required for the tubes (although [8] is an exception).

Beam switching tubes

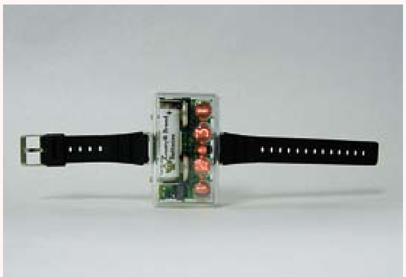
Originally a Nixie would have been driven by a 'beam switching tube'; a vacuum tube decade counter which counts using the electromagnetic effect. The fastest versions could be clocked at speeds up to 10 MHz [9].

The tube can interface to a Nixie tube with very little additional circuitry directly. This method was originally used by Burroughs; these tubes are however more scarce nowadays than Nixies. In addition they are quite bulky [10].



Precisely two clocks!

These two clocks are the work of Loek Riemens. The first clock (at the bottom) receives time information via DCF while the second uses GPS satellite data to provide time information. The display of the GPS version changes color from orange to red when it is receiving a signal from less than two satellites.



A remarkable watch

A wristwatch with Nixie tube displays? Reader Hugo Marien flagged up this project designed and built by Jeff Thomas. This watch measuring 7 x 4 x 3 cm uses miniature Nixie tubes and is sure to turn heads. Go to Jeff's website (www.amug.org/~jthomas/watch.html) for more information.

Nixie voltmeter

Nixies are seldom used in voltmeter designs but this project designed by the author of this article can be found on his website. It uses Russian tubes type IN-14 and IN-19B. (www.jb-electronics.de/html/elektronik/nixies/n_voltmeter.htm).

Illuminated room thermometer

This rather elegant room thermometer is the work of Simon Law and Alex Tsekenis. The temperature is displayed using an IN-13-Nixie tube. The current version has both Celsius and Fahrenheit scales and the backlight colour changes according to temperature — awesome!

Discrete Driver ICs

With the advent of digital technology came the driver IC type LS74141 (or the Russian equivalent K155ID1). It is a BCD to decimal decoder together with ten driver transistors in a 16-pin DIL outline [11]. The circuit is given in **Figure 4**. These chips are widely available (eBay or [12]) but their price is steadily rising, currently they cost 1 to 2 US$. The advantage of this chip is the space saved on a PCB layout. One disadvantage is that only one output can be active at any time (the BCD to decimal decoder activates 1 of 10 outputs). In addition these chips cannot handle too much current; 7 mA (i.e. 80 mW) maximum.

Transistor drivers

Driving the tube using discrete transistors is also a possibility. The MPSA42 (NPN) and the MPSA92 (PNP) are the most common 'Nixie transistors'. Both of these are available in SMD and THT packages at reasonable cost. The disadvantage of this approach is that a transistor is required to drive the cathode of each displayed element so it consumes a relatively large area of the PCB layout (see **Figure 5**). Compared to the driver IC method described above discrete transistor drivers are more flexible and can be used to drive any bit pattern that may be required by the Nixie tube and not just one single element in the tube. Transistors can also drive more current (up to 100 mA), enough for all types of Nixie.

The Supertex HV series

The company Supertex [13] produce chips for high voltage applications for driving displays such as vacuum fluorescent (VFD) and plasma displays, some of these chips are also suitable for use with Nixies.

These devices are more sophisticated than the methods described above; not only can they drive high voltage outputs but they also contain shift registers to store the displayed bit pattern. They therefore have few input signals (Data input, Clock, Strobe and Blanking) but 20, 32 or up to 64 outputs. **Table 1** gives an overview of some of the more interesting ICs.

Some of the chips in the HV family of chips do not allow multiple outputs to be switched simultaneously so make sure you study the relevant data sheets. These chips are not stocked by the usual chip suppliers in the UK. It will be necessary to do some investigative work to track down a source [14].

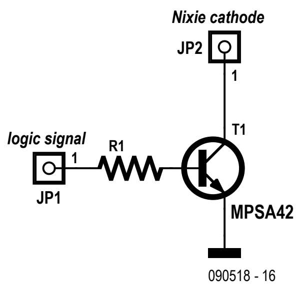


Figure 5. A circuit using discrete driver transistors.

Supplying the juice

We have already mentioned that these devices require a high voltage supply but

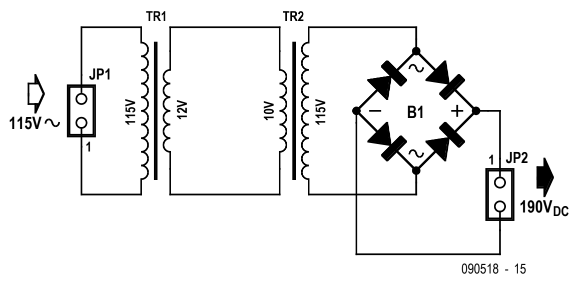


Figure 6. The high voltage is produced by reverse-connected TR2.

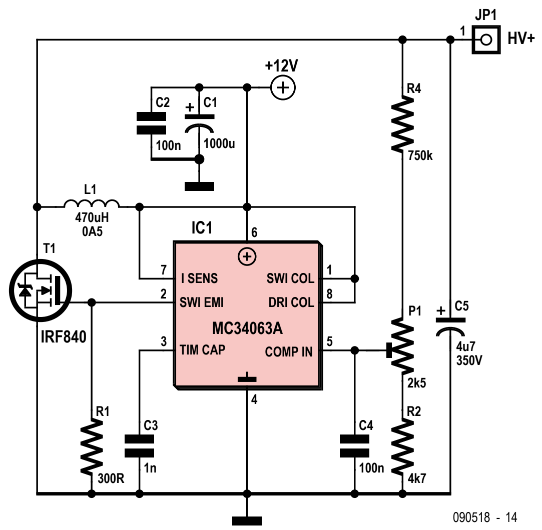


Figure 7. Boost converter using a (Standard) switch regulator type MC34063A [16].

not yet suggested how this can be achieved. A number of possibilities exist:

Direct from the AC outlet?

The simplest and least expensive option (as the author has sadly too often witnessed) is to rectify the AC outlet voltage. With this approach the complete circuit will be at AC grid potential and therefore hazardous. You have been warned!

Back to back

A power transformer with a 140 V secondary is a fairly rare beast. A better alternative is to use two low voltage transformers wired back to back. This achieves galvanic isolation for the entire circuit. The first PCB mounted 12 V transformer is wired to the AC as usual but its secondary is wired to the low voltage winding on the second transformer (see **Figure 6**). Choosing a 10 V transformer for T2 will give an output voltage of 138 VAC at its primary winding. After rectification and smoothing a DC voltage of 190 V is produced — good enough for the majority of Nixies. The maximum output current from this design is limited by the transformer ratings.

A Switch Mode Power Supply (SMPS)

Switch mode power supplies using the Boost-Converter (Step-up-Converter) principle can be used to generate the high voltage. The circuit relies on the principle of electromagnetic induction to generate high voltage. A current is passed through a coil and then abruptly interrupted. The voltage induced in the coil is proportional to the change of magnetic flux. A very fast step change will induce a voltage much higher than the supply voltage to the circuit. The induced voltage is then passed through a diode and smoothed with a high voltage capacitor. When this process is repeated it produces a stable high voltage supply.
In **Figure 7** shows the circuit for boost-converter supply using a standard switch regulator IC type MC34063A (thanks to Dieter Wächter for this circuit [15]).
Ready-made, fully assembled and tested switch mode supplies are also available for the less adventurous, designing a low-noise supply is not a trivial exercise. A good overview of some commercial designs can be found at [16].

Table 1. High voltage driver

Name	Output	Voltage	Current	Outline	Price
HV5522	32 (open drain)	220 V max	100 mA *	44 PLCC, 44 PQFP	$ 8
HV5630	32 (open drain)	300 V max	100 mA *	44 PLCC, 44 PQFP	$ 9
HV9708	32 (push/pull)	80 V	20 mA, 5 mA	44 PLCC	$ 6
HV5812	20 (push/pull)	80 V	3,5 mA	DIP28, 28 PLCC	$ 3.50

* check max power dissipation!

The Author

Jens Boos studied physics at RWTH Aachen, Germany. He includes electronics and collecting Nixie tube as hobbies. He already has over 300 tubes in his collection gathered from all over the world including some rare and valuable examples. For more information visit the authors website

www.jb-electronics.de.

Web links and Literature

[1] Elektor (German), January and February 1972, 'Digital Frequency Counter'

[2] www.elektor.com/050018

[3] www.elektor.com/090784

[4] US-Patent US2142106, issued on 3rd January 1939 to Hans Paul Boswau

[5] Serial number '72020699', applied for in 1955, view under http://tess2.uspto.gov/

[6] www.amug.org/~jthomas/clockwork.html

[7] www.jb-electronics.de/html/elektronik/nixies/index.htm

[8] http://dos4ever.com/QandA/QandA.html

[9] www.decadecounter.com/vta/tubepage.php?item=18

[10] www.radiomuseum.org/forum/nixie_and_trochotron_haydu_vs_burroughs.html

[11] www.tube-tester.com/sites/nixie/74141-NDT/74141-NDT.htm

[12] www.askjanfirst.de

[13] www.supertex.com/

[14] www.mouser.com/

[15] www.nixie.tube-tester.com

[16] www.tayloredge.com/storefront/SmartNixie/PSU/comparison.html

[17] www.nocrotec.com

[18] www.kosbo.com

A bright future for Nixies

There is no doubt that Nixies are of interest not just to collectors of electronic curiosities but also to home brewers worldwide. The following page shows some fascinating Nixie based designs. The enduring appeal of them is evident from their rising prices on the second-hand market. The tubes are now changing hands at four or five times the price they were fetching at the beginning of the year 2000. A good selection can usually be found on eBay or from specialist websites ([12] [17] [18]). Whether the existing stocks of Nixies will be sufficient to cater for the growing interest in this technology remains to be seen.

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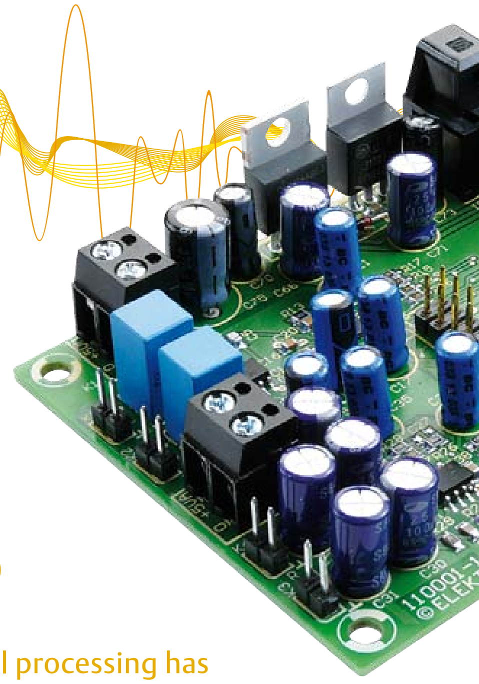


Audio DSP Course (1)

Part 1: Audio signal processing with a DSP

Since the advent of digital signal processing around 30 years ago, audio signal processing has increasingly shifted from analog technology to digital technology. In this course, in addition to introducing you to the properties of digital signal processors for audio signals and the associated programming aspects, we present several applications based on an inexpensive but nevertheless high-performance signal processing module.

By Alexander Potchinkov (Germany)

Just as an operational amplifier is a general-purpose component for the analog processing of audio signals, a digital signal processor (DSP) is a general-purpose component for the digital processing of audio signals. However, this comparison tells only part of the story, since a digital signal processor — besides having more pins than an operational amplifier — is considerably more complex and can do a lot more. This series of articles begins with a brief discussion of digital processing of analog audio signals. Next we present and describe the key features of the Freescale DSP56374 digital signal processor, which comes in a 'soldering-friendly' 52-pin package and is specifically designed for the task of digitally processing audio signals. With a processor clock frequency of 150 MHz and sophisticated signal logic, it provides enough computing power to implement very complex audio signal processing tasks.
We also present three practical projects based on a DSP board developed for this series of articles:

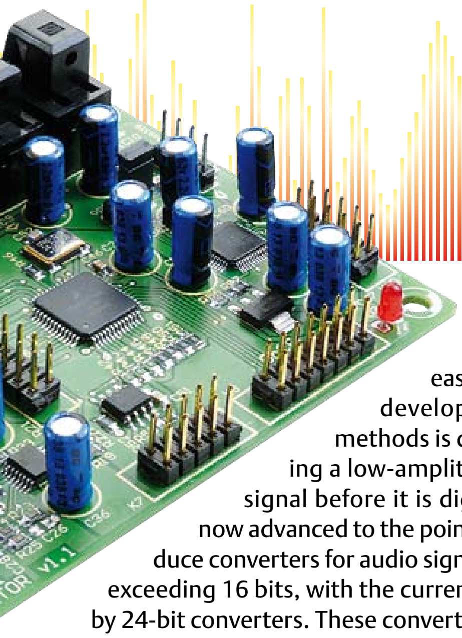
- A digital audio signal generator that can output low-distortion sine-wave signals, white and pink noise, as well as octave band or one-third octave band noise
- A peak-value signal level meter with LED bargraph display
- A dynamic signal processor with compression, limiting and noise gate functions

Digital processing of analog audio signals

A microphone generates an analog signal, and loudspeakers are driven by analog signals. For many decades, audio technology was analog all the way from the microphone to the speaker. High-fidelity technology in the period from the late 1960s to the 1980s was also analog, and as many of us know, it achieved highly satisfactory results. CDs as replacements for phonograph records first appeared on the scene in 1982, and they left phonograph record far behind on the cost and quality fronts. At first, relatively little digital audio signal processing was needed for CD technology. In simplified terms, all that was necessary was to use an analog to digital converter (ADC) to digitise the analog signal from the microphone, copy the resulting digital data to a CD, read it out in a CD player, and use a digital to analog converter (DAC) to change it back into an analog signal. From an external perspective, this is a signal path with analog input and output interfaces.

As you know, CDs work with 16-bit word resolution. It is not especially easy to produce converters (ADCs and DACs) with suitable quality. This relates not only to the converters themselves, but also to the analog filters necessary for their operation: the anti-aliasing filter ahead of the ADC and the reconstruction filter after the DAC. The engineers at Philips who developed the CD technology recognized this early on, and they came up with a clever idea for sophisticated digital signal processing. In simplified terms, Philips managed to achieve nearly 16-bit quality with a 14-bit DAC by using oversampling and noise shaping in an upstream digital filter, which amounted to genuine digital signal processing.

In this connection we should mention a fundamental problem in the digital processing of audio signals. Analogue audio signal processing has the highly desirable property that nonlinear distortion is low at low signal levels and high at high signal levels. This matches our sense of hearing, since we hear better at low acoustic levels than at high acoustic levels. Unfortunately, digital audio signal processing has exactly the opposite property. At low signal levels the amount of nonlinear distortion is high relative to the desired signal, while at high signal levels it is relatively low. This has inspired engineers and mathematicians to approximate the analog situation by devising methods that reduce the perceived amount of nonlinear distortion at low signal levels or allow the distortion to be filtered out of the audible frequency range relatively



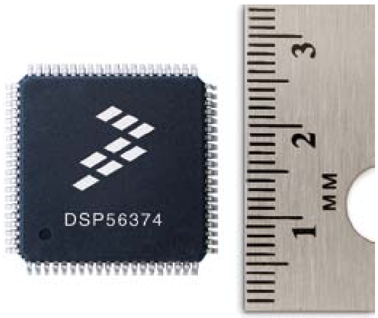
easily. Along with the techniques developed by Philips, one of these methods is dithering, which involves adding a low-amplitude noise signal to the audio signal before it is digitized. These methods have now advanced to the point that they can be used to produce converters for audio signal processing with resolutions exceeding 16 bits, with the current state of the art represented by 24-bit converters. These converters employ almost exclusively digital techniques for audio signal processing and require only a little bit of supplementary analog signal processing.

Digital signal processors

A digital signal processor is a special type of processor designed to provide many functions that fulfil the typical requirements of digital signal processing. This involves the processing of repetitive algorithms, usually with fairly simple structures but a large number of computation steps, under real-time conditions. The clock rate for executing the algorithms is determined by the sampling rate of the digital data, which in the case of a CD is set by the sampling frequency of 44.1 kHz. This means that the DSP algorithm must be fully processed in approximately 22.7 µs, from which the time necessary for servicing the audio interfaces must be subtracted.

Processor architecture

Figure 1 shows the block diagram of the DSP56374. It has a typical Harvard architecture, with multiple data and address busses and several memory areas that can be accessed in parallel. DSPs are register-based processors. The operands and the results of the computations, most of which are arithmetical, are stored in registers or read from registers. This enables single-step operations without microcode, but it also requires load and store transactions between the memory areas and the registers. Fortunately, the hardware architecture and the address generation units (AGUs) allow this to be done in parallel with the arithmetic computations. AGUs are computation units that convert memory addresses into typical DSP addressing modes independently of the actual data processing.



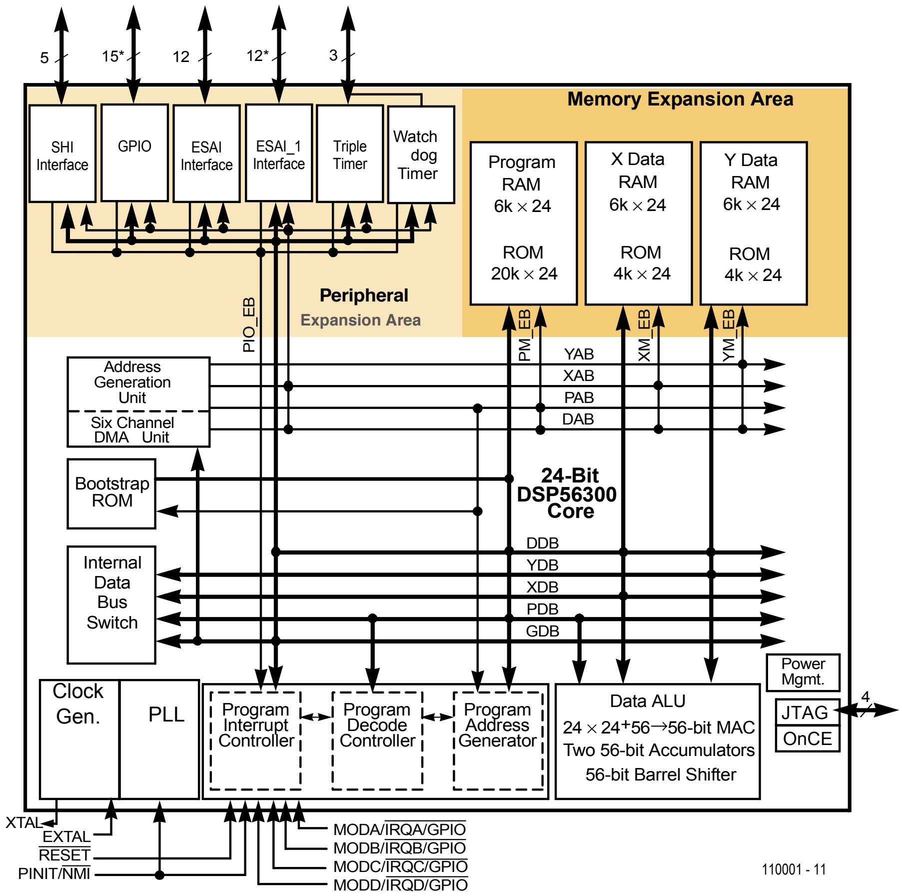


Figure 1. Block diagram of the DSP56374 digital signal processor.

The Serial Host Interface (SHI) block is a synchronous serial interface that can be operated in SPI or I²C mode. In both of these modes, the DSP is able to act as a bus master or as a bus slave. This interface can be used for connection to a microcontroller, among other options. The General Purpose Input/Output (GPIO) block provides I/O ports for general tasks, similar to the I/O ports found in just about ever microcontroller. Each of the two Enhanced Serial Audio Interface

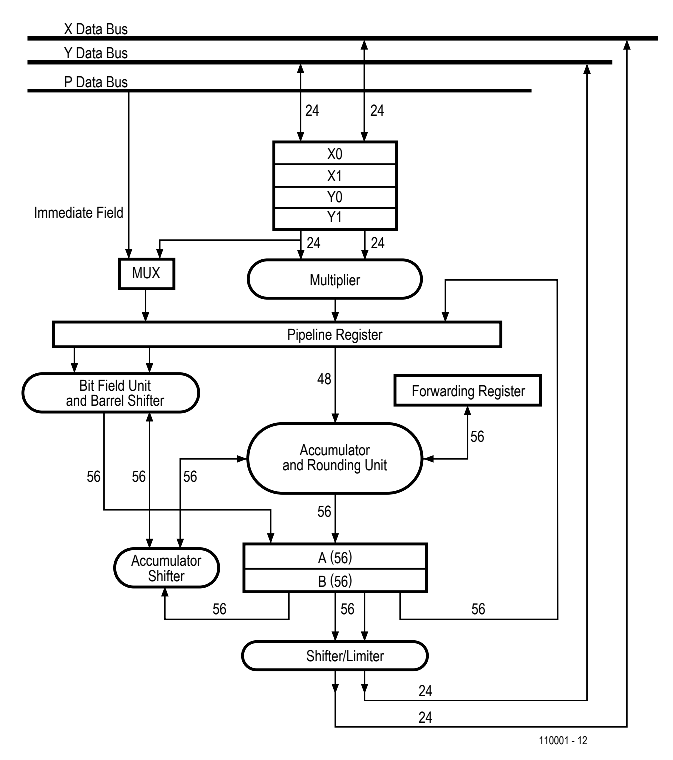


Figure 2. Data path of the DSP56K 'Symphony' family of audio data processors.

blocks (ESAI and ESAI_1) provides six audio data ports together with the ports necessary for synchronization. The ESAI_1 block is omitted in the 52-pin DSP56374 version. The outputs of the three timers in the DSP and a watchdog timer, which can be used to check whether the DSP is still running or has crashed, are fed out over three ports. The Memory Expansion Area group contains three banks of RAM, comprising X and Y RAM for data and program RAM (P RAM) for executable code. The ROM portions of these memory areas are not significant for our purposes. The sizes of the individual memory partitions (X, Y and P) are configurable.
The AGU block contains two high-performance, versatile processing engines that can simultaneously compute two addresses in a single processor clock cycle. The bootstrap ROM contains the code for booting the DSP. For example, the DSP can be booted serially over the SHI port. The Clock Generator and PLL blocks jointly generate the processor clock signal. The DSP can be used with a low-frequency external clock generator, whose signal is multiplied to achieve the processor clock frequency with a maximum value of 150 MHz. The Program Interrupt Controller block handles the numerous internal interrupt options. Many interrupt sources are available from the interfaces. Next to it is the block that controls the command sequences. To its right there is the Data ALU block, which is the data path. This is where the digital signal processing is executed. Finally there is the JTAG/OnCE block, which can be used to download and debug DSP programs with the aid of a PC-based program (debugger).

Data path

The data path is shown in **Figure 2**. The core of the data path is the MAC unit. 'MAC' stands for 'multiply and accumulate', which is a

FIR filters with the DSP56374

The number format used to represent samples in the DSP is called twos-complement fractionals, or simply fractionals. The filter coefficients, which are also fractionals, are stored in DSP memory as 24-bit words. They define the characteristics of the filter.

There is a certain amount of filter design software available, which can be used to design both finite impulse response (FIR) and infinite impulse response (IIR) filters. Both types of filter employ signal feedback loops and are suitable for the direct implementation of well-known analog filters.

Figure 3 shows the signal flow diagram of five-stage filter. This is a graphic representation of the following differential equation:

$$y(n) = b_0x(n) + b_1x(n-1) + b_2x(n-2) + b_3x(n-3) + b_4x(n-4),$$

which specifies the computation rule of the filter.

The square box labeled z^{-1} represents the storage of a 24-bit sample. The triangle symbol represents the multiplication of a sample by a 24-bit factor, which in this case is a filter coefficient. The circle with a plus sign (+) represents the addition of two 48-bit numbers.

At sample time *n* the time window contains five samples of the input signal: *x(n)*, *x(n-1)*, *x(n-2)*, *x(n-3)* and *x(n-4)*, which for example may originate from an ADC with 24-bit word width. The value *x(n)* is the current sample, while the values *x(n-k)* are the previous samples obtained *k* sample intervals in the past. The calculation of the current output value *y(n)* requires five MAC operations as well as the initialization of the accumulator to zero. Accordingly, the following six steps must be executed, and a counting loop can be for this purpose:

```
a := 0;
a := a + b0 * x(n)
a := a + b1 * x(n-1)
a := a + b2 * x(n-2)
a := a + b3 * x(n-3)
a := a + b4 * x(n-4)
```

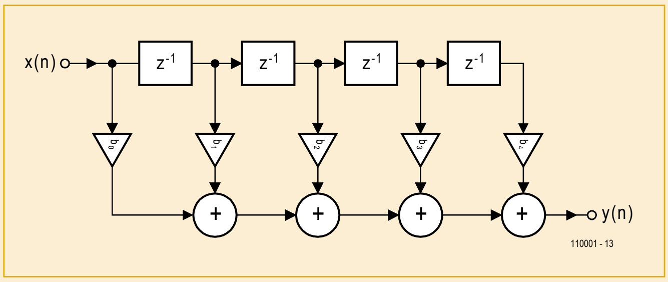


Figure 3. Signal flow diagram of an FIR filter.

Before we describe the DSP code, we need to say a few words about the two memory areas needed for this purpose. In X RAM we use linear addressing to store the coefficients in a memory area with length *n* = 5 and an arbitrary base address. The data for the current time window is always stored in Y RAM. Ring buffer addressing in achieved by using modulo *n* addressing. In the following code, `cbase` is the base address of the coefficient memory area and `dpntr` is a memory location in Y RAM that holds the data area pointer between calls to the filter routine. At the start of the process this memory location holds the base address of the data storage area.

```
        move    #N-1,M4                             ; modulo N indexing
        ...
Audioloop
        ...
        movep   x:RX0,y1                            ; read audio sample
        move    #cbase,R0                           ; set coefficient pointer
        move    y:dpntr,x0
        move    x0,R4   ; load data pointer
(1)     clr     a    x:(R0)+,x0    y1:y:(R4)+       ; read 1st. coeff, save 1st data
(2)     rep     #N-1
(3)             mac  y1,x0,a    x:(R0)+,x0    y1:y:(R4)+

(4)     macr    y1,x0,a      (R4)-                  ; requantization
        move    a,x:TX0                             ; write audio sample
        move    R4, x0
        move    x0, y:dpntr                         ; save data pointer
        jmp     Audioloop
```

In instruction (1), the accumulator is initialized to 0 concurrently with two data transfers and pointer incrementing (using modulo arithmetic in the case of the *R4* pointer). Filter coefficient b_0 is written to register *x0*, and the current audio data (sample) is written to the ring buffer. For the next `mac` instruction, this filter coefficient can be used along with the current audio data, which is located in register *y1*. Instruction (2) initiates a hardware counting loop whose body is called and executed *N-1* times. Loop instruction (3) computes and accumulates a partial product, while at the same time writing the coefficient and data for the next partial product to registers *x0* and *y1*. The result of the accumulated partial products is held in the accumulator, which has a word width of 56 bits. The `macr` command in instruction (4) performs the final partial product computation and accumulation operation and requantizes the 56-bit result to 24 bits as required for the DAC. The pointer to the data area is decremented by 1 at the same time.

computation with the form $a := a + x * y$. This is one of the key computations in digital signal processing. Among other things, it is used to implement digital filters. An accumulator holds the product $x * y$, which requires the services of a multiplier, an adder and an accumulator register with suitable connections and word widths. As you can see in the figure, the two operands used to generate the product can be loaded over two data busses (*X* and *Y*) into any of four 24-bit registers (*x0*, *x1*, *y0* and *y1*) forming a small register file.

The DSP has two accumulator registers (*A* and *B*), which are connected to the busses. This avoids the need to store the intermediate results of an accumulation operation in memory. When a series of such MAC operations must be performed in a digital filter algorithm, the DSP allows the samples and filter coefficients for the next computation step of the following MAC operation to be fetched while the current MAC operation is being executed. As you can see from the figure, the DSP performs computations with 24-bit data, but the accumulators are 56 bits wide. This provides enough room to hold 48-bit multiplication results without any bit loss. as well an additional 8 bits for left-hand number range extension, which is especially useful in accumulation processes.

The operand registers are connected over two 24-bit paths to the hardware fractional multiplier, which performs each multiplication operation in one processor clock cycle. The 48-bit multiplication results can be processed further in the Accumulator and Rounding Unit of the ALU or written to DSP memory over the data busses. The Accumulator and Rounding Unit is used primarily for accumulation, and the combination of this unit and the multiplier forms the MAC unit. The computation engine of this unit can also be used

About the author

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for the addition or subtraction of samples or for logical operations (AND, OR and EXOR). The Bit Field Unit and Barrel Shifter perform bit-string operations and multi-bit shifts, which are also executed in a single processor clock cycle. The Shifter/Limiter below the accumulator registers in the figure is used for tasks such as requantization, which means conversion of multiplication results to the 24-bit word width of the DSP. Finally, we should mention that the DSP can also perform longword computations, for which purpose two pairs of 24-bit registers (*x0* & *x1*, *y0* & *y1*) are combined into 48-bit registers (*x* and *y*). In this case the instruction

```
add x,b
```

results in a 48-bit addition, while the instruction

```
add a,b
```

results in a 56-bit addition.

There is also something you need to know about programming the data path. The *mac* and *mpy* instructions (*mpy* stands for 'multiply') are what are called 'three-address instructions. An instruction such as

```
mac x0,y0,a   or   py x1,y1,b
```

specifies three addresses: the addresses of the two operand registers and the address of the result register. The addition and subtraction commands are two-address instructions. In case of a instruction such as

```
add x0,a   or   sub y0,b
```

one of the two operands must be loaded from one of the two accumulator registers before the command is executed, since it is not possible to connect both inputs of the ALU in the Accumulator and Rounding Unit to the operand registers. The operand in the accumulator register is overwritten by the result of the computation. Due to this loading operation, processing of a two-address instruction requires the execution of two commands.

Special computation techniques, such as saturation arithmetic (saturation at the maximum or minimum end of the number range), allow the DSP to mimic the overdrive characteristic of analog devices. With other types of processors, this characteristic must be emulated in software.

Control logic and address generator

DSPs have special control logic to boost their throughput. In this connection. one of the major features is 'zero overhead loop' hardware, which allows counting loops to be executed with virtually zero instruction overhead. In particular, this means that configuring the hardware loop takes only a few processor clock cycles and the body of the loop contains only signal processing instructions. A hardware loop with only one instruction (such as an arithmetic operation on signal data, possibly with concurrent data transfer) is needed for the FIR filter whose DSP code is described in the **inset**. With this arrangement the loop initialization overhead is especially low, allowing virtually all of the processing power of the DSP to be used for the FIR filter. With a sampling rate of 48 kHz and a processor clock rate of 150 MHz, FIR filters with lengths up to approximately 3000 can be implemented. In addition to the previously mentioned capability for parallel data transfers, this requires the ability to perform memory addressing in the background without using the data path.
The DSP has eight pointer registers (*R0* to *R7*) available for indirect addressing. The type of address arithmetic and the offsets for address incrementing and decrementing are specified in two auxiliary registers for each pointer, which are called the Modifier Register and the Offset Register (otherwise known as the *M* and *N* registers). All 24 registers in the AGU are 24 bits wide, and they can also be used to hold intermediate results or to specify the lengths of counting loops.
Values for incrementing or decrementing the pointer can be entered in the *N* register. For example, samples located *n* intervals in the past can be read from a ring buffer to implement a signal delay, which can be used for purposes such as compensating for propagation time differences between the drivers in a bi-wired speaker box and the listener.
TheM register is used to specify the type of address arithmetic that is used. In addition to linear addressing, the DSP can perform modulo addressing or reverse-carry addressing, which are commonly used in DSP applications. Modulo addressing is needed for the implementation of ring buffers, which hold sequential sets of samples used in digital filters and are updated at the sampling clock rate. Modulo-*n* arithmetic is limited to the *n* numbers from 0 to *n*–1, which can be imagined to be arranged on the perimeter of a ring.

Interrupts

Hardware interrupts can be initiated by the DSP processor core, by the DSP interfaces, and by external sources. Software interrupts can be initiated by a running DSP program. In many cases interrupts can be assigned selectable priority levels in order to distinguish between important and less important events.

A major difference between digital signal processors and general-purpose processors is that the entries in the interrupt vector table are not the start addresses of the interrupt routines (ISRs), but instead two instructions. This allows two classes of interrupts to be defined:

- fast interrupts, consisting of one or two instructions without a return instruction;
- long interrupts, which jump to an ISR (which may be fairly extensive) that is executed in place of the calling program.

Fetching data from one of the DSP interfaces is an especially important DSP transaction. This requires a suitable `move` instruction with the target address in DSP RAM, which can be executed as a fast interrupt. This eliminates the need for saving the processor state on the stack, which is otherwise necessary with an interrupt.

DSP56374 audio interfaces

The audio interfaces comprise six control and synchronization ports as well as six data ports. Different transmit and receive clock rates may be used. One of the options is the I²S interface protocol, which is the best known audio data format. Up to six audio outputs or four audio inputs can be used, as long as the total number of inputs and outputs does not exceed six. The programmer simply sees six 24-bit registers on the transmit side, into which the audio data to be output is written at the sampling clock rate of the DSP program, along with four 24-bit registers on the receive side, from which data is read by the DSP program.

Coming up next...

This description of the internal architecture of the DSP concludes the first installment of our audio DSP course. In the next installment we'll turn our attention to programming the DSP563xx family

(110001-I)

Internet Link

www.freescale.com/webapp/sps/site/prod_summary.jsp?code=DSP56374

Microphone Conferencing System
For more effective online meetings

The scope of the online world is forever increasing, while the perceived distances are forever shrinking. (Video) chatting with the children (or the parents) who live far away, international meetings were the manufacturing department in Taiwan can talk via an online connection to the head office in San Hose… It is becoming increasingly commonplace. For meetings that do not involve too many people the microphone built into the webcam or laptop is usually sufficient, but for larger groups or in acoustically less than ideal rooms (with a lot of reverberation, for example) the degree of intelligibility at the other end of the line is often very low. To solve this problem we designed a simple circuit.

By Thijs Beckers (Elektor Netherlands Editorial)

An increasing number of companies make use of online (video) conferencing. This includes Elektor. The intelligibility can be a problem with this. When there is a large group behind the one (laptop) microphone there is the potential that your online colleagues have great difficulty in following the conversation. The quality of the microphone plays an important role, of course,

Characteristics

- Can be used with any PC or laptop with Line or Mic input.
- Simple to operate
- Two units are easily connected
- Pickup pattern of the microphones is easily adapted to suit the situation
- Easy to build using standard components

but in larger rooms, which are not acoustically optimal (lots of reverberation) it is a good idea to use multiple microphones. And Elektor wouldn't be Elektor if we weren't going to have an attempt at solving this ourselves. This article describes our first result: a simple meeting system.

What does it do?

So we are working with microphones. Or to be more accurate: electret capsules, because these are easily obtained and are not nearly as expensive as a 'real' microphone. In addition, they are much more suitable for our intended purpose. And for this reason:

For this application, we thought that it would be good idea to use a so-called 'figure-of-8' recording pattern. We can then position the microphone in the middle of the meeting table where it can be used by four people simultaneously, while the remainder of the incoming sound (reverberation and the like) is rejected as much as possible (see **Figure 1**). We use a trick to do this: by using two back-to-back connected microphone capsules, each having its own omnidirectional characteristic [1], and by amplifying their electrical signals inverted from each other, we obtain the desired recording pattern.

This design has already been described in Elektor March 2003 [2] where we also discussed the distance between the two capsules. This is not allowed to be too large, mainly because the distance between the membranes determines the corner frequency above which the gain will begin to decrease. When this distance is equal to half the wavelength of the frequency then the electrical signals from the capsules are shifted exactly 180° in phase with respect to each other. The difference amplifier will then amplify this signal even more. As the frequency increases and as a consequence

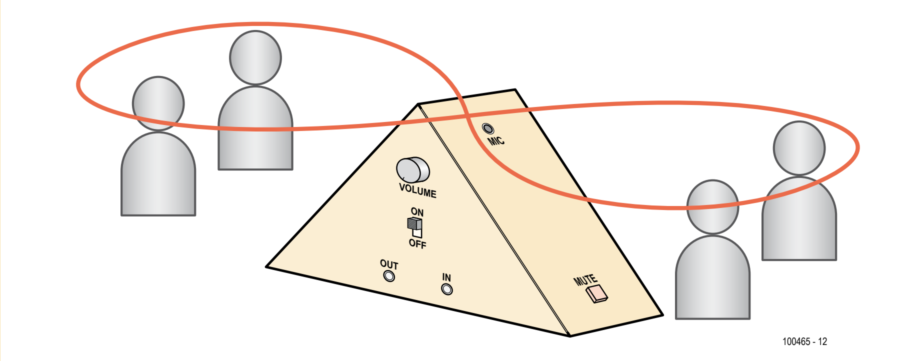


Figure 1. A 'figure-of-8' microphone pattern is created not only to ensure that the registered sound is actually from the people around the table, but also to suppress room noise and reverberation.

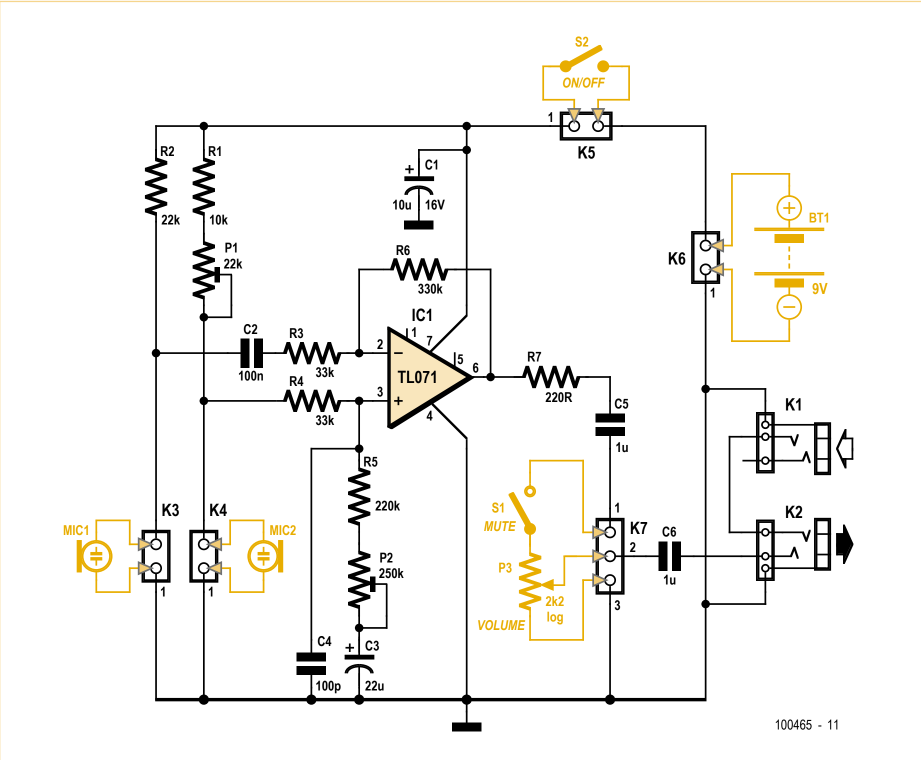


Figure 2. The schematic for our meeting system only contains the essential parts. It doesn't get much simpler than this.

Elektor Products & Services

- PCB # 100465-1
- PCB layout files (pdf and Eagle): # 100465-1.zip
- Hyperlinks in article
- All items accessible via www.elektor.com/100465

skype™ is oddball

We haven't tried all available chat and meeting software, but there appear to be differences in the way the various programs use the sound signal. Windows Live Messenger nicely sums the left and right input signals, while Skype only propagates the left signal. In our circuit this would then only transmit one of the microphone signals, while we are offering two.

So that it is nevertheless possible to use two microphone modules with Skype we have made —– in the spirit of the design of this circuit — a rudimentary 'Skype cable'. Figure 3 shows how we did this.

Using two 470 ohm resistors we superimpose both signals and then send them combined through the cable. At the PC or laptop end of the cable we connect the combined signal to the left input only.

As a consequence, each of the circuits do affect one another a little, but this is hardly noticeable in practice. For the sake of simplicity we think this workaround is an excellent solution.

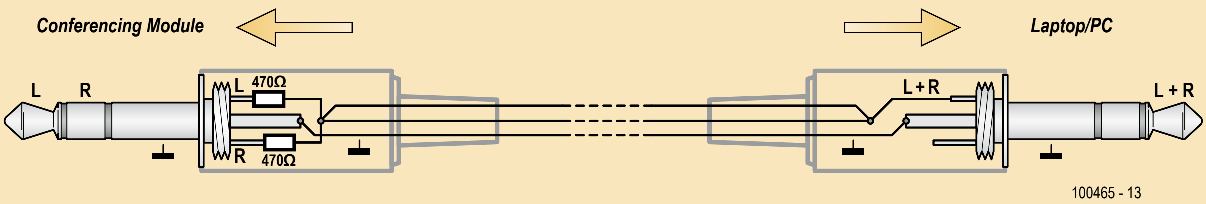


Figure 3. The 'Skype cable' simply sums the left and right channels.

the distance between the membranes becomes greater than half a wavelength, then the gain drops. When, for example, the membranes are mounted with a separation of 2 cm from each other, the corner frequency amounts to:

$$f = \frac{v}{\lambda} = \frac{330\,m/s}{0.04\,m} = 8.25\,kHz$$

where *v* = speed of sound in air. This is still sufficiently high for speech.

To ensure the simplicity of the design we decided, as a first instance, to allow for a maximum of two identical modules to be connected. One of the modules is connected with a mini jack plug to the other module and the latter is then connected with a mini jack to the Line (audio) input of the PC or laptop. Now it would of course be very useful if the gain of the circuit could be adjusted. For this purpose a simple potentiometer has been added to the circuit. And a Mute button — for when you would like to discuss something amongst yourselves without disturbing the entire meeting — is also an essential feature.

How does it work?

The starting point for the design of this circuit was to make a simple schematic that would realize the desired functionality. And simple it certainly is, see **Figure 2**. Only a single opamp and a handful of resistors, capacitors and connections. Nevertheless we will talk you through its operation.

The microphone capsules are connected via PCB headers. In this way you can easily mount the capsules in the correct place inside an enclosure. In the sketch of **Figure 1** you can see how we mounted the capsules (there is another one on the opposite side at the same height) as high as is possible in a triangular enclosure. The closer together they are, the better. To provide the FETs in the capsules with their power supply voltage, the outputs of the capsules are connected with R1, R2 and P1 to the power supply. The values have been selected so that the input of the opamp is at about half of the power supply voltage. This is not that important for the output signal of MIC1, because it is DC decoupled using C2 from the input of the amplifier. This is very important for the output signal from MIC2, because it determines the DC bias of the entire circuit. P1 has to be adjusted so that the voltage at the input of the opamp is equal to half the power supply voltage, i.e. 4.5 V.

Resistors R3 through R6 and pot P2 determine the gain of the opamp. An amplification *A* of up to 10 times was selected, which turned out to be sufficient in practice. The output voltage is expressed by:

$$v_{out} = -v_1\left(\frac{R6}{R3}\right) + v_2\left(\frac{R5+P2}{R4+R5+P2}\right)\left(1+\frac{R6}{R3}\right)$$

where v_1 and v_2 represent the voltages at the inputs of the opamp.

As can be seen from the formula, P2 has an effect on the gain that is applied to the signal from MIC2. This allows for differences between the two capsules to be eliminated and also allows for the characteristic of the microphone formed by the two capsules to be changed from cardioid or hyper-cardioid to figure-of-8 pickup pattern. If the modules are exactly the same then P2+R5 would be exactly equal to R6 and there would be a perfect figure-of-8 characteristic.

Capacitor C4 prevents the tendency of the opamp to oscillate and R7 protects the output from short circuits. C5 decouples the volume control potentiometer from the DC voltage that is present on the output. To make it easy to select a location for the volume potentiometer (P3) in the enclosure this potentiometer is also connected to a header. The Mute button can them simply be connected in series with this potentiometer.

To allow the modules to be connected together, K1 and K2 are connected in such a way that the output signal of a module is always connected to the tip of the jack plug and the looped-through signal from the other module is on the ring of the jack plug. In this way it does not matter how the modules are connected together and the signals from the modules are always on the left and right channels of the output connector.
To keep the number of wires on the meeting table to a minimum we chose to power the circuit from a 9-V battery. The current consumption of the circuit is only about 2 mA, so a 9-V battery with a capacity of 250 mAh will last about 125 hours.

How do you build it?

A small printed circuit board was designed for this circuit (see **Figure 4**). The design is available free in PDF and Eagle file format from the Elektor website [3]. The assembly of this is a piece of cake. The headers K3 through K7 are optional; the wires can, of course, be soldered directly into the circuit board.

The mechanical construction of this project does require some attention however. In particular the building-in of the microphones can be a bit tricky. These need to be attached in a 'decoupled' manner, otherwise they will transmit direct vibration. In addition to the 'normal' sound transmission through the air, every tap on the table will also be amplified by direct mechanical coupling, which has a considerably negative influence on the sound quality and intelligibility. A good solution is to wrap the capsules in foam rubber and then glue this into the enclosure. The triangular enclosure suggested in **Figure 1** is an idea of ours, but is not something that we have worked out the details for. Our prototypes consisted of two wooden boards, which were attached to each other to form an inverted T, where the microphone capsules were attached to the vertical board in a piece of foam rubber.

COMPONENT LIST

Resistors
R1 = 10kΩ
R2 = 22kΩ
R3,R4 = 33kΩ
R5 = 220kΩ
R6 = 330kΩ
R7 = 220Ω
P1 = 22kΩ trimpot, horizontal
P2 = 250kΩ trimpot, horizontal
P3 = 2.2kΩ logarithmic potentiometer

Capacitors
C1 = 10µF
C2 = 100nF
C3 = 22µF
C4 = 100pF
C5,C6 = 1µF

Semiconductors
IC1 = TL071

Miscellaneous
K1,K2 = 3.5mm jack socket, PCB mount
K3–K6 = 2-pin pinheader
K7 = 3-pin pinheader
Mating headers for K3–K7
S1 = pushbutton, 1 make contact
S2 = on/off switch
Electret microphone capsule, e.g Panasonic MCE-2020U or WM-61A
PCB # 100465-1, see www.elektor.com

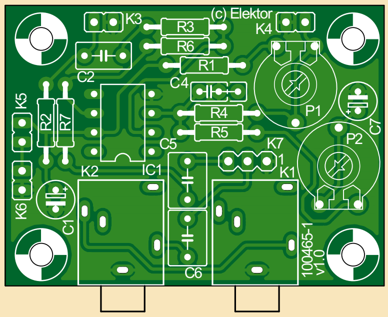
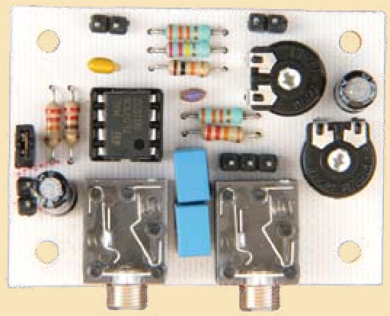


Figure 4. With a simple circuit comes a simple printed circuit board.



Connecting and adjusting

Adjust the output voltage of the opamp with the aid of P1 to half of the power supply voltage (4.5 V). With P2 the pickup pattern of the combined capsules can be varied from cardioid or hyper-cardioid to figure-of-8. Figure-8 is the best for situations such as that in **Figure 1**, a cardioid or hyper-cardioid is better when the sound has to be picked up from only one side of the module. Connect one module to the other via K1 of one and K2 of the other. Now the module that has K2 still available is connected to the line-input of the PC or laptop. Don't forget to set the software that you are using for your online meeting to use the line-input as the source of the sound.

Incidentally, when testing with the commonly used Skype software, it turned out that this program does not sum the audio line inputs but only uses the left channel, while other programs such as Windows Live Messenger do properly sum the left and right signals together. With our circuit it would then only transmit the sound from one module only. To solve this we have made a 'skype-cable' (see sidebar).

(100465-I)

Internet Links

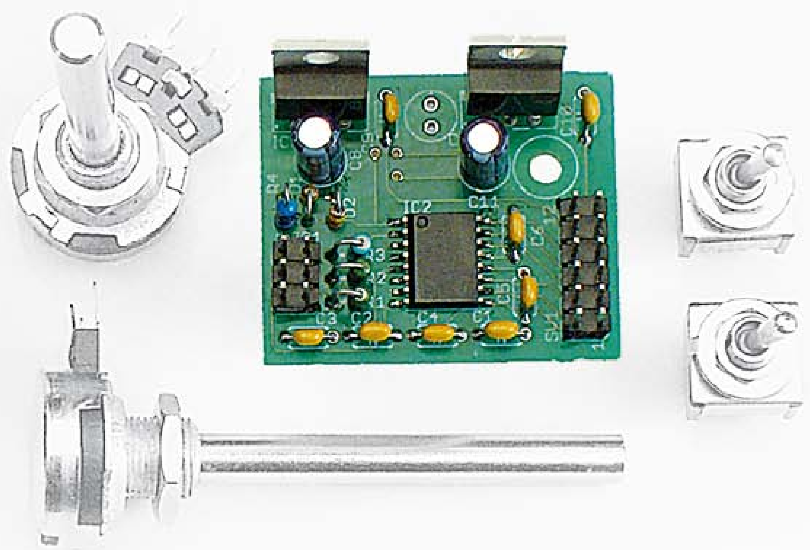
[1] http://en.wikipedia.org/wiki/Microphone
[2] www.elektor.coml/010123
[3] www.elektor.com/100465

Perfectly Balanced

Noise-free volume control for Hifi amplifiers

By Jan Breemer (The Netherlands)

Decent potentiometers for setting the volume in amplifiers are still quite expensive. However, there is a cheaper alternative, and it's better too! The PGA2311 made by Texas Instruments can be used to make an almost perfect volume control. A simple circuit using an 8-pin Freescale microcontroller and a linear potentiometer are all you need to control this IC.



The volume control in audio amplifiers is usually implemented using a (stereo) potentiometer, which in reality is just a resistor with a variable tap. This tap can be adjusted with the control knob, setting the volume to the required level. The potentiometer is often a logarithmic type. This means that for the same angle of rotation anywhere along its track the corresponding change in dBs will be the same (with the resistance changing logarithmically with respect to the angle of rotation).

Even high quality amplifiers occasionally suffer from problems caused by potentiometers. They sometimes exhibit a number of failings:

- The wiper can make a bad contact with the resistance track, resulting in a crackling sound when the knob is turned.
- Under certain circumstances a bad wiper contact can result in non-linear distortion (creation of harmonics and sum and difference frequencies).
- The tracking of stereo potentiometers leaves a lot to be desired. Even the most expensive types are only slightly better than the cheaper ones.
- Volume controls suitable for more channels (5.1, 7.1) are very difficult to get hold of.

Alternatives

We can think of several alternatives for the potentiometer:

- An expensive potentiometer with very high specifications. As we mentioned earlier, these still aren't perfect and they can easily cost tens of pounds.
- A stepped volume control with a large number of steps and resistors. Even if you can find them, they'll be very expensive (over $ 100). It would be a good alternative for home construction, but the problem is that you need a switch with a large number of steps. It's possible to buy a 24-way switch, but that isn't enough for a smooth volume change. You really need at least 40 steps and such switches are very difficult to find and rather expensive.
- A circuit using light dependent resistors (LDRs). These will also have tracking problems.
- An analog circuit, whether integrated or not. It's possible to make an analog multiplier circuit or get one in chip form. The problem with these circuits is that the distortion is often too large and the range too small.
- Digital potentiometers. Intersil [1] has a number of these in its catalog, but these are mostly linear. It's also difficult to guarantee that two mono potentiometers will exhibit good tracking.
- A digital integrated circuit, specifically designed for audio use.

In this article we'll cover a circuit that comes in the last category.

The circuit

In the April and May 2004 issues of *Elektor Electronics* the design for the High-End-Preamp was published. In the preamp, the volume control was implemented using a PGA2311AP IC made by Texas Instruments. The specifications for this IC are superb; there simply isn't any mechanical potentiometer that can improve on it.

The required digital control signals are fairly complex, so a microcontroller was added to take care of those. The SpYder project from Freescale and Elektor (published in the March 2007 issue) is just perfect for this task. Using this, it becomes easy to control the PGA.

The PGA2311 is controlled on the digital side by the /CS, SDI and SCLK signals, originating from the microcontroller (see **Figure 1**). On the analog side are the analog inputs and outputs, made available on a dual-in-line header, JP2. The linear potentiometer is connected via 6-pin header JP1A.

Via this connection you can also have a mute switch and an optional LED that indicates when the control IC is updated by the microcontroller (see **Figure 2**). The voltage returned by the potentiometer is filtered by a capacitor, before being fed to the A/D converter of the microcontroller. This reduces the noise in the signal, which is important as it prevents the output of the A/D converter from flicking backwards and forwards between two states when the potentiometer is exactly halfway between two bits.
The PGA2311 has a fairly low input impedance (about 10 kΩ). It is recommended to use a source with a low output impedance in order to keep the distortion to a minimum. This shouldn't be a problem with modern audio sources such as CD/DVD/SACD/MP3 players, receivers, tuners, satellite receivers and PCs. These devices usually have an output impedance of 500 Ω or less. Older equipment (in particular those with DIN sockets) may have a higher output impedance. In that case the PGA2311 has to be preceded by a (simple) buffer stage.
The output impedance of the PGA2311 is very low. It won't have any problems driving all types of amplifier.
The PGA2311 can deal with input signals of almost ±5 V maximum, which is 3.5 V RMS. Larger signals are suddenly distorted a great deal. The output signal can go as high as 4 volts peak-to-peak, or 2 V RMS.

Power supply

There are several ways in which the supply voltage can be generated, depending on the amplifier to which the volume control is added. We have taken account of this in the design of the circuit. Table 1 has an overview of several possibilities. This overview is far from complete, since there are many other possibilities and every amplifier is different.
The circuit requires a supply of +5 and -5 Volts. The current consumption from the positive supply line during the changing of the volume is about 20 mA and 15 mA when the circuit is at rest. For the negative supply line this figure is about 15 mA at all times.
The microprocessor operates at 3.3 Volts. This voltage is derived from the +5 volt supply using diodes D1 and D2. This isn't exactly according to the worst-case specifications, but from experience we found that it still works reliably.
Should the audio outputs be loaded with, for example, 600 ohms from a set of headphones, it can easily add another 10 mA to the current consumption, depending on the output volume. In that case the symmetrical 5 V supply lines need extra buffering with electrolytic capacitors of a few hundred microfarads at 6.3 V. It is also recommended to use the TO220 versions for the voltage regulators.

Construction

The author has made several kits of parts available for this project via his website [2]. This also includes variations for the different power supply options.
There is a choice from a complete kit of parts, or the PCB and a ready-programmed

Specifications

- Stereo volume control with steps of 0.5 dB over a range of 128 dB (optional; a smaller range was chosen for this project)
- Extremely low distortion
- Extremely good tracking
- Controlled via a standard linear rotary or slide potentiometer
- No interference caused by the digital circuit; intelligent software turns off the external digital signals about a second after the last change in volume
- Optional mute switch and activity LED
- Can be added to virtually any amplifier
- No exotic or expensive components

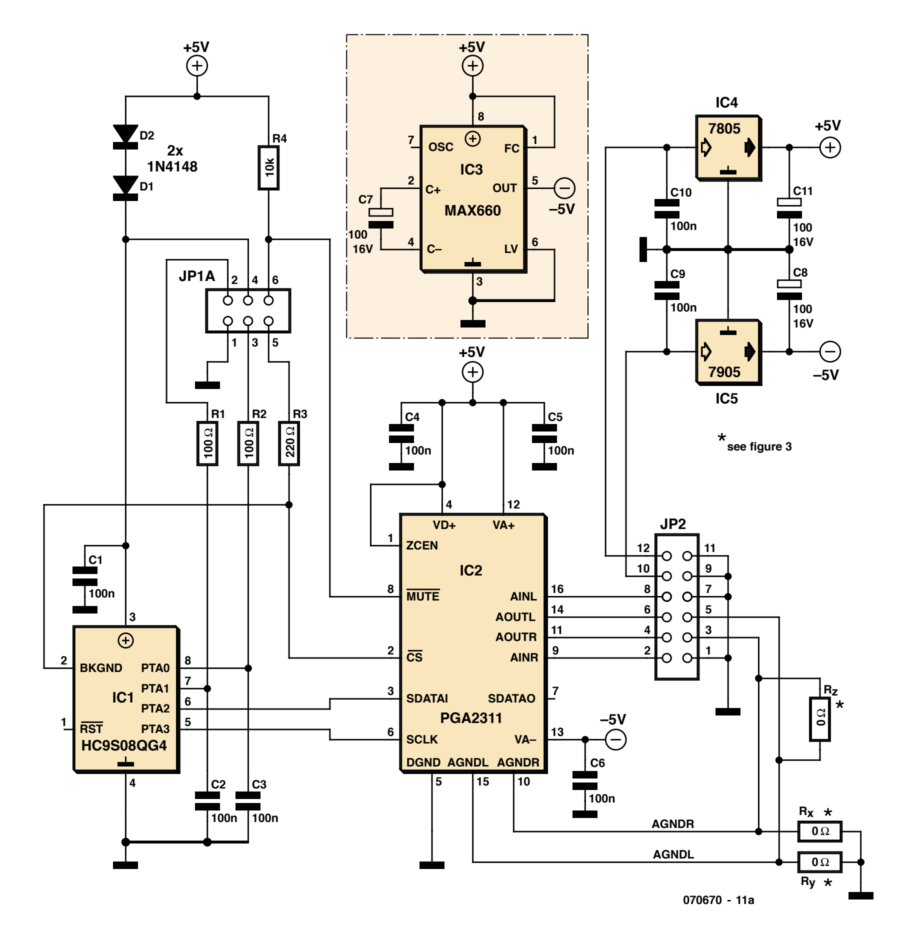


Figure 1. The circuit diagram for the volume control is fairly straightforward. In the colored section is the optional MAX660, which is fitted depending on the type of power supply used.

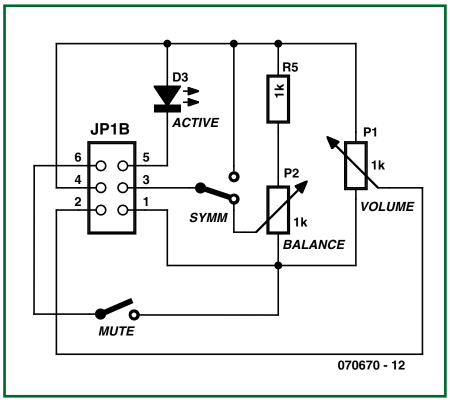


Figure 2. The potentiometers, switches and indicator LED aren't mounted on the PCB. They could, for example, be mounted on the front panel of the amplifier.

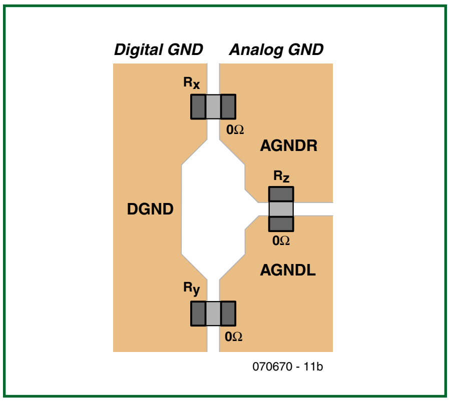


Figure 3. Suggested ground plane layout.

controller. But it is also possible to order just the PCB and have somebody program the controller for you, or even do it yourself. In that case you'll need to find the remainder of the components yourself.

During the construction of the circuit it is best to start with the smallest (SMD) components, as usual. IC1 comes in an SOIC-8 package, which makes it a prime candidate for the hot tin. Then it's a matter of common sense and keeping the power supply option in mind. JP1A should be connected to JP1B using a one-to-one ribbon cable. It's possible to leave out JP1B and solder the wires directly to the potentiometers and switches. Make sure that you don't forget about R5. There is no space reserved for this on the PCB and it needs to be soldered directly to the potentiometer.

The input and output signals are connected to the circuit via JP2. The inputs are on pins 8 (left) and 2 (right), the outputs on pins 14 (left) and 11 (right). The supply is connected to pins 10, 12 and any of 1, 3, 5, 7, 9 or 11. Refer to the circuit diagram in Figure 1 for more details.

The Software

The starting point for the software is the 'Blinking LED' demo program in the Elektor/Freescale SpYder Discovery kit, which is then modified for our use. Only 'main.c' needs to be changed, with the remaining files staying the same. The inset 'DIY programming' describes the steps you have to take to program the firmware into the microcontroller yourself. There are four routines inside the main.c program:

1. void PeriphInit (void)

Compared to the 'Blinking LED' demo, the only change is the data direction of the output ports. Pins 5 to 8 have now been configured as outputs. The configuration for the analog input (pin 8) is overwritten later by the A/D converter configuration.

2. void SendData (VolumeSetting)

This routine is written in assembly language and controls the /CS, SDI and SCLK lines that go to the PGA2311. There is a sub-routine that is called twice, once for the right channel and once for the left channel, both with the same data (unless the balance control is used, when the volume for the right and left channel can differ). A couple of NOP (No OPeration) instructions have been added to make the run-time identical for both branches. This isn't vital for the operation of the program, but it makes the interface signals on an oscilloscope look a lot better. The /CS line stays low at the end so that the activity LED stays lit. It's only when no new data has to be sent that the /CS line goes high.

3. Byte AdConvert (void)

This configures the A/D converter and starts a conversion. The routine then waits for the conversion to finish and finally returns the result. It isn't really necessary to configure the converter every time, but it doesn't do any harm either. The converter is used in a 'slow' 8-bit mode, but that is still more than fast enough for this application.

4. main (void)

This is the starting point and also the 'body' of the program. The 'main' loop never ends. After calling the initialization routine *PeriphInit()* once, there is an infinite loop where 100 A/D conversions take place. The result is averaged out and compared with the previous result. If there is a sufficient difference the new result is scaled and sent to the PGA2311. This process happens about 100 times per second, but stops after about a second during which no changes took place. That way there won't be any digital interference in the audio signal.

The criterion for 'no changes' is somewhat loosely implemented. The change has to be at least three units before the sending process is started again. This stops a change being made when the potentiometer is positioned exactly between two A/D conversion points. It would of course be quite noisy if the volume was continuously changed up and down by a 1/2 or 1 dB step.

Incidentally, a little trick is used for the balance control. As soon as the microcontroller detects that the balance potentiometer has moved beyond ¾ of its range, it is interpreted as 'balance control is turned off'. The left and right channels are then amplified or attenuated by the same amount. The 'SYMM' switch (**Figure 2**) has the same effect, by the way.

All of the HEX file and source code files can be downloaded free of charge from the Elektor website [2].

Interference suppression

There are three ways in which audible interference could be introduced:

- Interference from the microprocessor signals finds its way into the audio signal path.
- When the gain is changed it can introduce audible clicks in the audio signal, because the change is so abrupt.
- The result of the A/D conversion could vary slightly, even though the state of the potentiometer hasn't changed.

The first type of interference is all but eliminated because all external microcontroller signals are shut down about one second after the volume control stops changing. The only activity on the chip itself is the reading of the A/D converter.

The PGA2311 has a facility where the gain is only changed when the audio signal passes through a zero-crossing point. This is set with pin 1, ZCEN, and works very well. It is only when music has dominant bass sounds of 50 Hz or less that you can hear an occasional soft click when changing the volume. This therefore mostly suppresses the second source of interference.

The final type of interference, where the A/D conversion varies, would cause the gain to change by ±0.5 dB. This is can be heard clearly, not as a change in volume, but as a soft click when the volume is changed. This can be trapped in the software. About a second after the potentiometer stops changing the PGA2311 stops updating the volume control. The /CS signal goes high and the LED turns off. Should the LED keep flashing you have probably used a very bad quality potentiometer for P1 and it should be replaced.

The right range

The PGA2311 has a control range from -95.5 dB to +31.5 dB. This is impractically large. In many cases a gain of 31.5 dB (that is about a 30x gain in the voltage) isn't required. Neither is an attenuation of -95 dB necessary. It was found that settings of 0 dB to -60 dB were sufficient. That's as quiet as a whisper when 0 dB corresponds to about 100 dB(A). There is a facility in the software to set the range, using the constants 'UpperLimit' and 'LowerLimit'. The standard setting is a maximum gain of 0 dB (1, or 'unity gain') and a minimum gain of -60 dB (1/1000). When the potentiometer is turned right down the control IC goes into a soft-mute mode and the audio signal is muted.

Listening tests

After building the circuit into his preamplifier, the first impressions of the author were so good that he wondered if the circuit was active. When changing the volume a soft click was sometimes heard if the music was dominated by strong, low bass sounds, such as occur in some organ music. As soon as the volume control was let go, this stopped. The range was originally set between -80 dB and 0 dB. This easily covers a range from deafeningly loud down to a quiet whisper. After several months of use it turned out that the range was too large; the quietest third of the control was never used. A few experiments showed that a range of 0 dB to -60 dB was the best.

(070670-I)

Internet Links

[1] www.intersil.com

[2] www.elektor.com/070670

DIY programming

It's of course also possible to program the microcontroller yourself, instead of buying a ready-programmed controller from the author. The instructions below show how the firmware can be easily programmed, using the "SpYder Discovery kit for Freescale MC9RS08KA, MC9S0QD and MC9S08QG Microcontrollers" many of you may have as result of special promotion by Elektor in 2007.

- The SpYder kit contains a USB stick with a microprocessor and a CD-ROM. Install the software according to the instructions given in the kit.
- Try out the demo of the Flashing Light LED according to the instructions given in the kit. If all is well you know that everything has been installed properly and works as it should.
- Make a copy of that project (...\USBSPYDER08\QG4\Demo) in another folder. But take care! When you make a copy of a project, some absolute paths remain that point to the old folder. You should therefore edit all references to the old path such that they point to the new folder, otherwise you'll include parts of the old project.
- Check once more that everything still works (verifying that the paths are correct).
- In the sub-folder ...\Sources\ replace the file main.c with the new main.c file, which should be downloaded from the Elektor website.
- Start the development environment by double-clicking on the file "Demo.mcp" in the new sub-folder.
- Compile the program (F5) and load it into the microprocessor in the stick ('Enter' in the debugger).
- Close the development environment, remove the stick from the USB socket and put the programmed microprocessor onto the volume control PCB.
- Check that everything works. While the potentiometer is turned the LED should stay on. About one second after you stop turning the LED should go off.

Table 1. Power supply options

Option	Available voltages	Mount
1	12 to 15 volts symmetrical	IC4 and IC5 in low-power case. Do not mount IC3.
2	15 to 30 volts symmetrical	IC4 and IC5 in TO220 case. Do not mount IC3.
3	12 to 30 volts asymmetrical	IC4 in TO220 case and IC3. Do not mount IC5.
4	Over 30 volts, pos or neg	As 1, 2, or 3, but the voltage first needs to be reduced to a value the regulators can cope with.
5	None	A home-made supply: a transformer with 2x9 to 12 V, a bridge rectifier and 2 electrolytic capacitors of about 500 µF, 25V. Then choose either option 1 or 2.

N.B.: The options where IC3 is used do have a small disadvantage: there is a continuous square-wave of about 40 kHz with an amplitude of 5 Vpp across C7. In combination with a CD player that doesn't adequately suppress the 44.1 kHz sampling frequency it could give rise to intermodulation signals.

COMPONENT LIST

Resistors
R1,R2 = 100Ω
R3 = 220Ω
R4 = 10kΩ
R5 = 1kΩ
P1,P2 = 1kΩ linear

Capacitors
C1-C6,C9,C10 = 100nF
C7,C8,C11 = 100µF 16V

Semiconductors
D1,D2 = 1N4148
D3 = LED, free choice
IC1 = HC9S08QG4CDNE (Freescale)*
IC2 = PGA2311 (Texas Instruments)
IC3 = MAX660 (Maxim)**
IC4 = 78x05**
IC5 = 79x05**
* available ready-programmed via www.breem.nl
** whichever applies

Miscellaneous
pinheader 2x3
pinheader 2x6
flatcable 2x3
flatcable 2x6
mute switch, single on/off
symmetry switch, single pole on/off
PCB available via www.breem.nl

Elektor Proton Robot

A versatile platform for learning and experimenting

By Bart Huyskens (Belgium)

The Proton robot from Elektor is a versatile platform that's suitable for students, enthusiasts and professionals alike. The robot can operate with a variety of microcontroller families, and it supports a broad spectrum of sensors and actuators. This is an ideal opportunity to invest in a unique combination of knowledge and fun.

The new Proton robot described in this article is a DIY system that can easily be extended in all sorts of ways. You can purchase the robot as a complete kit or ready-made, or you can purchase the individual components separately. This makes it easy to adapt the system to your own wishes and needs, as well as the available budget. **Figure 1** shows an overview of the Proton robot and its key features.

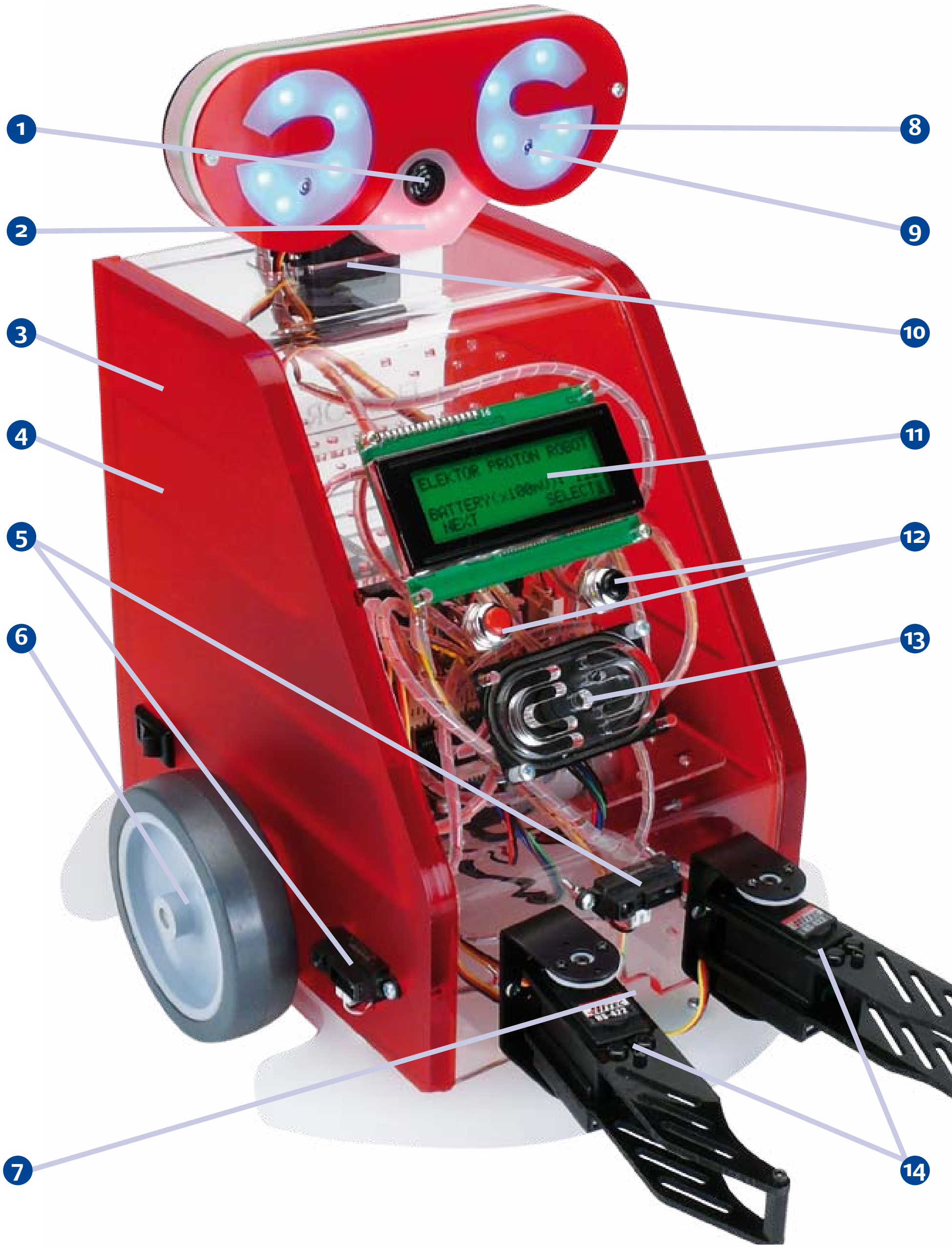
Your choice of microcontroller

The most important feature is undoubtedly the fact that you, as the user, can **personally** decide which microcontroller to use to control the robot and which language and/or programmer you want to use for this purpose. When you buy the robot, you can choose from an add-on PCB for the PIC15F887 or a PCB for the AVR ATmega32, but with a piece of prototyping board and a minimum of soldering work you can also control the robot with virtually any microcontroller, as long as it supports a bit of digital I/O, a couple of analog inputs, I²C and RS232. Experience with I²C, RS232 or analog inputs is by no means necessary. The robot comes with macros that radically simplify the task of configuring the necessary settings.

As you can see from the overview in Figure 1 and the block diagram in **Figure 2**, most of the components are controlled over the I²C bus. The I²C protocol is very simple, and most microcontrollers have a hardware I²C interface module on board.

Your choice of programming language

Example programs in both Flowcode and C have been developed for all of the modules of the Proton robot, for both the PIC and the AVR microcontrollers. The C compiler for the PIC MCU is Hitech-C Lite, and for the AVR MCU it is WinAVR GCC. Both of these tools are free, but



you can also select other compilers and languages. The developer has created a customer header file for both of these C compilers, which makes programming in C a lot easier. For Flowcode there is a set of macros that simplify the relatively complex settings. In both cases, all of the code is open source, so there is nothing to stop you from adapting it to your own purposes.
The developer used the AVRISPM Mk2 and PickIT2 programmers, both of which are good low-cost programmers available from Atmel and Microchip. However, other types of programmer hardware can also be used.

Extensive support

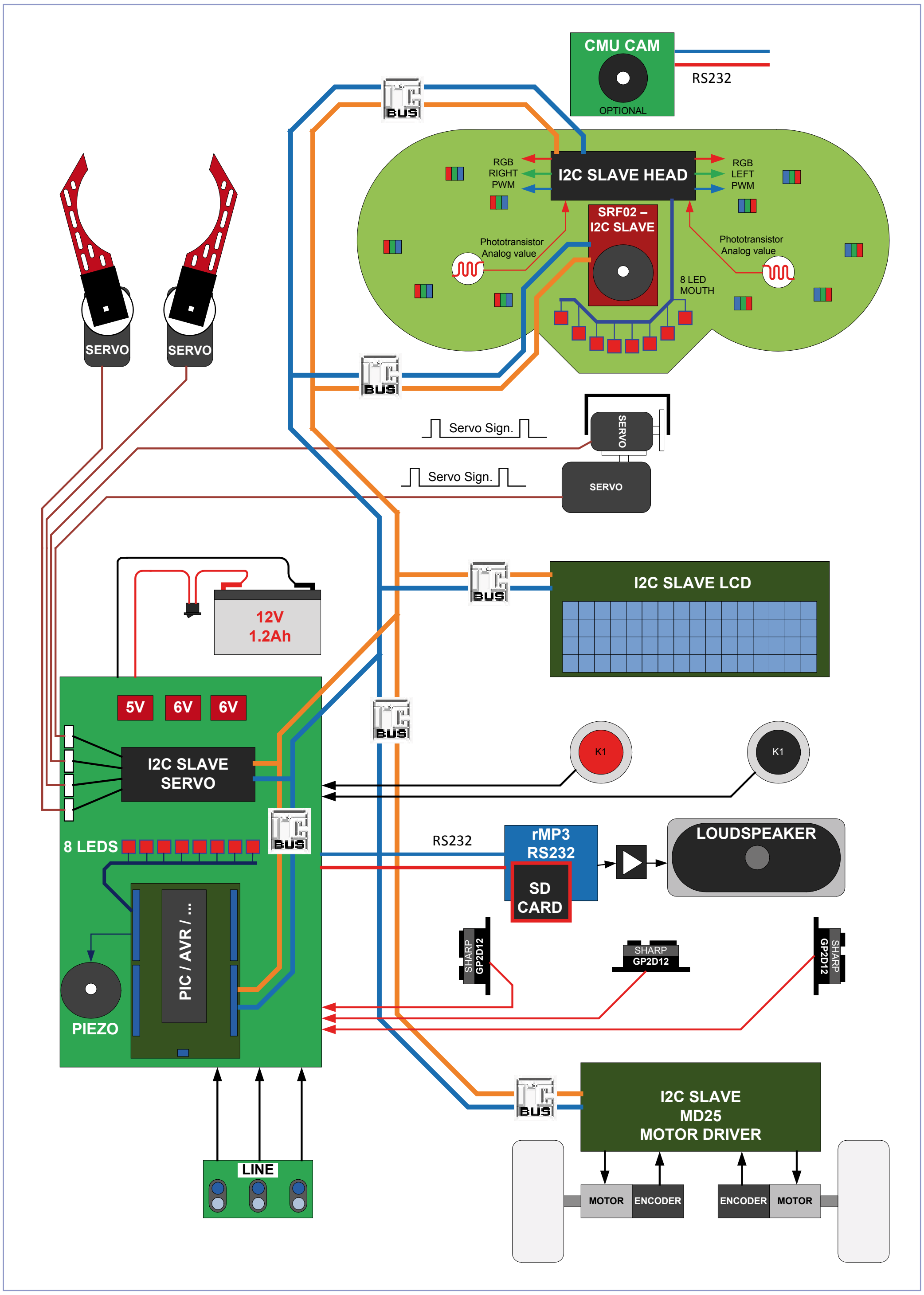
A variety of activities are being organized around the Proton robot to support its users.

User guide: First of all, there is a very extensive user guide that provides useful information for everyone from neophytes to professionals to help them program the various components of the robot. Every component is described in detail, and for each component there are four fully coded examples that show how it can be programmed in Flowcode or in C: FC-PIC, C-PIC, FC-AVR and C-AVR.

Forum and website: A separate page on the Elektor website will be totally dedicated to the Proton robot. There you will always find the latest version of the user guide, various tips and tricks, and of course downloads. On the Elektor forum you'll be able to share your ideas and experience with other Proton users and the Proton developer. You can also share code, schematics and videos on this page.

Creative challenge: We challenge you to develop your own add-on projects and connect them to the robot. The motherboard is equipped with spare I/O, A/D, RS232, SPI and I^2C ports, and there is plenty of room on the robot to install your own projects. Some ideas: control the robot with your mobile phone, via Bluetooth or

Features		
1	Ultrasonic distance sensor	An ultrasonic distance sensor controlled by simple I^2C commands. The readings are provided in centimeters, inches or microseconds. **Function:** Measuring distances from 4 to 300 cm.
2	8 LEDs in the mouth	The robot's mouth is formed by eight LEDs that can be driven individually in normal mode. In audio mode they serve as a VU meter for the music from the audio module, so the robot's mouth moves in sync with the speech or music. **Function:** Indicating the robot's response to sound perception.
3	Piezoelectric speaker	A small high-impedance speaker connected to a digital output. It can generate all audible frequencies. **Function:** Beep sounds, alarms, ringtones.
4	8 LEDs in the body	Connected to eight digital outputs of the MCU. **Function:** Debugging and initial program steps.
5	3 infrared distance sensors	Three analog IR sensors that can measure distances from 4 to 80 cm. **Function:** Detecting and/or avoiding obstacles.
6.	Motor drive module	This robust DC motor drive module is controlled over the I^2C bus. Rotary encoders in the motors provide constant feedback on the position and angular motion of the motor module. These values can be queried at any time by the MCU, along with the battery voltage and the current drawn by each motor. **Function:** Setting the speed and rotation direction of the two motors with the aid of simple commands.
7	3 line detectors	Three infrared sensors underneath the robot, connected to three digital inputs of the MCU. **Function:** Following black or white lines.
8	LED eyes	Five RGB LEDs in each eye, individually dimmable under PWM control in order to create any desired color. **Function:** Generating light effects.
9	2 phototransistors	Two phototransistors in the head, which communicate over the I^2C bus. **Function:** Measuring light intensity and determining the location of a light source.
10	2 servomotors	These two motors move the robot's head under the control of I^2C commands. **Function:** Adjusting the vertical and horizontal position of the head.
11	LCD	Messages appear on a large blue LCD with four lines of twenty characters each. The included example programs and macros make driving the LCD very easy. **Function:** Displaying measured sensor values or user interface menus.
12	Red and black buttons	Two buttons connected to two digital inputs of the MCU. **Function:** Selecting menu items.
13	Audio module	This module plays MP3 and WAV files directly from an SD card. It is controlled by a set of RS232 commands. **Function:** Playing MP3, WAV and other audio files from an SC card (to enable the robot to speak, among other purposes); saving data and readings on an SD card; generating equalizer data.
14	Gripper	Optional gripper. **Function:** Picking up and moving cans and other small objects.



via WiFi; let robots communicate with each other; fit a camera and experiment with image recognition; let your robot respond to voice commands; etc. — the sky's the limit. Document your add-on project, and maybe it will be selected for publication in Elektor or nominated for an attractive prize at one of the events organized in connection with the Proton robot. Among other activities at these events, we plan to hold contests with a special challenge on each occasion.

Kit or fully assembled

You can order the robot as complete kit for DIY assembly, or you can order the individual components separately. A detailed assembly guide with photos and instructions helps you put them together. All circuit boards are fully assembled and tested; all you have to do is mount or fit them and solder a few cables. This is certainly not difficult, although a bit of experience with soldering will come in handy. If you wish, you can also order the Proton fully assembled and equipped with extensive test software. See the Elektor website for all of the options!

(110263-I)

Further information and ordering options

www.elektor.com/proton

YouTube video

http://www.youtube.com/watch?v=4WiH3LCzYJk

About the author

The Elektor Proton robot was designed by Bart Huyskens. Bart is an instructor of Electronics and Embedded Systems at the St-Josef Institute in Schoten (Belgium) with a passion for his work, and he has already designed several robots, including the popular Formula Flowcode robot and the Robu robot. He spent over two years developing the Proton, and the results speak for themselves.

Help! I'm stuck...

By Thijs Beckers (Elektor Labs)

In the lab we don't just design circuits. Technical questions also find their way to the heart of the company. Despite the fact that we do our utmost to test the published designs thoroughly, write the articles as clearly as possible and make as much supplemental information as possible available via our website, it can of course happen that something goes wrong. Not surprisingly, a flood of questions then comes in. Most of these have been sent using the Contact Form on the Elektor website [1].

A 'good' example of this is what happened to the Digital Multi-Effects Unit from the September 2010 issue. In the rush to meet the deadline for the article some of the electrolytic capacitors were drawn the wrong way round in the circuit diagram (C23, C25, C30 and C32), with the result that they also had the wrong polarity on the printed circuit board. In principle this wasn't such a big problem; since the voltages across the electrolytics were relatively low they shouldn't be affected by the polarity reversal. A much bigger problem was that the supplier made a mistake in programming the first batch of the ATmega8 on the main board. Several fuse settings were wrong, which made the chip use its internal clock, whereas the intention was that it should use the external 8 MHz crystal. The result: just a flashing cursor appeared on the display. This led to a number of disappointed customers and a large amount of extra work for the lab, customer services and the logistics department. We obviously try to correct mistakes such as these as soon as possible after they are discovered. All got rectified in the end.

"The amplifier I built in 1975 from your mag is becoming noisy. Could you please send me an update and a new PCB?"

Many other technical questions relate to much simpler subjects, such as: "Where should I put capacitor C15?" and "Which type of solder should I use?". These types of question are of course a piece of cake for our colleague Jan Visser. But some questions made him struggle: "So what's the difference between an ATmega and an 8051 core?" "I would like to use circuit *xyz* from Elektor, but I want (*xx*+33) outputs instead, the supply voltage should be 12 V and I'd also like to have 512 KB memory in the processor... What changes do you suggest?" and "I'm looking for a particular sensor to measure ... Could you find a suitable type for me that isn't too expensive and preferably is available around the corner?". We hope you'll understand that we don't have enough time to research the answers to such specific questions. The difference between an ATmega and an 8051 processor can't be explained briefly without having an in-depth knowledge of both processor families. Furthermore, there is a wealth of information available for both processors, which should help you choose the one that is most suitable for your project.

A question that comes up regularly concerns the availability of components. SMD parts in particular are rarely in stock in electronics stores. In that case you could try asking the shop if they can order some of the components for you. It is of course not possible to turn up with an Elektor parts list and ask them if they could order the lot from, say, Mouser. Some dedicated components are usually available as one-offs; 'standard' components are often only available in multiples of 10, 25 or even 100. This is not such a big problem with SMD resistors, which cost only a few pence each, but when it concerns capacitors that cost $0.25 each, and you have to order a minimum of 10 and you have to do this for five different values, you'll soon see the cost mount up. It can therefore take some time to figure out how best to deal with this. In some countries people club together to buy bulk quantities of components, generally via forums that are visited by hobbyists, i.e. people who also ran into the same problems. As far as availability is concerned: here at Elektor we do our best to choose as many current components as possible. However, we can't prevent that some components are declared obsolete by the manufacturer after only three years (and sometimes sooner). In the electronics world changes happen almost as fast as in the computer world: these days a ten year old circuit is almost considered prehistoric, and dedicated ICs in particular are often difficult to find...

"Could you please design a LED message board for the restored windmill in our village, similar to your LED Spin-Top?"

To help us deal with questions as quickly and thoroughly as possible we have added a number of input boxes on our online query form [1]. It's a great help if you take the trouble to enter the article number, title, and the month and year of publication. If you also include a clear description of your problem or question we can often give you an answer straight away, without having to ask you for further details because you didn't make it clear just what you wanted to know in the first place. Elektor Labs says *thank you*!

(110131)

Internet Link

[1] www.elektor.com/contact

A quick temperature measurement (2)

By Thijs Beckers (Elektor Netherlands Editorial)

What's impossible for an IR thermometer, such as those in last month's test, is a piece of cake for a so-called thermal camera, which is also known as an IR camera. Prompted by our test, Vincent van der Walle (**photo 1**), a sales engineer from FLIR distributor KWx B.V. [1],[2], came to us to explain thermal cameras. This, of course, included a demonstration of a number of the thermal cameras developed by FLIR. Although the cheapest model, with a price tag of just under $ 1200 (the FLIR i3), is perhaps a bit too expensive for the enthusiast but when used in research and development departments even the more expensive model will pay for itself in a very short time. How? Continue reading...

Foremost it is important to understand what you are measuring. This was already highlighted in the IR termometer test published in last month's issue of Elektor. In particular, the emissivity of an object has a significant influence on the measured temperature (also refer to the sidebar 'Emissivity' in last month's test article). Something that is difficult to see with an IR-thermometer but is easily demonstrated with a thermal camera: measuring the temperature of a simple (soup) tin, filled with water that has just been boiled, will quickly show the 'problem' when using an IR-thermometer (see **photo 2**). When the emissivity is not adjusted to match the material (in this case a tin can with an emissivity of about 0.15), the measured value deviates so much that it is essentially useless. Our reference model, the Fluke 572, indicated a value of 34.5 °C when the emissivity was not adjusted.

1

With an IR thermometer this measurement error is difficult to spot. But with a thermal camera (which essentially uses much the same sensor as that in an IR-thermometer, but many of them and arranged in a matrix) it is immediately obvious that something 'strange' is happening (see **photo 3**). The tin appears to be reasonably cool (the measuring spot in the center reads 28.9 °C), while the water and the pieces of electrical tape on the side are shown very bright; about 72 °C, when referring at the scale at the bottom of the display.

What the camera actually 'sees' when it is pointed at the tin is the reflected heat-emission from the surroundings of the tin and part of the heat of the tin itself (that's why the temperature is a little higher), instead of (only) the temperature of the tin by itself. However, the pieces of colored electrical tape do give the correct result. The actual color of the tape is not important, as can be seen in the photo. Only the material and the specific emissivity play a role (and this is about 0.95 for the pieces of tape). So, with an IR camera you can very quickly see where the measurement is going wrong and where it is going right.

But despite this, it is nevertheless a good idea to remain cautious and you still have to understand what you are doing. For example, we pointed the IR cameras under test at the heatsinks of a dual output power supply, one half of which supplied 2 ampères into 8 ohms and the other half 0.5 A (also into

2

3

8 ohms). The heatsinks had quite a matt surface and while the manufacturer had selected different colors for the heatsinks, the IR cameras had no problem showing the correct image of the heat distribution across the heatsinks (see **photo 4**). The heatsink on the right is clearly much warmer and almost appears to glow on the camera screen (this heatsink was about 55 degrees centigrade).

What we did notice however, is that the top of the heatsinks appeared to be much cooler (even cold) when we held the camera at the same level as the power supply (that is, looking straight at the back of the power supply). What's happening now? The top of the aluminum heatsinks acted as a mirror and reflected the temperature of the relatively cold wall behind the power supply (just as an asphalt road surface on a hot summer's day sometimes behaves like a mirror when you look into the distance).
The same effect is clearly visible in **photo 5**: The thermal image of the tin can with hot water is mirrored by the surface of the table, while the table has a higher temperature only directly underneath the tin can.
Such a measuring error can only be noted — and cannot be avoided. It is not possible, unlike when making sound measurements, to have a kind of 'dead room' where you can measure thermal radiation to prevent these types of reflections. Every object emits thermal radiation and influences the measurement. That is why you have to understand what you are actually measuring and with an IR camera the result is much easier to interpret than with an IR thermometer.

What kind of applications does the design department have for an IR camera, you may perhaps wonder. The answer is simple: IR cameras can very accurately determine the temperature of any object that appears in front of its lens. This is very practical when looking for problems on a printed circuit board. Point the camera at the board and you can see immediately where the temperature is (too) high and where there is, in all likelihood, a (design) fault. The FLIR T425 in photo 6 was so accurate, that we could see the 'IR-fingerprint' of the silicon inside the FV1-chip in the digital multi-effects unit (Elektor September 2010) through the top of the package, even though the temperature was only a few degrees above the ambient temperature (chip temperature: 27 °C). And for the observing reader: towards the left of the image you can see that the two voltage regulators have also acquired quite a bit of color.

When you've had enough of looking at electronic circuits, you can also imitate CSI with such a camera... A hand print on a table will leave a thermal trace for at least five minutes, which is easily seen with such a camera. Footsteps are often easily traced, particularly on carpet. Follow your colleague who just walked past and try to find out where he or she just came from...

You can often also see exactly which part of a dropped object hit the ground first and where on the ground it hit. This is really just simple physics, when the object hits the ground the kinetic (moving) energy is converted into heat. And this can be easily seen on the IR camera.

(110273-I)

Internet Links

[1] www.kwx.nl
[2] www.flir.com

5

4

6

One-eared Skype

By Thijs Beckers (Elektor Netherlands Editorial)

When we tested the Microphone Conferencing System described elsewhere in this edition we were initially satisfied with the results. The left and right microphone signals entered the PC as expected. Several tests using Windows Live Messenger went smoothly and we could be understood clearly by the people at the other end. Everything appeared to work as it should.

However, when we had our French Editor on the line via Skype, using the laptop belonging to the International Editor-in-Chief, things started going wrong. Only one microphone worked. Was there a cable fault? Was the sound driver on the laptop installed properly? Was it a setting in Skype? Perhaps a 9 V battery was flat? But no, all these were in order and worked properly. To be completely sure, the cables were changed with known working ones, but the problem persisted.

Then we swapped the modules over and we noticed that the other module stopped producing sound. This got our thoughts going. With Windows Live Messenger everything worked perfectly. With Skype only the left input channel worked, and swapping the modules didn't make any difference. A quick search on the Internet made it clear that we weren't the only ones who came across this 'feature' in Skype. It was just impossible to send a stereo signal with Skype. Granted, Windows Live Messenger also sent a mono signal, but at least it did things properly and combined the left and right input channels. If the various forums are to be believed, Skype has failed to do this since at least 2005! We're sure they had a good reason for this... Anyway, in order to use our system with Skype we had to connect both channels to the left-channel input of the PC or laptop. The simplest solution is to use two resistors to combine the signals. This isn't the most elegant solution, but at least it's effective. A quick test confirmed that it all worked properly, and an inset in the article explains how to make such a 'Skype-cable'. All's well that ends well!

(110314)

Problems with noise

Thijs Beckers (Elektor Netherlands Editorial)

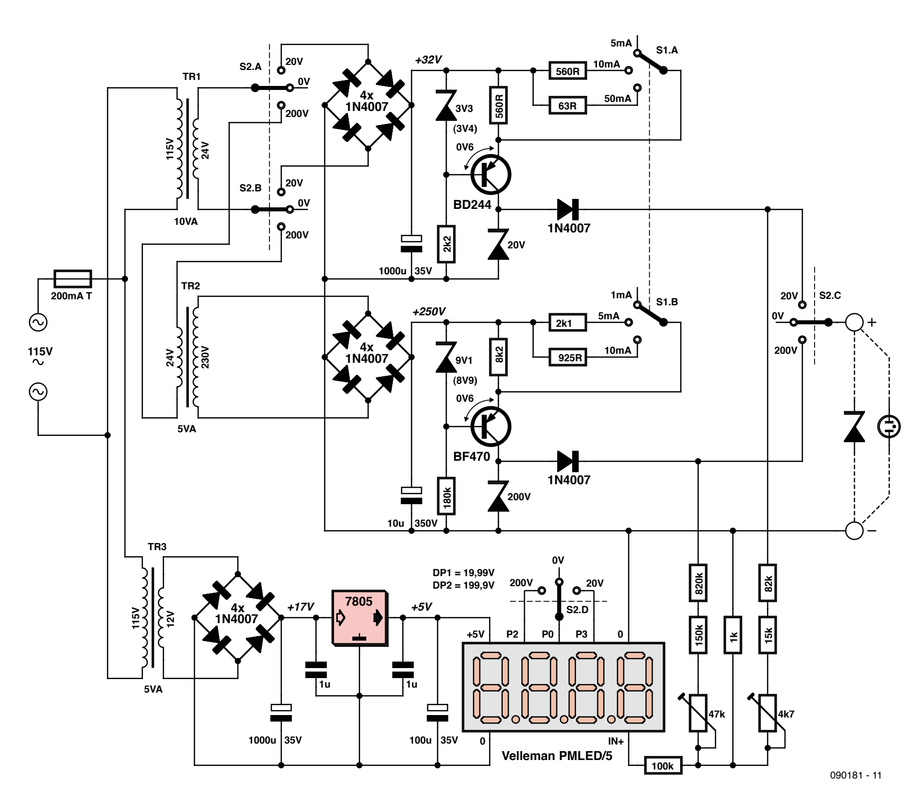
Generally speaking, audio-oriented enthusiasts tend to dislike noise and would rather see the back of it. However, for once it was the opposite when we designed the Wave Sound Generator published elsewhere in this edition. This design required a transistor that produced as much AF noise as possible. If you refer to the circuit diagram, you'll see that T2 is being 'misused' as a noise source.

The original circuit from 1996 made use of a BC547 and a 12 V power supply. Today, Chris Vossen of Elektor Labs preferred to use a lower supply voltage allowing the circuit to operate from a 9 V battery. One problem he ran into was that the noise generating transistor T2, which was replaced in the new circuit with an SMD version type BC847. This required, just as for the original BC547, a minimum of 10.5 V in order to generate a decent amount of noise. Consequently a simple 9 V battery could not supply a sufficient voltage. We also tried using a BC850, which requires a slightly lower voltage to work as a noise generator in this circuit, but unfortunately the 9 V supply was too low for this as well.

We could of course have made some drastic changes to the circuit, for example adding a boost converter to increase the 9 V supply voltage, or using a zener diode and designing a completely new circuit around that, but the editorial, the DTP and the printer were all telling us to hurry up because there were deadlines to meet, so in the end we had to cut the knot... no 9 V supply then. Oh well, at least with an AC adapter you don't have to worry about running out of power.

(110280)

Zener diode tester



By Jean Herman (Belgium)

The instrument described here lets you check that zener diodes up to 200 V are working correctly, and it lets you find out the reverse breakdown voltage of an unknown zener diode (note that zener diodes are only called zeners from 2 V to 5.6 V — those above 5.6 V ought strictly speaking to be referred to as 'avalanche diodes', as the avalanche effect then becomes predominant) The voltage stability of a zener diode depends on its internal resistance and its temperature coefficient. It's for this reason that this tester lets you measure them at various currents.

The internal resistance can be calculated from $R_{INT} = dV/dI$. The dI is achieved by subjecting the diode under test to two different currents (e.g. 10 mA and 5 mA). dI is the difference between these two currents (= 5 mA). By measuring the voltage in both cases (let's say 6.6 V and 6.3 V), we can determine dV (6.6 V − 6.3 V = 0.3 V) and hence calculate the value of R_{INT} (0.3/0.005 = 60 Ω).

A zener diode's temperature coefficient depends on its reverse voltage. For a diode of less than around 5.6 V, the temperature coefficient is negative, around 5.6 V it is zero, and above 5.6 V it is positive (not for all device brands). We can determine it by measuring the voltage across the diode and the diode's temperature with a constant current (10 mA) passing through the diode.

The device has two voltage ranges, 0–20 V and 0–200 V, which requires at least two different transformers. To generate the required voltage differences, we have three small standard transformers. Transformer TR3 is only used to provide a 5 V dc supply for the digital voltmeter module.

Switch S2 (A to D) is the 4-gang voltage range selector, and also has a central 'off' position.

20 V position

Transformer TR1 feeds a bridge rectifier via the 20 V position of S2.A. This produces a DC voltage of around 32 V. The BD244 transistor is wired as a constant current generator. Switch S1.A changes the emitter resistor in order to generate three different currents: 5 mA, 10 mA, and 50 mA. The current generated by the BD244 can be calculated roughly as:

$I_{CONST} = V_Z\ (3.4\ V) - V_{BE}\ (0.6\ V)$ / emitter resistor

A 20 V zener diode (select on test) limits the output voltage to 20 V (or if possible to 19.9 V) so as to avoid saturating the digital voltmeter. A 1N4007 diode in series with the current generator output avoids shorting out the measurement circuitry. In this case, S2.C is also in the 20 V position.

200 V position

Switch S2.A redirects the 24 V AC voltage to transformer TR2, which steps the voltage up from 24 V to 230 V. This is an ordinary 230 V / 24 V 5 VA transformer. The bridge rectifier here produces a DC voltage of around 250 V. The BF470 transistor is also wired as a constant current generator.

It's not easy to find high-voltage PNP transistors – the BF470 is a type used as a video driver for CRTs. Here again, switch S1.B this time changes the emitter resistor in order to generate three different currents: 1 mA, 5 mA, and 10 mA (see calculation above). These currents are lower, as the diodes have a higher voltage. But at 10 mA and 200 V, that still means the BF470 transistor has to dissipate 2 W with the output shorted — i.e. for a 200 V zener.

0 V position

Note that selector S2 also has a middle position where nothing is switched.

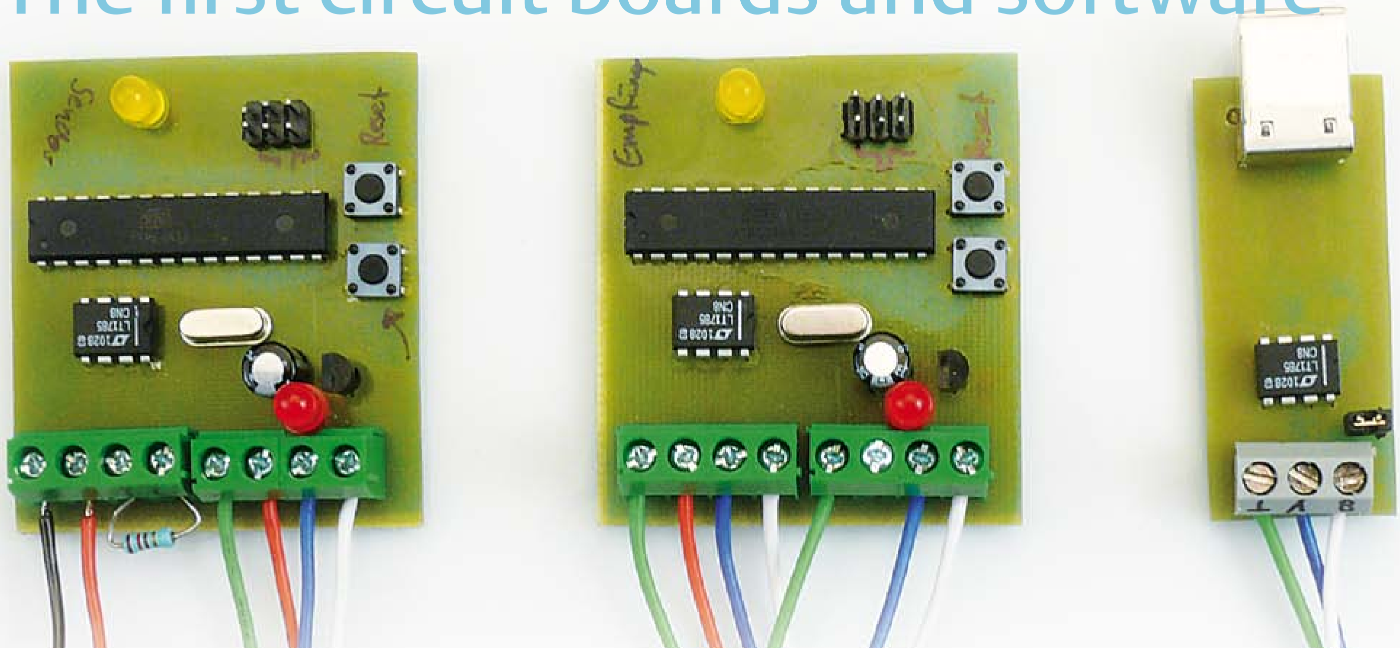
With this device, you can also test the insulation of ordinary diodes, as well as gas regulator tubes like the OA2, OB2, etc. and VDR varistors (some are polarized). The measurement accuracy of the voltmeter will give the true value of the zener voltage and the temperature drift of the device voltage.

Selector S2.D changes the module's decimal point position between 19.99 V and 199.9 V — though the sensitivity always stays the same at 199.9 mV. Don't forget to remove the solder bridge which is fitted by default on the voltmeter module's P3.

(090181)

Here Comes the Bus! (5)

We’re off!
The first circuit boards and software



After all the theory we covered in the previous articles in this series, we are now finally ready to try to send some real bytes over some real wires! The test hardware takes the form of two ATmega88 test nodes and a compact USB-to-RS-485 converter, and to these we add a dash of BASCOM and Visual Basic. Oscilloscopes at the ready! As always, we find that there are lessons to be learnt as we lay the foundation stone for future hardware and software developments.

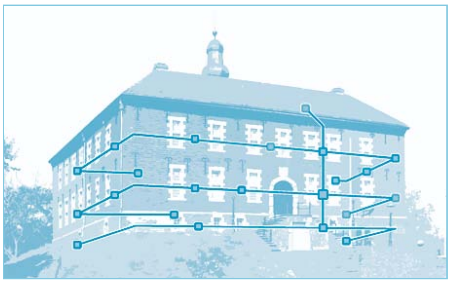
By Jens Nickel (Elektor Germany Editorial)

In the previous installment in this series we described a very simple bus communication protocol, where a message just consists of 16 bytes [1]. The first byte always has the value 10101010 binary = AA hex = 170 decimal and can be used for synchronization. The second byte determines where the address and data payload are located within the packet and whether the last two bytes are used for error detection. That’s that sorted out then, I thought as I sat back after polishing off the previous article; now I can relax for a bit. How deluded I was!

The newly-set-up mailing list for interested readers (including some highly experienced designers) was not going to let me rest. Readers were chipping in with ideas and suggestions drawn from their own or other people’s bus designs. Since RS-485, as normally defined, does not include a built-in mechanism for detecting bus collisions, there was a lively discussion on the topic of how we would avoid collisions in our system in the future. Scheduling was a frequently-aired idea, whereby a special network node would be responsible for allocating ‘transmission slots’ to the other bus participants. The simplest form of this seemed to me to be a kind of query-response structure, with the scheduler node sending a message to another node to prompt it to transmit, the node in question then sending a suitable reply. The scheduler’s attention would then turn to the next node, and so on. This approach, which I dubbed ‘round-robin ping-pong’, gives rise to a problem, however: if 32 bus participants are to be interrogated in turn, then each one will only be given a chance to speak about once per second (assuming our low-speed bit rate of 9600 baud). Another topic of discussion was robustness (what to do if the scheduler fails?) computing time in the bus nodes (each must be continuously listening) and the rather tricky problems that arise when you try routing messages between two interconnected bus segments.

The first prototypes

From my own experience I was aware that during a theoretical discussion like this it can be useful to do a few experiments, and that when you see something actually working for the first time, it is a great motivational boost. So we must press on with our first prototypes and software! We could come back to the question of schedul-



ing later, and in any case we had already discussed possible solutions to the problems mentioned above. For now, we just wanted to send a few bits over some physical wires. Otherwise I would have had to put things off for a while, as the editorial team was in the middle of putting the April issue together and our labs were about to be inundated with other projects.

Fortunately we had on our ElektorBus team a highly experienced engineer in the form of Günter Gerold, who could not wait to get to work on the project. He's the kind of chap who rarely lets his soldering iron get cold, and who thinks nothing of etching a couple of printed circuit boards. So, just a few days after we had sent him a couple of components, a parcel arrived on my desk containing two fully-populated boards corresponding to the circuit diagram we gave in the previous issue. Not only that, Günter had also designed, etched and populated a small USB-to-RS-485 converter board! And, as if even that wasn't enough, he had also written a couple of lines of BASCOM to test the boards by sending a byte over the bus. This was accompanied by some test software in Visual Basic to check that the PC could also receive the byte via the converter board.

Test nodes and USB converter

The circuit board layouts are included in the download available from the web pages accompanying this article [2]. Populating the boards is not too difficult, although the design does reflect Günter's fondness for SMD components. The circuit diagram for the test node is repeated in **Figure 1** (and the photograph at the start of this article shows the prototypes). We used a standard two-by-three header for in-system programming (ISP): note that it is of course important to fit the AVR ISP connector the right way around.

The circuit for the USB-to-RS-485 converter (see **Figure 2**) is based on the one given in the datasheet for the FTDI FT232R USB-to-TTL converter IC [3]. The circuit is not too difficult to understand, especially when compared side-by-side with the circuit of the test node. In this case the DI and RO pins of the RS-485 driver are connected to the TXD and RXD pins of the FT232R, which deals with all the details of USB communication. The FT232R's CBUS2 pin by default brings out the TXDEN signal, which we can use to provide half-duplex operation on the RS-485 bus. When data are received over the USB connection the DE pin of the LT1785 is taken high so that it drives the RS-485 bus. We used the same pin arrangement in the 'modded' full-duplex USB-to-

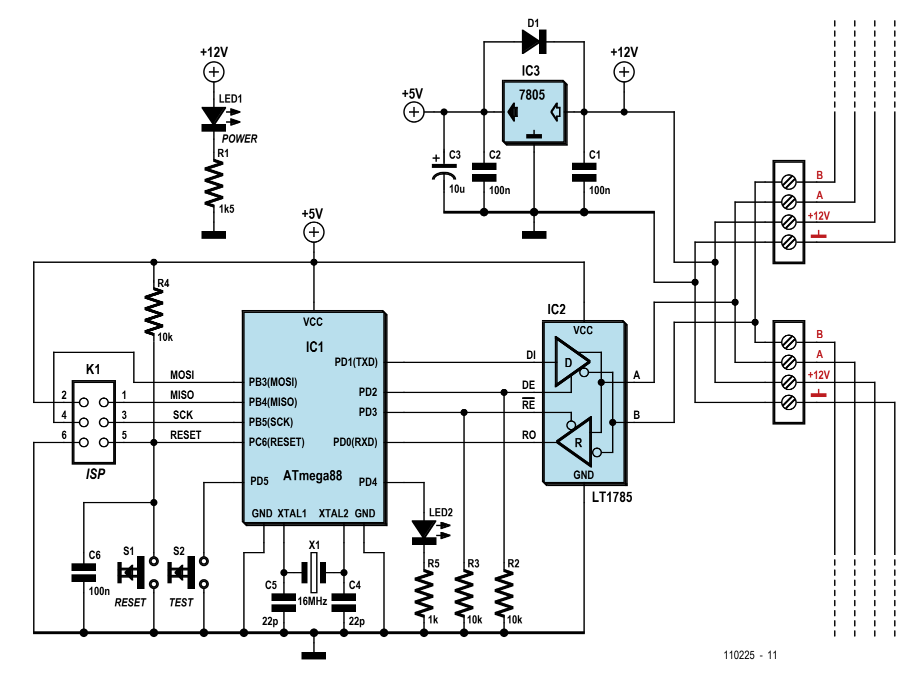


Figure 1. Circuit of the test node, as given in the previous installment in this series. Two screw terminals are available for each bus wire, making it easier to extend the bus from node to node.

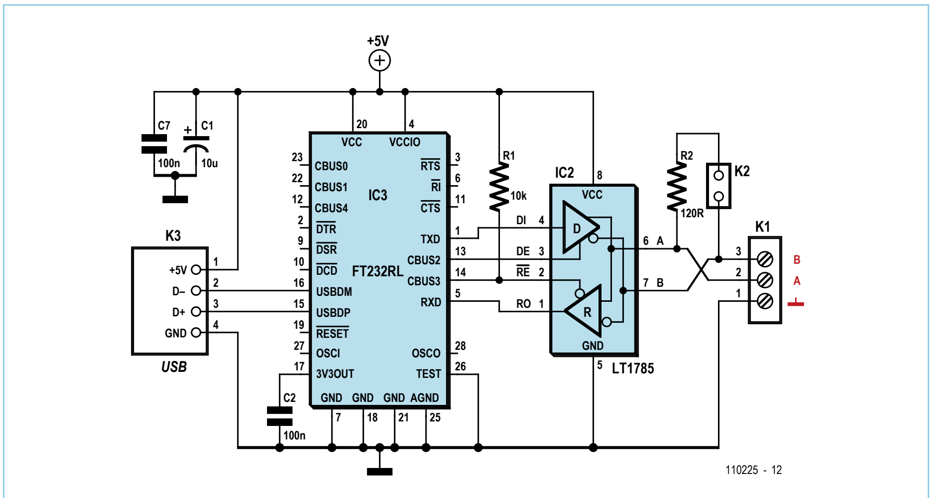


Figure 2. Circuit diagram of the USB-to-RS-485 converter based on the ever-useful FT232R.

Listing: BASCOM software (excerpt)

```
Readeeprom Ownaddress , 2      'Addresses in EEPROM
Readeeprom Otheraddress , 3

Do

 If Button = Pressed Then      'Button alias Portpin PD5
    If Buttonstatus = Released Then Sendeventflag = True
    Buttonstatus = Pressed
 Else
    Buttonstatus = Released
 End If

 If Sendeventflag = True Then
   Driver = Enabled          'Portpin PD2=1
   Receiverstop = Enabled    'Portpin PD3=1

   Set Ucsr0a.6              'flag (see below) must be (re)set

   Sendmessage(1) = 170            'Byte 0 in ElektorMessageProtocol (EMP)
   Sendmessage(4) = Otheraddress   'EMP Byte 3 = address-byte of receiver
   Sendmessage(6) = Ownaddress     'EMP Byte 5 = address-byte of sender
   Sendmessage(7) = 10             'EMP Byte 6 = first databyte of sender
   Printbin Sendmessage(1) ; 16    'send 16 bytes message

   Do
    Loop Until Ucsr0a.6 = 1    'wait until all bytes sent

    Driver = Disabled
    Receiverstop = Disabled

    Sendeventflag = False
 End If

 If Receivedeventflag = True Then       'an incoming message?
    Commandbyte = Receivedmessage(7)    'first data-byte

    If Commandbyte = 10 Then
       Toggle Testled
    End If

    Receivedeventflag = False
 End If

 Waitms 10

Loop


Onrxcomplete:         'Interrupt on first incoming byte

 Startbyte = Udr
 If Startbyte = 170 Then
    Inputbin Receivedmessage(2) ; 15    'Read following 15 bytes
    If Receivedmessage(4) = Ownaddress Then
       Receivedeventflag = True         'incoming message
    End If
 End If

Return
```

RS-485 converter that we described in the December 2010 issue [4]. The CBUS3 pin gives us access to the PWREN# signal, which is low during normal USB operation [3]. Hence the receiver in the LT1785 is always active and the USB chip is always listening to the bus.

The jumper allows a 120 Ω termination resistor to be fitted between the A and B bus lines. The bus itself is connected via screw terminals, and the third contact of the terminal block is the ground connection for the board, and hence also for the USB connector, which is normally at earth potential. The significance of this connection (under normal conditions the bus will work without the earth) is described in more detail in the text box.

Fitting the FT232R requires a little delicacy and soldering know-how: it is only available as an SMD component (**Figure 3**). Elektor may produce a partially-populated version of the converter board at some point in the future; alternatively, it is possible to make use of the popular USB-to-TTL adaptor cable available from FTDI, which already includes an FT232R device [5].

First tests

For our first tests we wired the nodes together using ordinary wire (see lead photograph: bus line A is blue, B is white, +12 V is red and earth is green). The doubling up of the screw terminal blocks makes things simpler here, as one of the nodes can easily be wired directly to the USB-to-RS-485 converter. If we consider the PC to be bus 'node 0', then we can call the two ATmega test nodes 'node 1' and 'node 2'. We need to make sure that there are termination resistors at either end of the bus: at the converter end, this is just a matter of fitting the jumper; at the other end, we can simply fit a (leaded!) resistor between the spare A and B screw terminals on the second test node.

For experimentation we need an AVR ISP-compatible programmer and a development environment. Since Günter had already put together a couple of lines of BASCOM, I decided to stick with this environment for now, though I promise to add some C code later on. Installing BASCOM is not difficult, and the manufacturer's site includes a good set of instructions [6]. Inci-

dentally, the free version of BASCOM, which is limited to a code size of 4 Kbyte, is more than adequate for our purposes: for comparison, the microcontroller has 8 Kbyte of flash memory of which the firmware described below occupies only about 10 %.
I used an original Atmel AVR ISP mkII programmer. To get BASCOM to work with this device, it is necessary to install the libusb driver (which is open source and also free) [7]. The BASCOM documentation [6] also includes a guide showing how to do this.
Next I turned my mind to writing a first version of the firmware capable of sending and receiving 16 byte messages according to the *Elektor* Message Protocol (EMP). Then I wrote some software for the PC, using Visual Basic (the Visual Studio Express development environment from Microsoft is also free [8], but if you prefer, you could use the open source Sharp Develop IDE [9] as Günter does). Some help in installing Visual Studio can be found at [10].
While working on this code I encountered a couple of anomalies: sometimes the PC would suddenly receive a stream of phantom data bytes; at other times the bus would work only when the programmer was disconnected; and still other times it would only work when the programmer was connected! After some head-scratching, my colleague Thijs Beckers (who already has a couple of audio projects under his belt) and I finally ran this puzzling problem literally to ground: see the text box 'Grounding for Dummies'.

Firmware

The results of our efforts are available for download from the website as source code. The same firmware runs in the two nodes: it allows a node to send a 16 byte message over the bus when its test button is pressed. In accordance with the EMP, the message consists of the following bytes (see **Figure 4**): a start byte (170 decimal); a mode byte (zero); two bytes each for the receiver and transmitter addresses; and finally the payload data. The CRC is not yet implemented, and so for simplicity's sake we have set the two bytes to zero. The payload consists of a byte with the value 10. Each node's own address, as well as the addresses of the other nodes, must be programmed permanently into the EEPROM of the ATmega using BASCOM: set bit G in the high fuse byte to zero ('preserve EEPROM') so that the EEPROM is not overwritten by subsequent firmware updates.
The listing shows an excerpt from the first version of the firmware. When a node receives the first byte of a message, it triggers a *URXC* (*UART RX complete*) interrupt in the microcontroller. The program then jumps to the label *Onrxcomplete*. The subsequent lines of code read the next fifteen bytes from the interface using the *Inputbin* command and store them in the byte array *Receivedmessage*. Then a flag bit internal to the program (not to be confused with the ATmega's flag register) called *Receivedeventflag* is set. This acts as a signal to the main program that a message has arrived and that data are waiting to be processed.
The main program itself consists of an infinite loop with three sections of program code within it. The first section checks whether the button has been pressed. If so, the dedicated *Sendeventflag* is set, which means that, as a result of an internal event, there is a message to be sent out over the bus. A further flag bit, *Buttonstatus*, is used to save the state of the button to prevent sending multiple messages if it is held down.
The two remaining sections of program code check whether *Receivedeventflag* or *Sendeventflag* are set. In the former case the received message is processed. If byte 6 of the message is equal to 10, the test LED on the node is toggled. (Note that BASCOM indexes arrays starting from 1, so byte 6 has index 7 in the byte array.) If *Sendeventflag* is set a message is assembled for sending. The correct address bytes for the receiver (i.e., the address of the other node) and the transmitter are retrieved from the EEPROM as mentioned above. Before the sending can commence the DE input of the bus driver must be taken high: in BASCOM this is done using the command *PORTD.2 = 1* (for more information, see the short BASCOM course at [11]). To avoid having to refer constantly to the circuit diagram, I have set up some constants and aliases at the start of the program. This makes the command rather easier to read: *Driver = Enabled*. The message is sent using the *Printbin* command, and then a small loop waits for all the bytes to be drained from the transmit buffer (bit 6 of the *UCSR0A* register in the Atmega88 is *TXC*). The DE pin of the LT1785 can then be taken low again.

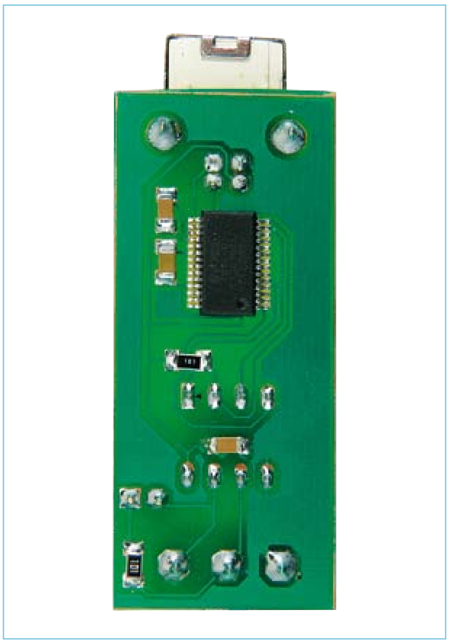


Figure 3. Soldering the FT232R is no easy task, and we are looking into ways to make construction easier for beginners.

PC software

To get communications working on the PC, the VCP (virtual COM port) driver for the FT232R chip has to be installed. This

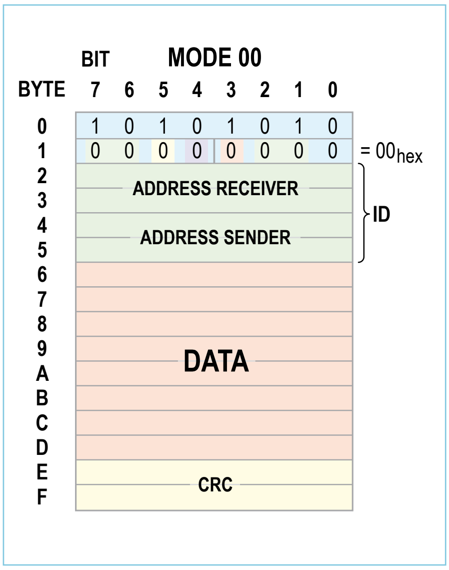


Figure 4. The structure of a 16-byte message using mode 00 (hex) of the Elektor Message Protocol. The CRC field is not yet implemented.

Grounding for Dummies

It took me a good hour or two to realize that it was essential to wire the ground connection on the bus (green wire) to earth, and, just as importantly, not to earth either of the two signal wires (blue and white)!

The latter can easily happen if you unthinkingly attach an oscilloscope across the bus to have a quick look at what is going on. What is the problem? The LT1785 bus driver can only drive the two bus lines between 0 V and +5 V relative to its ground, and represents one bus state by a positive differential voltage (taking one differential output High and the other Low) and the other bus state by a negative differential voltage (taking the first differential output Low and the other High) [16]. When the bus is idle the two wires typically both float to a 'common mode' voltage of about 2.5 V (relative to the driver's ground), with approximately zero differential voltage between them. Now, attach an oscilloscope probe across the bus wires and a short can be created via the ground clip on the probe, AC power earth, the PC's earth connection and hence its USB ground connection, and the ground point on the USB-to-RS-485 converter board. The driver will no longer be able to take the output corresponding to the shorted bus wire to +5 V relative to its ground, and it will therefore not be possible for it to establish one of its two output states.

The ground screw terminal must be connected to the bus ground at each node, and hence to the ground of all the other bus participants. An interesting experiment that we inadvertently tried is to power the test nodes independently from common-or-garden (switching) mains adaptors whose outputs are not connected to AC grid earth. The ground output of these devices floats (or, more accurately, oscillates freely at 50 Hz) relative to AC grid earth, and hence so does the common mode voltage of the bus. As long as the only connection between the nodes remains the bus, everything will still work; but woe, when the properly-earthed USB-to-RS-485 converter is plugged in! The oscillating voltages on the bus are interpreted by the receiver as bits and bytes, and all the PC software sees is junk. Connect the earth between the converter and the other nodes and all will be well again.

The idea of using a third screw terminal came from John Dammeyer. He points out that the earth connection also has a protection function: without it, if a wiring fault should mean that a high potential relative to mains earth appears on the ground connection (and hence on the bus wires) at one node, the only protection for the computer's USB connector is the RS-485 driver on the converter board. With the extra ground connection at mains earth potential, it is likely that at worst a track on one of the bus nodes will be damaged. Repairing that is a rather cheaper prospect than replacing the motherboard in the PC!

can be downloaded from the FTDI website [12], and there is an installation guide at [13]. With that done, it should be possible use a terminal program running on the PC to view the bytes received on the bus by the converter (although I have not actually tried this). Our first PC software is based on Günter's VB.NET program that he used to test the converter board he assembled. He had already worked out how to use the .NET *SerialPort* class [14] to configure a (virtual) COM port and receive characters. I also found the book 'Serial Port Complete' by Jam Axelson [15] very useful. In the book Jan, whom incidentally I was able to persuade to join our mailing list, covers the basics of COM ports, RS-232 and RS-485, with a wealth of practical tips and advice on isolation, cabling, termination and the like. Program examples on the PC side are equally practical, using the .NET framework throughout. Listings are given in VB and in C#.

A detailed description of the PC software is outside the scope of this article, but the source code is commented. *ComPort* is the instance of the *SerialPort* class that we use. Its *DataReceived* event [14] is used to trigger a call to the subroutine *Receiver*, which processes the incoming messages. We have used the property *ComPort.ReceivedBytesThreshold* to ensure that the event is triggered only when a total of 16 bytes, or one complete message, has been received: being able to do this is a handy consequence of our choosing a fixed message length. Unfortunately it is not possible to visualise the incoming message by changing elements in a form directly from the routine *Receiver*; instead, it has to be done in its own routine, called from *Receiver* using the *BeginInvoke* method. The received bytes have to be transferred to this new routine in an array. Here is the grisly explanation for more advanced programmers (we recommend less advanced programmers just put up with the situation and leave the relevant code alone!): the *DataReceived* event is trig-

Weblinks

[1] www.elektor.com/110012

[2] www.elektor.com/110225

[3] www.ftdichip.com/Support/Documents/DataSheets/ICs/DS_FT232R.pdf

[4] www.elektor.com/100369

[5] www.elektor.com/080213

[6] http://avrhelp.mcselec.com/index.html

[7] http://sourceforge.net/projects/libusb-win32/

[8] www.microsoft.com/express/Downloads/#2010-Visual-Basic

[9] www.sharpdevelop.net/opensource/sd/

[10] www.elektor.com/100539

[11] www.elektor.com/080330

[12] www.ftdichip.com/Drivers/VCP.htm

[13] www.ftdichip.com/Support/Documents/InstallGuides.htm

[14] msdn.microsoft.com/en-us/library/system.io.ports.serialport.aspx

[15] www.lvr.com/spc.htm

[16] http://cds.linear.com/docs/Datasheet/178591fc.pdf

gered in its own thread, and changing user interface elements is only possible in the main thread. We therefore need to communicate the data between the two threads. The routine *ShowMessage* is responsible for processing and displaying the message.

Operation

After starting up the PC software the correct COM port must be selected in the combo box. Then press the *Connect* button to set up the connection. The software will now listen to the bus and display all received messages, along with timestamps, in the text box. Messages sent from the PC will also appear here. The two test nodes are depicted in the middle of the form, each with its test LED and test button. Pressing the 'node 2' button is equivalent to pressing the button on that node's board, and the LED on the other node should turn on or off. The software can easily be extended. For example, I modified it to incorporate an acknowledgement from the receiver: when its LED is turned on, it transmits a message containing the byte value '11', and when its LED is turned off it sends '12'. This allows the actual state of the LEDs to be displayed on the PC, and marks the first step on the way to making a complete home automation controller. I'm sure you will quickly think of lots of further ways to extend and improve the system!

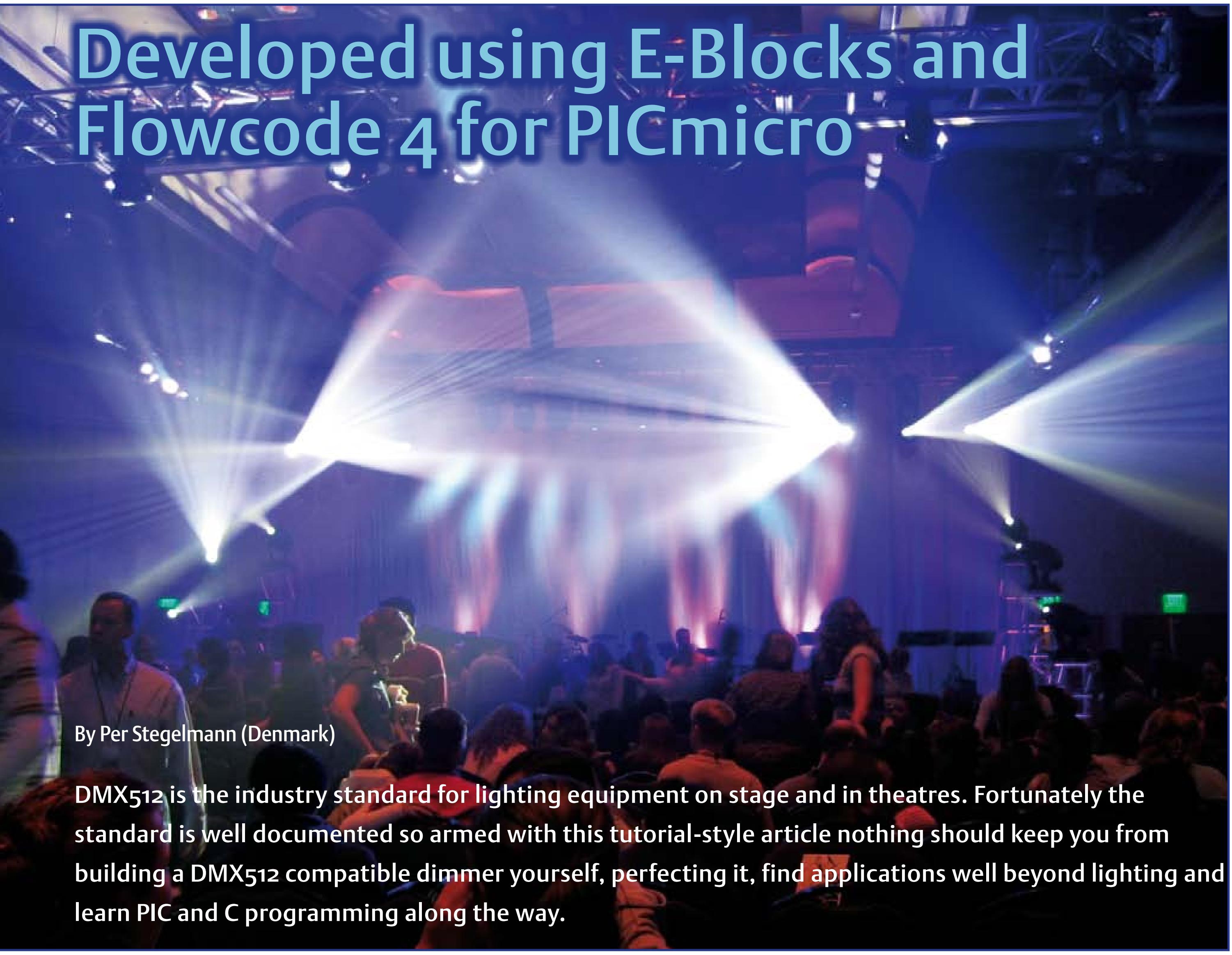
(110225)

What do you think?

Feel free to write to us with your opinions and ideas for the development of this system.

Figure 5. Screenshot of the PC software in action. Our mini-controller can switch the LEDs on the nodes and also show all the messages being sent on the bus.

1-Channel DMX512 Light Dimmer



Developed using E-Blocks and Flowcode 4 for PICmicro

By Per Stegelmann (Denmark)

DMX512 is the industry standard for lighting equipment on stage and in theatres. Fortunately the standard is well documented so armed with this tutorial-style article nothing should keep you from building a DMX512 compatible dimmer yourself, perfecting it, find applications well beyond lighting and learn PIC and C programming along the way.

The DMX512 dimmer discussed here was developed out of the **DMX512 Tester** from Elektor June 2002 [1]. The tester proved a valuable device as you can select any channel you want to work with (up to 480), as well as change the 'Start of Frame' (SOF) character used, allowing you to test other DMX512 equipment besides dimmers.

The microcontroller used in the DMX512 Dimmer is a PIC16F88 with its built-in serial UART that's ideal for the DMX receiver function. The 16F88 also has the usual TMR0 timer/counter module, which is used here to control the triggering of the triac, which in the end governs the effective voltage applied to the load connected — observing the AC voltage zero-crossing of course with the help of a detector. When a zero-crossing is detected PIC timer TMR0 is loaded with a value that controls the triac's firing instant, where effectively 0x00 = zero power and 0xFF = maximum power. Actually, when 0x00h is written to the lamp, it is not fully quenched. Instead a small permanent glow is established to extend the lifetime of the lamp and make it respond faster. The ramp eventually governing the lamp brightness can be altered in the firmware.

Circuits and sub-circuits

The circuit of which the schematic is shown in **Figure 1** can be thought of as consisting of a number of sub-circuits identified as power supply, microcontroller, zero-crossing detector, AC powerline interface, DMX address selector and RS485 driver. Let's have a look at them.

Features

- BCD thumbwheel setup of DMX address – all 512 channels are selectable.
- LED indication of wrong DMX address selected. (slow flashing LED)
- Power-down of module on overheating
- LED indication of thermal power-down (fast flashing LED)
- All Flowcode v. 4 programmed

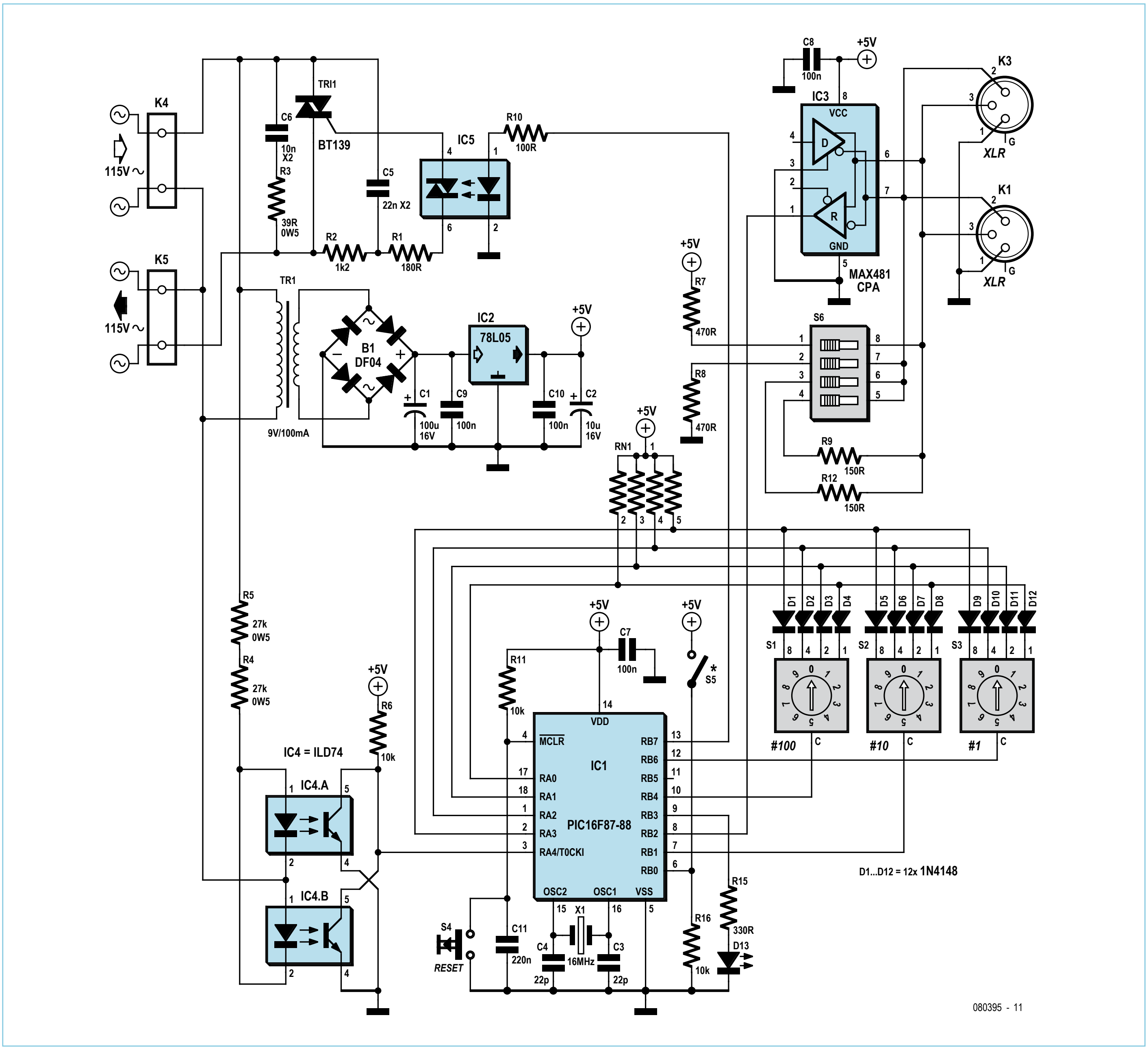


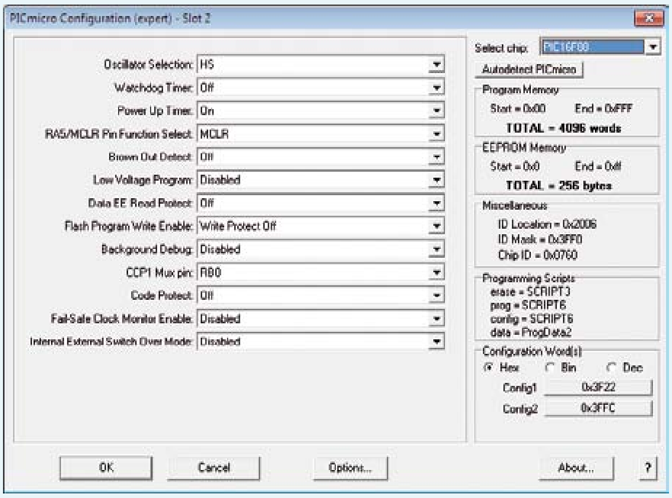
Figure 1. Circuit diagram of the Flowcode-developed DMX512 Dimmer.

Elektor Products & Services

- E-Blocks PIC Multiprogrammer: # EB006
- Flowcode 4 for PIC4 Student version: # TEFLCST4
- Flowcode program (.fcf), C program, source code, hex files (free download): # 080395-11.zip
- Hyperlinks in article
- Items accessible through www.elektor.com/080395

Programming the microcontroller

The programming of the PIC 16F88 microcontroller is straightforward. If you have a programmer that works with Flowcode you just set up the chip as shown in the screenshot below and then press the '**Compile to chip**' icon. If you don't have a programmer that works with Flowcode you use the **Compile to HEX** option instead and then use your own programmer to program the chip.



A problem was encountered when a PIC was programmed for the first time. It looked like everything was fine, but it turned out the code was not programmed to the chip. After many desperate attempts the problem was identified as one setting in the PPP v3 options screen.

The culprit turned out to be the field **"Confirm HEX file format"**. By checking the box and saying No to PIC18 hex file when programming, it worked. Next, the tick was removed again, and the setup continued to work! What went wrong shall remain a mystery, but try this if you are having trouble when programming the chip, maybe it's only a W7 problem?

The power supply in straightforward with its power transformer (Tr1), bridge rectifier (B1), 100 µF reservoir capacitor (C1), 78L05 voltage regulator (IC2), smoothing and decoupling capacitors (100 nF and 10 µF; C9, C10, C2), Note Tr1 must be chosen to match the local line voltage (230 VAC or 110-127 VAC).

The microcontroller for this project is a PIC16F87/88 ticking at 16 MHz. It has an RC circuit connected to its /MCLR terminal allowing a reset button to be connected. Port line RB0 is used for the thermal protection function (S5 being the thermal switch), and TMR0 for zero-crossing detection and timing of the triac firing instant. Port line RB2 is the DMX data input pin, and RB5 the TX pin (not used here).

The zero crossing circuit consist of a dual optocoupler type ILD74 (IC4) and voltage droppers R4 and R5. The circuit detects both zero crossings.

The AC power circuit is built around a type MOC3023 optotriac (IC5) driving a BT139 power triac for control of the power to the load. This circuit can be traced back to a Fairchild application note.

The DMX address selector comprises three BCD switches, four pull-up resistors and 12 diodes. By multiplexing the common pins of the BCD switches, the value from each switch is read.

The RS485 driver is only one IC type MAX481CPA, a 4-way DIP switch and a couple of resistors. It's set up to receive data only.

Software development, step by step

While developing the firmware for the PIC in the DMX512 Dimmer the author went through several steps, these were documented and rendered below for you to follow and appreciate the ease of using Flowcode.

Step1. The code for reading the DMX channel address was placed in a loop that tested the switches and flashed the LED if the DMX address was not valid. An address must be in the range 1 to 512 to be valid. Once this was working, the function was turned into a Flowcode macro so it could be called as needed from the main program. The value of each switch is read by pulling a port B pin line Low, effectively enabling the connected BCD switch so that the value can be read via port A.

Step2. The next thing was the DMX receiver part, this was a bit more tricky to get right as it makes use of the standard Flowcode RS232 component and a C code box. The RS232 macro call is used to setup the baud rate for the receiver (250 Kbits/s) and to enable the hardware. The C code box (**Figure 2**) contains the code that takes care of receiving incoming DMX data and testing for errors. The DMX data format is defined as (in sequence and extremely simplified):

1. a Break on the DMX line (1 ms).
2. a Start of Frame (0x00 for dimmers).
3. the actual DMX channel values; this can be up to 512 data bytes but not all equipment sends all channels.

A Break condition on the DMX line is detected by testing for frame errors on incoming data (RCSTA = 0). When no more frame errors are received, the next data byte must be a Start of Frame (0x00), otherwise the receiver is reset (DMX_STATE = 0), and another Break on the DMX line is awaited. If there was a Start of Frame, the DMX channel count is set to 1 and DMX_STATE to 1. Now, when the selected DMX channel address is reached the DMX_VALUE is updated with RX_DATA, the DMX_STATE is set to zero, and the receiver loop can start over again.

Step 3. With the receiver part working it was possible to proceed with the actual dimmer part of the software. This uses the TMR0 interrupt on overflow, and it's used for zero crossing detection as well as a timer to define the triac firing instant. This is done by means of a Flowcode interrupt component to enable the TMR0 interrupt, choosing TMR0 as interrupt source, T0CKI as clock source, the Low to High transition as the clock, and setting the prescaler to 1:1; see the screendump in **Figure 3**. Using a C code component to preset the TMR0 to 0xFF will enable the zero crossing detector as an overflow will occur at the first zero crossing of the AC line voltage. This in turn will call the macro called 'Fire_triac' containing a decision component at the start that decides which way to branch in the program. If Enable_trigger = 1 the triac will be fired, Enable_trigger is reset to zero, and TMR0 is ready to overflow on the next zero crossing. If Enable_trigger = 0 TMR0 is loaded with a value so that it will produce an overflow when the triac is due to fire.

Step 4. Soon, TMR0 value calculations were required. With the microcontroller running at 16 MHz, the clock cycle lasts 16 MHz / 4 = 4 MHz ~ 250 ns. Now the TMR0 prescaler is set to 1:256, giving 256 x 250 ns = 64 µs, being the basic clock for TMR0. If we now take 256 x 64 µs = 16.38 ms, that's the maximum period TMR0 can measure, which is more than enough here as you only need to count to approximately 10 ms (one half cycle at 50 Hz AC line frequency, if you use 60 Hz you will need to alter the software). Consequently TMR0 has to be preloaded with a value that will shorten the time, this value can be found as: 10 ms / 64 µs = 156, i.e. a preload value of (256 – 156) = 100 is called for. By adding this preload value to our DMX value (DMX value is divided by 2) we get the actual TMR0 preload value, this is calculated in a 'C code' box in Flowcode.

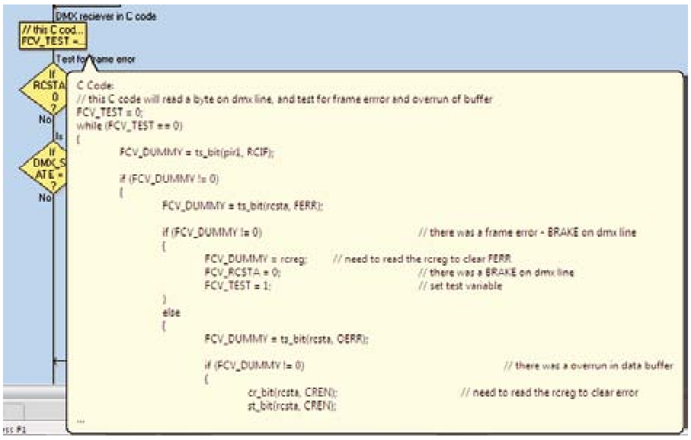


Figure 2. The C code box handles the DMX512 data reading and frame error / overrun detection.

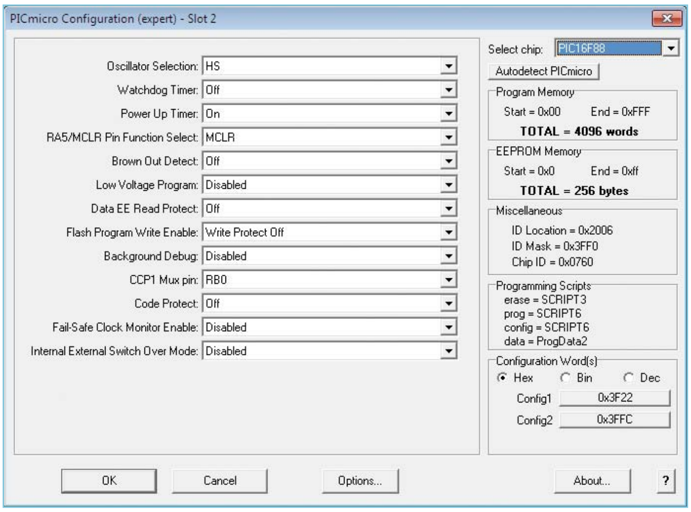


Figure 3. Flowcode method of configuring TMR0 for interrupts.

Step 5. The last thing that got added was the thermal protection circuit. This will protect against thermal damage using a temperature switch that closes at a temperature of about 60–80 degrees C, the switch proper being a normally open type. If not, the software must be changed accordingly.

Software structure

The software for the DMX dimmer was developed with **Flowcode 4 for PICMicro** and works as described below. The complete Flowcode program developed for the project is available free of charge from the web page set up for the project [2]. Got it handy? Here we go.

The program has three submacros, the first reads the BCD switches to obtain the DMX channel address to be used and the second is a TMR0 interrupt macro that detects zero-crossing and controls the triac firing. The last macro is a thermal shutdown feature, if called this macro will turn off power to the load; it is only called and activated if a thermal switch (S5, NO) is connected between RB0 and +5 V. Reading of the BCD switches is done at the start of the program, so if the channel setting is changed you will have to reset the dimmer or switch the AC power to the module off and on again.

In the main program, the software is setting up the serial port by doing a dummy read. Now the DMX channel address is read and TMR0 is initialized to interrupt-on-overflow, as well as count on the rising edge input to pin A4. Also, TMR0 register is preset with 0xFFh, causing it to generate an interrupt when there is a rising edge on this pin — that's the way a zero crossing is detected.

Now the program goes into 'loop forever', this is where the actual DMX data byte receiving is performed (one of Apple's head offices in Cupertino CA, is at the address: *1, Infinite Loop)*. First, the program has to detect a 'break' on the DMX line. This is done in the outer loop where frame errors on received bytes are detected. Once bytes without frame errors are received the next thing to test for is a Start of Frame (SOF) byte, which for dimmer modules equates to 0x00h. If it was a SOF byte, then the next thing to do is count the received bytes until the selected DMX address is reached, then copy the received DMX data to the register used in the TMR0 macro, that's it! A part of this routine is shown in **Figure 3**.

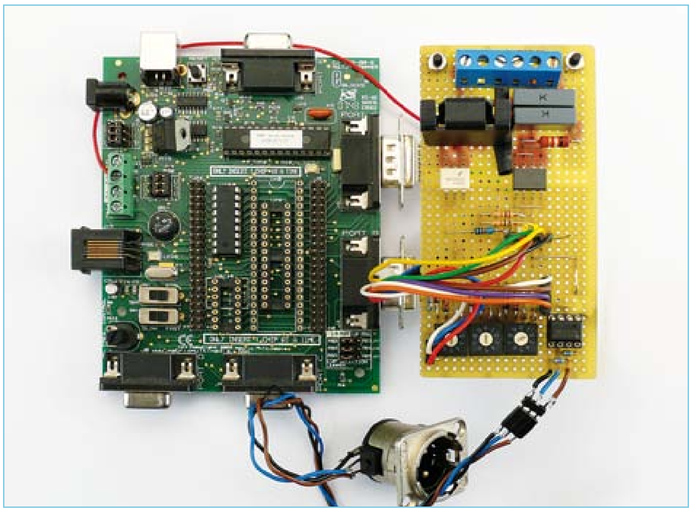


Figure 4. Experimental construction of the DMX Dimmer on a piece of breadboard connected to the E-Blocks PIC MultiProgrammer.

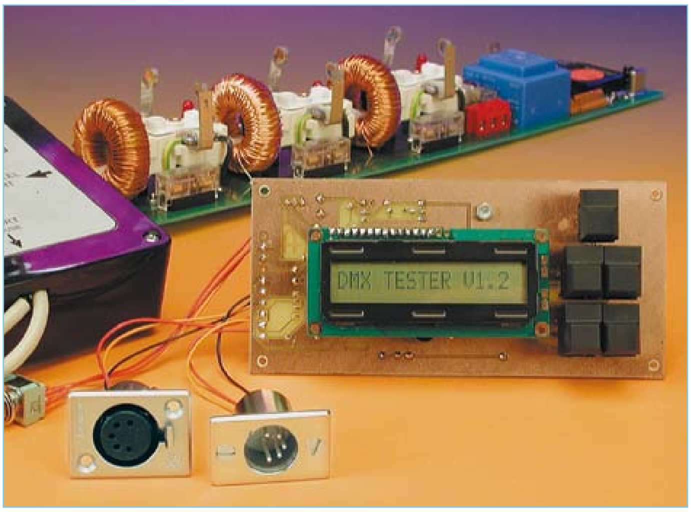


Figure 5. The Elektor DMX Tester described in the June 2002 edition.

Inside the TMR0 interrupt macro, when there is a TMR0 interrupt the software checks if it was a zero-crossing overflow or an TMR0 timer overflow interrupt. If a zero crossing interrupt occurred the TMR0 register is preset with the DMX value after calculation, and TMR0 is started again this time as a timer. The next interrupt-on-overflow effectively marks the triac firing, this is done with three trigger pulses to ensure proper triggering at any time in the AC half period. Now TMR0 is enabled again, this time for counting on the rising edge of A4 and preset with 0xFFh — this completes the macro.

Construction

Figure 4 shows the first setup for testing the idea. The perfboard (breadboard) contains a zero-crossing detector, AC line interface, RS485 interface, and three BCD switches for setting the DMX channel address. A LED is connected on port B (PB.3) on the sub-D connector, it's used for debugging and status display. The board and the EB006 MultiProgrammer [3] are powered externally by a wallwart with 9 V 250 mA output. The breadboard circuit was used for various experiments, not only with PIC microcontrollers but also Atmel and other devices, as it is fully isolated from the AC line voltage via optocoupler and a optotriac driver. For good measure we should add that no PCB was designed for this project by Elektor Labs.

The experimental dimmer board is connected to the E-Blocks PIC MultiProgrammer using 9-pin sub-D plugs connected to port A and port B. The Elektor DMX tester is pictured in **Figure 5** mainly to recall another brilliant Elektor design.

What enclosure to choose for this project will depend mostly on the conditions under which the dimmer is to be used. If it is for indoor use only the box does not need to be IP65 class (waterproof), but if it's to be used out of doors IP65 is a must. Also, all relevant precautions in respect of electrical safety must be observed when installing the board in a box and fitting the wiring.

(080395)

Internet Links and References

[1] Portable DMX512 Tester, Elektor June 2002. www.elektor.com/010203

[2] www.elektor.com/080395

[3] www.elektor.com/e-blocks

About the author

Per Stegelmann (44) lives in Denmark. Trained as an electronics technician, his current profession is building and repairing test equipment for the production of hearing aids. Per writes: "*When one of my colleagues asked me if I had ever seen a program for developing microcontroller code that used icons to code with, he showed me a demo version of Flowcode, the software tool for E-Blocks. I tried it out, and soon I was hooked — it was a whole new way to do the code development. Earlier I had done some assembly language and C coding, but this I had never tried before. I had seen some ads for Flowcode but thought it would not be constructive or capable of producing useful code. As it turned out, Flowcode proved very useful indeed producing valuable code while also making the documenting of your program a breeze — you just print out the flowchart. So I bought a licence and an E-Blocks PIC Multiprogrammer, and a few weeks later I had my first application up and running.*"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Wave Sound Generator
Restful electronics

The sound of the sea, or more precisely the sound of waves, has a relaxing and restful effect on people. In these busy and hectic times there are many people who need this, for example to help them fall asleep at night. It's fairly easy to simulate the sound of waves with a compact bit of electronics.

By Harry Baggen (Elektor Netherlands Editorial)

Elektor Products & Services

- PCB: # 100922-1
- Fully assembled and tested board: # 100922-91
- Special enclosure available
- PCB layout (free download): # 100922-1.zip
- All items accessible via www.elektor.com/100922

In some way or another, the sound of waves breaking on the shore has a calming effect on most people. The reason for this has been investigated by innumerable scientists, but up to now nobody has been able to find a definitive explanation for this phenomenon. Of course, the reason isn't all that important; the fact is that many people benefit from listening to wave sounds. Especially for people who suffer from insomnia, wave sounds can provide a good alternative to sleeping pills. Even if you are not an insomniac, it's very pleasant to go to sleep at night with the sound of gently rising and falling waves in the background. You're virtually guaranteed to wake up the next morning feeling especially well rested.

It doesn't take a lot of electronics to produce simulated wave sounds. A variety of circuits for this have been published in past issues of Elektor magazine. In light of recent growing interest in a design for a wave sound generator, we took a close look at the previous version (published in February 1996) and transformed it into an updated and very compact design.

Noise, square waves and triangle waves

When you think about wave sounds, it's natural to immediately think of noise. That's something we normally try to avoid as much as possible in electronic circuits, but here we expressly want to produce noise. There's a well known way to do this, which is to reverse-bias the base-emitter junction of a transistor so that it acts like a zener diode. In the schematic diagram shown in **Figure 1**, this task is handled by T2. Resistor R15 limits the reverse current through the junction, resulting in a voltage across the junction of around 7 to 9 V. The noise signal is feed via coupling capacitor C7 to a gain stage built around T1, which amplifies the signal considerably. The gain can be adjusted by potentiometer P2. The amplified signal then goes via C10 to a small semi-discrete power amplifier composed of IC2a, T3, T4, and a handful of other components. Thanks to the push-pull output stage formed by the discrete transistors, this mini-amplifier can deliver enough current to drive a small loudspeaker directly with sufficient power to produced clearly audible noise in a living room or bedroom.

So now we can listen to noise, but that's not so special. The noise still needs to be modulated to produce the characteristic sound

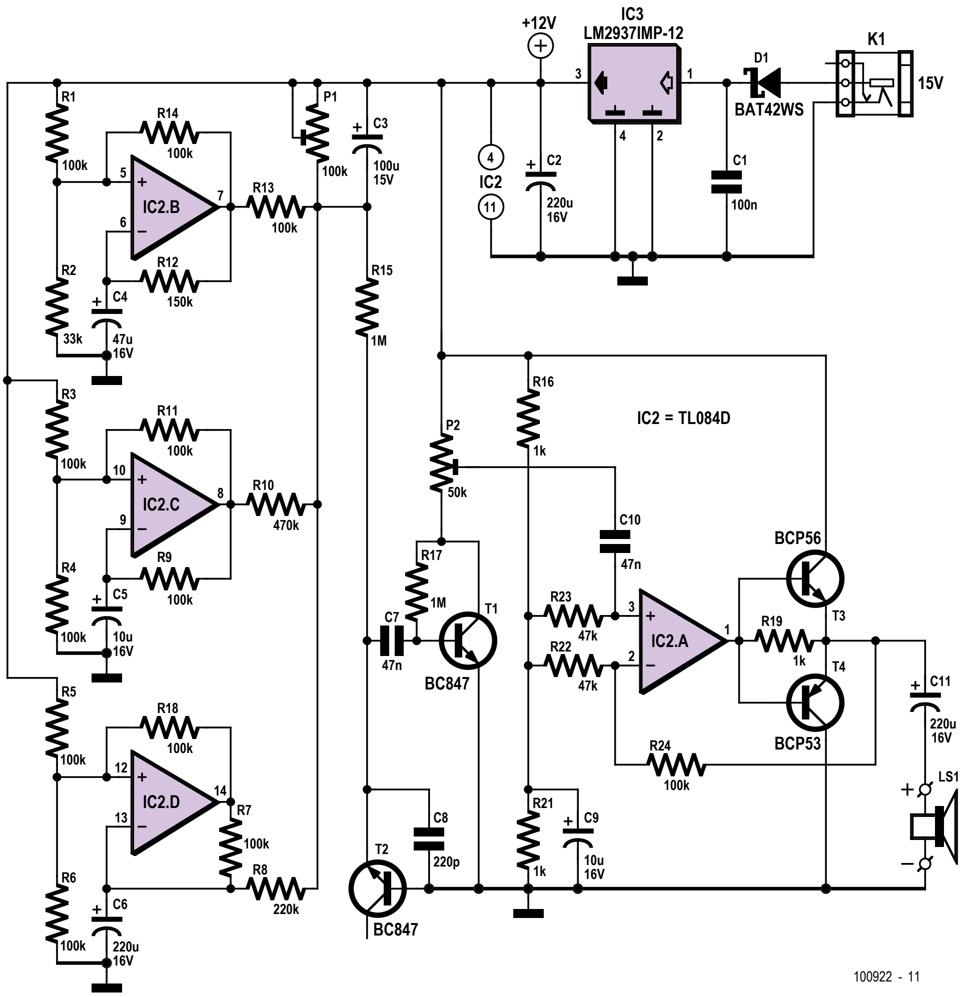


Figure 1. The wave sound generator circuit consists of three square-wave generators, a noise source, a gain stage and a small output amplifier.

of breaking waves. For this purpose, we use the three remaining opamps in the same package as IC2a. Each of these opamps (IC2b, IC2c and IC2d) is wired as a square-wave generator, with widely different frequencies determined by the time-constant networks R12/C4, R9/C5 and R7/C6. The upper two oscillator circuits (built around IC2b and IC2c) generate square-wave signals that are fed via R13 and R10 to C3. This capacitor integrates the step changes in the signal levels to produce a sort of triangle-wave signal. This triangle-wave signal causes the current through T2, and with it the level of the generated noise signal, to vary periodically in simulation of the sound of rising and falling waves. The bottom oscillator produces such a low frequency that C3 has scarcely any integrating effect. For this reason, the signal at the junction of R7 and C6, which already has a triangular waveform, is connected via R8 to C3 instead of the square-wave signal at the output of the oscillator. As a consequence of C6 being connected to the positive supply voltage via R8 and P1, the voltage across capacitor C6 is closer to a sawtooth than a triangle wave. This signal simulates the effect of the large waves that occasionally roll onto the beach.

As the three oscillators operate at unrelated frequencies due to the values of the timing components and are not synchronized to each other, the resulting waveform is fairly random. Here are a few numbers for your information: the period of the square-wave signal from IC2b is nearly 10 s, the period of the signal from IC2c is approximately 1.5 s, and the period of the slowest waveform (from IC2d) is almost 1 minute. Summing these three signals yields a slowly varying voltage at the junction of P1 and R15 with a level between 9 V and 11 V.
The frequency spectrum of real waves is actually much broader, with very low frequencies as well as very high frequencies, but in light of the fact that the frequency range of the miniature speaker used here is fairly limited, we didn't try to simulate the full spectrum.

Low-drop voltage regulator IC3 ensures that the entire circuit is powered from a stable 12 V supply voltage. Diode D1 is included in the circuit to provide reverse polarity protection, so that nothing will go up in smoke if you accidentally connect the AC power adapter's output the wrong way round. The operating input voltage range is 15–25 V, and the maximum current consumption is 100 mA.

COMPONENT LIST

Resistors (SMD)
R1,R3,R4–R7,R9,R11,R13,R14,R18,R24 = 100kΩ (0805)
R2 = 33kΩ (0805)
R8 = 220kΩ (0805)
R10 = 470kΩ (0805)
R12 = 150kΩ (0805)
R15,R17 = 1MΩ (0805)
R16,R19,R21 = 1kΩ (0805)
R22,R23 = 47kΩ (0805)
P1 = 100kΩ trimpot (3306W)
P2 = 50kΩ trimpot (3306W)

Capacitors (SMD)
C1 = 100nF (0805)
C2,C3 = 100µF 16V (case-d)
C4 = 47µF 16V (case-d)
C5,C9 = 10µF 16V (case-b)
C6,C11 = 220µF 16V (case-e)
C7,C10 = 47nF (0805)
C8 = 220pF

Semiconductors (SMD)
D1 = BAT42W
T1,T2 = BC847
T4 = BCP53

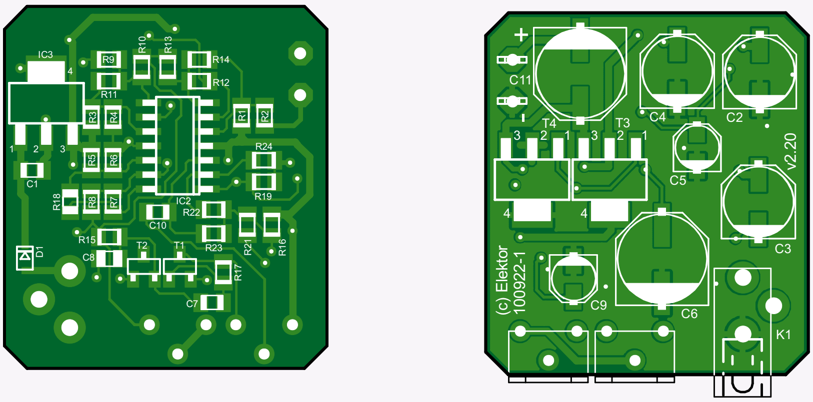


Figure 2. The PCB for the wave sound generator (shown here at 1.5 times actual size) is extremely compact thanks to the use of SMDs.

T3 = BCP56
IC3 = LM2937IMP-12/NOPB
IC2 = TL084ACD

Miscellaneous
K1 = power adaptor socket (CUI PJ-007)
LS1 = miniature loudspeaker, e.g. Kingstate KDMG20008, Farnell # 1502730)
PCB # 100922-1
Assembled board # 100922-91 (see www.elektor.com/100922)

Compact PCB

To keep the circuit as small as possible, which makes it easier to fit it into an enclosure, we chose SMDs for all of the components. This allows the dimensions of the PCB (see **Figure 2**) to be limited to approximately 28 × 32 mm. Although this makes manual assembly a good deal more difficult, this should not form a problem for most potential users, since we also offer a fully assembled version of the circuit at a quite modest price. If you nevertheless wish to do things the hard way, you can download the PCB layout file free of charge from the Elektor website or order a bare PCB.

As already mentioned, thanks to its small size the board can be fitted in virtually any available enclosure. The necessary dimensions are largely dependent on the size of the speaker that is used. Especially for this project industrial designer Rein van der Mast has developed an enclosure in the form of a seashell, which interested DIYers can order. A link to his product will be posted on the project page for this article. The case yields an attractive unit that can claim a fixed place in your home, such as on a bedside table.


Figure 3. Artist's impression of the seashell enclosure specially designed by Rein van der Mast of SOLide for the Wave Sound Generator.

It's a good idea to test and adjust the assembled board before you fit it into the enclosure. To do so, connect a loudspeaker and a suitable AC power adapter (15 V at 100 mA is sufficient) to the board. Start by setting both trimpots to the center of their travel, and listen for noise coming from the speaker. P2 is a sort of volume control; you can adjust it to make the noise as loud (or as quiet) as you wish. Then adjust P1 to obtain an audible rising and falling effect in the noise level. You should still hear a certain amount of noise even in the 'quiet' passages. Once everything is working the way it should, you can fit the board in the enclosure and start enjoying wave sounds.

But please don't go to sleep right away — you still have the rest of the magazine to read!

(100922-I)

Reference

Wave Sound Generator, Elektor February 1996

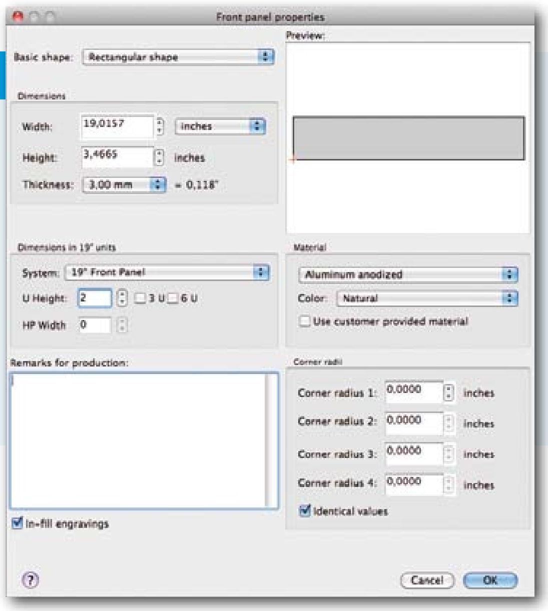
The Finishing Touch

Design professional front panels for free

The first thing that catches the eye of the just-completed amplifier, measuring instrument or other electronic device is without doubt its ‘user interface’: the front panel.
Making an attractive (that’s: professionally finished) front panel for an electronic circuit is a difficult hurdle to surmount for many electronics enthusiasts. In addition to a degree of materials knowledge, you also have to possess cutting, drilling and milling machinery and especially the skills to use them properly.

By Giel Dols (Elektor DTP/Graphics department)

Front Panel Express, LLC supplies enclosures and front panels offering an efficient solution for this problem. With the aid of their software tool called Front Panel Designer, which you can download for free, anyone can now design professional front panels and have them manufactured.
The software is available in English, German and French and there are versions available for Windows, Linux and Mac OS [1].
In this article we show in a broad outline how easy it is to design a professionally looking front panel with Front Panel Designer and have it manufactured. The software has a very good help facility built in which gives an excellent explanation in every situation. So download the software and install it.
As an example, here we create a design for a front panel to be used in a 19” rack, to house the preamp [2] that makes it possible to connect an electric guitar to the Elektor Multi-Effects Unit [3].

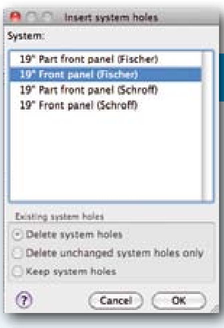


Step 1: The characteristics of the front panel

The menu option ***File -> New*** opens a window where all the physical characteristics of the front panel have to be defined: basic shape, length, width and thickness. A special option here is the choice for front panels intended for use in a 19” rack, where the height is indicated in ‘units’.

We obviously also need to indicate what material the front panel needs to be made of and (eventually) what color it will be. Here we have the choice between aluminum (in various finishes) and Perspex.

The final option that can be defined is the radius for rounding the corners of the front panel.



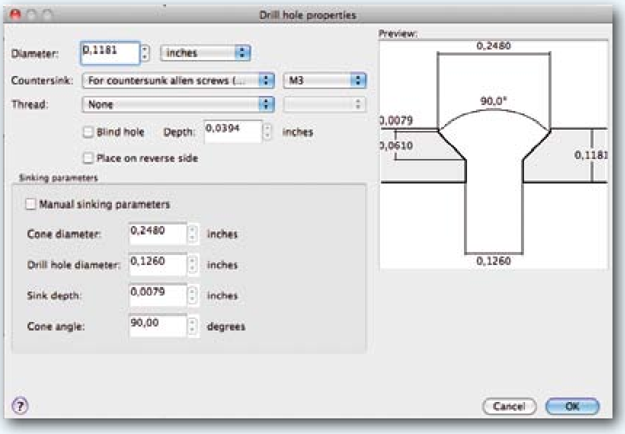
Step 2: Holes, holes and holes

This is definitely well thought through: a 19” front panel needs mounting holes in exactly the right places. The software takes care of all this. There are ready-made definitions for the mounting holes for two large manufacturers of 19” racks. Via ***Insert -> System holes*** you arrive at the menu where you can select the appropriate option.

The control panel for the Elektor Multi-Effects Unit requires an opening for the LC-display, five holes for the spindles of K1 and S1 through to S4. Another four holes are required to allow the PCB to be mounted behind the front panel.

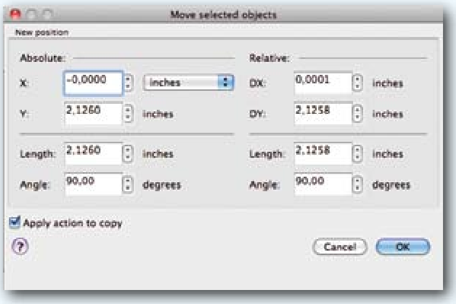
Our preamp requires five holes: three for the potentiometers JP3, JP4 and JP5 and two for the 6.3-mm jack sockets for the connections to the guitar and the Mute footswitch.

Select ***Insert -> Drill hole*** and click on the front panel where the hole has to be. Now there appears the drill hole menu. Here we define what the desired drill hole is supposed to look like. We chose a 3 mm hole intended for M3 socket cap screws with countersunk heads *(countersunk Allen screws)*. The software fills in all the relevant data and displays a window showing it will look like in cross-section.



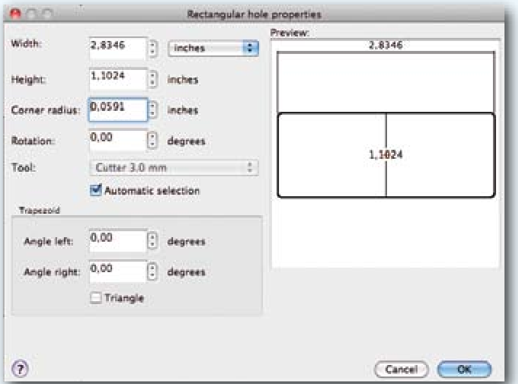
When in ***Select mode*** and clicking on a part of the front panel, all the characteristics for that part then appear in the top left corner of the screen. Any of the characteristics can be changed in this window. So here we can enter very accurately the *x* and *y* coordinates of a part (in this case our drill hole).

These coordinates are relative with respect to the location of the origin. By default this is at the bottom left corner of the front panel. To avoid having to calculate the coordinates of every part on the front panel relative to this point, it is possible to move this datum point somewhere else. To do this, we click on Set origin and then click very accurately (after zooming in considerably) on the new place where we would like the origin to be. By positioning the origin at our drill hole it becomes much easier to put the other drill holes and the LCD display opening in their correct places.



Positioning the other drill holes can also be done by using the move option. First select the drill hole already placed and then indicate via ***Selection -> Move*** the displacement for the second drill hole (in our case 54 mm). Don't forget to tick the box '***Apply action to copy***', otherwise the selected hole will be moved and not copied! Now select both drill holes and repeat the procedure; but this time with a horizontal displacement of 85 mm.

Now we have to draw the opening for the LCD display. Via ***Insert -> Rectangular cutout*** we arrive at a menu for entering the characteristics of our 'window': length, width and corner radius in our case. Select the window and enter in the ***'Object properties'***-window (top left) the exact coordinates for the center point of the desired display window.

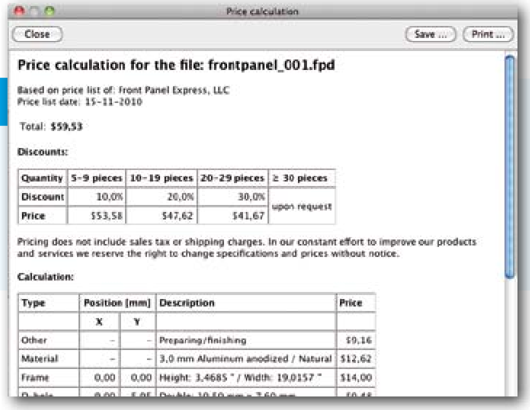


Now it is time to position the holes for the four operating buttons S1 through to S4, followed by the spindle for K1. The y-coordinates for all these holes are the same (they are all on one line). We determine the x-coordinates by taking measurements from the original circuit board.

The software already has a modest, but handy, library with special openings for fans, switches, sub-D and SCART connectors from a number of well-known manufacturers. These special items are accessible via ***Insert -> Macro object***. When an item is clicked, a preview appears in a window below the macro library. The software also offers the ability to select items or combinations of items yourself and store them an a user-library. To do this select ***Selection -> Create macro***

Step 3: Text

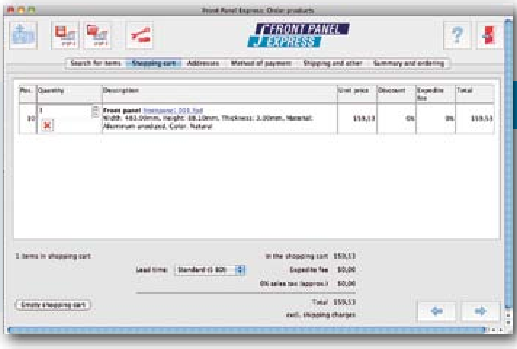
The menu option ***Insert -> Text engraving*** opens a window where you can enter the desired text and its characteristics. Each separately defined block of text can be selected at any time to position it accurately or to change it.



Step 4: What does it cost?

A click on the right most icon, clearly identifiable by two coins, opens a window with the price for the front panel.

The costs are specified to the smallest detail and there is also an overview with quantity pricing. Fortunately there is no room for surprises!



Step 5: Go ahead and order...

The final step before we can attach our newly designed front panel to our device is obvious: the ordering. This option too is seamlessly integrated in the software. The option ***Order -> Order current front panel*** (or: ***Start ordering program***) starts an interface where all the relevant details have to be entered, after which the order is completed online.

(110238-I)

Internet Links

[1] **Front Panel designer software**
Europe: www.schaeffer-ag.de/en/download/front-panel-designer.html
USA: www.frontpanelexpress.com/download/front-panel-designer/index.html

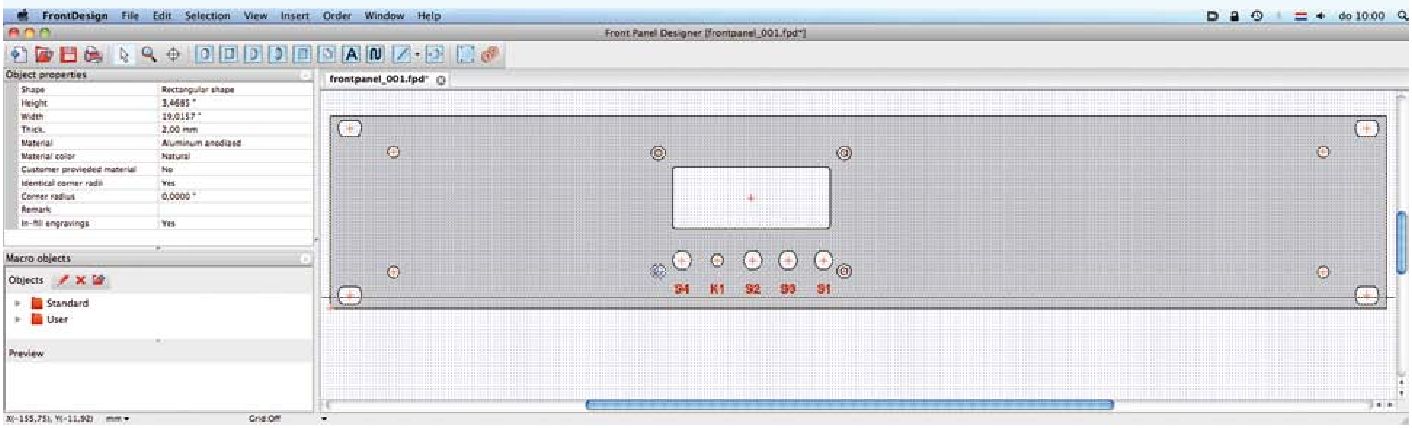
[2] **Guitar Input for Multi-Effects Unit:** www.elektor.com/100923

[3] **Digital Multi-Effects Unit:** www.elektor.com/090835

[4] **Front panel download:** www.elektor.com/110238

Try it out?

While evaluating this software we designed (part of) the front panel. So this is not quite finished yet. The holes for the potentiometers for the preamp still have to be placed, just as the openings for the two 6.3-mm jack chassis sockets. We invite you to try it for yourself! You can download the front panel 'in the making' from our website [4].



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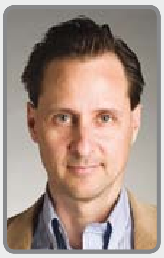

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Virtual PCs

What is virtualization and what are its uses?

Using virtualization, more than one operating system can run at the same time on a single computer. For those of you who aren't yet familiar with this concept, you'll be surprised by the large number of applications this lends itself to. You'll also find out that free software is available on the Internet that lets you use virtualization on your home computer.

By Evelien Snel (The Netherlands)

A virtual PC doesn't refer to the laptop carried by the avatar in **Figure 1, or** the servers that can be seen in the racks behind him. In this article, a virtual PC means 'a PC **inside** a PC': with the help of some software a PC can simulate the behavior of another machine.

Figure 1. A virtual businessman works on his virtual laptop. In the background is a number of virtual servers.

What is virtualization?

A very simple example of a virtual machine is the calculator in Windows/Linux/Mac OS: this program simulates all properties of a pocket calculator, apart from one: We can't put it in our pocket! When a PC simulates the behavior of another PC this way, we speak of a virtual PC. The physical PC (the hardware) is called the 'host' and the simulated PC(s) are called 'guest(s)'. There is no need to limit ourselves to a single guest: As long as the host PC is powerful enough it can simulate the behaviour of several PCs at the same time. We aren't restricted to a single operating system either: On a Windows PC we can reliably run a Linux system, and vice versa. Virtualization itself isn't exactly a new technology, but in the past PCs weren't powerful enough to make a guest PC run at a reasonable speed. These days that is different: The processors are now much faster and on top of that, modern processors have special operation modes that make virtualization easier. The most important bottleneck affecting the performance is the amount of RAM memory available.

Applications

For the electronics engineer it is very useful to have the facility to create a complete development environment in a virtual environment, which can be easily copied (backed up) and returned to (years) later for debugging purposes. The development environment in the virtual PC can have access to USB ports (and any COM ports) of the host PC via the virtualization software. The same also applies to CD, DVD and Blue-Ray drives, network connections, etc. This means that the virtual system is hardly or not restricted in its use.

When regular backups are made of the virtual system (it's usually sufficient to make copies of the few files used by the virtualization software for the virtual system) the continuity of the design is assured. In the event of a virus infection the complete development environment can be restored in an instant and you can continue from where you left off. Making regular backups is a good habit in this case as well.

Another application is when you want to experiment with Linux, but don't want to affect the Windows installation on your PC. You can experiment to your heart's content in a virtual PC on your PC. Nothing can go wrong with the host PC since the two operating systems are kept isolated from each other by the virtualization software. You could use the same principle to investigate computer viruses in a virtual PC without infecting the host. In the same way, you could set up a Windows development environment on a Mac or

Figure 2. Installation of the Vmware Player.

Figure 3. The VMware Player has been installed.
Now we need a virtual machine.

Linux PC. Or any other combination of operating systems of course. It is also possible to save costs this way: Many PCs in an office environment spend most of the day waiting for some user input. It is therefore advantageous to simulate a large number of PCs in one central server, which makes much better use of its power. This saves on maintenance and energy costs. Thanks to the reduced energy consumption there may also be environmental subsidies available.

Available packages

A summary of the best-known virtualization programs for the PC follows:

Windows virtualization

Microsoft offers many products for virtualization, but isn't exactly helpful when it comes to supporting operating systems other than Windows. This is not to say that it is impossible to run Linux under Microsoft Virtual PC, for example. It's just that it's not recommended.

Xensource

XenSource has recently been taken over by Citrix, which is probably the start of the commercialisation of this great product. The Xen hypervisor is an open source product developed by a group from the University of Cambridge. Xen is aimed mainly at the professional market. Despite this, a free version has always been available.

Parallels

Parallels offers a wide range of virtualization products. There are a number of different products for use at home or work, running under either Windows or Mac or Linux. Unfortunately, there is no completely free version available. It is possible to download a trial version that works with a temporary registration key, however.

VMware

VMware, which is probably the best-known company, also offers a wide range of products. Some of those are full-featured virtualisation packages that are free to use for as long as you like. If you want to get your teeth into virtualization without having to get out your wallet then VMware is the perfect choice. Let's have a closer look at what they have to offer.

Free software from VMware

As with the other suppliers of virtualization products, you can find a large number of programs on Vmware's website. The following products can be downloaded at no charge and have no time limit:

VMware Player

Until recently, the VMware Player could only run existing virtual machines, but since version 3.0 of Player it can also be used to create new virtual machines [2].

Virtual appliances

The 'Virtual appliances' from VMware are ready-made virtual machines that can be loaded in VMware Player. There is a choice from many hundreds of applications, although many have to be paid for. The Linux installations are all free though. A (free) registration on their website is required before you can download any files [3].

VMware Converter

VMware Converter can make an image of an existing PC, which can then be used as a virtual machine. It's even possible to use the source PC itself to create the image, or you could create the hard-drive image using a backup program such as Ghost, or some Linux tools.

VMware Tools

A virtual PC is completely isolated from the host system, which you find out soon enough if you try send something from the virtual PC to the host. That's just not possible! The VMware Tools are installed on the guest PC and they create a small gap in the isolation. With these tools it becomes possible to transfer files directly from the virtual system to the host system. A bit less straightforward, but still possible, is to use the network to transfer files from the virtual PC to the host PC, since both PCs are visible on the network.

Figure 4. Watching the Elektor channel on YouTube...
On a virtual Ubuntu PC!

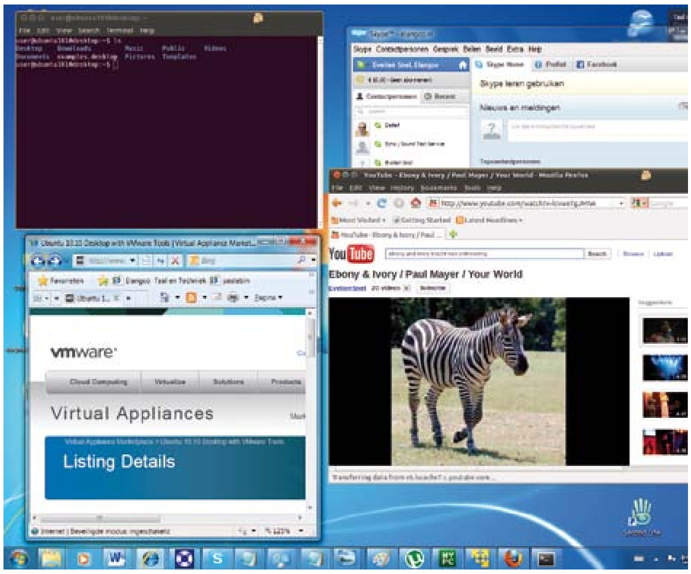


Figure 5. Ebony & Ivory;
Windows and Linux together in harmony on the desktop!

Get cracking

To start with, you have to download the VMware Player from [2]. This program can be installed under Windows just like any other program (**Figure 2**). Once the installation has completed we can run the program (**Figure 3**), when you'll find out that there are no virtual machines available! From the menu *File -> Download a Virtual Appliance* we can navigate straight to Vmware's website, where a number of applications can be found [3]. The button 'Operating Systems' takes you to a large number of Linux distributions. These are ready-made for use. (With each distribution mention is made of the details you need to log in to the downloaded system later. Please make a note of these!)

A good choice is 'Ubuntu 10.10 Desktop with VMware Tools' [4]. This has been made available by Chrysaor.info and it is their website that we land on when we click on 'Download'. The file has to be downloaded using BitTorrent. For those of you who have no experience of this, you can find a reputable torrent-client at [5]. (When you're installing the client, don't forget to untick those check-boxes that download tool bars and such like.)

The downloaded image has been compressed as a tgz file. In Linux this can easily be decompressed, but we don't yet have Linux! We're still busy installing it... Fortunately, it can also be decompressed using the free software from 7-zip [6].

When the file has been decompressed, we end up with a folder called 'ubuntu1010desktop.vmwarevm', which could be stored in 'My Documents\Virtual Machines' (This is the default location where VMware Player looks for them). The virtual machine can then be opened via the button 'Open Virtual Machine' and then started using 'Play Virtual Machine'. VMware Player now sees the machine for the first time and will ask if it has been moved or copied. The correct answer in this case is "I copied it". It is possible that a dialog box pops up with information about connected USB devices; for the time being, this can be ignored and closed.
We can now log in to our new Linux system, using the login details that we noted down earlier. Open a terminal window via the menu: *Applications -> Accessories -> Terminal*. Then type in the following to start vmware-toolbox and vmware-user to enable the Copy&Paste function to and from Windows:

```
user@ubuntu1010desktop:~$ vmware-toolbox & [1]
19318
user@ubuntu1010desktop:~$ vmware-user
```

Start the virtual machine again using 'Restart...' from the menu at the top-right. The Copy&Paste function will in future be available immediately after starting up. Welcome to Linux!
Once all that has been done you can see how fast (or slow) everything works. A simple test is the viewing of YouTube movies on our virtual Linux PC (**Figure 4**).

And finally: Unity

The icing on the cake of the integration between Linux and Windows can be found via the menu in *Virtual Machine -> Enter Unity*. This detaches the windows from the Linux desktop and makes it possible for them to be shown on the standard Windows desktop (**Figure 5**). Who would have thought this possible? Windows and Linux together in harmony...

Next stop: the virtual development environment!

(100585)

Internet Links

[1] en.wikipedia.org/wiki/Virtualization

[2] www.vmware.com/products/player

[3] www.vmware.com/appliances

[4] www.vmware.com/appliances/directory/767933

[5] www.utorrent.com

[6] www.7zip.com

Hexadoku

Puzzle with an electronics touch

Fancy taking your mind off electronics for a spell and do a relaxing mind exercise? Then this month's Hexadoku is just the ticket to keep you busy and amused for a couple of hours. Sit up, focus the brain and enter the right numbers in the puzzle. Next, send the ones in the grey boxes to us and you automatically enter the prize draw for one of four Elektor Shop vouchers. Have fun!

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

Solve Hexadoku and win!

Correct solutions received from the entire Elektor readership automatically enter a prize draw for one Elektor Shop voucher worth $ 140.00* and three Elektor Shop Vouchers worth $ 70.00* each, which should encourage all Elektor readers to participate.

Subject to exchange rate.

Participate!

Before June 1, 2011, send your solution (the numbers in the grey boxes) by email, fax or post to

Elektor Hexadoku – 4 Park Street – Vernon CT 06066

USA.

Fax 860 8751-0411 Email: hexadoku@elektor.com

Prize winners

The solution of the March 2011 Hexadoku is: **9302F**.

The PSoC 5 FirstTouch Starter Kits kindly sponsored by Cypress have been awarded to Edgar Wolff (Germany), A. van Maris (The Netherlands), Jean-Pierre Demangeon (France), Benjamin F. Creech (USA), Lars-Göran Göransson (Sweden), Alfonso Carillo Morales (Spain), Simon Eichinger (Austria), Ron Ware (UK), Alex Lo Furno (Italy) and Larry Burns (Canada).

Congratulations everyone!

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

9	D	A	2	B	F	1	6	5	C	E	0	7	4	8	3	10-2009
6	0	1	3	8	E	4	5	7	9	B	D	F	C	A	2	06-2009
8	5	7	C	9	3	0	2	F	4	6	A	1	B	E	D	05-2009
E	F	B	4	7	A	D	C	8	3	2	1	0	9	6	5	09-2009
A	7	2	0	1	8	B	E	3	6	9	5	C	D	4	F	02-2010
F	1	4	8	2	D	6	9	B	0	7	C	5	E	3	A	12-2009
B	E	C	D	A	5	F	3	2	1	4	8	6	7	9	0	11-2009
5	9	3	6	0	C	7	4	E	A	D	F	B	1	2	8	04-2010
7	C	D	E	F	6	8	B	A	2	5	4	3	0	1	9	04-2009
1	2	8	A	3	0	9	7	D	F	C	E	4	5	B	6	02-2009
4	3	9	5	C	1	2	D	6	7	0	B	8	A	F	E	01-2009
0	B	6	F	5	4	E	A	9	8	1	3	D	2	7	C	03-2009
C	8	5	1	E	7	A	F	4	D	3	2	9	6	0	B	03-2010
2	6	F	B	4	9	5	0	C	E	8	7	A	3	D	1	01-2010
3	4	0	9	D	2	C	8	1	B	A	6	E	F	5	7	05-2010
D	A	E	7	6	B	3	1	0	5	F	9	2	8	C	4	06-2010

It's not Immaterial

Gerard Fonte (USA)

Material science is an often neglected area in engineering. Who cares about the physical, electrical and chemical properties of various forms of matter, anyway? It's not going to help me design an oscillator or an electric car or anything like that, is it? Actually, it can and does. Material science is the driving force behind many technological leaps. Being able to exploit the special characteristics of materials can give you a big advantage in the laboratory and marketplace.

Let There be Light

Most everyone knows that Edison invented the light bulb. Actually, this isn't exactly correct. He invented the first commercially viable lightbulb. It was already well known that different materials would glow and even get white hot if enough electricity was shoved through it. The problem was that these filaments wouldn't last for more than a few minutes. Edison systematically tried thousands of materials and his best results came with carbonized bamboo (taken from a bamboo fishing pole). I suspect that this is probably not the first choice most people would choose as a filament for a light bulb. But, it lasted 1,200 hours.

Nowadays, most lamp filaments are made from tungsten. It has the property of having a high positive temperature coefficient (PTC). That is, its resistance gets larger the hotter it gets. A 100 watt lightbulb has an "on" resistance of about 150 ohms. But a cold lamp is around 20 ohms. "So what?" you ask.

Well it turns out that after WWII, a young engineer named Bill Hewlett wanted to build an oscillator to sell. The oscillator design he chose was called a Wien-bridge. It could produce very clean sine waves, but the amplitude was not stable. He knew about the PTC of tungsten and used a small pilot lamp as a simple automatic amplitude control. The result was a very elegant oscillator that produced very pure sine waves with excellent amplitude stability. He was able to sell it for about $50 while other major companies charged about $200 for an inferior oscillator. And that's how Hewlett-Packard was born.

Charge It

There's a quiet revolution going on right now in the auto industry. It's the move to electric cars. It's not the electric car itself, it's the means to power it. The current standard is to use batteries. There are different types but they are all fairly close in terms of price, performance, weight and volume. And while there have been steady advancements in battery technology, there haven't been any huge leaps. In fact, the lead-acid starter-battery, still used today in all gasoline powered cars, has been around for over a hundred years. The basic problem is that batteries rely on the electro-negativity of different materials. And there isn't much room to dance to that tune.

The revolution is the move to use capacitors to power a car. Capacitors have lots of inherent advantages. They weigh much less than current batteries, can be charged and discharged thousands of times more, can be charged quickly, can be deep-discharged without damage and have less (or none!) heavy or dangerous metal. These capacitors are based on aero-gels. Yes, that's the same basic material that's used to protect the Space Shuttle from the heat of re-entry into the atmosphere. (Thank you NASA.)

Capacitor technology has exploded in the last decade or so. It wasn't that long ago when it was a joke to consider a one farad capacitor. I remember a cartoon showing a man using a wheelbarrow to carry one home. Now, multi-farad capacitors are common, inexpensive and can be held in a closed fist. I've seen surplus 2600 farad capacitors (that's right — 2.6 Kilo-farad!) for $20 each. They're about the size of a can of soda.

As I understand, there are only two relatively small technical problems with using capacitors for electric cars. The first is that they are very leaky. The self-discharge rate is pretty high. So, if you leave your car parked for a week or so, you may need to re-charge it. The second problem is that they have poor life at elevated temperature. However, these are exactly the type of problems that can be solved in an incremental fashion over time. I suspect that in five or ten years, battery-powered cars will be old-fashioned.

Homework

Here are a couple of materials that have interesting properties that anybody can experiment with. The first is rare-earth magnets. They've been around for a while and are easily available. They're super-strong and have their poles very close together. But, I haven't seen any really new magnetic applications. I am only aware of enhanced performance of existing products. Like better motors and so forth. And, while these are certainly important improvements, there should be new products that can only be realized with these new magnetic properties. Any Bill Hewletts out there?

The other material is gold leaf (Remember the old gold-leaf electroscope?). This is 24 carat gold that is so thin it's almost gone. Typically gold leaf is about 0.2 microns, or 0.0000078" thick. This is about the wavelength of green light.

It's amazing stuff. I've played with it and I can best describe it as a one-dimensional fluid. If you place it on a coin it will follow the contours exactly. You can see the image and read the date just by draping the gold over the coin. The material is extremely fragile, of course. It can't be handled with fingers. And a slight puff of breath can blow it away. However, it's also pretty inexpensive and easy to get. Craft stores and sign-painters are possible local sources. Then there's E-Bay and other internet sites. Get pure 24 caret gold that does NOT have a backing sheet. A backing sheet is used for pressure transfers or "gilding" and the gold leaf can't be removed as a sheet. The cost is a few dollars.

The first thing the scientists on the Manhattan Project (WWII Atomic Bomb) did when they isolated Plutonium was to measure its physical properties. They found that it had a negative temperature coefficient of expansion. That is, it shrunk as it got hotter. This means that a sphere of plutonium just below critical mass can become a critical mass if it's heated. And upon reaching critical mass it gets hotter, so there's a thermal runaway. Material science is important.

(110351)

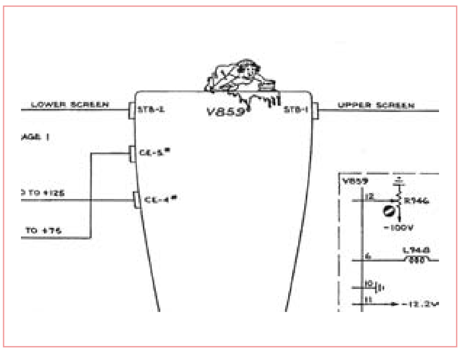
Tektronix 564 Storage Oscilloscope (1963)

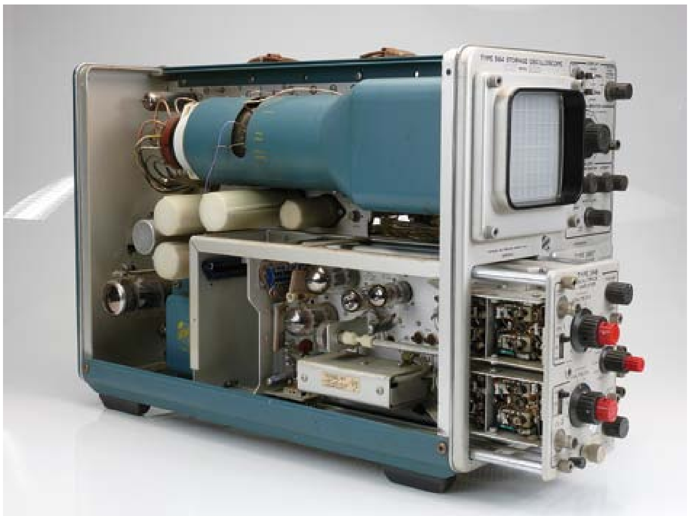
By Jan Buiting (Elektor UK/US Editorial)

It's doubtful you can consider yourself an old hand at electronics if do not instantly recognize a Tektronix 500 series oscilloscope. These beasts in their light blue cases were all over electronics labs, colleges and other 'places scientific' for more than two decades before being scrapped or traded in for gear with transistors inside. Many users still resent that. On one website dedicated to Tektronix tube-based test equipment the word 'transistor' is banned, with a single occurrence only of "trnsstr".
It's easy to see why Tek 500 series 'scopes now stir up nostalgic feelings of 1960s and 1970s 'college & lab' days. For one thing, they are incredibly solid builds compared to the current generation products with their plastic covers, rubber knobs and arcane texts on the screen. Add to that the massive weight (the 564 without plug-ins weighs in at 13.8 kgs / 30.5 lbs), the noise of the extractor fan (not on all models), the razor sharp image on the CRT screen, the famous plug-ins and the clic-clac feel and sound of the immense black and red controls on the front panel— and you have a non-erasable item in your memory.

In the 1970s and 1980s my Tek 'scope was a Type 535 (I think) with a two-channel channel plug-in. Compared to the DIY grot my friends were using, my 535's frequency range was such it got hauled around the province in my dad's car, 'Scope-Mobile' trolley and all, to do complex measurements and observe elusive glitches mostly in Elektor projects with CMOS ICs. I also used it to heat my little workshop in the attic. One channel I never managed to get stable vertically though on the vertical plug-in despite exchanging tubes. It was the first time I saw nuvistors and gold plated contacts.
Speaking of contacts, most parts and wires in the Tek 500 series oscilloscopes are soldered using 3% silver bearing solder to guarantee a joint that would last a lifetime. One of the HV supply panels inside the 'scope has a plastic spool with spare silver-bearing solder secured to it for repair purposes. At the age of 20, having written for a new supply of that precious solder (in the kindest US American words I could manage), after about a month I received a package with two spools inside from Tektronix' European plant on Guernsey, Channel Islands. There was also a cover letter with courteous advice on soldering as well as two 'revision notes'. My mother said it was a miracle and "so like the Tommies in 1945 — always good humoured"; to which I replied "I reckon it's just service-friendly".

According to the instrument manuals, plug-in units can be changed without switching the main instrument off, so 'hot-plugging' is not a 1990s invention. I never had the guts to try this out for fear of





damaging my precious 535 and having to borrow another 'scope to repair it. After about 10 years I sold it on — with a profit.

The 564 shown here is a lightweight and a dwarf compared to the 535. I got it from my neighbor in exchange for a bucket of prunes last fall. The instrument was excavated from a pile of assorted household goods and furniture in a cellar in her parents' apartment building. For plug-ins it contained the 2B67 timebase and the 3A6 dual-trace amplifier. Having done the usual cleaning, dusting, vacuum cleaning and careful initial powering up of the 564 I decided to do a round of 'Tektronix vintage' searching on the Internet. To my amazement I came across a method of thoroughly cleaning an oscilloscope actually applied by Tektronix themselves at Factory Service Center and offered as a service to clients. Remarkably, instruments got washed using warm distilled water and a lab glassware cleaning detergent, with critical parts sealed in plastic. The method was maintained and publicized till the late 1970s for the 7000-series with trnsstrs and even ICs [1]. The crux is not the washing proper but the controlled drying of the instrument in an oven for 24 hours at a low temperature. Tek dryly write: *Place the instrument (with washed plug-ins installed) in the oven and dry for at least 24 hours (Oven makes good storage place until item is needed to be worked on. More drying is o.k.).* The washing and drying is followed by a round of lubrication and greasing of switches, pots and motors using Tektronix Lubrication kit p/n 003-0342-01 (what else!). I decided to wash my car instead of the 564.

Opening the case of a tubed Tektronix oscilloscope is like opening the bonnet of a 1930s American car with a big engine in the nose. Each of the two partly perforated covers at the sides of the instrument can be removed after loosening just two screws. You are greeted by a dozen or so tubes, dust, PATENTs printed on the chassis and the smell of vintage electronics 'US style'. In some cases, the plug-ins contain more tubes and trnsstrs than the main chassis. My 564 turned out to work okay on one channel (trace). This is a storage oscilloscope with zero (no) RAM. Instead, storage screens, flood guns and collimation electrodes inside the purpose-designed CRT provide a primitive display memory. Once you see the signal you want to 'freeze' on the CRT, you use the ERASE, INTENSITY and STORE controls in a certain sequence. A not too sharp image appears and is retained in phosphor (Tek claim) for at least one hour. My 564 managed about 15 minutes before the (poor) image had vanished completely. Some recalibration may be in order and failing that I'm planning on writing to Oregon for a replacement CRT and some spare solder tin. The stored image is erased by moving the lever to ERASE whereupon the screen flashes a bright green. The stored trace may be used for good/fault comparison to the live trace as well as for photography. The latter application is discussed in detail in the 564 Instruction Manual.

In good US tradition, retired Tektronix staff have nice anecdotes to share like: mail was received at the factory from users in what was politely described as "technologically less advanced parts of the world". Although the envelopes were addressed: *Tektronix Inc., Portland, Oregon, USA, VERTICAL*, they got duly delivered by US Mail. The Instruction Manual that came with the 564 is a typical 1960s US electronics engineering product. Extensive, comprehensive and nicely illustrated, with full descriptions of the electrical operation of the instrument, maintenance and repair guidance. Frankly I wasn't expecting to find any light-hearted stuff in the manual but on the very last page the *564 Washer Woman* suddenly appears cleaning the face of CRT V859. Engineers' humor. On ClassicTek.org other funny characters can be seen like the *7A26 Cowboy*, the *184 Disabled Man* and the *502 Mountain Climber*. Gotcha — my mother was right after all.

(100920)

Internet References

[1] www.classictek.org

[2] www.r-type.org/exhib/aaa0273.htm

For further reading

The Museum of Tek Scopes:
www.chiark.greenend.org.uk/scopes/tek.html

BarryTech:
www.barrytech.com/tektronix/vintage/tekvintage.html

Tek Museum:
http://tekmuseum.ebaman.com/main.html#tline

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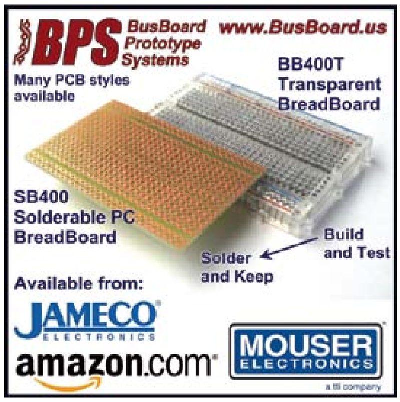

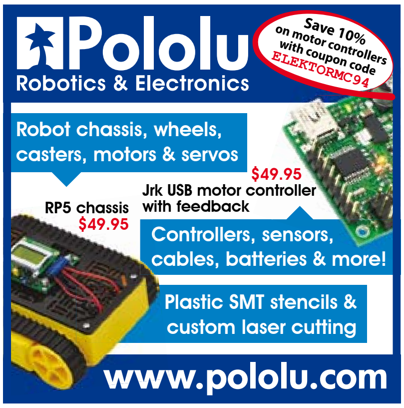

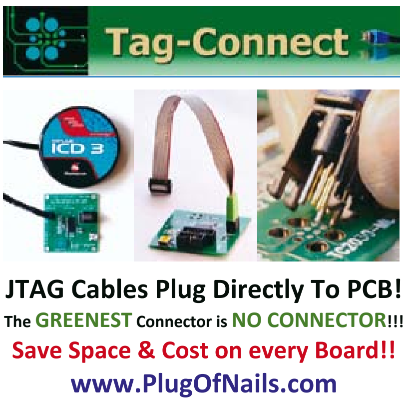

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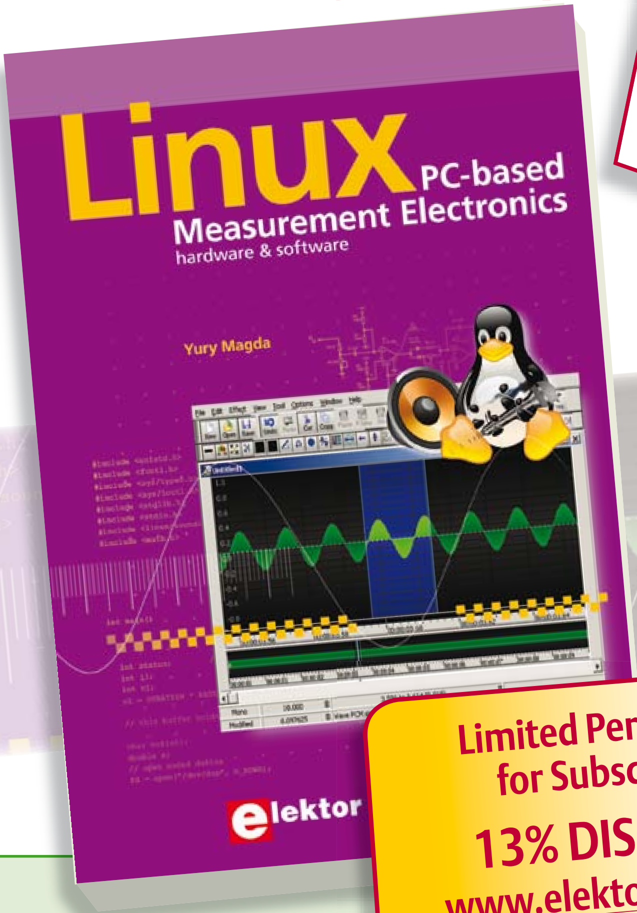

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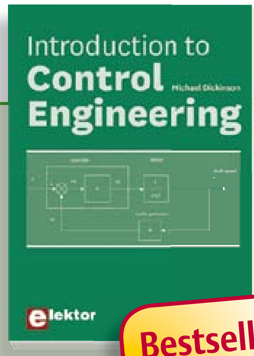

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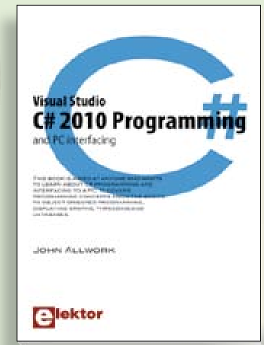

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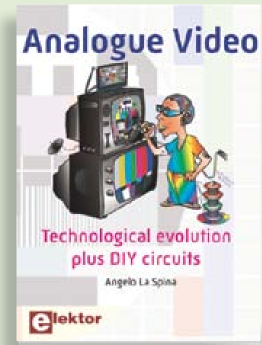

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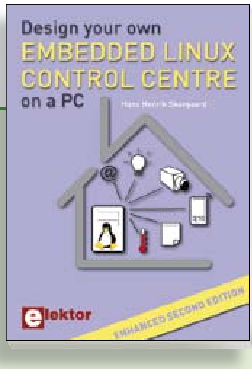

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(April 2011)

RF and radio repair fans probably do need to be told, but when it comes to measurements below 200 pF or so, modern DMMs will produce coarse if not ridiculous results. Elektor's purpose-designed Pico C does a far better job. Beating many DMMs hands down, this little instrument easily and accurately measures capacitances down to fractions of a picofarad!

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(April 2011)

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SatFinder

(March 2011)

Those of you who regularly need to realign a satellite TV dish will find this gadget extremely valuable. Caravan owners and campers on long journeys who crave their home TV channels can now keep up with developments in sports, news and the soaps back home with the help of the SatFinder. This GPS based design includes a database containing positional information of a number of popular TV satellites. With the help of GPS data it calculates the precise angles to find the satellite first time!

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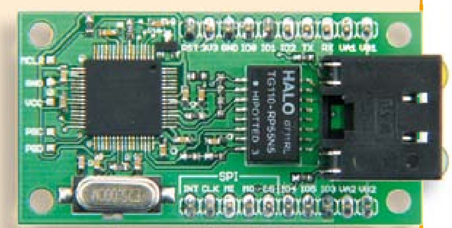

NetWorker

(December 2010)

An Internet connection would be a valuable addition to many projects, but often designers are put off by the complexities involved. The 'NetWorker', which consists of a small printed circuit board, a free software library and a ready-to-use microcontroller-based web server, solves these problems and allows beginners to add Internet connectivity to their projects. More experienced users will benefit from features such as SPI communications, power over Ethernet (PoE) and more.

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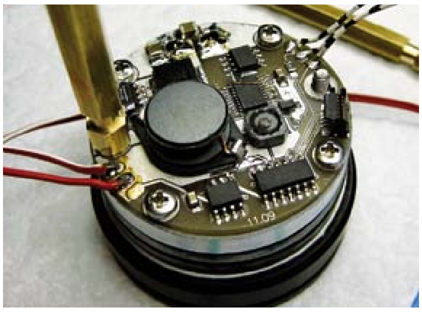
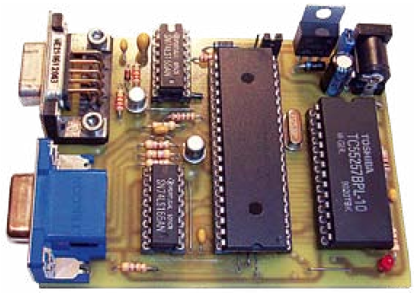


LED Bicycle Headlight

As many a cyclist will be able to confirm, the average amount of light produced by a bicycle headlight is disappointing. The Readers Project presented in the June 2011 edition is enlightening in more than one way. The headlight to be described has four Cree LEDs which together assure a bright beam worth 600 lumens. Power is provided by four Li-ion batteries of 2200 mAh each. A microcontroller looks after the LED controlling and charging of the batteries.



VGA Add-On for Microcontrollers

Many projects require a large amount of information to be displayed, but the size of the display itself is often a problem. One solution is to use an old 14” or 15” computer monitor that’s been scrapped but is still working. The VGA board described in the June 2011 edition lets you do just this, and is compatible with any microcontroller that has a serial port.

Android on a Beagle Board

Although the free open-source Android operating system is actually designed for mobile phones, it may also very well work on other systems, such as a TI Beagle board with its low-power ARM processor. Next month we will tell you more about Android, its origins and the methods of developing custom applications. Furthermore, we show how to create a complete Android system yourself. (Photo: BeagleBoard.org)

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