DOUBLE SUMMER ISSUE
100+ SMALL PROJECTS TIPS & IDEAS
PLUS!
OBD-2 car diagnostics
and chip tuning

OBD-2 and a souped up BMW
NEW Catalogue Out Now

Get Your FREE Pounds Sterling Priced Catalogue - all 400+ pages! Just fill out the catalogue request form at www.jaycarelectronics.co.uk/elektor

Check our website!
- Browse our website www.jaycarelectronics.co.uk
- All of our 6,000+ products with search facilities.
- 128-bit secure on-line ordering - safe & secure.
- Over 3,500 product datasheets & application notes.
- And we’re from Australia, so you can trust us!
- Postage and Packing includes airmail to the UK

400+ page Catalogue

JUST ONE OF OUR MANY GREAT PRE-BUILT & TESTED PRODUCTS!

Vibrating Pillow Alarm Clock
KC-0252 £7.75 + post and packing
This ingenious alarm clock just slips under your pillow, and vibrates to wake you up instead of the usual loud beeps. It means you don’t have to disturb your partner, and still has the option of a beeping alarm. A large screen also displays calendar information and temperature.

We Stock...

Electronic Components & Sub-Assemblies
Power Products & Accessories
Audio & Visual Equipment & Accessories
Computer & Telecoms Accessories
Home and Car Alarms & Surveillance Equipment
Lighting Products & Accessories
Gadgets & Unique Gifts

400+ page Catalogue

Midi/PC Based Theremin Synthesiser Kit
KC-5410 £52.75 + post and packing
Many thousands of people are enjoying playing our traditional Theremin synth, but this new design blows out of the water! It actually interfaces with a MIDI accessible synthesiser or a PC with a sound card. This allows it to play up to 120 different instrument selections, in 15 types by 8 variations, that is also of sounds! These notes are then changed in pitch by moving your hand between the antenna and plate, just like the traditional theremin. See our website for a full list of great features. The kit includes the circuit board, machined and printed front panels, all electronic parts, and clear english instructions.

Fuel Mixture Display Kit for Cars
KC-5195 £4.95 + post and packing
Using this simple kit will give you a good indication of how rich or lean your car’s engine is running. It uses the factory EGO exhaust gas, oxygen sensor to indicate the fuel mixture on a series of LEDs. If your engine does not have an EGO sensor, one can be obtained from an automotive junk yard. Kit includes circuit board, all electronic components, and clear English instructions.

50MHz Frequency Meter Kit with LCD Display
KC-5369 £22.50 + post and packing
If you want a great value frequency meter, then this project is for you. It features autoranging operation for ease of use, switching between its three ranges. High resolution of 0.1Hz up to 150kHz, 1Hz between 150Hz and 16MHz, and 10Hz above 16MHz. It can be powered by a 9V battery or wall adaptor (not included) and the case measures just 5 1/8” x 2 5/8” x 1”. Kit includes laser cut & silk screened case, circuit board, electronic components, & clear English instructions.

Get the Video Quality You Paid For With Our Doctor Video Kit
KC-5390 £31.95 + post and packing
Copy protection is put in place on videos and DVDs for a good reason, but this rob you of the true high quality reproduction that is capable of. Get the quality you paid for and stop out these annoying signals! It supports composite and S-video signals and can be configured for NTSC or PAL format. Kit includes case, circuit board, all electronic components, and clear English instructions. Note: Some SMD soldering required.

Cautions: During signal conditioning, this unit removes copyright protection. Piracy is a crime, & Jaycar Electronics takes no responsibility for its potential for unlawful use.

Log on to www.jaycarelectronics.co.uk/elektor for your FREE catalogue!
0800 032 7241
(Monday - Friday 09.00 to 17.30 GMT + 10 hours only). For those that want to write:
100 Silverwater Rd Silverwater NSW 2128 Sydney AUSTRALIA

Jaycar Electronics
New B² Spice V5
Our hottest Spice ever

New B² Spice Version 5 has all the power and functions you expect from a professional Spice package, but without the high cost:

- Real design flexibility with over 30,000 models, unlimited circuit size and a huge range of new virtual instruments
- New Circuit Wizard saves time by auto-generating many designs for you
- Sweep all parameters for any component and simulation type with the powerful new Scenario Editor
- Live Circuit feature allows values to be adjusted while simulations are running, displaying the results in real time

Professional standard Spice simulation for just £229 + VAT. Plus educational and multi-user licence discounts available and FREE comprehensive telephone technical support. Try the full version completely free for 30 days.

www.spice-software.com
Tel: 01603 872331

Research House, Norwich Road, Eastgate
Norwich, NR10 4HA. Fax: 01603 879010
Email info@looking.co.uk
12 Vehicle Diagnostics using OBD-2

The OBD interface has been standardised in the EU under the name EOBD, and is mandatory on all newly-registered cars, both petrol and diesel. At the same time, the number of different protocols used for transferring data has risen from three to five, with the CAN bus protocol becoming more and more successful. High time for an up to date backgrounder on OBD-2.

18 OBD-2 Analyser

Modern cars are jam-packed with electronics. That's great until something goes wrong. Then you're at the mercy of the dealer. At least until now, because in many cases you can use the EOBD adapter described here to track down the problem yourself.

24 Chip Tuning

Can a car ever be powerful enough? As far as we're concerned, 'more is better'. Here we investigate how chip tuning (after all, we are an electronics magazine) can improve the performance of our sacred cow. Our testbed is a BMW 320d and we've also made use of the OBD2 analyser in this issue. The results, as it turned out, are worth the effort!
Circuits 2005

Hobby & Modelling
- Carriage Detection for Model Railway 79
- CCO Metal Detector 113
- Converting a DCM Motor 48
- FT639 One-Chip Servo Controller 32
- LED Flasher for 230 V 91
- Long Delay Stop Switch 76
- Noise Suppression for R/C Receivers 104
- Servo Points Actuator 72
- Two-Cell LED Torch 54

Power Supplies & Batteries
- Balancing LiPa Cells 114
- Converter IC with Integrated Schottky Diode 56
- Discharge Circuit 43
- Efficient Current Source for High-power LEDs 130
- Extension for LiPa Charger 86
- Gentle Battery Regulator 43
- High Voltage Regulator 101
- Improved DECT Battery Charger 80
- Low-cost LiPa Charger 69
- Low-Cost Step-Dawn Converter with Wide Input Voltage Range 103
- Low-drop Regulator with Indicator 131
- Micropower Voltage Regulator 46
- Negative-Output Switching Regulator 47
- Overcurrent Cutoff Switches 39
- Phosphor Supply from Batteries 50
- Protection for Voltage Regulators 62
- Simple Overcurrent Indicator 131
- Solar-Powered SLA Battery Maintenance 83
- Stable USB Power Supply 129
- Step-up Converter for 20 LEDs 123
- Three-Component Li-Ion Charger 87
- Transformerless 5-volt Power Supply 77
- USB Power Booster 122

RF (radio)
- Short-Wave Regenerative Receiver for AM and DRM 80
- Short-Wave Converter 107
- Medium-Wave Modulator 74
- Short-Wave Superregenerative Receiver 73
- DRM Direct Mixer Using an EF95/6AK5 54
- DRM Double Superhet Receiver using on EF95/6AK5 88

Test & Measurement
- 1 MHz Frequency Counter 100
- Cable Tester 53
- Cheap Dot-Mode bargraph Display 97
- Digital VU Meter 70

IR Testing with a Digital Camera 41
Passive 9th-order Elliptical Filter 126
Simple Cable Tester 99
Simple Oscillator / Pipe Locator 40
Simple Short-Circuit Detection 51
Simulator for Bridge Measurements 89
Transistor Dip Meter 87

Miscellaneous Electronics
- 1:800 Oscillator 81
- 9-in-1 Logic Glue / Level Translators 93
- Adjustable Duty Cycle 128
- Bidirectional I2C Level Shifter 64
- Bridge-Rectifier LED Indicator 129
- DIL / SOIC / TSSOP Experimenting Boards 70
- Extended Timer Range for the 555 65
- Filter-based 50-Hz Sinewave Oscillator 75
- Luxeon LEDs 64
- Modifying Stripboard for SO Packages 95
- Navigator Assistant 132
- Optical Mixer 35
- PDM Pulse Generator 102
- Resistor-programmable Temperature Switch 124
- Simple Stepper Motor Driver 85
- Simple Window Comparator 84
- Virtual Prototyping Board 57

PLUSI articles and ideas
- Mailbox 8
- New Products 10
- Vehicle Diagnostics using OBD-2 12
- OBD-2 Analyser 18
- Chip Tuning 24
- Signal Wizard v2 from UMIST (review) 28
- Quizz' Away 134
- Elektor SHOP 138
- Sneak Preview 140

Bold article title = PCB design included!

100+
SMALL PROJECTS
TIPS & IDEAS
Design and Run a Digital Filter in SECONDS!

Signal Wizard 2: Easy-Use Real-Time Digital Filter and Analyser

Signal Wizard 2 is a unique real-time audio-bandwidth digital filter with infinitely adjustable characteristics – available at the click of a button. It uses a DSP unit that runs the filter and a Windows interface for designing and downloading almost any kind of filter. You don't need to know about maths, DSP or filter design – all you need to know is what filter you want. Signal Wizard designs finite impulse response (FIR), infinite impulse response (IIR) and adaptive filters in seconds. You can even import your own impulse or frequency responses. After you've designed the filter, click a button to download and run. Simple! Its flash memory means it can run filters from start-up, without the need for a PC.

Key Features:

- Runs under Windows 98 and XP.
- FIR: Multiple pass, stop or arbitrary; Butterworth, Chebyshev; analog networks.
- Linear or arbitrary phase, response, input mode.
- Rectangular, Bartlett, Hamming, Hanning, Blackman and Kaiser windows.
- Inverse or flipped filters.
- IIR: Butterworth, Chebyshev and arbitrary.
- Adaptive filter for noise cancellation.
- Independent dual channel operation with 24-bit resolution.
- Real-time dual channel scope and spectrum analyzer with data capture.
- Mixing, inversion and delays from 1 microsecond to 1.8 seconds.
- Real-time gain and sample rate control.
- Up to 8 filters in flash, two selectable, one per channel.
- Stand alone operation.
- Twelve sample rates from 48 kHz down to 4 kHz.
- Versatile plot and export of impulse and frequency responses.
- Off-line filter option for wave files.
- Includes board, CD, power supply and all cables.
- Serial interface operating at 115.2 kilo baud (auto-selected).

Full details and ordering information at: www.saelig.com/Suppliers/ezflr/signalwizard2.htm

Subscriptions
Worldwide Subscription Service Ltd., Unit 4, Goffs Reed Farm, Pashley Road, Titchmarsh, NN3 7HE, England. Telephone: (+44) (0)1580 200657, Fax: (+44) (0)1580 200616. Email: avw@avw.demon.co.uk. Rates and terms are given on the Subscription Order Form.

Head Office
Segment b.v., PO. Box 75, NL-6190 AB Beek, The Netherlands. Telephone: (+31) +36944-1, Fax: (+31) +370161.

International Advertising
Klaus Calkoenen, address as Head Office. Email: advertisement@eklektur.nl. Advertising rates and terms available on request.

Copyright Notice
The circuits described in this magazine are for domestic use only. All drawings, photographs, printed circuit board layouts, programmed integrated entries, disks, CD-ROMs, software systems and artefacts published in our books and magazines (other than third-party advertisements) are copyright Segment b.v. and may not be reproduced or transmitted in any form or by any means, including photocopying, scanning an recording, in whole or in part without prior written permission from the Publishers. Such written permission must also be obtained before any part of this publication is stored in a retrieval system of any nature. Patent protection may exist in respect of circuits, devices, components etc. described in this magazine. The Publisher does not accept responsibility for failing to identify such patent(s) or other protection. The submission of designs or articles implies permission to the Publishers to alter the text and design, and to use the contents in other Segment publications and activities. The Publishers cannot guarantee to return any material submitted to them.


Design and Run a Digital Filter in SECONDS!

Signal Wizard 2: Easy-Use Real-Time Digital Filter and Analyser

Signal Wizard 2 is a unique real-time audio-bandwidth digital filter with infinitely adjustable characteristics – available at the click of a button. It uses a DSP unit that runs the filter and a Windows interface for designing and downloading almost any kind of filter. You don't need to know about maths, DSP or filter design – all you need to know is what filter you want. Signal Wizard designs finite impulse response (FIR), infinite impulse response (IIR) and adaptive filters in seconds. You can even import your own impulse or frequency responses. After you've designed the filter, click a button to download and run. Simple! Its flash memory means it can run filters from start-up, without the need for a PC.

Key Features:

- Runs under Windows 98 and XP.
- FIR: Multiple pass, stop or arbitrary; Butterworth, Chebyshev; analog networks.
- Linear or arbitrary phase, response, input mode.
- Rectangular, Bartlett, Hamming, Hanning, Blackman and Kaiser windows.
- Inverse or flipped filters.
- IIR: Butterworth, Chebyshev and arbitrary.
- Adaptive filter for noise cancellation.
- Independent dual channel operation with 24-bit resolution.
- Real-time dual channel scope and spectrum analyzer with data capture.
- Mixing, inversion and delays from 1 microsecond to 1.8 seconds.
- Real-time gain and sample rate control.
- Up to 8 filters in flash, two selectable, one per channel.
- Stand alone operation.
- Twelve sample rates from 48 kHz down to 4 kHz.
- Versatile plot and export of impulse and frequency responses.
- Off-line filter option for wave files.
- Includes board, CD, power supply and all cables.
- Serial interface operating at 115.2 kilo baud (auto-selected).

For more information
Email: info@saelig.com

US $450
(£235 approx)

FULL DETAILS AND ORDERING INFORMATION AT: www.saelig.com/Suppliers/ezflr/signalwizard2.htm
**Quick FIRE**

**SUPERCONTROLLERS**

Our range provides:

- The fastest 68000 based Core up to 66 Mhz.
- Extensive I/O: Serial, IrDA, SPI, PC, Analogue, Timers/Counters, RTC, etc.
- Large Memory Capacity: Flash, SRAM, DRAM.
- Supports: Mono & Colour LCD's, Touch Panels & Keypads, Very Low Power.

**ALSO LOW COST**

**DEVELOPMENT**

- Target easily & quickly.
- Full ANSI ‘C’ compiler, assembler & linker all Windows 32 based.
- Source Level Debug.
- Full Driver Support with Libraries.
- Real Time Multitasking OS with a free run time licence.
- FREE Unlimited email support.

**Total Telematics**

Control The World

£49

**Ethernet uController**

PIC18F452 CPU, 24LC256 EEPROM and demo Web Server.
32K bytes FLASH, 1536 Bytes SRAM and 32K bytes EEPROM.
Web Server uses about half the available EEPROM memory, heaps of space left for custom web pages!
Server based on the excellent Microchip TCP Stack.
13 user programmable I/O pins, 5 can be Analog Inputs.
LED's indicate Power, Collision/Link, Rx/Carrier, Tx.
RS232 interface via 3 pin connector or Front End connector.
Cable included for connection to PC or DTE Device.
Has an ICSP (In Circuit Serial Programming) connector.
Full Technical and Programming Documentation.

Pay us a visit

Loads of uController and Automation Kit

www.total-telematics.com

www.cms.uk.com

see our web site for full details

CAMBRIDGE MICROPROCESSOR SYSTEMS LTD

Unit 17-18 Zone 'D' Chelmsford Rd. Ind. Est.
Great Dunmow, Essex CM6 1XG

Telephone: 01371 875644
email: sales@cms.uk.com
Dear Editor

I've discovered that some code lines for LEDTest program printed in the article on the LPC210x ARMee Board (April 2005) do not work as expected due to notation errors. After some experimentation I was successful in obtaining code that does work. I would gladly offer it to your readers.

```
arm-elf-gcc -o ledst.c
arm-elf-gcc -T1pc2106-rom.ld -nostartfiles -Wl, -nostdlib -s -o ledst boot.s ledst.o
```

I hope this is of use to other readers having experienced similar problems with the printed code.

**Arne Crouwels (Belgium)**

The author/designer, Tony Dixon, replies: I've looked into the problem and Arne is correct. There are a couple of typos in the command listing given in the article, for which I apologise. Please feel free to print Arne's corrected version and give him full credit.

**Black Box for Model airplanes**

**Dear Jon** — even though I am into R/C electric model planes I am not at all an electronic buff. However, I do hope you, or someone else, can come up with some advice on how to approach the subject: telemetry for RC model airplanes. Over the last few years several "Black Boxes", "Flight Data Recorders", "RC Logs" — call it whatever you like — have been available on the market for model airplanes. You can either get the readouts in real time or stored on the onboard data logger I guess it's called. This is simply a matter of how much you will pay. However, I believe it is much more challenging to see if you can create something on your own. I have a book called Fundamentals of Radio Telemetry by Marvin Tapper from 1959, (no typo) and I know very well that much has happened since then, so the book is more nostalgic.

For RC electrically powered model planes weight is of course a vital factor. Maybe you could run an article or explain how these small 'black boxes' work. I imagine it should be possible for an amateur like me to create something usable — call it a 'poor man's telemetry system'. Besides, I am sure many others like me would like to know how these gadgets work.

By the way I just read the article about Super Lithium Batteries and the Simple LiPo charger. Excellent stuff.

**Torben Bæk Sørensen (Denmark)**

Our resident R/C modelling enthusiasts Giel Dals and Paul Goossens may take up the project but to be able to do so they would appreciate the input and suggestions of other readers. This discussion may be continued in our on-line Forum so have a look there.

---

**Mobile telephone masts near schools (2)**

Dear Editor — mobile telephone masts are just another bogeyman the tabloids can fill up with.

They put out very little power (a few watts), and that diminishes with inverse square of distance. By the time it reaches people, it is minuscule.

People probably get more RF from phones right up against their heads. But of course people don't want to abandon these.

Radio amateurs often have much higher RF output than phone masts, and as far as I know nobody has ever demonised them.

If I remember correctly, phones do turn up the power to reach the nearest mast, so having a mast near a school may well mean that kid's phones don't have to transmit as loud. People often fail to perceive risks in perspective. Diarrhoea and malaria for example dwarf any man-made causes of death.

**Kryten (on EE Forum)**

---

You seem to forget that radiation from the masts (and DECT base stations) is present around the clock, 365 days a year.

The effects of long-term exposure to low-level SHF radiation are not known (yet).

Also, GSM/UMTS radiation is TDMA-pulsed at about 200-250 Hz which is well within the response of the human brain and nervous system.

I'm curious to see what *ELEKTOR* has on the subject in the June issue. Their website poll (now removed) showed that the majority of respondents worried about the effects of mobile phone radiation (see p. 20-22, June 2005, Ed.)

**Gonzod (on EE Forum)**

This discussion may be continued on our website Forum under the topic "Radiation a health hazard".

---

**LPC210x ARMee Development System**

**Dear Editor**

I've discovered that some code lines for LEDTest program printed in the article on the LPC210x ARMee Board (April
Keep 'm separated
Dear Editor — within the April 2004 edition of Elektor Electronics, the highend pre-amplifier specification for channel separation at 20kHz is 62dB. This seems much lower than the other channel-separation figure and cross talk figures. From the PGA2311 datasheet I am unable to determine if this is a device specification, or the design implementation specification limit for the 62 dB figure. If possible, would you be able to confirm if this is a design implementation or IC specification limit? Thanks.
Richard Shadbolt (UK).

Our in-house audio designer Ton Giesberts replies: the measurements of the Pre-Amplifier were made on the device as a whole. In this case the lower channel separation at higher frequencies is mainly caused by the input relays. But the rest of the circuitry (wiring, PCB, placing of the connectors and the PGA2311PA) also determines the overall channel separation.

Fond memories of SC/MP
Dear Jon — having only just started reading Elektor again after many years I was amazed by your editorial mentioning the SC/MP and the Retronics article (both in the April 2005 issue). I cut my microprocessor teeth with the Elektor SC/MP projects back in 1978 and they were responsible for shaping my subsequent career path. I was then an apprentice with BT and I had built Uncle Clive Sinclair's MK14 kit but what I wanted was a real computer experience, it's still in service to this day which I find very satisfying. Ten more years at BT followed until I eventually broke away to start an assembly business of my own and now it's me that advertises in Elektor. So thank you Elektor — you truly were an inspiration to me and others. As a result of the MPU revolution which then led to the BBC Micro we had for a time a huge lead in programming capability in this country. I fear not for much longer though — my own kids are software users now, not creators. What we need is an SC/MP for the 21st century! Peter Allgood (UK)

How about our 89S8251 Flash Micro Board Peter? So far about 3,000 of these have been sold and the project comes complete with a programming course. For the more ambitious microcontroller fans I'd suggest venturing out into ARM land with our LPC210x ARM Development System (also in April 2005, no coincidence as the issue focused on microcontrollers 1978-2005).

MailBox Terms
— Publication of reader’s correspondence is at the discretion of the Editor.
— Viewpoints expressed by correspondents are not necessarily those of the Editor or Publisher.
— Correspondence may be translated or edited for length, clarity and style.
— When replying to Mailbox correspondence, please quote issue number.
— Please send your MailBox correspondence to: editor@elektor-electronics.co.uk or Elektor Electronics, The Editor, P.O. Box 190, Tunbridge Wells TN5 7WY, England.
LIN controlled alternator voltage regulator

International Rectifier recently introduced the local interconnect network (LIN)-controlled alternator-regulator for next-generation vehicles. IR’s solution is claimed to optimize performance in intelligent automotive charging systems for increased efficiency and improved fuel economy.

Intelligent vehicular charging systems are used when dynamic control of the alternator output and torque is desired for optimal battery charging, electrical system power management, and alternator-engine interaction. Dynamic alternator control enables improved electrical system efficiency and reduces engine idle speed for greater fuel economy.

The IR LIN-controlled alternator regulator is assembled using thick-film hybrid technology for reliable high temperature operation and excellent parametric stability over the entire operating temperature range of -40°C to 150°C. The hybrid circuit can be customized to the application to optimize performance and reliability, and can be assembled into a custom housing with an insert-moulded lead-frame specifically designed for flame-soldering or heavy wire bonding.

Thick-film technology also enables precise laser trimming of discrete resistors so that patented current sensing technology can be used to achieve the highest tolerance capability in the industry.

International Rectifier, European Regional Centre, 439/445 Godstone Road, Whyteleafe, Surrey CR3 0BL Tel +44 (0)20 8645 8003 www.irf.com

Record temperature & humidity with dew diligence

The EL-USB-2 is reportedly the world’s first standalone humidity & temperature data logger with direct USB interface. The unit is capable of recording relative humidity from 0 to 100%RH, temperature from -35°C to +80°C and calculating dew point. Configuration of the unit is simple. After installing the software supplied with the unit, simply insert the logger into the computer’s USB port and choose the required sampling rate, set high and low alarms for each parameter, and set the logger start time. Once configured, the EL-USB-2 can be removed from the computer and log independently. The waterproof plastic casing allows use of the logger in hostile environments if required. Two LEDs indicate when the unit is logging, when an alarm level has been reached, when the battery needs replacing or when the device has reached full memory capacity (32,000 readings). To download data, the user reconnects the unit to the USB port. A graphing utility in the software plots and displays relative humidity, temperature and dew point along with the time and date for each reading. Data can also be imported into many industry standard spreadsheet packages. The EL-USB-2 is available immediately from Lasca Electronics at a price of £49.00.

Lasca Electronics Limited, Module House, Whiteparish, Salisbury, Wiltshire SP5 2SJ. Tel (+44) (0)1794 884567, Fax (+44) (0)1794 884616. Internet: www.lascarelectronics.com

World’s smallest Ethernet controller

Microchip recently announced the ENC28J60 — the world’s first 28-pin stand-alone Ethernet controller — which provides a low-pincount, cost-effective, easy-to-use solution for remote com-
munication between embedded applications and local or global networks.

Designers who require communication for remote control or monitoring are often faced with the complexity of large-footprint, expensive Ethernet controllers that are tailored for personal-computing systems. While most Ethernet controllers came in greater than 80-pin packages, the IEEE 802.3-compliant ENC28J60 offers comparable features in a 28-pin package. The ENC28J60 Ethernet controller employs the industry-standard SPI™ serial interface, which only requires four lines to interface to a host microcontroller. These features, combined with Microchip's free TCP/IP software stack for PIC18 microcontrollers, provide the smallest whole-product Ethernet solution for embedded applications.

By adding Ethernet connectivity to an embedded system, microcontrollers can distribute data over a network and can be controlled remotely. Ethernet's infrastructure, performance, interoperability, scalability and ease of development have made it a standard choice for embedded application communications, such as within the growing VoIP market.

Supporting development tools include the PICtail™ Ethernet Interface board (part # AC164121), designed to ease development with the ENC28J60 Ethernet controller, it plugs into a selection of Microchip's standard PICDEM™ demonstration boards and is expected to be available soon. Microchip's free TCP/IP stack, which is designed for all PIC18 host 8-bit microcontrollers, is available now for download from Microchip's web site. Information on a third-party stack for all PIC16 host 8-bit microcontrollers can also be found there.

Package options include 28-pin SPDIP, SOIC, SSOP and QFN.

Tiny, low-power temperature sensors

Microchip recently introduced two temperature sensors that offer low cost, a small SC-70 package and low current consumption of 6 microamps (typical), making them an attractive alternative to thermistors. The MCP9700 and MCP9701 temperature sensors provide a complete solution for thermal protection, temperature measurement or thermal calibration.

The low power consumption of 6 microamps (typical) is less than most of the thermal sensor ICs on the market, enabling longer battery life and reducing self-heating for better accuracy. The linear output slope of the MCP9701 is 19.53 millivolts per degree Celsius while the MCP9700 output is 10 millivolts per degree Celsius. Overall temperature error is +/- 4 degrees Celsius (maximum) from 0 degrees Celsius to 70 degrees Celsius.

The low output impedance allows direct connection to an analog-to-digital converter input, without the need for buffering amplifiers. The devices are ideal for use with Microchip's 8-bit PIC 16-bit dsPIC digital signal controllers. The extremely small SC-70 package (40 percent smaller than a SOIC-20 package) and the elimination of external components results in a more compact board layout.

The MCP9700 and MCP9701 temperature sensors are available today for sampling and volume production. For additional information visit the Microchip Web site.

Coldfire suite supports Freescale MCF547x/8x chips

Crossware, a leading embedded software tools developer, has enhanced its ColdFire® Development Suite by adding support for Freescale Semiconductor's MCF547x and MCF548x ColdFire microprocessors.

The MCF547x and MCF548x are high-speed microprocessors based on the advanced V4e ColdFire Core. All microprocessors in the range have a wide range of connectivity peripherals, a memory management unit, a dual precision floating point unit (FPU) and an enhanced multiply and accumulate unit (eMAC).

The Crossware Suite includes a separate C header file for each microprocessor in the range. This ensures that the developer has access only to the structures that are relevant to the chosen microprocessor and cannot therefore inadvertently write code for a peripheral that the chosen microprocessor does not have.

The Crossware C compiler generates code that takes full advantage of the FPU and the Crossware simulator fully simulates both the FPU, including FPU exceptions, and the eMAC. This enables developers to run code that uses these units both with and without hardware.

Crossware's FireFly USB BDM (background debug mode) interface has also been enhanced to handle features that are specific to Freescale's System-On-Module (SOM) Fire Engine boards for these chips. This includes the programming of Intel's advanced K3 Stratolflash memory chips.
Electronic diagnosis systems have been used in vehicles for almost as long as digital engine management units — some twenty years now. In order to monitor vehicle exhaust emissions more effectively, OBD (on-board diagnosis) systems have been mandatory in the USA since 1998. In 1995 the more highly-developed OBD-2 standard was introduced. This unified diagnostic interface, standardised across manufacturers, was used by the EU Commission as the basis for an EU directive, the effect of which is to oblige European manufacturers to incorporate a unified, accessible diagnostic interface, to make major parts of their existing diagnosis systems compatible with one another, and to publish information about them. The EOBD (European on-board diagnosis) system has been mandatory in the EU on all newly-developed models since 2000 for petrol engines and since 2003 for diesel engines. One year later, EOBD became mandatory on first registration for all vehicles (from 1 January 2001 for petrol engines, 1 January 2004 for diesel engines).

**OBD-2 Diagnostics connector**

The requirements for EOBD are mostly included in the ISO standards listed in Table 1. ISO 15031-3 mandates a 16-pin socket which, in contrast to earlier systems, must now be fitted near the driver's seat rather than in the engine compartment. It may be located, for example, below the dashboard, behind a flap in the central console, or even under the ashtray. Since this type of connector was already used by some manufacturers for the diagnostics system (for example, by VW and Audi since 1993), the presence of the connector by itself is no guarantee that the interface conforms to the EOBD standard. If the vehicle was first registered before the deadlines mentioned above, it may be necessary to make enquiries of the manufacturer or look on the Internet.

Some of the pins of the EOBD socket (Figure 1) may not be present. The actual number of pins depends on which protocols are used (see the next section). That is not to say, however, that pins not listed in the pinout charts (Table 2) will necessarily be absent. It can happen that a manufacturer will use these pins for dedicated functions which do not form part of the EOBD standard.

**Protocols**

The electronics in a modern car consists of a network of microcomputer systems connected together over a bus, called, in automotive engineering circles, 'electronic control units', or ECUs. More complex systems such as engine management, ABS, ESP and airbags, each have their own ECU. Of
Mitsubishi system in EU02 and very successful standardised in the EU under tested cars, both petrol and diesel, used for transferring data in protocol becoming left.

Course, not all manufacturers use the same (serial) bus system to connect their ECUs together; a variety of bus systems can even coexist within one vehicle. When the OBD-2 diagnostics interface standard was drawn up the most widespread bus protocols in use at the time were considered: these were, in the United States, the PWM protocol used by Ford and the VPWM protocol used by General Motors. PWM stands for 'pulse width modulation' and VPWM for 'variable pulse width modulation'. European and Asian manufacturers preferred the relatively simple ISO 9141-2 protocol, which is similar to that handled by a UART. We described only these three protocols in the article on OBD-2 in Elektor Electronics in October 2002. Since then two further protocols have been added: the KWP2000 protocol, a derivative of the ISO 9141-2 standard (KWP stands for 'Key Word Protocol'), and our old friend the CAN protocol, which has only surprisingly recently started to become popular in diagnostics systems. As the footnote to Table 1 hints, the simpler serial protocols according to ISO 9141-2 and ISO 14230-4 (KWP2000) will only be permitted in the USA until the end of 2007, and worldwide the CAN protocol is being used for the diagnostic socket on practically all new models. Table 3 gives an overview of the five protocols which you might (still)

Table 1

| ISO 9141-2 | Communication link* |
| ISO 11519-4 | Low speed serial data communication* |
| ISO 14230-4 | Keyword protocol 2000* |
| ISO 15765-4 | CAN Requirements for emission-related systems |
| ISO 15031-3 | Diagnostic connector |
| ISO 15031-4 | Test tool characteristics |
| ISO 15031-5 | Diagnostic services |
| ISO 15031-6 | Emission related fault codes (DTC) |
| ISO 15031-7 | Data link security |

*not permitted in the USA from 1 January 2008.

Table 2

| Pin 2 | J1850 bus + |
| Pin 4 | Vehicle ground |
| Pin 5 | Signal ground |
| Pin 6 | CAN high (J2284) |
| Pin 7 | ISO 9141-2 K output |
| Pin 10 | J1850 bus - |
| Pin 14 | CAN low (J2284) |
| Pin 15 | ISO 9141-2 L output |
| Pin 16 | Battery positive |

Figure 1. The 16-pin OBD-2 diagnostics socket (source: Gerhard Müller).
The CAN bus

(Contribution by Bülent Özen)

The Controller Area Network connects together a number of peer units (called nodes) using a two-wire bus. The CAN protocol was developed by Bosch in 1983 for use in vehicles.

ISO 11898 defines the physical characteristics of CAN and many other bus protocols, including, for example, PROFIBUS. There are many ICs available to meet this specification, including the PCA82C250 from Philips. One of the ways used to help protect against interference is to transmit a bit on two wires simultaneously using voltage swings in opposite directions: a so-called differential signal. Since the logic level is encoded by the voltage difference between the two wires, interference, which tends to affect the two wires equally, is rejected. This is called common mode rejection.

The CAN high and CAN low signals carry the inverted and non-inverted serial data signal. Open-collector drivers are used (PNP to drive the CAN-H signal to VCC and NPN to drive the CAN-L signal to GND), which means that multiple devices can be connected to the bus in parallel without causing short-circuits when bus conflicts occur.

The bus state where the CAN-H and CAN-L signals carry different voltage levels is called the ‘dominant’ state (with a voltage difference of greater than 3.5 V); the state where the levels are approximately the same (the difference is less than 1.5 V) is called the ‘recessive’ state. According to the definition of CAN, the dominant state corresponds to a logic zero: if one node applies a logic zero to the bus, it overrides a logic one applied by another node. The bus between the nodes thus in effect provides a wired-AND connection.
Volkswagen-Audi group. Since this manufacturer has been using the ISO 9141-2 protocol since around 1993, the software also works with older models from VW and Audi whose data transfer format is not compatible with OBD-2. Unfortunately VAG-COM will not work with cars from other manufacturers which are OBD-2 compatible.

A simple level shifter is not enough to run diagnostics on all OBD-2 compatible cars. In order to make the software running on the PC independent of the bus protocol used by the car, a microcontroller is needed in the OBD-2-to-RS232 interface to perform the necessary conversion to and from the car’s protocol. This intelligent OBD-2 interface is able to decode the results it reads out and deliver them to the PC in plain ASCII characters. In the simplest case a terminal program is all we need on the PC, the user will then have to search out the various fault and sensor code tables available on the Internet in order to fathom the meaning of the received ASCII strings. Fortunately there is a Windows program available for this purpose [4], which offers a wide range of functions even in its shareware version.

### OBD-2-compatible solutions

The OBD-2 interface published in Elektor Electronics in November 2002 used a preprogrammed microcontroller made by a Canadian company, but could only be used with cars that use the ISO 9141-2 protocol. The VAG-COM approach has the advantage over this of being independent of any manufacturer. It is also suitable for use with any OBD-2-compatible car that uses the ISO 9141-2 protocol, which, at that time, was the case for most of the more modern cars from European and Japanese manufacturers.

The new OBD-2 Analyser presented in this issue uses a T89C51 microcom-

---

**Format of a CAN message**

A message needs to be formatted in a particular way for transmission on the CAN bus. The packet is called a ‘frame’. A frame consists of seven fields:

- Start of frame
- Message identifier
- Control bits
- Data (0 to 8 bytes)
- Check bits
- Acknowledge bit
- End of frame

A CAN frame always contains eight data bytes. If not all are used, zero bytes must be added as padding. The first byte in the data field is called the PCI byte, and indicates whether we are dealing with a single frame or a multiple frame. In the single frame case the byte also indicates the number of bytes in the data field that are actually used.

![Format of a standard frame in accordance with CAN Specification 2.0A.](image)

<table>
<thead>
<tr>
<th>Field</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>07</td>
<td>DF 02</td>
</tr>
<tr>
<td>01</td>
<td>0D</td>
</tr>
<tr>
<td>CRC</td>
<td></td>
</tr>
</tbody>
</table>

**EOBD request for speed sensor reading (11-bit identifier)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>DB 33</td>
</tr>
<tr>
<td>F1</td>
<td>02</td>
</tr>
<tr>
<td>01</td>
<td>0D</td>
</tr>
<tr>
<td>CRC</td>
<td></td>
</tr>
</tbody>
</table>

**EOBD reply containing speed sensor reading (11-bit identifier)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>DA</td>
</tr>
<tr>
<td>F1</td>
<td>xy</td>
</tr>
<tr>
<td>03</td>
<td>41 0D</td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>CRC</td>
<td></td>
</tr>
</tbody>
</table>

**EOBD request for speed sensor reading (29-bit identifier)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>DB 33</td>
</tr>
<tr>
<td>F1</td>
<td>02</td>
</tr>
<tr>
<td>01</td>
<td>0D</td>
</tr>
<tr>
<td>CRC</td>
<td></td>
</tr>
</tbody>
</table>

**EOBD reply containing speed sensor reading (29-bit identifier)**

<table>
<thead>
<tr>
<th>Field</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>DA</td>
</tr>
<tr>
<td>F1</td>
<td>xy</td>
</tr>
<tr>
<td>03</td>
<td>41 0D</td>
</tr>
<tr>
<td>W</td>
<td></td>
</tr>
<tr>
<td>CRC</td>
<td></td>
</tr>
</tbody>
</table>
troller with firmware developed by Özen Elektronik from Turkey [5] which is currently the nec plus ultra in its field: it supports all five protocols (see Table 3). This OBD-2 analyser is thus the first EOBD interface using a microcontroller that also supports the CAN protocol. In view of the migration of manufacturers to the CAN protocol, this support is essential for a future-proof system.

In most cases using the OBD-2 analyser in conjunction with a notebook will be the most powerful as well as the most cost-effective and appropriate solution. A stand-alone OBD analyser with built-in LCD has the advantage that it can easily be used while on the move, and it can even be installed permanently. Commercial hand-held OBD analysers are, however, still rather costly, although some hobbyists have built their own.

Functions available

In recent years OBD-2 has evolved in more than just the protocol used. The range of diagnostic facilities available over the standardised interface has increased considerably. It is certainly no longer the case (if it has really ever been the case) that OBD-2 can only be used for reading out data related to exhaust gases. Legislators have so far only required an OBD-2 or EOBD connection for control units associated with the power train. Other systems such as ABS, climate control etc., are left to the whim of the manufacturer: they can offer diagnostics over OBD-2 or they can use their own protocols instead, and take advantage of pins of the OBD-2 socket which are not reserved in the standard. Some manufacturers already make vehicles where all the control units are on an OBD-2 compatible network. The extended OBD-2 standard covers all currently-used control units as well as those expected in future, so in principle the diagnostics for the entire vehicle can be carried out over OBD-2 or EOBD. The EU Competition Commissioner could therefore consider the possibility of further extending the EOBD standard to cover all control units associated with vehicle maintenance.

The range of functions available is chiefly determined by the nine test modes in the standard:

- 01 - gives real-time data
- 02 - gives the so-called ‘freeze frame’ data
- 03 - gives fault codes
- 04 - erases fault codes and stored values
- 05 - gives the self-test results for the Lambda probes
- 06 - gives the self-test results for systems that are not continuously monitored
- 07 - gives the self-test results for systems that are continuously monitored
- 08 - dedicated control mode
- 09 - vehicle data request: information such as software version and VIN (vehicle identification number)

Many further test modes are specified in the standardised extension (according to SAE J2190). Provision is also made for future expansion and for manufacturer-specific uses. The number of standardised fault codes has also increased significantly, including a large number of manufacturer-specific fault codes. Manufacturers are required to define their own fault codes in relation to the standardised codes, although it is frequently not possible to deduce their meaning without the manufacturer’s documentation. Full and shareware versions of diagnostics software are often differentiated by the number of fault codes they understand.

OBD-3

The next generation of technology, OBD-3, is already on the horizon in the USA. In the name of ‘Homeland Security’ data protection is taking a back seat and surveillance is now in the driving seat: OBD-3 reportedly will secretly and silently transmit its data to a central monitoring station by mobile radio or satellite.

Digital reprints of these articles may be obtained from www.elektor-electronics.co.uk

Table 3

<table>
<thead>
<tr>
<th>OBD-2/EOBD protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ISO9141-2</td>
</tr>
<tr>
<td>2. KWP2000</td>
</tr>
<tr>
<td>3. J1850-PWM</td>
</tr>
<tr>
<td>4. J1850-VPWM</td>
</tr>
<tr>
<td>5. CAN-BUS</td>
</tr>
</tbody>
</table>

Further reading:

SERIAL COMMUNICATIONS SPECIALISTS
Test and Measurement Solutions

NETCOM Ethernet - Serial Servers
NetCom are industrial strength, network based serial device servers for connecting RS232, RS422 and RS485 serial devices directly to a 10/100Mbps Ethernet network running TCP/IP. Netcom can control 1 or more serial devices located virtually anywhere (via Ethernet or Internet). NetCom can be configured over Driver Panels, WEB Browser, Serial Port, Telnet or SNMP and serves as a transparent serial channel without platform and distance limitation. Housed in a sturdy metal enclosure including DIN rail mount, one to eight port models are available. 19in rack-mount versions with internal switch mode PSU can also be supplied.

NetCom-613
8 Port RS232/RS422/RS485 model £350

NEtCOM Ethernet - Serial Servers

USB Instruments - PC Oscilloscopes & Logic Analyzers
Our range of PC Instruments may be budget priced but have a wealth of features normally only found in more expensive instrumentation. Our DS1M12 and PS40M10 oscilloscopes have sophisticated digital triggering including delayed timebase and come with our EasyScope, oscilloscope / spectrum analyzer / voltage and frequency display application software and our EasyLogger data logging software. We also provide Windows DLLs and code examples for 3rd party software interfacing to our scopes. Our ANT8 and ANT16 Logic Analyzers feature 8/16 capture channels of data at a blazing 500MS/S sample rate in a compact enclosure.

USB-16COM-RM
16 Port USB Serial Server Rack Mount with internal PSU £265

PCl-800C
8 Port PCI RS232 Serial card £150 (including cables)

NETCOM Ethernet - Serial Servers

NETCOM Ethernet- Serial Servers
NetCom are industrial strength, network based serial device servers for connecting RS232, RS422 and RS485 serial devices directly to a 10/100Mbps Ethernet network running TCP/IP. Netcom can control 1 or more serial devices located virtually anywhere (via Ethernet or Internet). NetCom can be configured over Driver Panels, WEB Browser, Serial Port, Telnet or SNMP and serves as a transparent serial channel without platform and distance limitation. Housed in a sturdy metal enclosure including DIN rail mount, one to eight port models are available. 19in rack-mount versions with internal switch mode PSU can also be supplied.

NETCOM Ethernet- Serial Servers

USB Instruments - PC Oscilloscopes & Logic Analyzers
Our range of PC Instruments may be budget priced but have a wealth of features normally only found in more expensive instrumentation. Our DS1M12 and PS40M10 oscilloscopes have sophisticated digital triggering including delayed timebase and come with our EasyScope, oscilloscope / spectrum analyzer / voltage and frequency display application software and our EasyLogger data logging software. We also provide Windows DLLs and code examples for 3rd party software interfacing to our scopes. Our ANT8 and ANT16 Logic Analyzers feature 8/16 capture channels of data at a blazing 500MS/S sample rate in a compact enclosure.

USB-16COM-RM
16 Port USB Serial Server Rack Mount with internal PSU £265

PCl-800C
8 Port PCI RS232 Serial card £150 (including cables)
If you’re like most of us, you occasionally notice that there’s something not quite right with your car. When all sorts of little lights go on, it’s pretty clear that there’s something wrong. In some cases your car even starts to talk to you and simply refuses to shut up. There can also be a vague sort of problem that is very difficult to describe to the mechanic. And although the service light indicates that something isn’t right, it doesn’t give you any sign of what it might be. That means you have to make an appointment with the garage.

Besides all this, many car owners would simply like to know more about everything that is happening in their cars. The problem is how to figure that out in all the jumble of electronics. The information must be there, but how can you get you hands on it? Fortunately, European legislation lends us a bit of a helping hand here. Car manufacturers are now required to provide access to all sorts of data about the engine and the trouble conditions. Readers of Elektor Electronics can use the adapter described here to easily read out a lot of useful information.

Will it work with my car?
In principle, it’s all very simple. All cars with petrol engines made from 2001 onwards, and all cars with diesel engines made from 2004 onwards, must be fitted with a standardized EOBD interface. The parameters and values that can be read out via the EOBD connector are also standardized. Unfortunately, the manufacturers could not agree on the protocol to be used for data transfer, with the result that there are five different protocols. The adapter described here can read all five protocols. You don’t have to know which protocol your car uses, because the adapter figures that out on its own.

What can you read out?
The European standard divides the data into groups, which are also called ‘services’. The first four services are presently available, and they are also constantly being modified and extended.

In Service Mode 1, you can read out the values measured by various sensors. Naturally, you can only read the values from the sensors that are actually fitted in your car. Some examples of sensor values are motor rpm, driving speed, calculated engine power (based on air consumption), cooling water temperature, and turbocharge pressure.

In Service Mode 2, you can retrieve stored data (which is called ‘Freeze Frame’ data). That generally consists of engine data stored while the car is underway so it can be analysed afterwards to determine whether the measured values stayed within the stipulated limits (including the environmental limits).

Service Mode 3 contains the trouble codes (DTC). Thousands of trouble codes have already been defined, and new ones are constantly being added. Here the manufacturers have a lot of freedom with regard to making the codes publicly available. You can find a more complete list at www.obd-codes.com. That list is still constantly being enlarged. Refer to the links at the end of the article for more information.

Finally, Service Mode 4 simply allows the trouble codes in Service Mode 3 to be reset. Be careful here: all of the codes will be deleted! If despite your troubles you have to take your car to the garage for service later on, the mechanic will not be able to see which trouble codes have occurred if you have deleted them.

What you need
Nowadays nothing works without software and a computer, so you’ll need a PC (desktop or notebook) and a program that can deal with the codes. No
loaded for free from www.ozenelektronik.com. If you simply register and log in (no charge), you can download 'mOByDic Computer Interface Version 1.2b' from the Downloads page.

Another option is the Scanmaster program. It provides a well-organised graphic interface (see Figure 1). Scanmaster can be downloaded from www.wgsoft.de or the author’s website www.ozenelektronik.com. The nice thing about this program is that it translates the codes into intelligible texts, which makes things a lot easier to understand. It will shortly also be available in non-freeware ‘professional’ version. The professional version will be more extensive and will include many more trouble codes.

**Hardware**

The EOBD interface adapter is built on a printed circuit board that is available by itself from *Elektor Electronics* Reader Services or as part of a complete construction kit. The assembled board enables the computer to understand the signals provided by the EOBD connector in your car. Besides converting the signals on the EOBD lines to RS232 levels, this also requires matching the protocols to each other. It shouldn’t come as any surprise that

---

**Table 1. Service modes**

<table>
<thead>
<tr>
<th>OBD operational data (SAE J1979 standard, ISO/DIS 15031-5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode 1</strong> Relevant actual exhaust gas values and system diagnostic data</td>
</tr>
<tr>
<td><strong>Mode 2</strong> Data from the engine region (Freeze Frame data)</td>
</tr>
<tr>
<td><strong>Mode 3</strong> Trouble codes related to exhaust gasses</td>
</tr>
<tr>
<td><strong>Mode 4</strong> Delete the trouble codes</td>
</tr>
<tr>
<td><strong>Mode 5</strong> Values from the control loop of the lambda sensor</td>
</tr>
<tr>
<td><strong>Mode 6</strong> Tests results (not continuously monitored)</td>
</tr>
<tr>
<td><strong>Mode 7</strong> Test values (continuously monitored)</td>
</tr>
<tr>
<td><strong>Mode 8</strong> Content different for each manufacturer; can be read out</td>
</tr>
<tr>
<td><strong>Mode 9</strong> Identification codes</td>
</tr>
</tbody>
</table>

---

![Figure 1. The screen of the Scanmaster program. The various service modes can be conveniently selected using the icons on the left-hand side.](image)
A microcontroller (T89C51) is used for the latter task (see Figure 2). It would exceed the scope of this article to fully describe the five protocols that the adapter can process, so here we'll limit ourselves to saying that they differ quite significantly from each other. In any case, you don't need to know anything about the protocols to be able to use the adapter successfully.

Incidentally, it appears that within a few years practically all car manufacturers will change over to the more standardized CAN bus protocol. That will make things a lot easier from a technical perspective, because it means that the EOBD interface will simply become another node in a network. For readers who would like to know more, the entire CAN bus was described extensively in the September through November 1999 issues of *Elektor Electronics*.

Thanks to its built-in CAN controller, the T89C51 microcontroller can communicate with all of the EOBD protocols. The external 16-MHz clock signal is doubled internally. That means the chip works at 32 MHz. IC7 generates the reset signal and monitors the 5-V supply voltage, which is derived from the battery voltage by a 7805. It's possible (and less expensive) to replace IC7 by capacitor C7. The microcontroller drives two low-current (5 mA max.) LEDs that act as state indicators. The serial interface is provided by the well-known Maxim MAX232, so the signal transfer with the FC takes place using nicely standardized RS232 levels.

A different part of the hardware is used for each protocol. For the ISO9141-2/KWP2000 protocol, transistors T3 and T4 provide level adjustment. According to the ISO standard, each of the two data lines must be fitted with a 510-Ω load resistor. The ISO signals are transmitted via the transistors. A comparator (IC2b) is used to receive the ISO signals. The reference input is connected to half the battery voltage (V<sub>batt</sub>). The microcontroller's internal pull-up resistor provides an adequate load for the open-collector output of the comparator.

In the case of the J1850-PWM protocol, T1 and T2 are used to transmit the differential signal. The received differential signal is processed by the comparator to yield the RX-PWM signal. R7 and RB
You should use the PCA82C251 with 24V. If you work with lorries, you should use the PCA82C251 version. If you only plan to use the adapter with passenger cars, the PCA82C250 is suitable.

If you find the American transistor numbers strange, you can use the European BC546B in place of the 2N3904 if you fit it rotated by 180 degrees. A BC4556B can be used in place of the 2N3906, again rotated by 180 degrees. In case of doubt, consult the relevant transistor data sheets to be certain.

The printed circuit board, whose layout is shown in Figure 3, fits exactly in the specified Hammond enclosure. You only have to make cutouts for the connectors at the two ends. The board is held in place between the lid and the vertical ribs of the enclosures without any additional fixing hardware.

**Initial use**

The EOBD interface has two DB9 connectors: one male and one female. Connect the female connector to the serial port of a PC using an RS232 extension cable. Be sure to use a 1:1 cable for this, not a null-modem cable.

The other DB9 connector is connected using a special cable that has a female DB9 connector at one end and a male OBD plug at the other end (see Figure 4). The most convenient solution is to buy this cable along with the PCB. It is specially made for this application. Connect the OBD plug to the OBD service connector in your car. Note: be sure to connect the OBD plug after all other connections have been made, due to the risk of static charges (see the inset).

It may take a bit of searching to find the OBD connector in your car, but according to the EU standard it should be within 1 meter of the driver's seat. Naturally, that means it can always be under the bonnet. If you can read a bit of German, there's a handy website at www.obd-2.de/tech_dtc.html. It identifies the location of the connector for many different types of cars.

The circuit is powered from the car. That means that the red LED (power indicator) should light up as soon as you switch on the ignition. After this, the adapter automatically searches for the right protocol. That is indicated by an irregular blinking of the yellow LED. As soon as the protocol has been found, the green LED lights up. If no valid protocol is found, the green LED remains off, and after a while the yellow LED will start blinking regularly at a 3-second interval. That means that no communication is possible.

After the green LED on the adapter has lit up as a sign that communication has been successfully established, you can start the desired PC program. Here we assume that you are using the Scanmaster program. Immediately after being started, the program starts to look for the adapter. You may have to configure the correct COM port and baud rate (9600). If you click on
'Update' at the lower left, the data will appear on the screen (see Figure 1). Now you're ready to use the program. Don't forget to click on 'Read' in the 'Sensor Data' menu, since otherwise everything will stay at zero (see Figure 5).

Although the mOByDic Computer Interface program does not present the data in such a nice graphic form, it does allow the measured data to be shown in the form of a chart. That gives a very clear picture of measurements made over a length of time. Finally, we'd like to note that wireless data readout is also possible. A Bluetooth adapter for the serial port is available, and it can be used to link the OBD interface adapter to the PC without using a cable. In any case, we hope you enjoy building the adapter and using it to measure data.

Figure 4. Signal connections in the OBD-to-serial cable.

Figure 5. Data can be read out in tabular form (using 'Table data' at the upper left) or graphic form.
Static charges

The adapter is not electrically isolated. That would have made the circuit quite a bit more complicated, and it would require a separate power supply. The OBD plug has two ground pins (4 and 5) that are somewhat longer than the other pins, so the ground connection is always made first to allow any potential difference to be equalized before contact is established between the signal lines. However, if you think there is a large potential difference you should always neutralize the potential difference before connecting the plug. The best way to do that is touch the circuit or PC (for example, by firmly grasping the metal shell of the DB9 plug) and then touch the car with your other hand to equalize the potential. In this case your body acts as a conductive link between the PC and the car. Do not connect the plug until after you have equalised the potential.

Links

www.ozenelektronik.com
www.obdii diag.com (This website will be entirely dedicated to the EOBD adapter. It was not quite ready when this article was written, but it is intended to be operational when this article appears in print.)

The following websites (among others) provide information about OBD error codes:
www.obd-2.de/tech_dtc.html
www.troublecodes.net/technical

For additional information, see:
www.elmelectronics.com
www.scan tool.net
www.iso.org
www.obd-2.de
www.sae.org
The turbo pressure is changed significantly, but within reason. These parameters protect the engine from overheating and limit the car’s top speed. We leave the protection untouched, but increase the top speed by 10 km/h.

The torque limiter. This graph is changed significantly, but within reason.

The ‘driver’s wish’ controls how the engine reacts to the accelerator pedal.

The turbo pressure is increased a bit as well.

Thijs Schoonbrood

In the past carburettors and distributors ruled the roost, but nowadays mainly injectors and sensors are found under the bonnet. The biggest difference between then and now is the way in which the engine is controlled. In a traditional system the carburettor ‘automatically’ controlled the fuel-mixture depending on the pressure and the size of the nozzles. A sophisticated mechanical system with centrifugal and vacuum advance continuously adjusted the ignition timing according to the revs and the engine load.

It's all very different these days: the engine management system is in total control. An electronic control unit (‘ECU’) receives information from sensors regarding the state of the engine. This includes the revs, the engine temperature, the ambient temperature, the position of the accelerator, the angle of the camshaft and the turbo pressure. The ECU controls the timing and the length of the fuel injection on the basis of this information. Is the engine still cold? Then more fuel is injected because part of the fuel condenses on the cylinder walls of a cold engine. Has the driver put the ‘pedal to the metal’? The engine management system can then temporarily increase the turbo pressure, or just ignore its guidelines for economical driving so the car becomes more responsive.

The ECU has a type of mini database on board that contains numbers for the ideal amount of fuel, the right time for fuel injection and, for petrol engines, optimal ignition timings. And all these numbers are available for various conditions. But are these numbers as good as possible? Manufacturers have to keep a large range of criteria in mind. For example, every engine has to have a similar performance despite small variations in its construction or when a less than optimal fuel is used. They also have to stay below certain emission and consumption levels. On top of this the manufacturers often include large safety margins. The resulting set of parameters in a standard ECU is therefore a compromise, which the manufacturer feels is right for the international market. This does however leave some room for fine-tuning, which is exactly what we’ll do next.

OBD and chip tuning

The parameters for the ECU (the professional tuner calls these ‘maps’) are stored in an EPROM or Flash memory. These memory chips can be easily read, copied and modified using a universal programmer. With the intro-
Can a car ever be powerful enough? As far as we’re concerned, ‘more is better’. Here we investigate how chip tuning (after all, we are an electronics magazine) can improve the performance of our sacred cow. Our testbed is a BMW from an enthusiastic reader and we’ve also made use of the OBD2 analyser that is elsewhere in this issue. We won’t give anything away yet, but the results are worth the effort!

duction of OBD (On Board Diagnostics) it became even simpler to read the ECU memory, since you no longer had to gain physical access to the memory. In the first case we talk about chip tuning, in the second it’s called OBD tuning. Although the names are different, they effectively refer to the same procedure: modifying the ECU parameters to retune the engine.

ECUs are usually built round a microprocessor. Apart from the parameter tables, the memory also contains a program. This software can interpolate the values from the parameter tables and also deals with the stream of information coming from the sensors. For our objectives there is no need to modify the program and it is even undesirable. In any case, it is often only possible to gain access to the program with an EPROM programmer; it’s not possible via the OBD.

Do-it-yourself?
Many electronics hobbyists probably already have access to the required hardware (EPROM programmer) or they can build it themselves (OBD interface). But you need more than just the hardware to successfully tune a car, such as an in-depth knowledge of engines. Which parameters can be modified and what values are safe to use? Changing values by trial and error can have disastrous consequences, so only attempt this when you are absolutely sure what you’re doing. First we have to find out the memory addresses of the parameter tables. For obvious reasons, the manufacturers are not very forthcoming with this information, which is often subject to change as well. Fortunately there are companies that provide such information. It is also possible to examine the memory yourself, but this requires a lot of patience and experience. If you decide to go ahead with chip tuning you should take a look at www.dimsport.com, the website of the Italian Dimensione Sport. This company supplies software whereby the addresses for the parameter tables are supplied as separate modules. You therefore only pay for the type of car that you want to retune. The parameters are also shown in a graphical format, which makes it easier to make the modifications.

It is outside the scope of this article to show you exactly which parameters should be modified; this is best left to the engine specialist. A number of parameters, such as the speed and rev limiters, are fairly obvious, but even here you should hold back a little. Are the tuned parameters to your liking? They can then be written to the EPROM, but not before a new checksum has been calculated. If you only change the parameters
A special sensor extracts the rpm of the engine from the vibrations.

On the rolling road we increase the speed until the rev limiter kicks in.

On our way to 220 km/h.

We return the car via the OBD.

Powerbox

There are other ways than OBD/chip tuning to improve engine performance. One of these is via the use of so-called 'powerboxes'. These are small modules that are placed in the signal path between the sensors and the ECU. By changing the signals the performance increases and the engine management can remain unchanged. The advantage of powerboxes is that they are relatively low cost. You normally fit the modules in your car yourself. They are usually supplied with adapters so that the original wiring loom can stay intact. When you take your car to the dealer, or you need to sell it, you can remove the powerbox in no time.

A powerbox is generally not as good as real chip tuning because such a module can only alter the information going into the ECU.

The ECU will think that the memory is faulty. In that case, the party-lights on the dashboard will probably come on and the car won't start. Good quality tuning software knows how to calculate the checksum and where to store it, so that you don't need to concern yourself with these frivolities.

In practice

We called in the help of a professional to demonstrate the potential of chip tuning. The subject of our test is a jet-black BMW 320d belonging to an Elektor reader. Mark Verhoeven from Engine Management Systems had the honour of converting this sports car into a true powerhouse. First Mark connects a laptop to the BMW via a special OBD interface and reads the current values of the tables. His software already knows the addresses of all relevant characteristics and it displays these in both numerical and graphical formats.

The first table we look at is the fahrerwunsch. This is used to translate between the position of the accelerator pedal and the amount of fuel. BMW has chosen the values for this table to give a smooth ride. The more the pedal is pushed down, the more torque is produced by the engine. The relationship between the two is normally about linear. So when the pedal is pushed down halfway the engine will produce half the amount of power possible. If the table is adjusted so that half the torque is produced when the pedal is only a third of the way down, the car reacts more quickly to the accelerator pedal.

Don't overdo this though; otherwise the car becomes undrivable because the accelerator would turn into an on/off switch.

The amount of fuel that was determined by the above method isn't injected without further ado; there are a few other tables that introduce restrictions. The most important of these is the torque limiter. Limited? That implies a tuning possibility! And it turns out that these values can be adjusted as well. Mark explains: "At certain revs this engine can produce more torque than the gearbox and driveshaft can cope with. The limiter normally has a very large safety margin. With this BMW it's quite possible to increase the power a bit without causing any damage." We now know how much diesel has to be injected. The fuel pump supplies fuel at a constant pressure to the injectors. Since the pressure is constant, the engine management can only adjust the amount of injected fuel by changing the injection times. Note that this involves two variables: the time at which the injectors open and the length of time they're open for.
It could report a turbo pressure to the ECU that is lower than the real value. This causes the wastegate, which protects the engine against a high pressure, to open a bit later. This unsuitable trick works with petrol engines because the electronics will automatically increase the fuel injection at a higher pressure. This does cause an extra strain on the engine, so it’s not a very nice tuning technique.

This won’t work with diesel engines, which run with a lean fuel/air mixture. Powerboxes for these engines make the fuel pump work harder, causing more fuel to be injected for the same opening times. This puts a greater stress on the fuel system and causes faster wear and tear. Another trick is to leave the injectors open a bit longer. This overcomes the disadvantage of extra wear, but it increases the chance of black exhaust fumes, especially when the powerbox doesn’t receive information for the engine revs.

It is better to get your car chipped by a competent tuner than to install a powerbox, even though it’s cheaper.

But when is the right time to inject? Not too late, otherwise you can’t inject enough fuel or the engine starts smoking. But certainly not too early either because the diesel could ignite too early. This would cause knocking of the engine and could even damage it.

To increase the amount of fuel injected we open the injectors for a longer period and also open them slightly earlier. OBD/chip tuning is different from, for example, most powerboxes because the injectors are not only left open for longer but they’re also opened earlier. Finding the right settings for the opening and closing of the injectors is an important aspect of the art of tuning and is best left to the professionals.

As to the question if there are more parameters that restrict the engine, Mark answers: “Certainly. This, for example, is the speed limiter. The standard car won’t go faster than 211 km/h, but this is easily changed. And this table shows another interesting restriction: when the engine heats up as a result of heavy loading, the ECU automatically cuts back the power a little bit. This could be changed as well, but I’d rather leave it alone.”

Rolling road

Up to now it’s all been theory, but has our BMW really gained extra power? And if so, how much extra acceleration can we expect when we pull away from traffic lights? We decide to get some exact figures and send the BMW for a rolling road test.

For comparative measurements we first need to see how the standard car performs and we load the standard tables back into the ECU. The results are the same as expected: the 320d delivers 140 bhp. This is a little bit more than the quoted 136 bhp, but it’s nothing to write home about.

The maximum torque was 318 Nm. The tuner connects his equipment to the OBD interface and reprograms the ECU with the modified tables. We’re curious what the results are. They meet our expectations and the meter now shows over 155 bhp! We try a few other settings and manage to get a maximum power of nearly 160 bhp. There is a considerable increase in torque as well. In the end, the BMW has nearly 380 Nm, which is an increase of about 20 percent. The chip tuning has certainly borne fruit.

We then take the car out onto the open road to see if the performance increase is clearly noticeable in practice. And it certainly is: the beamer has, especially at medium and higher revs, a noticeable increase in acceleration and it shoots off into the distance. This makes us wonder why we didn’t stick a chilli up its tailpipe before ...

With thanks to:

The BMW in this article was modified by:

**Engine Management Systems**
De Flommer 1021, 5854 NA Nieuw-Bergen, The Netherlands
Tel: (+31) 485 343191 - Fax: (+31) 485 343181
Web: www.ems-tuning.nl

The rolling road test was performed by:

**Van Kronenburg Autosport**
Spaanport Dorst 19, 5667 RT Geldrop, The Netherlands
Tel: (+31) 40 2854064 - Fax: (+31) 40 2867765
Web: www.van-kronenburg.nl
Digital filters without headaches

Signal Wizard v.2 from UMIST

Paul Goossens

Filter designing is a competence and taken very seriously in audio and measurement and control technology. The associated theory is massive, most textbooks concentrating on analogue approaches. Thanks to a tremendous increase in computing power of today’s chips, the art of filter design is shifting to the digital domain. However, converting an analogue filter to digital is not too easy, and that is why Manchester University have released Signal Wizard, a hardware/software suite to help the budding designer get to grips with DSP-based filters.

The Signal Wizard package is, in a way, a virtual breadboard for digitally implemented filters, not forgetting that the kit may also be used for a suitably developed stand-alone application. The latter may turn out to be great solution for one-offs and low-volume applications. The circuit board in the package contains, among others, a Freescale DSP chip, a Flash memory and the required 24-bit D/A and A/D converters. There’s also a programmer link in the form of an RS232 connector. The audio connections on the board are cinch (RCA 'Line') sockets and a cinch-to-jack adapter cord is supplied, as well as a mains adapter and an RS232 cable.

Although the hardware outfit is pretty comprehensive, it needs a software complement.

Software

The software that comes with Signal Wizard is capable of first defining filters in various ways. Next, it will generate a filter program for the DSP chip and allow the chip to be actually programmed. All this is possible without deep knowledge of DSPs and/or digital filters.

Having launched the software and set up the SW hardware we’re ‘ready for take off’. It is just possible you will get a number of error reports like ‘not a floating point value’. In that case you will need to change the lon-
guage setting of your Windows operating system. This is best done by changing the Country settings in Control Panels. Select US/UK settings, i.e., the point (,) for the decimal and the comma (,) for the thousands separator. This may be just the other way around in some other European countries. The UK/US settings will prevent further error reports from appearing.

DSP program is created containing all relevant filter coefficients. All it takes is one more mouse click and the software is actually programmed into the DSP chip on the SW board.

**Conclusion**

Signal Wizard is excellent if you want to develop skills in designing digital filters fast. The great thing about it is that filters can also be tested in practice, allowing a designer to see what’s ahead of him/her while experimenting with all the bells and whistles of digital filters.

For everyone else who’s keen on delving deeper, there is no alternative to start (or continue) studying digital filter theory. Fortunately, Signal Wizard offers plenty of power and options to achieve above-average results in audio signal processing and filtering.

The ‘Filter Design Interface’ window allows us to design our own filters. The first selection we need to make is between FIR or IIR filter (see inset). Independent of the way we wish to implement the filter, it is now possible to design simple filters, Chebychev or Butterworth filters. All of this is remarkably simple.

FIR filters offer some more options like accurately defining the desired frequency response, whereas the software will compute the necessary coefficients.

**Testing**

During the design phase the filter’s transfer function is conveniently shown in the ‘Graphical Interface’ window. The graph is constantly updated on every change in the design window, providing a very quick way to check the response of the filter to changes you’re making.

As soon as you’re finished tweaking the filter response, a whole host of other options are available, including Bode plots, pole-zero diagrams, and many more tools to help you design your filter.

**FIR and IIR**

When reading up the subject of digital filters you’ll soon stumble on the terms FIR and IIR. FIR stands for Finite Impulse Response and IIR, for Infinite Impulse Response. Great, but what does it all mean?

Any filter has its own characteristic response to a pulse applied to its input. As soon as we know the impulse response we are in a position to calculate back towards the filter’s amplitude and phase behaviour. The reverse also applies — if we ensure that our ‘transfer function’ exhibits a certain response at the output we have in fact created a filter. This property is exploited with a FIR filter. Each sample is separately considered as a pulse and allowed to cause a response at the output, with the value of the input sample determining the level. The pulse response may comprise just 10 consecutive samples, but equally well, several thousands!

The formula for a FIR filter is

\[ y[n] = a_0 x[0] + a_1 x[1] + \ldots + a_N x[N] \]

where \( y[n] \) is the output signal at instant ‘n’, \( x[n] \) the input signal at instant ‘n’, and \( N \) is the number of samples in the pulse response.

Of course, an IIR filter also has a certain impulse response, but compared with the FIR variant these are a bit harder to read from the coefficients. The reason is that feedback is used in an IIR filter.

Mathematically an IIR filter may be described as

\[ y[n] = a_1 y[n-1] + a_2 y[n-2] + \ldots + a_N y[n-N] + b_1 x[n-1] + b_2 x[n-2] + \ldots + b_M x[n-M] \]

which clearly shows that the output signal \( Y \) is fed back to the input.

The advantage of an IIR filter is that a reasonable filter may be created with just a few coefficients, where a FIR variant may require a worrying number of these. Also, an IIR filter requires less computing power than an FIR equivalent. An FIR filter, on the other hand, is not only easier to design but may also achieve absolutely flat phase response thanks to the impulse response being entirely subject to defining. FIR filters are also unconditionally stable while their IIR counterparts when poorly designed are prone to instability and, in the worst case, oscillation effects.
Q U A S A R e l e c t r o n i c s

**Controllers & Loggers**

Here are just a few of the controller and data acquisition and control units we have. See website for full details. Suitable PSU for all units: Order Code: PSU445 £6.95

*NEW!* Bidirectional DC Motor Controller Controls the speed of most common DC motors (rated up to 32VDC/5A) in both the forward and reverse direction. The range of control is from fully OFF to fully ON in both directions. The direction and speed are controlled using a single potentiometer. Screw terminal block for connections. Kit Order Code: 3165KT - £4.95 Assembled Order Code: AS3166 - £24.95

DC Motor Speed Controller (5A/100V) Control the speed of almost any common DC motor rated up to 100V/5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15VDC. Box supplied. Dimensions (mm): 60x70x100H. Kit Order Code: 3067KT - £11.95 Assembled Order Code: AS3057 - £19.95

*NEW!* PC/Standalone Unipolar Stepper Motor Driver Drives any 5, 6 or 8 lead unipolar stepper motor rated up to 6 Amps max. Provides speed and direction control. Operates in stand-alone or PC-controlled mode. Up to six 3179 driver boards can be connected to a single parallel port. Supply: 5V DC, PCB: 65x55mm. Kit Order Code: 3179KT - £9.95 Assembled Order Code: AS3179 - £16.95 Assembled Order Code: AS3113 - £24.95

*NEW!* Bi-Polar Stepper Motor Driver Drive any bi-polar stepper motor using externally supplied 5V levels for stepping and direction control. These usually come from software running on a computer. Supply: 5-30V DC, PCB: 75x85mm. Kit Order Code: 3158KT - £12.95 Assembled Order Code: AS3165 - £25.95

*NEW!* DTMF Telephone Relay Switcher Call your number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User selectable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. 85 BT approved. 130x110x30mm. Power: 12VDC. Kit Order Code: 3140KT - £39.95 Assembled Order Code: AS3140 - £43.95

Computer Temperature Data Logger 4-channel temperature logger for serial port. °C or °F. Continuously logs up to 4 separate sensors located 200m+ from board. Wide range of free software applications for storing/using data. PCB just 35x33mm. Powered by PC. Includes one DS1820 sensor and four header cables. Kit Order Code: 3145KT - £18.95 Assembled Order Code: AS3145 - £26.95 Additional DS1820 Sensors - £3.95 each

Rolling Code 4-Channel UHF Remote State-of-the-Art High security. 4 channels. Momentary or latching relay output. Range up to 40m. Up to 15 Tx's can be learnt by one Rx (kit includes one Tx but more available separately). A indicator LED's. Rx: PCB 77x98mm, 12VDC/6mA (standby). Two and Ten channel versions also available. Kit Order Code: 3180KT - £41.95 Assembled Order Code: AS3180 - £49.95

Serial Isolated I/O Module Computer controlled 8-channel relay board. 5A mains rated relay outputs. 4 isolated digital inputs. Useful in a variety of control and sensing applications. Controlled via serial port for programming (using our new Windows interface, terminal emulator or batch files) includes plastic case 130x100x30mm. Power Supply: 12VDC/600mA. Kit Order Code: 3108KT - £45.95 Assembled Order Code: AS3108 - £64.95

Infrared RC Relay Board Individually control 12 on-board relays with included infrared remote control unit. Toggle of momentary. 15m+ range. 112x112x38mm, 12VDC/0.5A. Kit Order Code: 3142KT - £41.95 Assembled Order Code: AS3142 - £51.95

Infrared RC Relay Board Individually control 12 on-board relays with included infrared remote control unit. Toggle of momentary. 15m+ range. 112x112x38mm, 12VDC/0.5A. Kit Order Code: 3142KT - £41.95 Assembled Order Code: AS3142 - £51.95

**PIC & ATMEL Programmers**

We have a wide range of low cost PIC and ATMEL Programmers. Complete range and documentation available from our web site.

**Programmer Accessories:**
- 40-pin Wide ZIF socket (ZIF40W) £15.90
- 18V DC Power supply (PSU180) £19.95
- Leads: Parallel (LDC13) £4.95/Serial (LDC44) £4.95/USB (LDC64) £2.95

NEW! USB 'All-Flash' PIC Programmer USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows Software. ZIF socket and USB Plug A-B lead not included. Kit Order Code: 3125KT - £34.95 Assembled Order Code: AS3126 - £44.95

Enhanced 'PICALL' ISP PIC Programmer Will program virtually ALL 6 to 40 pin PICs plus a range of ATMEL AVR, SCNIX and EEPROM 24C devices. Also supports In System Programming (ISP) for PIC and ATMEL AVRs. Free software. Blank chip auto detect for super fast bulk programming. Available in assembled format with ZIF socket only. Assembled Order Code: AS3142CF - £64.95

**ATMEL 8xxxxx Programmer**

Uses serial port and any standard terminal comms program. 4 LED's display the status. ZIF sockets.

Europe: 16-18VDC 12K3 - £28.95
Assembled Order Code: AS3123 - £34.95

NEW! USB & Serial Port PIC Programmer USB/Serial connection. Header cable for ISP. Free Windows software. See website for PICs supported. ZIF Socket/USB Plug A-B lead extra. Supply: 18VDC. Kit Order Code: 3149KT - £34.95 Assembled Order Code: AS3149C - £49.95

**Secure Online Ordering Facilities**
- Full Product Listing, Descriptions & Photos
- Kit Documentation & Software Downloads

**Postage & Packing Options**
(Up to 2Kg gross weight)
- UK Standard 3-7 Day Delivery - £9.95
- UK Mainland Next Day Delivery - £8.95
- Europe (EU) - £20.55 Rest of World - £24.95

*Order online for reduced price U.K. Postage*

We accept all major credit/debit cards. Make cheques/P.O.'s payable to Quasar Electronics. Prices include 17.5% VAT.

**Call now for our FREE CATALOGUE with details of over 3000 kits, projects, modules and publications. Discounts for bulk quantities.**

**Www.quasarelectronics.com**

**QUASAR electronics**

0871 717 7188

Credit Card Sales

Most items are available in kit form (KT suffix) or assembled and ready for use (AS prefix).
MikroElektronika
MICROCONTROLLER DEVELOPMENT TOOLS

from Breadboarding Systems

Make PICmicro® development easy with the EasyPIC2 - only £99!

EasyPIC2 Development Board features:
- High quality development/experiment board with built-in USB programmer.
- Programming software compatible with Windows operating systems including 2000 and XP.
- Comes with a PIC16F877A microcontroller but compatible with virtually all 8, 14, 18, 28 and 40-pin PICmicro® devices in the 12F, 16F and 18F families.
- On-board I/O devices including switches, LEDs, seven-segment displays, potentiometers and RS-232 Interface.
- Provision for easy fitting of optional LCD display and DS1820 temperature sensor.
- All I/O lines available for off-board expansion.
- Wide range of optional add-on boards available including ADC, DAC, EEPROM, Compact Flash, RTC, RS-485, CAN and IrDA.
- Powered from your PC's USB port or optional mains adapter.
- Supplied with example programs written in assembly language, BASIC, C and Pascal.
- Supplied with Microchip Technology’s MPLAB development software and demonstration versions of MikroElektronika’s MikroBASIC, MikroC and MikroPascal compilers.

The MikroElektronika EasyPIC2 Development Board combines a versatile development/experiment board with a built-in USB programmer. With its wealth of on-board I/O devices and support for virtually all 8, 14, 18, 28 and 40-pin PICmicro® microcontrollers in the 12F, 16F and 18F families, we’re certain you won’t find a more versatile high quality board at such a low price.

The EasyPIC2 Development Board is supplied with USB programming/power cable, programming software and useful example programs.

Also available are similar boards for the 8051, AVR and dsPIC, each at the same great price of £99 including UK delivery and VAT—please telephone or see our website for further details.

Learn about microcontrollers with our EasyPIC2 Starter Pack - just £149!

We’ve taken the EasyPIC2 Development Board and added a 16x2 character LCD display, matrix keypad, DS1820 temperature sensor, RS-232 serial communications cable, various different PICmicro® microcontrollers and our own easy-to-follow microcontroller tutorial to form a complete and self-contained Starter Pack—everything you need to learn about and experiment with microcontrollers! With this pack you will quickly become proficient in microcontroller programming and interfacing. Please see our website for list of covered topics.

Please visit our website for details of other MikroElektronika products

We stock the full range of MikroElektronika development boards and compilers for PICmicro, AVR, 8051, PSoC and dsPIC microcontrollers. Products may be ordered on-line at www.breadboarding.co.uk or by telephoning 0845 226 9451 using all major credit and debit cards. Our prices include delivery within the UK and VAT.

Call 0845 226 9451 or order online at www.breadboarding.co.uk
To beginners in electronics, servos have a great appeal, probably because you can do lots of real-life 'things' with them. However, long faces soon appear and pages are turned when a servo control has to be designed and built. Even if that can be done with the good old 555 chip and a handful of parts, the next objection from the new generation is that 'it ain't computer-controlled'.

The edeFT639 is an 8-pin chip that will control five servos through one 2400-baud serial line. As you can see from the schematic, the only external components required are a decoupling cap, plus two resistors and a diode to withhold the negative swing of the RS232 line the circuit is connected to. In case TTLswing (5 V) serial control is available, such as in PIC or Parallax Stamp systems, the control signal to the edeFT639 may be applied directly to pin 4.

The serial data format is a dead simple 2400 bits/s, no parity, 1 stop bit so you can practice away using any terminal emulation or general purpose serial commms utility like HyperTerminal.

The edeFT639 will always start in Setup mode, then switch to Active Mode. The chip can set a servo to one of 256 positions from 0 to 90 degrees using a 'short' pulse (1 ms) or from 0 to 180 degrees using a 'long' pulse length. The starting position of each individual servo can also be adjusted by using a different header length. Full details about bit-banging the device over a 2400-baud serial line are given in the 'FT639 Ferret' datasheet, which also contains a simple program (in QBASIC) showing the nitty-gritty of talking
to the device using software and the PC's printer port (LPT). The 'get-to-know-u' program can be downloaded from the Elab Inc. website (see below) and should not be too difficult to convert into PIC or AVR code. On the same website we also found a Visual BASIC programming example complete with source & executable code to illustrate how the edeFT639 servo controller can be driven via Windows and RS232 (see screenshot).

Apart from the edeFT639 chip and its input protection network R1/R2/D1, the PCB shown here also accommodates a simple step-down voltage regulator. RC Modellers wishing to use the circuit in a plane or boat may want to exchange the 7805 for a low-drop regulator and omit D1 in order to juice the craft battery. The servos are connected via the usual 3-pin connectors. As servo manufacturers use different pinouts for pulse (p), ground and +5 V on their connectors, you should check the data available.

**COMPONENTS LIST**

**Resistors:**
- R1 = 22kΩ
- R2 = 10kΩ

**Capacitors:**
- C1, C4 = 100µF 25V radial
- C2, C3 = 100nF

**Semiconductors:**
- D1 = IN4001
- D2 = IN4148
- IC1 = 7805
- IC2 = edeFT639 (Elab Inc.; www.elabinc.com)

**Miscellaneous:**
- 5 off-3-way 5P pinheader
- Evaluation software [VB application] from Elab Inc. website
- PCB, ref. 054016-1 from The PCBShop

**GigaBit Crossover Cable**

Henri Derksen

We previously described a crossover cable in last year's Summer Circuits issue (Home Network for ADSL, p. 81). However, that cable cannot be used for GigaBit links, since all eight conductors are important in that case. A GigaBit link uses four signal pairs. If the cable is longer than 8 metres, it is also necessary for each pair to use conductors to be twisted together. Otherwise crosstalk will occur, which will cause data communication errors.

A crossover cable that is suitable for 1000-Mbit networks must have all of the conductors connected differently at one end. TX is thus connected to RX, and the two other pairs are also swapped. The connection scheme is shown clearly in the drawing. Naturally, such a cable can also be used in a 10-Mbit or 100-Mbit network, but it is not suitable for use in combination with lines for an analogue telephone, such as was suggested in the article in the 2004 Summer Circuits issue.

**SOURCE:**
Elab Inc. (formerly FerTronic) FT639
Ferrite datasheet: www.elabinc.com

**SHEET:**
EdeFT639 (Elab Inc.; www.elabinc.com)
The purpose of this circuit is not only to extend an optical digital audio connection (Toshiba Toslink) but also to function as a splitter, so that two devices can be connected to one Toslink output.

The circuit consists of the standard application for the Toslink receiver module TORX173 [IC1] and the Toslink transmitter module TOTX173 [IC2 and IC3], that we have used on previous occasions. Inverters from a 74HCU04 are connected between the input and output and act as pulse restorers. To keep the quality as high as possible, each of the transmitter modules is driven individually. The first inverter is AC-coupled and ensures that the received S/PDIF signal is centred on the threshold of the inverter. The other inverters (except one) amplify the signal to the maximum output voltage before presenting it to the transmitter modules.

For the power supply a standard 7805 was selected with D2 as reverse polarity protection. L2 decouples the power supply voltage of IC4 some more. This does L1 for IC1 and R3 and R5 for IC2 and IC3 respectively. R4 and R6 are required...
for the internal adjustment of the transmitter modules. The required power supply voltage amounts to a minimum of 9 V and can be provided by a mains adapter. A panel mounting socket can be fitted in an enclosure (that you can choose yourself) to suit the plug on the mains adapter. A printed circuit board has been designed for the circuit that contains all the components. Two pins are provided to connect the power supply. LED D1 indicates that the power supply is present. The current consumption without optical signal is 103 mA. When the cables are connected and with a frequency of 48 kHz, the current is 70 mA. This is because the transmitter modules will now turn the internal LEDs on and off [when there are no cables connected, the LEDs are on continuously]. At 96 kHz the current is about 3 or 4 mA higher.

An FFT (fast fourier transform) analysis shows that the noise floor with a 16-bit PCM signal is about 40 to 45 dB higher compared to a 24-bit PCM signal.

## Optical Mixer

Peter Lay

Mixing signals at different frequencies is common practice in many areas of electronics. Audio systems, communications systems and radio systems are typical application areas.

With conventional frequency mixers, feedback capacitance can cause the signal sources to be affected by the output signal, thus making supplementary filter circuits necessary. The signals from the individual signal sources can also affect each other.

In an optical mixer, LEDs or laser diodes are used to first convert the signals to be mixed into optical signals. The light beams are then aimed at a shared photosensor (a light-sensitive resistor, photodiode, phototransistor, or photovoltaic cell). The current in the output circuit is thus controlled by the combined input signals, so signal from the photosensor is the sum of the input signals. The amount of feedback capacitance can be made quite small, depending on the construction. Another benefit is that the input and output circuits have separate grounds, which can be electrically connected if necessary. This operating principle directly encourages experimentation. Additional input stages can be added to act on the shared photosensor. If the receiver signal is applied to a component with a curved characteristic, such as a diode, this produces amplitude modulation, which can be used in a heterodyne receiver. If the difference between the frequencies of the two input signals is small, a beat effect occurs. The components must be selected according to the frequency range that is used.
Mobile Phone Operated Code Lock

Heikki Kalliola

Suitcase numberwheels and doarside keypads have evolved from well-known code locks, to hat topics now mainly due to Dan Brown’s bestseller novel The daVinci Code.

The main ideas behind the lock described here are minimum abtrusiveness and minimum user interface.

A typical code lock is operated with a four-digit secret code and the lock can be opened by presenting this code. The lock described here has no buttons or keypad at all, a small hole or other hiding place for the microphone capsule is enough.

Nawadays practically everyone has a keypad in the pocket — it’s on your mobile phone! The lock listens to mobile phone keytones (DTMF tones) and responds to the valid, pre-set four digit code. No visible interface is needed as the microphone capsule can be located behind a small hole. Note that the mobile is used ‘off-line’, so no phone expenses are involved.

Eлектret microphone M is connected via transistor amplifier stage T1 to the input pin (2) of DTMF-receiver/decoder IC7. The decoder’s four-digit output word (on pins 11, 12, 13, 14) and ‘valid digit present’ flag (pin 15) are connected to two shift registers, IC1 and IC2. A rising edge on pin 15 of the ’B870 chip triggers each shift register to read its input code and shift it by one increment.

Shift register outputs are connected to BCD to Decimal-converters type 4028 (IC3-IC6). The register status is shown as a high signal level at certain pins of DIP switches S1-S4. Depending on the switch settings, one combination causes High...
levels at all AND gate inputs and the lock is opened for a moment. Due to the operation of the shift registers, the latest input digit appears on IC3's outputs. So if the desired code is, for example, 2748, S1 contact 2, S2 contact 7, S3 contact 4 and S4 contact 8 are closed.

When four digits in sequence match with the code set by the switches, relay RE1 is activated for a user-defined time. Upon a rising edge on input pin 8, monostable multivibrator (MMV) IC8 pulls pin 10 high for a moment, activating relay Re1 via transistor T2. The duration of active time can be adjusted with the preset between pins 2 and 3. A green LED can be connected across the relay coil to indicate lock opening.

The minimum distance from the microphone is about 20 cm.

Minimalist Microcontroller

Christoph Fritz

They say that things were always better in the old days, although perhaps they were not thinking of microcontrollers and their complex support circuitry. In the ATTmega8, microcontroller specialists Atmel have introduced a device that lets you construct a prototype circuit using just two resistors and one potentiometer in addition to the microcontroller chip. Not even a crystal is required: an internal 8 MHz oscillator provides the clock. We thus have a four-component circuit that is a powerful and practical development kit; not only that, it can be programmed directly from the parallel port of any PC without additional hardware. Incredible!

The circuit shown offers a number of I/O pins and an A/D converter input; not only that, it is ready to be connected to a commercially-available liquid crystal display. The whole thing can be built on a simple prototyping board, and no heroic soldering skills are required.

Software, in the form of a C compiler (AVR-GCC under Linux or WinAVR under Windows) is available free on the internet. Example applications, expansion ideas, programming tools and code collections are also widely available. And, since the circuit is so simple, it can easily be modified to use other types of microcontroller from Atmel: just take a look at the relevant data sheets and determine which pins are used for the various functions.

Links:

Introduction to development tools

- for Linux etc.: www.nongnu.org/avr-libc/ user-manual/install-tools.html

Procyon AVRlib (examples and libraries): http://hubbard.engr.scu.edu/ embedded/avr/avrlib/index.html

JTAG-Hardware: http://avr.openchip.org/bootice
WinAVR: http://winavr.sourceforge.net
Energy-saving Switch

Helmut Kraus

Lights do not always need to be on at full power. Often it would be useful to be able to turn off the more powerful lights to achieve softer illumination, but this requires an installation with two separately-switchable circuits, which is not always available.

If the effort of chasing out channels and replastering for a complete new circuit is too much, then this circuit might help. Normal operation of the light switch gives gentle illumination [LA1]. For more light, simply turn the switch off and then immediately (within 1 s) on again. The circuit returns to the gentle light setting when switched off for more than 3 s. There is no need to replace the light switch with a dual version: simply insert this circuit between switch and lamp.

How does it work? Almost immediately after switch-on, fast-acting miniature relay RE2 pulls in, since it is connected directly after the bridge rectifier. Its normally-closed contact then isolates RE1 from the supply, and thus current flows to LA1 via RE1's normally-closed contact. RE1 does not have time to pull in as it is a power relay and thus relatively slow. Its response is also slowed down by the time constant of R1 and C1. If the current through the light switch is briefly interrupted, RE2 drops out immediately. There is enough energy stored in C1 to activate RE1, which then holds itself pulled in via 0 s, normally-open, contact. If current starts to flow again through the light switch within 1 s, LA2 will light. To switch LA1 back on it is necessary to turn the light switch off for more than 3 s, so that C1 can discharge via R2 and RE1. The printed circuit board can be built into a well-insulating plastic enclosure or be incorporated into a light fitting if there is sufficient space.

Caution:
the printed circuit board is connected directly to the mains-powered lighting circuit. Every precaution must be taken to prevent touching any component or tracks, which carry dangerous voltages. The circuit must be built into a well-insulated ABS plastic enclosure.
Overcurrent Cutout Switches

Gregor Kleine

Overcurrent sensors using external low-resistance sense resistors are fairly common. However, the members of a new family of ICs from Maxim (www.maxim-ic.com) feature an internal sensor resistor and a switch for disconnecting the load if the current limit is exceeded. The members of this IC family are listed in the table. There are two sorts of overcurrent switches in the family. The types listed in the 'latching' column store any occurrence of an overcurrent condition and indicate it at the FLAG output until they are switched off and then on again by a pulse on the ON input. The types in the 'Auto-Retry' column automatically attempt to reconnect the load after a delay time. When the delay time expires, they check whether an overcurrent recurs, and if necessary they immediately switch off again. The auto-retry types do not have a /FLAG output. They switch on for approximately 40 ms every 300 ms (typical) to measure the current. During this 40 ms 'blanking time', the IC checks whether the current is less than the selected limit level. The latching types have the same time delay before the switch opens and the FLAG output is asserted. The FLAG output can act as signal for a microcontroller or simply drive an LED. In the latter case, the input voltage

COMPONENTS LIST

Resistors:
R1 = 100Ω
R2 = 680Ω

Capacitor:
C1 = 4700µF 25 V

Semiconductors:
D1,D2 = 1N4001

Miscellaneous:
K1,K2,K3 = 2-way PCB terminal block, lead pitch 7.5 mm
F1 = fuse, 4AT (time lag) with PCB mount holder
TR1 = mains transformer, 12V @ 1.5 VA, short-circuit proof, PCB mount
B1 = 880Ω1400, round case [80V piv. 1.4A]
RE1 = power relay, 12V, 2 x c/o, PCB mount
RE2 = miniature relay, 12V, 2 x c/o, PCB mount
must be greater than the forward voltage of the LED. R1 must be dimensioned for the desired current through the LED. Capacitors C1 and C2 provide decoupling and prevent false triggering of the IC by spurious voltage spikes.

The MAX47xx family of ICs operates over a supply voltage range of ±2.3–5.5 V. The ICs have undervoltage lockout (UVLO) and reliably switch off when the supply voltage is below the type-specific limit, even if the current flows in the reverse direction (from the load to the input). The table indicates the possible range of the overcurrent threshold for each type. For instance, a given MAX2791 might switch off at a current as low as 250 mA. However, other examples of the same type may switch off until the current reaches 350 mA. The same threshold values apply to reverse currents. An overtemperature cutout circuit protects the IC against thermal destruction.

The latching types come in a 5-pin SMD package, while the auto-retry types without a /FLAG output manage with only four pins. The 50-mA and 100-mA versions fit into the tiny SC70 package. The types for higher current levels require an SOT23 or SOT143 package.

There are also other Maxim ICs with similar functions, such as the MAX4795–MAX4798 series with typical cutoff thresholds of 450 mA and 500 mA. Finally, there are the MAX4772 and MAX4773, which have a programmable threshold that can be set to 200 mA or 500 mA using a Select input. However, the IC types mentioned in this paragraph require a different circuit arrangement than what is shown here.

<table>
<thead>
<tr>
<th>Latching</th>
<th>Auto-Retry</th>
<th>min. Limit</th>
<th>max. Limit</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX4785</td>
<td>MAX4786</td>
<td>50 mA</td>
<td>120 mA</td>
<td>SC70</td>
</tr>
<tr>
<td>MAX4787</td>
<td>MAX4788</td>
<td>100 mA</td>
<td>240 mA</td>
<td>SC70</td>
</tr>
<tr>
<td>MAX4789</td>
<td>MAX4790</td>
<td>200 mA</td>
<td>300 mA</td>
<td>SC70</td>
</tr>
<tr>
<td>MAX4791</td>
<td>MAX4792</td>
<td>250 mA</td>
<td>375 mA</td>
<td>SOT23/143</td>
</tr>
<tr>
<td>MAX4793</td>
<td>MAX4794</td>
<td>300 mA</td>
<td>450 mA</td>
<td>SOT23/143</td>
</tr>
</tbody>
</table>

---

**Simple Oscillator / Pipe Locator**

**Rev. Thomas Scarborough**

Sometimes the need arises to construct a really simple oscillator. This could hardly be simpler than the circuit shown here, which uses just three components, and offers five separate octaves, beginning around Middle C (Stage 14). Octave 5 is missing, due to the famous (or infamous) missing Stage 11 of the 4060B IC. We might call this a Calpit's 'L' oscillator, without the 'C'. Due to the reactivity of the 100µH inductor and the propagation delay of the internal oscillator, oscillation is set up around 5 MHz. When this is divided down, Stage 14 approaches the frequency of Middle C (Middle C = 261.626 Hz). Stages 13, 12, 10, and 9 provide higher octaves, with Stages 8 to 4 being in the region of ultrasound.

If the oscillator's output is taken to the aerial of a Medium Wave Radio, L1 may serve as the search coil of a Pipe Locator, with a range of about 50 mm. This is tuned by finding a suitable heterodyne (beat note) on the medium wave band. In that case, piezo sounder Bz1 is omitted. The Simple Oscillator / Pipe Locator draws around 7 mA from a 9–12 V DC source.

---

**Audio Click/Pop Suppressor**

**Gregor Klein**

Audio amplifier circuits with a single supply voltage have output coupling capacitors that produce audible clicking or popping sounds when the supply voltage is switched off. Since they must be initially charged to half the supply voltage, similarly, a clicking or popping noise can be produced by the discharge current when the supply is switched off. The capacitance (C<sub>out</sub>) of the output capacitors cannot be reduced, since it determines the lower limit of the frequency range. The process of establishing the DC operating point in upstream amplifier stages also generates switch-on and switch-off noises. For headphone outputs in particular, this can be remedied using an 8-pin IC from Maxim (www.maxim-ic.com), the MAX9890, which can be connected between the output stage and the output capacitors to suppress irritating clicks and pops.

The secret of the MAX9890 is that it changes the shape of the charging current for the output capacitors from an abrupt (and thus audible) step to an opti-
IR Testing with a Digital Camera

Dirk Gehrke

If a device fails to respond to an IR remote control unit, the problem is often in the remote control, and it usually means that the batteries are dead. If the remotely controlled device still doesn't respond to the IR remote control after the batteries have been replaced, you're faced with the question of whether the remote control is not sending a signal or the device isn't receiving it properly. After checking for trivial errors, such as incorrectly fitted or defective batteries, the next thing you should check is whether the remote control transmits a signal. In the past, you would have needed an IR tester or a special IR detector cord (as shown in the photo) for this. Nowadays you can use a digital camera (still or video), which is commonly available in most households. That's because the CCD chip is sensitive to infrared as well as visible light, which allows pictures to be taken at night to a certain extent. If you switch on the camera and the display, aim the remote control unit toward the camera, and press one of the buttons on the remote control, you should see a blinking light coming from the IR LED. If the LED remains dark, you can safely assume that the remote control unit is defective.
Proximity Switch

Rev. Thomas Scarborough

This circuit is for an unusually sensitive and stable proximity alarm which may be built at very low cost. If the negative terminal is grounded, it will detect the presence of a hand at more than 200 mm. If it is not grounded, this range is reduced to about one-third. The Proximity Switch emits a loud, falling siren when a body is detected within its range.

A wide range of metal objects may be used for the sensor, including a metal plate, a doorknob, tin foil, a set of burglar bars — even a complete bicycle. Not only this, but any metal object which comes within range of the sensor, itself becomes a sensor. For example, if a tin foil sensor is mounted underneath a table, metal items on top of the table, such as cutlery, or a dinner service, become sensors themselves.

The touch plate connected to the free end of R1 detects the electric field surrounding the human body, and this is of a relatively constant value and can therefore be reliably picked up. R1 is not strictly necessary, but serves as some measure of protection against static charge on the body if the sensor should be touched directly. As a body approaches the sensor, the value of C1 effectively increases, causing the frequency of oscillator IC1.A to drop. Consequently capacitor C2 has more time to discharge through P2, with the result that the inputs at IC1.B go Low, and the output goes High. As the output goes High, so C3 is charged through LED D2. D2 serves a dual purpose — namely as a visual indication of detection, and to lower the maximum charge on C3, thus facilitating a sharper distinction between High and Low states of capacitor C3.

The value of R4 is chosen to enable C3 to discharge relatively quickly as pulses through D2 are no longer sufficient to maintain its charge. The value of C3 may be increased for a longer sounding of the

COMPONENTS LIST

Resistors:
- R1 = 10kΩ
- R2 = 4kΩ
- R3 = 1kΩ
- R4 = 47kΩ
- R5 = 47kΩ
- P1, P2 = 100kΩ multturn cermet, horizontal

Capacitors:
- C1, C2 = 22pF
- C3 = 22μF 40V radial
- C4 = 10nF
- C5 = 100μF 25V radial

Semiconductors:
- D1 = 1N4148
- D2 = LED, red
- IC1 = 4093

Miscellaneous:
- BZ1 = AC buzzer
- PCB, ref. 040219-1, from The PCBShop
siren, with a slight reduction in responsiveness at the sensor. When C3 goes High, this triggers siren IC1.C and IC1.D. The two NAND gates drive piezo sounder X1 in push-pull fashion, thereby greatly increasing its volume. If a piezo tweeter is used here, the volume will be sufficient to make one’s ears sing.

The current consumption of the circuit is so low a small 9-V alkaline PP3 battery would last for about one month. As battery voltage falls, so sensitivity drops off slightly, with the result that P1 may require occasional readjustment to maintain maximum sensitivity. On the down side of low cost, the hysteresis properties of the 4093 used in the circuit are critical to operation, adjustment and stability of the detector. In some cases, particularly with extremely high sensitivity settings, it will be found that the circuit is best powered from a regulated voltage source. The PCB has an extra ground terminal to enable it to be easily connected to a large earthing system. Current consumption was measured at 3.5 mA stand-by or 7 mA with the buzzer activated. Usually, only P1 will require adjustment. P2 is used in place of a standard resistor in order to match temperature coefficients, and thus to enhance stability. P2 should be adjusted to around 50 k, and left at that setting. The circuit is ideally adjusted so that D2 ceases to light when no body is near the sensor. Multturn presets must be used for P1 and P2.

Since the piezo sounder is the part of the circuit which is least affected by body presence, a switch may be inserted in one of its leads to switch the alarm on and off after D2 has been used to check adjustment. Make sure that there is a secure connection between the circuit and any metal sensor which is used.

## Discharge Circuit

**Gregor Kleine**

The author encountered a problem with a microcontroller system in which the +5-V supply voltage did not decay to 0 V sufficiently quick after being switched off. A certain residual voltage remained, and it declined only very slowly. As a result, certain system components could not perform a clean reset if the power was quickly switched on again.

To remedy this problem, a very simple circuit was used to discharge the +5-V supply. It consists of two resistors and a type S19945 dual MOSFET from Vishay Siliconix (www.vishay.com/mosfets). These MOSFETs switch fully on at a threshold gate voltage between +1 V and +3 V. MOSFET T2 connects discharge resistor R2 for the +5-V supply line to ground if the voltage on its gate exceeds the threshold voltage. When the +5-V supply is switched off, the first MOSFET (T1), whose gate is connected to the +5-V supply voltage, no longer connects pull-up resistor R1 to ground, so the standby voltage is applied to the gate of T2 via R1. This requires the standby voltage to remain available for at least as long as it takes to discharge the +5-V supply, even when the system is switched off.

R2 is dimensioned to avoid exceeding the 0.25-W continuous power rating of a type 1206 SMD resistor. It may be necessary to change the component value for use in other applications.

The circuit can be constructed very compactly, since the dual MOSFET is housed in an SO8 SMD package, but it can also be built using ‘ordinary’ individual FETs, such as the BS170.

http://www.vishay.com/doc?70758

## Gentle Battery Regulator

**Wolfgang Zeller**

This small but very effective circuit protects a lead-acid battery (12-V solar battery or car battery) against overcharging by a solar module when the incident light is too bright or lasts too long. It does so by energising a fan, starting at a low speed when the voltage is approximately 13.8 V and rising to full speed when the voltage exceeds 14.4 V (full-charge voltage). The threshold voltage (13.8 V) is the sum of the Zener diode voltage (12 V), the voltage across the IR diode (1.1 V), and the base-emitter voltage of the 2N3055 (0.7 V).

In contrast to circuits using relays or IC amplifiers, the circuit has a gradual switching characteristic, which avoids relay chatter and the constant switching on and off near the switching point produced by a ‘hard’ switching point. The circuit does not draw any current at all (auto power-off) below 13 V. Pay attention to the polarisation of the Zener and IR diodes when building the circuit. The transistor must be fitted to a heat sink, since it becomes hot when the fan is not fully energised (at voltages just below 14 V). A galvanised bracket from a DIY shop forms an adequate heat sink. The indicated component values are for
a 10-W solar module. If a higher-power module is used, a motor with higher rated power must also be used. The circuit takes advantage of the positive temperature coefficient of the lamp filament. The filament resistance is low at low voltages and increases as the voltage rises. This reduces the speed of the fan to avoid generating an annoying noise level. The lamp also provides a form of finger protection. If you stick your finger into the fan blade, the lamp immediately takes over the majority of the power dissipation and lights brightly. This considerably reduces the torque of the fan. An ordinary 10-W or 20-W car headlight (or two 25-W headlights in parallel) can be used for the lamp.

Don’t try to replace the LED by two 1N4001 diodes or the like, replace the ZPY12 by a ZPY13, or fit a series resistor for the LED. That would make the ‘on’ region too large.

**Telephone Line Watchdog**

Dick Sleeman

Circuits have been published on earlier occasions that keep an eye on the telephone line. This simple circuit does it with very few components and is completely passive.

The operating principle is simplicity itself. The circuit is connected in series with one of the two signal lines. It does not matter which one of these two is used. When the telephone receiver is lifted off the hook, or the modem makes a connection, a voltage will appear across the four diodes. This voltage is used to drive the duoLED. Depending on the direction of the current, either the red or the green part of the duoLED will light up.

In some countries, the polarity of the telephone line voltage is reversed after a few seconds. This does not matter with this circuit since a duoLED has been used. Depending on the polarity of the line, the current will flow through either one branch or the other. The 22-Ω resistor is used as a current limiter, so that both colours are about the same brightness. The duoLED can be ordered from, among others, Conrad Electronics (part number 183652). You can, of course, also use another, similar LED. For the diodes use the ubiquitous 1N4148.

**Comparing Signed Integers**

Paul Goossens

Every once in a while it is necessary to compare two signed integers with each other. Unfortunately, some programming languages do not support signed integers. This problem presented itself with a design in Verilog. This language has a direct method of comparing two unsigned integers. With comparing we mean determining whether integer A is more than or less than integer B, or equal. After some thought for an efficient solution we found the following: By inverting the MSB (Most Significant Bit) of both signed integers, both can be compared as unsigned integers with the correct result. “How can this be,” you will ask. The solution is simple. The difference between an unsigned integer and a signed integer is that the MSB of an unsigned integer has a value of $2^n$,

while that same MSB of a signed integer has the value $-2^{n-1}$. With positive numbers nothing special happens, that means, the value is the same whether they are treated as signed or unsigned. With a negative number (where the MSB=1) and is therefore significant) the value increases by $2^n$ instead of $-2^{n-1}$ the weight of the MSB becomes $2^{n-1}$. By inverting the MSB, $2^{n-1}$ is added to both negative and positive numbers. A necessary condition is that the
MSB of a signed value is equal to '1' (thus indicating a negative value) and zero for an unsigned value. In this way the relative difference between the two numbers remains exactly the same. In the example you can see clearly that after the operation the value of each has been increased by exactly 128, provided they are both considered as unsigned integers. This is independent on whether the original integer was positive or negative. Now both numbers can be compared as unsigned integers with (of course) the correct result.

Resistor Colour Band Decoder

Carlos Alberto Gonzales

Despite claims to the contrary by the non-initiated, electronics is still very much an exact science, so unless your memory is rock-solid you can not afford to make a mistake in reading a resistor value from the colour bands found on the device. So why not use the computer for the job? The program supplied by the author comes an Excel spreadsheet that does all the colour-to-value converting for you in response to a few mouse clicks.

The program is extremely simple to use. Just click on the various colours to put them on the virtual resistor. Check the colour band structure against the real resistor on a board, on the floor or in the ‘spares allsorts’ drawer. The window below the colour bands will indicate the resistor’s E series, nominal, high/low values and tolerance. The program supports the E6 and E12 through E192 series.

The program may be obtained free of charge from www.elektor-electronics.co.uk as archive file 040203-11.zip [July/August 2005].

MSP430 Programmer

Dirk Gehrke

For many applications, programming a microcontroller after it has been soldered to the circuit board in the target application is more convenient than using a separate programmer. With the Texas Instruments MSP430F11x1, this can be done quite easily using the JTAG pins.

The Flash Emulation Kit makes it very easy to develop programs for the MSP430, debug the programs and program them into the microcontroller. However, prototype testing usually reveals a need for minor improvements to the software. The MSP430 has a JTAG port that can be enabled by applying a High level to the
Micropower Voltage Regulator

Reinhold Oesterhaus

This circuit was developed to power an AVR microcontroller from a 12 V lead-acid battery. The regulator itself draws only 14 µA. Of course, there are dedicated ICs, for example from Linear Technology or Maxim, which can be used, but these can be very hard to get hold of and are frequently only available in SMD packages these days. These difficulties are simply and quickly avoided using this discrete circuit.

The series regulator component is the widely-available type BS170 FET. When power is applied it is driven on via R1. When the output voltage reaches 5.1 V, T2 starts to conduct and limits any further rise in the output voltage by pulling down the voltage on the gate of T1. The output voltage can be calculated as follows:

\[ U_{\text{OUT}} = \frac{U_{\text{LED}} + U_{\text{BE}}}{R4 + R2} \times R4 \]

where we can set \( U_{\text{LED}} \) at 1.6 V and \( U_{\text{BE}} \) at 0.5 V. The temperature coefficients of \( U_{\text{LED}} \) and \( U_{\text{BE}} \) can also be incorporated into the formula.

The circuit is so simple that of course someone has thought of it before. The author’s efforts have turned up an example in a collection of reference circuits dating from 1967: the example is very similar to this circuit, although it used germanium transistors and of course there was no FET. The voltage reference was a Zener diode, and the circuit was designed for currents of up to 10 A. Perhaps Elektor Electronics readers will be able to find even earlier examples of two-transistor regulators using this principle.

Garage Timer

Daniel Lomitzky and Mikolajczak Tyrone

The circuit described here is a testament to the ingenuity of two young designers from a specialist technical secondary school. The ‘garage timer’ began as a school electronics project and has now made it all the way to publication in our Summer Circuits special issue of Elektor Electronics. The circuit demonstrates that the application possibilities for the 555 and 556 timer ICs are by no means exhausted. So what exactly is a ‘garage timer’?

When the light switch in the garage is pressed, the light in the garage comes on for two minutes. Also, one minute and forty-five seconds after the switch is pressed, the outside light also comes on for a period of one minute. The timer circuit is thus really two separate timers. Although the circuit for the interior light timer is relatively straightforward, the exterior light timer has to deal with two time intervals. First the 105 second period must expire; then the exterior light is switched on, and after another 60 seconds the light is turned off. To realise this sequence of events, a type 556 dual timer device, a derivative of the 555, is used. The first of the two timers triggers the second after a period of 105 seconds. The second timer is then active for 60 seconds, and it is this timer that controls the exterior light. The interior light timer is triggered at the same moment as the dual timer. In this case a simple 555 suffices, with an output active for just two minutes from the time the switch is pressed. Push-button S1 takes over the role of the wall-mounted light switch, while S2 is provided to allow power to be removed from.

References and software

[1] IAR Embedded Workbench Kickstart Version 3 Rev. D
Document ID: slac050d.zip
(US $49)
(http://focus.ti.com/lit/ug/sla138a/sla138a.pdf)
the whole circuit if necessary. The circuit could be used in any application where a process must be run for a set period after a certain delay has expired.

For the school project the two garage lights are simulated using two LEDs. This will present no obstacle to experienced hobbyists, who will be able to extend the circuit, for example using relays, to control proper lightbulbs. The principles of operation of type 555 and 556 timers have been described in detail previously in Elektor Electronics, but we shall say a few words about the functions of IC1a, IC1b and IC2. When S1 is pressed (assuming S2 is closed) the trigger inputs of both IC1a and IC2 are shorted to ground, and so the voltage at these inputs [pins 6 and 2 respectively] falls to 0 V. The outputs of IC1a and IC2 then go to logic 1, and D2 [the interior light] illuminates.

Capacitors C1 and C8 now start to charge via P1 and R2, and R8 and P3 respectively. When the voltage on C8 reaches two thirds of the supply voltage, which happens after 120 seconds, the output of IC2, which is connected as a monostable multivibrator, goes low. D2 then goes out. This accounts for the interior light function.

Likewise, 105 seconds after S1 is closed, the voltage on C1 reaches two thirds of the supply voltage and the output of IC1a goes low. Thanks to C4, the trigger input of IC1b now receives a brief pulse to ground, exactly as IC1a was triggered by S1. The second monostable, formed by IC1b, is thus triggered. Its pulse duration is set at one minute, determined by C5, R5 and P2. D1 thus lights for a minute. Potentiometers P1, P2 and P3 allow the various time intervals to be adjusted to a certain extent. If considerably shorter or longer times are wanted, suitable changes should be made to the values of C1, C5 and C8. The period of the monostable is given by the formula

\[ T = 1.1 \cdot RC \]

where T is the period in seconds, R the total resistance in ohms, and C the capacitance in farads.

**Negative-Output Switching Regulator**

Gregor Klaine

There are only a limited number of switching regulators designed to generate negative output voltages. In many cases, it's thus necessary to use a switching regulator that was actually designed for a positive voltage in a modified circuit configuration that makes it suitable for generating a negative output voltage.

The circuit shown in Figure 1 uses the familiar LM2575 step-down regulator...
The field winding has to be disconnected from the rest (3 wires). A freewheeling diode (D1, Schottky) is then connected across the whole winding. The centre top of the winding is no longer used. When FET T1 turns on, the current through the winding increases from zero until it reaches about 0.5 A. At this current the voltage drop across R4-R7 becomes greater than the reference voltage across D2 and the opamp will turn off the FET. The current through the winding continues flowing via D1, gradually reducing in strength. When the current has fallen about 10% (due to hysteresis caused by R3), IC1 will turn on T1 again. The current will increase again to 0.5 A and the FET is turned off again. This goes on continuously.

The current through the field winding is fairly constant, creating a good imitation of a permanent magnet. The nice thing about this circuit is that the total current consumption is only about 0.2 A, whereas the current flow through the winding is a continuous 0.5 A. We made this modification because we wanted to convert the locomotive for use with a DCC decoder. A new controller is needed in any case, because the polarity on the rotor winding has to be reversed to change its direction of rotation. In the original motor this was done by using the other half of the winding. There is also a good non-electrical alternative: put a permanent magnet in the motor. But we didn’t have a suitable magnet, whereas all electronic parts could be picked straight from the spares box.

Karel Waraven

We recently bought a train set made by a renowned company and just couldn’t resist looking inside the locomotive. Although it did have an electronic decoder, the DCM motor was already available 35 (!) years ago. It is most likely that this motor is used due to financial constraints, because Märklin (as you probably guessed) also has a modern 5-pole motor as part of its range. Incidentally, they have recently introduced a brushless model.

The DCM motor used in our locomotive is still an old-fashioned 3-pole series motor with an electromagnet to provide motive power. The new 5-pole motor has a permanent magnet. We therefore wondered if we couldn’t improve the driving characteristics if we powered the field winding separately, using a bridge rectifier and a 27Ω current limiting resistor. This would effectively create a permanent magnet. The result was that the driving characteristics improved at lower speeds, but the initial acceleration remained the same. But a constant 0.5 A flows through the winding, which seems wasteful of the (limited) track power. A small circuit can reduce this current to less than half, making this technique more acceptable.

The field winding has to be disconnected from the rest (3 wires). A freewheeling diode (D1, Schottky) is then connected across the whole winding. The centre top of the winding is no longer used. When FET T1 turns on, the current through the winding increases from zero until it reaches about 0.5 A. At this current the voltage drop across R4-R7 becomes greater than the reference voltage across D2 and the opamp will turn off the FET. The current through the winding continues flowing via D1, gradually reducing in strength. When the current has fallen about 10% (due to hysteresis caused by R3), IC1 will turn on T1 again. The current will increase again to 0.5 A and the FET is turned off again. This goes on continuously.

The current through the field winding is fairly constant, creating a good imitation of a permanent magnet. The nice thing about this circuit is that the total current consumption is only about 0.2 A, whereas the current flow through the winding is a continuous 0.5 A. We made this modification because we wanted to convert the locomotive for use with a DCC decoder. A new controller is needed in any case, because the polarity on the rotor winding has to be reversed to change its direction of rotation. In the original motor this was done by using the other half of the winding. There is also a good non-electrical alternative: put a permanent magnet in the motor. But we didn’t have a suitable magnet, whereas all electronic parts could be picked straight from the spares box.

Converting a DCM Motor
USB has never been so simple...

USB to TTL Serial Cable
- Simple and easy way to give USB capabilities to your designs
- Connects directly to microcontroller UART or I/O pins
- PC compatible as a standard serial device
- All circuitry integrated into sleek, modified USB plug
- Easy connectivity (One RX, TX and GND)
- Supplied with PC drivers, example code and tutorial
- Suggested Price of only £29.99 including VAT

AVIT Research also supply:
IC Bus Tool - Allows your PC to monitor and control the IC Bus
- Replacable for applications using the IC bus
- See website for full details

www.avitresearch.co.uk

PCB-POOL®
Servicing Your Complete Prototype Needs
- Prototypes at a fraction of the cost!
- Industry standard quality
- Follow up services offered
- Call 1800 series runs
- CAD / CAM consulting

FREE
EUROCARD sop 11 + Tooling + Photoplots + VAT

= £ 29.89*

*Starting from price, price = VAT

0800-389 8560

PicoScope 3000 Series
PC Oscilloscopes

The PicoScope 3000 series oscilloscopes are the latest offerings from the market leader in PC oscilloscopes, combining high bandwidths with large buffer memories. Using the latest advances in electronics, the oscilloscopes connect to the USB port of any modern PC, making full use of the PC's processing capabilities, large screens and familiar graphical user interfaces.

- High performance: 10GS/s sampling rate
- 200MHz bandwidth
- 1MB buffer memory
- High speed USB 2.0 interface
- Advanced display & trigger modes
- Compact & portable
- Supplied with PicoScope & PicoLog software

Tel: 01480 396395
www.picotech.com/scope276
Phantom Supply from Batteries

Ton Giesberts

Professional (directional) microphones often require a phantom supply of 48 V. This is fed via the signal lines to the microphone and has to be of high quality. A portable supply can be made with 32 AA-cells in series, but that isn't very user friendly. This circuit requires just four AA-cells (or five rechargeable 1.2 V cells).

We decided to use a standard push-pull converter, which is easy to drive and which has a predictable output voltage. Another advantage is that no complex feedback mechanism is required.

For the design of the circuit we start with the assumption that we have a fresh set of batteries. We then induce a voltage in the secondary winding that is a bit higher than we need, so that we'll still have a high enough voltage to drive the linear voltage regulator when the battery voltage starts to drop (refer to the circuit in Figure 1).

T1 and T2 are turned on and off by an astable multivibrator. We've used a 4047 low-power multivibrator for this, which has been configured to run in an astable free-running mode. The complementary Q outputs have a guaranteed duty-cycle of 50%, thereby preventing a DC current from flowing through the transformer. The core could otherwise become saturated, which results in a short-circuit between 6 V and ground. This could be fatal for the FETs.

The oscillator is set by R1/C1 to run at a frequency of about 80 kHz. R2/R3 and D1/D2 make T1 and T2 conduct a little later and turn off a little faster, guaranteeing a dead-time and avoiding a short-circuit situation. We measured the on-resistance of the BS170 and found it was only 0.5 Ω, which isn't bad for this type of FET. You can of course use other FETs, as long as they have a low on-resistance.

For the transformer we used a somewhat larger toroidal core with a high A1 factor. This not only reduces the leakage inductance, but it also keeps the number of windings small. Our final choice was a TX25/15/10.3E5 mode by Ferroxcube, which has dimensions of about 25x10 mm. This makes the construction of the transformer a lot easier. The secondary winding is wound first: 77 turns of 0.5 mm dia. enameled copper wire (ECW). If you wind this carefully you'll find that it fits on one layer and that 3 meters is more than enough. The best way to keep the two primary windings identical is to wind them at the same time. You should take two 30 cm lengths of 0.8 mm dia. ECW and wind these seven times around the core, on the opposite side to the secondary connections. The centre tap is made by connecting the inner two wires together. In this way we get two primary windings of seven turns each.

The output voltage of TR1 is rectified by a full-wave rectifier, which is made with fast diodes due to the high frequency involved. C4 suppresses the worst of the RF noise and this is followed by an extra filter (L1/C5/C6) that reduces the remaining ripple. The output provides a clean voltage to regulator IC2. It is best to use an LM317HV for the regulator, since it has been designed to cope with a higher voltage between the input and output. The LM317 that we used in our prototype...
worked all right, but it wouldn't have been happy with a short at the output since the voltage drop would then be greater than the permitted 40 V. If you ensure that a short cannot occur, through the use of the usual 6kΩ resistors in the signal lines, then the current drawn per microphone will never exceed 14 mA and you can still use an ordinary LM317. D7 and D8 protect the LM317 from a short at the input.

There is virtually no ripple to speak of. Any remaining noise lies above 160 kHz, and this wasn't be a problem in most applications.

The circuit can provide enough current to power three microphones at the same time (although that may depend on the types used). When the input voltage dropped to 5.1 V the current consumption was about 270 mA. The reference voltage sometimes deviates a little from its correct value. In that case you should adjust R4 to make the output voltage equal to 48 V. The equation for this is: 

$$R_4 = \frac{48 - V_{ref}}{5 + 50 \mu A}$$

To minimise interference (remember that we're dealing with a switched-mode supply) this circuit should be housed in an earthed metal enclosure.

---

**Simple Short-Circuit Detection**

Karel Waha
e

This circuit is suitable in every situation where over-current protection is required. Here we give an example from the model train world.

Every seasoned model train enthusiast knows that there is nothing worse than having to find the cause of a short-circuit. On a small model railway with one locomotive it is obviously fairly easy, but on large layouts all locomotives stand still when there is a short and then you have to check each one in turn to find the culprit. If the track is divided into sections then we can use this super simple circuit to make our lives a lot easier.

A multifuse is inserted into one of the supply lines for each of the sections. (A multifuse is also called a multiswitch, polyfuse or polyn switch, depending on the manufacturer). This is a type of fuse that cools down and conducts normally again once the short has been removed.

The advantage is that only the section with the short becomes isolated. All the other locomotives in the other sections continue to move. The stationary locomotive is in principle the culprit, but it's quite likely that several locomotives aren't moving since not all of them would be travelling in the first place. For this reason we connect an LED indicator across each multifuse, making it clear which section caused the problem. You can choose any colour LED, but we recommend that you use low-current types that emit a lot of light at only a few mA. The value of the current limiting resistor may be changed to give an acceptable LED brightness. As long as the current is small, the resistance of the multifuse is also low and there will barely be a voltage drop. At high cur-

---

**Table**

<table>
<thead>
<tr>
<th>Model</th>
<th>(V_{\text{max}}) (V)</th>
<th>(I_{\text{hold}}) (mA)</th>
<th>(I_{\text{trip}}) (mA)</th>
<th>Initial resistance (Ω)</th>
<th>Max. time to trip (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF-R005</td>
<td>60</td>
<td>0.05</td>
<td>0.10</td>
<td>7.3</td>
<td>11.1</td>
</tr>
<tr>
<td>MF-R010</td>
<td>60</td>
<td>0.10</td>
<td>0.20</td>
<td>2.50</td>
<td>4.50</td>
</tr>
<tr>
<td>MF-R017</td>
<td>60</td>
<td>0.17</td>
<td>0.34</td>
<td>2.00</td>
<td>3.20</td>
</tr>
<tr>
<td>MF-R020</td>
<td>60</td>
<td>0.20</td>
<td>0.40</td>
<td>1.50</td>
<td>2.84</td>
</tr>
<tr>
<td>MF-R025</td>
<td>60</td>
<td>0.25</td>
<td>0.50</td>
<td>1.00</td>
<td>1.95</td>
</tr>
<tr>
<td>MF-R030</td>
<td>60</td>
<td>0.30</td>
<td>0.60</td>
<td>0.76</td>
<td>1.36</td>
</tr>
<tr>
<td>MF-R040</td>
<td>60</td>
<td>0.40</td>
<td>0.80</td>
<td>0.52</td>
<td>0.86</td>
</tr>
<tr>
<td>MF-R050</td>
<td>60</td>
<td>0.50</td>
<td>1.00</td>
<td>0.41</td>
<td>0.77</td>
</tr>
<tr>
<td>MF-R065</td>
<td>60</td>
<td>0.65</td>
<td>1.30</td>
<td>0.27</td>
<td>0.48</td>
</tr>
<tr>
<td>MF-R075</td>
<td>60</td>
<td>0.75</td>
<td>1.50</td>
<td>0.18</td>
<td>0.40</td>
</tr>
<tr>
<td>MF-R090</td>
<td>60</td>
<td>0.90</td>
<td>1.80</td>
<td>0.14</td>
<td>0.31</td>
</tr>
<tr>
<td>MF-R090-O-9</td>
<td>30</td>
<td>0.90</td>
<td>1.80</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>MF-R110</td>
<td>30</td>
<td>1.10</td>
<td>2.20</td>
<td>0.10</td>
<td>0.18</td>
</tr>
<tr>
<td>MF-R135</td>
<td>30</td>
<td>1.35</td>
<td>2.70</td>
<td>0.065</td>
<td>0.115</td>
</tr>
<tr>
<td>MF-R160</td>
<td>30</td>
<td>1.60</td>
<td>3.20</td>
<td>0.055</td>
<td>0.105</td>
</tr>
<tr>
<td>MF-R185</td>
<td>30</td>
<td>1.85</td>
<td>3.70</td>
<td>0.040</td>
<td>0.07</td>
</tr>
<tr>
<td>MF-R250</td>
<td>30</td>
<td>2.50</td>
<td>5.00</td>
<td>0.025</td>
<td>0.048</td>
</tr>
</tbody>
</table>
rents the resistance increases, which causes a voltage drop across the multfuse that is large enough to light up the LED. As we don't know the direction of the current flow (the train could be moving either forwards or backwards and digital controls use on alternating current) we connected two LEDs in parallel with opposite polarities. Multifuses are available for many different trip currents. Choose a value that is slightly higher than the maximum current consumption of a locomotive in a section. The table below shows the characteristics of several types from the MFR series made by Bourns. (Raychem is another well-known manufacturer of polyswitches.) I_{hold} is the current at which the multfuse still conducts normally, I_{mp} is the short-circuit current.

**Reflection Light Barrier with Delay**

Goswin Visschers

This circuit can be used to check, for example, whether the door of a refrigerator has been properly closed. An LED sends out a beam of light, which, if the door is closed, is reflected. An optical sensor (CNY70) then detects the amount of light. If the sensor does not receive the right amount of light, the buzzer will sound after about a minute. When the door is closed (and the CNY70 receives enough light again), the buzzer turns off.

The power supply for the circuit requires about 12 mA at 12 V. Potentiometer P1 adjusts the sensitivity of the sensor. The sensor works reliably from a distance of one centimetre. If the current through the LED is increased, the distance can be increased a little. The delay can be adjusted with C3. C4 provides extra filtering for the reference voltage. The buzzer would otherwise switch on with a 'chirping' sound. The well-known NE555 is used to drive the buzzer. The buzzer is driven with a duty cycle of 2:1, which improves the audibility.

**Swapping Without a Buffer**

Paul Goossens

Most programmers will have their own library of commonly used snippets of code. One task that appears very often is the exchange of the contents of two variables. The code for this usually looks as follows:

```c
int c;
c=a;
a=b;
b=c;
```

There doesn’t appear to be anything wrong with this, but it does make use of a third variable and this takes up more memory. In general, modern processors tend to have enough memory on board, but it never harms being economical with the available memory. Another way in which the variables can be exchanged is shown below:

```c
a=a^b;
b=a^b;
a=a^b;
```

It isn’t immediately obvious that the contents of the two variables are exchanged.
Cable Tester

Uwe Reiser

Microcontroller-based circuits for testing cables, sometimes in conjunction with a PC, are easy to use and very flexible. For the hobbyist, however, the complication of such devices is not justified. The circuit described here is an economical, but nevertheless easy-to-understand tester for cables with up to ten conductors.

The basic idea for the cable tester is to apply a different voltage to each conductor in the cable at one end. The voltage seen at the other end of the cable is indicated by light-emitting diodes. The eight reference voltages are generated using a row of nine LEDs connected in series (D1 to D9). The first and the tenth conductors are connected to the positive and negative terminals of the power supply respectively. The LEDs are powered from a constant current source, which allows us to dispense with the current-limiting series resistor that would otherwise be necessary. For the constant current source we use a type LM317 voltage regulator. R1 is selected using the formula

\[ I_{\text{const}} = \frac{1.25 \text{ V}}{R1} \]

to produce a current of 5 mA. This part of the circuit forms the transmitter end of the cable tester. The conductors of the cable under test can be connected to the transmitter in any order. The receiver consists of five LEDs whose connections are taken directly from terminal block X3. If the corresponding points in the two parts of the circuit are wired to one another using a working cable, all the LEDs on both receiver and transmitter sides will light. If there is a fault in the cable, the following situations are possible.

- Two LEDs opposite one another fail to light: two conductors are crossed or shorted.
- Only the LED on the transmitter side lights: one or both of the conductors in the pair is broken.
- One of the even-numbered LEDs on the transmitter side (D2, D4, D6 or D8) fails to light: there is a short between the outer conductors of the neighboring pairs.
- Several neighboring LEDs fail to light: the conductor corresponding to the first unit LED is crossed with the one corresponding to the last unit LED, or they are shorted.

If all LEDs light on both sides, there is a chance that two pairs might be interchanged. Buttons S1 to S5 can be used to test this: the same LED should extinguish on each side when the button is pressed. If the wrong LED goes out on the receiver side, a pair must be swapped over.

More complicated effects can result from
combinations of these five faults. Different colours of LED have different forward voltage drops, and so the same type of LED should be used throughout. The required current can be put into the formula to calculate R1, which can then be altered if necessary. Of course, these remarks do not apply to the power indicator LED (D15). The LM317 used for the constant current source can only deliver the calculated current if its input voltage is at least about 3 V higher than the voltage required at its output. The load voltage depends on the number of LEDs in the transmitter and on their forward voltage drop. For nine red LEDs at least 20 V is required.

**DRM Direct Mixer Using an EF95/6AK5**

**Burkhard Kainka**

This hybrid DRM receiver with a single valve and a single transistor features good large-signal stability. The EP95 (US equivalent: 6AK5) acts as a mixer, with the oscillator signal being injected via the screen grid. The crystal oscillator is built around a single transistor. The entire circuit operates from a 6 V supply. The receiver achieves a signal-to-noise ratio of at up to 24 dB for DRM signals. That means the valve can hold its own against an NE612 IC mixer.

The component values shown in the schematic have been selected for the RTL2 DRM channel at 5990 kHz. That allows an inexpensive 6 MHz crystal to be used. The input circuit is built using a fixed inductor. Two trimmer capacitors allow the antenna matching to be optimised. The operating point is set by the value of the cathode resistor. The grid bias and input impedance can be increased by increasing the value of the cathode resistor. However, good results can also be achieved with the cathode connected directly to ground.

**Two-Cell LED Torch**

**Wolfgang Zeiller**

It sometimes comes as a bit of a shock the first time you need to replace the batteries in an LED torch and find that they are not the usual supermarket grade alkaline batteries but in fact expensive Lithium cells. The torch may have been a giveaway at an advertising promo but now you discover that the cost of a replacement battery is more than the torch is worth. Before you consign the torch to the waste bin take a look at this circuit. It uses a classic two-transistor stable multivibrator configuration to drive the LEDs via a transformer from two standard 1.5 V alka-
line batteries. The operating principle of the multivibrator has been well documented and with the components specified here it produces a square wave output with a frequency of around 800 Hz. This signal is used to drive a small transformer with its output across two LEDs connected in series. Conrad Electronics supplied the transformer used in the original circuit. The windings have a 1:5 ratio. The complete specification is available on the (German) company website at www.conrad.de part no. 516236. It isn’t essential to use the same transformer so any similar model with the same specification will be acceptable.

The LEDs are driven by an alternating voltage and they will only conduct in the half of the waveform when they are forward biased. Try reversing both LEDs to see if they light more brightly. Make sure that the transformer is fitted correctly; use an ohmmeter to check the resistance of the primary and secondary windings if you are unsure which is which. The load impedance for the left-hand transistor is formed by L in series with the 1N4002 diode. The inductance of L isn’t critical and can be reduced to 3.3 mH if necessary. The impedance of the transformer secondary winding ensures that a resistor is not required in series with the LEDs. Unlike filter type light sources, white LEDs are manufactured with a built-in reflector that directs the light forward so an additional external reflector or lens glass is not required. The LEDs can be mounted so that both beams point at the same spot or they can be angled to give a wider area of illumination depending on your needs. Current consumption of the circuit is approximately 50 mA and the design is even capable of producing a useful light output when the battery voltage has fallen to 1 V. The circuit can be powered either by two AAA or AA size alkaline cells connected in series or alternatively with two rechargeable NiMH cells.

---

**Hard Drive Switch**

*Dieter Brunow*

Readers of *Elektor Electronics* who have both a PC and children face a particular problem. Since the young tend to be too circumspect in their surfing habits, parents’ files are in permanent danger of being infected with viruses or deleted. There is also the risk of children or their friends gaining unauthorised access to files not intended for their eyes.

Perhaps a separate PC for the children would take up too much space or is ruled out for pedagogical reasons; in that case, the solution is to install two separate hard drives in the PC, one for the children and one for the adults. Ideally the two hard drives will each carry their own operating system and have their own software installed. As long as things are arranged so that the children can only boot their own drive, the parents’ data will remain secure. All that is required, besides a second drive, is a specially-designed hard drive switch. This can be achieved, as has already been described in *Elektor Electronics*, by switching the two drives between master and slave modes using the IDE cable, and only activating the master drive in the BIOS. However, the IT skills of children should not be underestimated: the BIOS is easily changed back. The solution described here is a bit more secure. Both drives are bootable and configured as masters. One is connected to IDE bus 1, and the other to IDE bus 2. The power supply voltages (+12 V and +5 V) are, however, only applied to one drive at a time. In principle, a simple double-pole changeover switch would do the job, but that has the disadvantage that it is possible to forget to reset the switch to child mode after use, especially if the switch is hidden. A better solution is to have to press a (hidden) button during boot to put the machine into parent mode. We will now see how this is done.

If the button is not pressed when the PC is switched on, then, after a short delay of about 0.7 s (determined by R1, C1, D2 and the base-emitter junction threshold voltage of the Darlington pair formed by T1 and T2) RE2 pulls in. RE1 remains unenergised and hence the children’s drive connected to K2 is active. Subsequently pressing S1 has no effect since RE1 has been isolated by the contacts of RE2.

If the secret button is pressed, either briefly or continuously, during the 0.7 s sensitive period after the computer is switched on, RE1 pulls in immediately and holds itself in this state. D3 now prevents RE2 being subsequently activated. Since the contacts of RE1 have changed over, the PC now boots from the parents’ drive. It is impossible to forget to return the computer to child mode, since the computer will always start up in this mode if the secret button is not pressed. A 12 V miniature relay with contacts rated for 100 mA is suitable for RE2. The
contacts of RE1 should be rated for the currents taken by a typical hard disk drive (say 2 A to 3 A). A key switch can be used instead of a secret button as a last resort against resourceful children, since the circuit will continue to operate correctly if S1 is left in parent mode permanently while the computer is on.

Remote Control Blocker

Paul Goossens

This circuit was designed to block signals from infrared remote controls. This will prove very useful if your children have the tendency to switch channels all the time. It is also effective when your children aren’t permitted to watch TV as a punishment. Putting the TV on standby and putting the remote control out of action can be enough in this case.

The way in which we do this is very straightforward. Two IR LEDs continuously transmit infrared light with a frequency that can be set between 32 and 41 kHz. Most remote controls work at a frequency of 36 kHz or 38 kHz.

The disruption of the remote control occurs as follows. The ‘automatic gain’ of the IR receiver in TVs, CD players, home cinema systems, etc. reduces the gain of the receiver due to the strong signal from the IR LEDs. Any IR signals from a remote control are then too weak to be detected by the receiver. Hence the equipment no longer ‘sees’ the remote control!

The oscillator is built around a standard NE555. This drives a buffer stage, which provides the current to the two LEDs. Setting up this circuit is very easy. Point the IR LEDs towards the device that needs its remote control blocked. Then pick up the remote control and try it out. If it still functions you should adjust the frequency of the circuit until the remote control stops working.

This circuit is obviously only effective against remote controls that use IR light!

Converter IC with Integrated Schottky Diode

Gregor Kleine

Conventional step-up switching regulator ICs need at least one external Schottky diode and have the disadvantage that there is no effective output short-circuit current limiting. This means that very large currents can flow via coil L and Schottky diode D. Such currents can overload upstream components or destroy circuit board tracks.

This situation is now remedied by the new LT3464 step-up switching regulator from Linear Technology (www.linear.com) in an 8-pin SO123 package. Not only does it have an integrated Schottky diode, it also has an internal switching transistor that isolates the output from the input voltage in...
the shutdown mode. The switching transistor also has short-circuit current limiting that becomes effective at around 2.5 mA. The IC operates with input voltages between +2.3 V and +10 V and can supply an output voltage as high as +34 V. The amount of output current that can be drawn increases as the input voltage increases. For example, the maximum output current is 15 mA with an input voltage of +9 V and an output voltage of +20 V. A quite common application is generating +12 V from a +5-V source, for which the maximum output current is 20 mA. The output voltage is regulated via the Feedback pin (pin 2), with the voltage being determined by resistors R1 and R2 according to the formulas

\[ V_{\text{OUT}} = 1.25 V \times (1 + \frac{R_2}{R_1}) \]

\[ R_2 = R_1 \times \left( \frac{V_{\text{OUT}}}{1.25 V} - 1 \right) \]

Voltage divider R1/R2 can also be connected to the CAP pin (pin 5) ahead of the switching transistor. This avoids having an open-loop condition when the output is switched off, but it reduces the accuracy of the output voltage setting. The circuit shown here generates a voltage spike when the IC is switched back on, since the feedback loop drives up the voltage on the CAP pin when the loop is open. A Murata type LQH32CN470K coil (47 µH) is used here as a storage choke due to its very compact construction. Other types of storage chokes in the range of 10–100 µH can also be used. The input capacitor, the capacitor connected to the CAP pin (pin 5), and the capacitor connected to the OUT pin (pin 3) are multilayer ceramic types (X5R and X7R).

### Virtual Prototyping Board

Paul Goossens

It is often very useful to test a small circuit before designing the printed circuit board. Often a small piece of prototyping board, also known as breadboard, perfboard or veroboard, is used for this. An alternative approach is to use simulation software. This is usually faster and more convenient. If the circuit doesn’t work as expected, then such software makes it very easy to try something different.

Most of the software available for this purpose is pretty expensive. However, there are fortunately also a number of freeware programs available.

One of these is ‘Virtual Breadboard’. This program can be downloaded from www.muvium.com.

This software allows for the simulation of digital circuits. A library with a number of standard parts is also provided. A small disadvantage is that the ICs are shown as they appear in reality, instead of a schematic block that indicates which functions each IC has. What is very practical however is that the simulator can also simulate PIC-microcontrollers and the BASIC-stamp. This allows not only the hardware to be tested, but the software as well. Reprogramming is done in no time. You only need to load the new HEX file and can test immediately.

This program is not only as extensive as the expensive, professional software packages, of course, but if you would like to test some small circuits (possibly including a PIC microcontroller or BASIC Stamp) then it is certainly worth it to check this program out!
**THE ORIGINAL SURPLUS WONDERLAND!**

**THIS MONTH’S SELECTION FROM OUR VAST EVER CHANGING STOCKS!**

**GIAN T 10” 7 SEGMENT DISPLAYS**

A full purchase entitles you to try these items无 without obligation! Please see details at www.distel.co.uk

**IC’S - TRANSISTORS - DIODES**

**Obsolete - Short Supply - Bulk**

10,000,000 Items EX STOCK

**CALL or see web site www.distel.co.uk**

**Computer Monitor Specials**

- **Legacy products High spec genuine multisync.**

- **Mitsubishi FH3A43E3T1XU 14” SVGA Monochrome colour monitor with fine 0.8mm dot pitch and resolution of 1024 X 768. A very exclusive model direct to a home of computers***

- **BM PC’s in CGA, EGA, VGA & SVGA back panels (including Adept 128)**

- **ARCHIMEDES and APPLE. Many features EKthorin included with specification.**

- **Fully guaranteed, in EXCELLENT little 12 month colour tested (behind glass).**

- **VGA cable for BM PC included.**

Only £129 (E) Order as T04

External cables for other types of computers available - Call.

**Generic LOW COST SVGA Monitors**

We choose the makes, which include, Compaq, Matsushita, Packard Bell, and Viewsonic. Tested and ready to run with all cables, Standard RTB 90 day guarantee.

- **14”**

- **£59.00**

- **order T09**

- **£69.00**

- **order T05**

- **£79.00**

Supplied in good running condition. Shipping code (E)

**VIDEO MONITORS**

**PHILIPS HCSS1 Ultra compact 9” colour video monitor with standard 12V DC power supply and FFR socket, suitable for all monitoring / security, applications. High quality, no equipment fully tested and guaranteed. Only £99.00**

- **Order as BC44**

- **£24.50**

- **Order as DVU**

- **£34.50**

- **Order as RV36**

- **£40.00**

- **Order as RV34**

**Call for shipping quotation**

**COLOUR CCD CAMERAS**

- **Unusually**

- **a miracle of modern technology**

- **grown on a silicon wafer and an optical lens**

- **Illuminated by a full 320 x 240 pixel system measuring only 22.8mm x 27.6mm x 38.0mm**

- **A true 16 bit CMOS image processing chip**

- **Integral audio powered audio operational amplifier circuit**

- **Connect direct to Alpha and Amiga BCC ideal for all video colour monitors and computer monitors.**

- **Tested and guaranteed.**

- **Only £99.00**

- **Order as BC31**

**Hard Drive disk 2.5” - 14”**

- **TOSHIBA MK4C271 10Gbp 125 (2.5 mm) Hard** £29.55

- **TOSHIBA MK4C311 4.3Gbp 125 (2.5 mm) Hard** £29.55

- **TOSHIBA MK4C661 5.4Gbp 125 (2.5 mm) Hard** £29.55

- **TOSHIBA MK6C661 14Gbp 125 (2.5 mm) Hard** £59.55

- **Maxtor 2/3” CDW2710A 1.5Gbp 125 (2.5 mm) Hard** £49.55

- **Maxtor 2/3” CDW2710A 1.5Gbp 125 (2.5 mm) Hard** £54.55

- **Maxtor 2/3” CDW2710A 1.5Gbp 125 (2.5 mm) Hard** £59.55

For overseas packs, state various 5 or 6 megabyte format. Special prices. Only £99.00

**Test equip. 4 Special interest items**

- **MITSUBISHI FM5A43E4T1XU 14” SVGA monochrome colour monitor**

- **PARNELL S306 DC 3G Amps Bench Power Supply**

- **KINGFISHER C3058 - 250W 3 phase power sources - ex stock**

- **BETWAY B329. Type 1. Tiptop rating tube unit drive**

**DC 200 volt**

**All power supplies are guaranteed and tested fully at close up low on mains.**

**AC 230 volt**

**Many other Floppy & Hard Drives, IDE, SCSI, EDI etc. from stock see our web site**

**Shipping our all drives is code E**

**Display Computers**

**Tiny space saving IBM compatible PC with 280 MB system measuring only (mm) 20 x 6 x 26 / 27 x 27 x 32.**

**An ideal portable solution for home working, schools, computer clubs etc.**

**A complete computer solution with Spec sheet**

**Only £345.00**

**Order as BC10**

**ORDER**

**Note:** To order these special items please telephone or call at the above telephone number. An extra £10.00 postage charge will apply per order. A VAT receipt will be issued with each order.

**Test equip. 4 Special interest items**

**All power supplies are guaranteed and tested fully at close up low on mains.**

**AC 230 volt**

**Many other Floppy & Hard Drives, IDE, SCSI, EDI etc. from stock see our web site**

**Shipping our all drives is code E**

**Display Computers**

**Tiny space saving IBM compatible PC with 280 MB system measuring only (mm) 20 x 6 x 26 / 27 x 27 x 32.**

**An ideal portable solution for home working, schools, computer clubs etc.**

**A complete computer solution with Spec sheet**

**Only £345.00**

**Order as BC10**

**ORDER**

**Note:** To order these special items please telephone or call at the above telephone number. An extra £10.00 postage charge will apply per order. A VAT receipt will be issued with each order.
PIC On Screen Display Project Board

A Versatile, Programmable, Low Cost Platform for Video Text Projects.

- PIC 16F828 microcontroller
- 28 by 11 character OSD
- Fully programmable
- Demo software available
- I/O lines for sensor interface
- RS232 serial interface
- PAL or NTSC compatible
- Enclosure option available

Visit www.STV5730A.co.uk

ESSENTIAL COMPONENTS

10% OFF TUESDAYS FOR DIRECT ORDERS

£4.99
£9.99
£4.99
£4.99
£14.99
£22.99
$US-052 Wirewound 400µH 16-56V
$US-051 Metal Film 22µF 16-56V
SN7403N 8-Channel 2-Input OR Gate
Capacitors 0.1µF (10V 25% TOL)
Mall order P&P: £2.50 (Free P&P orders over £10)

www.fastcomponents.co.uk
Tel: 0870 270 4468 Fax: 0870 137 0001

André Lamotte's

XGAMESTATION

Learn Step-by-Step How to Build
AND DESIGN YOUR OWN VIDEO GAME CONSOLE!

...and more...

- uVISION® Industry-Standard Workbench for Microcontrollers
- Options Wizard for Tool Configuration
- Customisable Editor
- Source Browser
- CPU & Peripheral Simulation
- Complete integration with emulators
- Dedicated high-optimisation C compilers
- Microcontroller language extensions
- Classroom training, see website for dates
- With free hands-on user guides and manuals

Download your trial compiler version from:

www.hitex.co.uk

Hitex (UK) Ltd
Tel: 012 356 2456
Email: sales@hitex.co.uk
Web: www.hitex.co.uk

KEIL SOFTWARE
OFFICIAL DISTRIBUTOR

Improve Your

C51

ARM Environment

- uVISION® Industry-Standard Workbench for Microcontrollers
- Options Wizard for Tool Configuration
- Customisable Editor
- Source Browser
- CPU & Peripheral Simulation
- Complete integration with emulators
- Dedicated high-optimisation C compilers
- Microcontroller language extensions
- Classroom training, see website for dates
- With free hands-on user guides and manuals

Download your trial compiler version from:

www.hitex.co.uk

Hitex (UK) Ltd
Tel: 012 356 2456
Email: sales@hitex.co.uk
Web: www.hitex.co.uk
There is no doubt that this small power amp packs a punch. It is capable of delivering a healthy 200 W into 4 Ω. Into 8 Ω it can still output 125 W (see Figure 2). These large power outputs are made possible through the use of Darlington transistors made by Sanken, the SAP16N and its opposite number, the SAP16P (in our prototype we used their predecessors, the SAP15N and P, because the SAP16 versions were not available at that time). These power transistors have an emitter resistor built in, as well as a diode for temperature compensation. Because of this, the whole emitter follower stage has just two components (and a preset for setting the quiescent current, shown in the circuit in Figure 1).

One small disadvantage is that the transistors have to operate at a relatively low
quiescent current, according to the datasheet. This causes an increase in distortion and a reduction in bandwidth. The current through the diodes has to be set to 2.5 mA, when the quiescent current will be 40 mA. This has the advantage that the driver transistors (T9, T10) do not need heat sinks, which helps to keep the circuit small.

The amplifier is of a standard design and doesn't require much explanation. The input is formed by two differential amplifiers (T1, T2), which are each followed by a buffer transistor (T9, T10). T9 and T10 together make a push-pull stage that drives the output transistors.

For T1 and T2 we've used special complementary dual transistors made by Toshiba. These, along with the driver transistors, have been used previously in the High-End Power Amp in the March 2005 issue. The driver transistors are a complementary pair made by Somyo, which have been designed specifically for these applications.

Compensation in the amplifier is provided by R7/C2, R12/C3, R21/C6, R22/C7 and R26/C8. The dual transistors are protected by D1 to D4. The output inductor consists of 8 turns of 1.5 mm diameter enameled copper wire (ECW).

Since the current through the diodes is just 2.5 mA, the operating point of T9 and T10 has to be set precisely. This operating point is determined purely by the operating point of the differential input amplifiers. Since the ambient temperature affects the operating point, any potential drift in the operating point of T9 and T10 is compensated for by the current sources of the differential amplifiers.

The voltage drop across D5 (D6) and the base-emitter voltage of T4 (T7) determine the current through P1 (P2) and R13 (R16). T4 (T7) controls the voltage at the base of T3 (T6) and creates a constant current that is independent from the supply voltage. Since the voltage across D5 (D6) and T4 (T7) depends on the temperature, the voltage at the base of T10 (T9) has been temperature-compensated as well as possible. T3 and T4 (T6 and T7) are fed by a simple constant current source built around JFET T5 (T8), which makes the differential amplifier around T2 (T1) even less dependent on the supply voltage. R14 (R17) restricts the maximum voltage across T5 (T8), which may not exceed 30 V. According to the datasheet the JFET current should be about 0.5 mA, but in practice a deviation of up to 50% is possible. The actual value is not critical, but the voltage across the JFET must

### Specifications

<table>
<thead>
<tr>
<th>Input sensitivity</th>
<th>1 ( \text{V}_{\text{ref}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input impedance</td>
<td>10 ( \Omega )</td>
</tr>
<tr>
<td>Sine-wave power</td>
<td>8 ( \Omega ), ( \text{THD+N} = 1 % )</td>
</tr>
<tr>
<td>4 ( \Omega ), ( \text{THD+N} = 1 % )</td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>135 kHz (1 W/80Ω)</td>
</tr>
<tr>
<td>Slow rate</td>
<td>20 ( \text{V/\mu s} )</td>
</tr>
<tr>
<td>Signal/noise ratio</td>
<td>101 dB (1 W/8 Ω, 22 Hz to 22 kHz)</td>
</tr>
<tr>
<td>THD+noise</td>
<td>104 dB</td>
</tr>
<tr>
<td>Damping factor</td>
<td>0.014 % at 1 kHz (60 W/8Ω)</td>
</tr>
<tr>
<td></td>
<td>&gt;700 (1 kHz)</td>
</tr>
<tr>
<td></td>
<td>&gt;400 (20 kHz)</td>
</tr>
</tbody>
</table>

### Components List

**Resistors:**
- R1, R10 = 470\( \Omega \)
- R2, R22 = 10k\( \Omega \)
- R3, R4, R8, R9 = 47\( \Omega \)
- R5, R6, R10, R11, R15, R18 = 2k\( \Omega \)
- R7, R12 = 220k\( \Omega \)
- R13, R16 = 1k\( \Omega \)
- R14, R17 = 39k\( \Omega \)
- R20, R21 = 15k\( \Omega \)
- R23, R24 = 100\( \Omega \)
- R25 = 1k\( \Omega \)
- R26, R27 = 10k 1W
- P1, P2, P3 = 250Ω2 preset

**Capacitors:**
- C1, C2, C3 = 1nF
- C4, C5 = 10μF 63V radial
- C6 = 47μF
- C7 = 220μF
- C8 = 33μF
- C9, C11 = 1000μF 63V radial
- C10, C12 = 100μF

**Inductors:**
- L1 = 8 turns 1.5mm dia. ECW, inside diameter 10mm.

**Semiconductors:**
- D1-D6 = 1N4148
- T1 = 2SC3381 (Toshiba) (Huijzer; Segar Electronics)
- T2 = 2SA1349 (Toshiba) (Huijzer; Segar Electronics)
- T3, T4, T9 = 2SA1209 (Sanyo) (Farnell # 410-3841)
- T5, T8 = BF245A
- T6, T7, T10 = 2SC2911 (Sanyo) (Farnell # 410-3853)
- T11 = SAP16N (Sanken) or SAP15N (Farnell # 410-3749)
- T12 = SAP16F (Sanken) or SAP15P (Farnell # 410-3750)

**Miscellaneous:**
- K1-K5 = 2-way spade terminal, PCB mount, vertical
- Heatsink = 0.5 k/°W
- Mica washers for T11 on T12, e.g., Canrad Electronics # 189049
- 4 wire links on PCB
- PCB, ref. 054008-1 from The PCBShop

---

7-8/2005 - elktor electronics

---

61
always stay below the maximum value (also take into account any possible mains voltage variations). If you do need to reduce the voltage, that should be done by lowering the value of R15 (R18). This causes the voltage across R14 (R17) to increase and hence the voltage across the JFET will drop.

P1 and P2 are required to compensate for various tolerances. With the input open circuit you should set the output to zero, while keeping the current through T9 and T10 as close as possible to 2.5 mA. This can be measured across R23 and R24. It is not a problem if the current is a few tenths of a mA more than this.

The quiescent current is set by P3. In the reference design a 200 Ω preset is used. We have put this together using a (standard) preset of 250 Ω in parallel with a 1 kΩ resistor. An incidental advantage of this parallel resistor is that it limits any possible current spikes when the wiper of the potentiometer makes a bad contact during the adjustment of the quiescent current.

This amplifier provides a good opportunity to experiment with the Darlington transistors. If you want to use the output stage in a complete power amplifier (refer to the print layout in Figure 3), you will need to add an input decoupling capacitor, a power-on delay with a relay for the loudspeaker and a beefy power supply. The input decoupling capacitor is certainly a necessity, since the offset is determined by the various tolerances and differences between the complementary transistors. In our prototype the input offset was 6.3 mV for a 0 V output voltage. This is amplified by a factor of 33, which would result in an output offset of over 200 mV if the input was shorted by, for example, a volume control.

Elsewhere in this issue is a design for a small board, which contains an input decoupling capacitor (MKT or MKP) and a relay with a power-on delay.

Ton Giesberts

People often forget that many voltage regulator ICs have an upper limit (usually 35 V) on the input voltage they can handle. That applies primarily to types with a fixed output voltage. Adjustable voltage regulators also have a maximum voltage specification, in that case between the input and output (commonly 40 V). The input voltage must thus be limited to that level in a fault situation in which the output is shorted.

This circuit shows a way to allow such regulators to be used in situations with higher input voltages. Although the solution consists of an additional three components, it is simple and can be built using commonly available components. The voltage across the regulator is limited by the combination of T1 and zener diode D1 to a value that allows the regulator to work properly with loads up to the maximum rated load. R1 provides an adequate operating current for D1 and the bias current for T1. It’s a good idea to use a Darlington type for T1 in order to keep the value of R1 reasonably high. The current through D1 is only 10 mA with an input voltage of 60 V. Naturally, we also measured what the circuit does when no load is connected. Surprisingly enough, the nominal output voltage of 5.02 V increased to only 5.10 V (with a 60-V input voltage).

In our experiments, we used a BDV65B

Protection for Voltage Regulators
for T1 and a value of 4.7 kΩ for R1. If you want to ensure that the circuit is truly short-circuit proof with an input voltage of 60 V, you must use a transistor that remains within its safe operating area at the maximum input voltage with the short-circuit current of the regulator (which can exceed 2 A). The BDV65B and TIP142 do not meet this requirement. The maximum voltage for the BDV65B is actually 40 V, and for the TIP142 is 50 V. If the transistor breaks down, the regulator will also break down. We verified that experimentally.

One possibility is to add SOA protection for T1, but that amounts to protecting the protection. Another option is to relax the requirements. For that purpose, R1 must provide enough current to ensure that T1 receives sufficient current in the event of a short circuit to keep the voltage across T1 lower, but that doesn’t make a lot of difference in practice, and it also increases the minimum load. Besides that, it should be evident that adequate cooling for T1 and IC1 must be provided according to the load. Ripple suppression is only marginally affected by the protection circuit, since the input is already well stabilised by T1, but the current through D1 does flow through the output. The presence of C2 must also be taken into account. In this circuit, with an adjustable voltage regulator such as the LM317 and an output voltage greater than 40 V, C2 will cause the voltage to be briefly higher than 40 V in the event of a short circuit, which can also cause the IC to be damaged. In that case, it will be necessary to find a different solution or use a different type of voltage regulator.

---

**Video Sync Generator**

Paul Gaossens

All video signals include synchronisation signals, which help the television set keep the horizontal and vertical deflection synchronous with the picture. For experimental purposes, it can be handy to build a generator for these synchronisation signals.

Synchronisation signals have a rather complicated structure. It's not easy to generate them accurately using onologue circuitry. By contrast, a design based on a CPLD is a lot easier. This design uses the experimenter’s board described in the May 2004 issue (‘Design Your Own IC’). The hardware extension for this generator is shown in Figure 1. The extension could hardly be simpler. The 20-way connector must be connected to connector K3 of the experimenter’s board by a flat cable. The synchronisation signals on pin 4 are routed to the output connector via voltage divider R1/R2.

R1 and R2 perform two tasks in this circuit. First, they provide the correct output impedance of 75 Ω. Second, they reduce the signal amplitude from around 4 V to 0.6 V. If the circuit is connected to a television set with an input impedance of 75 Ω, the maximum output voltage will be only 0.3 V, which complies with the specifications for the CVBS signal. As you’ve surely guessed by now, the majority of the design is contained in the CPLD. We generated this design in Quarat 4.2. The top-level schematic is shown in Figure 2. As can clearly be seen from that diagram, the design consists of three separate sections. In combination with the crystal on the circuit board, the inverter at the bottom provides the clock signal. The crystal must generate a frequency of 10 MHz for this circuit. If a different crystal is already fitted, it must be replaced by a 10MHz type.

The clock signal finds its way back into the circuit via another input of the top left. It ensures that both ports of the circuit operate synchronously. The section named ‘sync_start’ keeps track of which part of the video signal is being generated. Here it should be remarked that each video line is divided into two parts in this circuit. That is done because the synchronising signal occurs at twice the normal rate during the vertical retrace interval. The ‘width’ output indicated how long the output signal should remain low. Assertion of the ‘endline’ input indicates to the subcircuit that the current portion of the video signal is ready and the next portion of the video signal can be processed. The ‘sync_start’ block then produces the associated value at the output.

The final block bears the revealing name ‘pwm_10bit’. As its name suggests, this section (which is actually implemented as part of the program code) generates a pulse on the output whose width is equal to the value of ‘width’. This PWM counts from 0 to 319, which corresponds to a total duration of 32 µs (half of one video line) or a clock frequency of 10 MHz. This period is divided into 320 intervals of 0.1 µs each. The PWM sets the ‘endline’ output high during the next-to-last interval. You might expect that this signal would be active during the final interval of the period, but making it active one interval earlier gives the
**Bidirectional I²C Level Shifter**

Luc Lemmens

In some cases I²C signals need to be level-converted if they are exchanged between sections of logic systems operating at different supply voltages. For example, one section of a circuit may work at 5 V while a newly added I²C device is happy at just 3.3 V. Without a suitable bidirectional level converter, signals from the 5-V system may disrupt or even damage the SDA/SCL inputs of the 3.3-V device, while the other way around signals emitted by the lower voltage device may not be properly detected.

As shown in the diagram, two n-channel enhancement MOSFETs inserted in the SDA and SCL lines do the trick. Note that each voltage section has its own pull-up resistors R_P connected between the respective supply rail (+3.3 V or +5 V) and the MOSFET source or drain terminals. Both gates (g) are connected to the lowest supply voltage, the sources (s) to the bus lines of the lower voltage section, and the drains (d) to the same of the higher voltage section. The MOSFETs should have their source connected to the substrate — when in doubt check the datasheet.

Other supply voltages than 3.3 V and 5 V may be applied, for example, 2 V and 10 V is perfectly feasible. In normal operation VDD2 must be higher than or equal to VDD1.

**Source:**
Philips Semiconductors
Application Note AN97055.

---

**Luxeon LEDs**

Karel Walraven

It won’t be very long before your new sitting room lamp will last forever. While our parents had to replace the lamp at least once a year, these days the energy-efficient lamps last five to ten times as long. Our children will buy an LED lamp once, which will keep working until their grave. Granted, what is written here is possibly a slight exaggeration, but that the development is in the direction of increased lifespan and higher efficiency is beyond dispute.

The company Lumileds (from Agilent and Philips) has as its goal the development of LEDs that are suitable for lighting. That is why they are available in various shades of white: 3200 K (warm white), 4100 K (commercial white) and 5500 K (cool white). By combining multiple LEDs of different brightness in one fitting, the different fittings will have equal brightness, even if you buy another new one years later.

With respect to power output, there are models rated 1 W and 5 W, and when you read this, the range is quite likely to have grown. Because the light output and life expectancy are strongly related to temperature, not only unmounted LEDs are available but also types integrated with a heatsink. This series has the beautiful name of Luxeon Star LED, because the...
heatsink has somewhat of a star shape. Because of the heatsink it is possible to use
the Luxeon Star LED at the rated current without any additional measures. For the 1-watt
type that is 350 mA DC. The current may be as high as 500 mA of the LED is multi-
plexed, however the average value may not be higher than 350 mA. Don't use a switch-
ing frequency of less than 1 kHz, otherwise the temperature of the chip varies too much.
The 3-watt type can be driven with a maximum of 1 A, also when multiplexing.
If you are going to use the LEDs at these limits it is advisable to drive them with an
electronically controlled current source, so that you can be sure that the limits are not
exceeded. In general this is not necessary, since a slightly lower current does not
reduce the brightness much. This is because the brightness reduces significa-
tly when the temperature of the chip increases. This can be as much as 10 %
per 20 degrees of junction temperature! It is therefore always a good idea to provide
the LED with as much additional cooling as is practicable, for example by mount-
ing the heatsink on a thermally conducting part of the fitting. We recommend that you
choose a current which is a little less than the maximum value. A simple current lim-
ing resistor is then all you need and additional electronics is not required. For exam-
pies and calculations see: www.luxonstar.com/
resistor-calculator.php
Note that the LED, in contrast to a halogen lamp, requires DC. So in the event of an AC power supply, apart from the resis-
tor, it is also necessary to add a bridge rectifier between transformer and LED! More information can be found in the Custom Luxeon Design Guide, which can be downloaded from:
www.lumileds.com/pdfs/A812.PDF

Extended Timer
Range for the 555

Tom Giesbers

Anyone who has designed circuits using
the 555 timer chip will, at some time have
wished that it could be programmed for
longer timing periods. Timing periods
greater than a few minutes are difficult to
achieve because component leakage cur-
rrents in large timing capacitors become
significant. There is however no reason to
opt for a purely digital solution just yet.
The circuit shown here uses a 555 timer
in the design but nevertheless achieves a
timing interval of up to an hour!

The trick here is to feed the timing capac-
itor not with a constant voltage but with
a pulsed dc voltage. The pulses are
derived from the unsmoothed low voltage
output of the power supply bridge recti-
fier. The power supply output is not refer-
enced to earth potential and the pulsing
full wave rectified signal is fed to the
base of T1 via resistor R1. A 100 Hz
square wave signal is produced on the
collector of T1 as the transistor switches.
The positive half of this waveform
Charges up the timing capacitor C1 via D2 and P1. Diode D2 prevents the charge on C1 from discharging through T1 when the square wave signal goes low. Pushbutton S1 is used to start the timing period. This method of charging uses relatively low component values for P1 (2.2 MΩ) and C1 (100 to 200 pF) but achieves timing periods of up to an hour which is much longer than a standard 555 circuit configuration.

**Fridge Thermostat**

Tony Beekman

What to do when the thermostat in your fridge doesn’t work any more? Get it repaired at (too) much expense or just buy a new one? It is relatively simple to make an electronic variation of a thermostat yourself, while saving a considerable amount of money at the same time. However, be careful when working with mains voltages. This voltage remains invisible and can sometimes be fatal!

This design allows for five temperatures to be selected with a rotary switch. By selecting suitable values for the resistors (R1 to R7), the temperatures at the various switch positions can be defined at construction time. With the resistance values shown here, the temperature can be adjusted to 16, 6, 4, 2 and -22 °C. 16 °C is an ideal temperature for the storage of wine, while 6, 4, and 2 degrees are interesting for beer connoisseurs and the minus 22 degrees position transforms the fridge into a large freezer. Note for wine connoisseurs: to prevent mould on the labels, it is necessary to place a moisture absorber or bag of silica gel in the fridge.

The circuit is built around an old workhorse among opamps, the 741. D1 provides a stable reference voltage of 5 V across the entire resistor divider. P1 allows adjustment of the voltage at the node of R1 and R2. To use the above-mentioned temperatures as setpoints this voltage needs to be adjusted to 2.89 V. D2 is a precision temperature sensor, which can be used from -40 to +100 °C. The voltage across this diode varies by 10 mV per Kelvin. In this way D2 keeps an eye on the temperature in the fridge. The reference voltage derived from the voltage divider [selected with S1] is compared by IC1 with the voltage across the temperature sensor. Based on this, the 741 switches, via the zero voltage crossing driver (IC2), a triac that provides voltage to the compressor motor. The zero voltage crossing IC switches only at the zero crossings of the mains voltage, so that interference from the compressor motor is avoided when turning on.

The power supply for the circuit is provided by a simple bridge rectifier and fil-
The wires to the connector at the front can be made elsewhere. You can, for example, make a thermostat for heating by swapping the inputs of the opamp.

USB for the Xbox

Paul Goossens

The Xbox is the well-known Microsoft game computer. The fact that the Xbox is based on PC technology should hardly be surprising, since Microsoft specialises in this computer architecture.

It's also not especially remarkable that if you open up on Xbox, you'll find several well-known ICs from the PC world. In fact, the Xbox is actually a PC. The major difference between the Xbox and a normal PC is that the operating system is stored entirely in Flash memory and users cannot add any functionality to the system.

There is also a protection system that prevents any software from being accepted if it does not have a digital signature from Microsoft.

At least, that was the intention. Naturally, there are people who have cracked the Xbox protection system and use the Xbox as a PC to run Linux. We plan to publish more information about this in Elektor Electronics in the near future.

The fact that the operating system is stored entirely in Flash memory and users cannot add any functionality to the system is that the operating system is stored entirely in Flash memory and users cannot add any functionality to the system.

As usual with game computers, the Xbox has connectors for controllers (enhanced joysticks) for playing the games. The Xbox has four such connectors on the front of the enclosure. They have a form that is totally new to us. After a bit of detective work, it turns out that the signals on these connectors are actually quite familiar: they're USB signals.

Once you know that, it's easy to connect a keyboard to the Xbox. If you fit a standard USB connector somewhere on the enclosure and wire it to the signal lines for one of the connectors, you can then connect a USB keyboard. Another benefit of this is that most types of USB memory sticks can be used by the Xbox as Xbox memory cards. USB memory sticks are often less expensive than 'genuine' Xbox memory cards.

The wires to the connector at the front can be clearly seen in Figure 1. The yellow wire is not important for our purposes.

Keep in mind the safety requirements when building and mounting the circuit.

Table 1. USB connections

| Pin 1 (red) | +5 V |
| Pin 2 (white) | D- |
| Pin 3 (green) | D+ |
| Pin 4 (black) | GND |

The other wires are used for the actual USB signals. A nice detail is that Microsoft uses exactly the same colours for these wires as those specified in the USB standard, which makes them much easier to recognise.

For the installation, you will some wire and a USB connector (Type A). That's the same type of connector as the USB connectors in a PC. Figure 2 shows an example of such a connector, along with the proper pin numbers.

Find a place on the Xbox where the connector can be fitted. It's easy to make a hole in the case with a small hand-held router or a drill and a small file. Next, make connections between the four wires leading to the Xbox connector and the four terminals of the USB connector, as shown in Table 1.

It's a good idea to check the connections before using the modified unit, in order to ensure that there aren't any shorts between the lines. As a second test, we recommend checking whether a voltage can be measured between pin 1 of the USB connector (+3.6 to 5 V) and pin 4 (ground) after the Xbox power has been switched on. If the test results are all OK, the USB connector is ready for use.

USB keyboards (and USB mice) are supported by Xbox Linux, and some Xbox games also use a USB keyboard to make it easier to control the game on and/or chat with other players.

Table 1.

USB connections

| Pin 1 (red) | +5 V |
| Pin 2 (white) | D- |
| Pin 3 (green) | D+ |
| Pin 4 (black) | GND |

The other wires are used for the actual USB signals. A nice detail is that Microsoft uses exactly the same colours for these wires as those specified in the USB standard, which makes them much easier to recognise.

For the installation, you will some wire and a USB connector (Type A). That's the same type of connector as the USB connectors in a PC. Figure 2 shows an example of such a connector, along with the proper pin numbers.

Find a place on the Xbox where the connector can be fitted. It's easy to make a hole in the case with a small hand-held router or a drill and a small file. Next, make connections between the four wires leading to the Xbox connector and the four terminals of the USB connector, as shown in Table 1.

It's a good idea to check the connections before using the modified unit, in order to ensure that there aren't any shorts between the lines. As a second test, we recommend checking whether a voltage can be measured between pin 1 of the USB connector (+3.6 to 5 V) and pin 4 (ground) after the Xbox power has been switched on. If the test results are all OK, the USB connector is ready for use.

USB keyboards (and USB mice) are supported by Xbox Linux, and some Xbox games also use a USB keyboard to make it easier to control the game on and/or chat with other players.
A dimmer is quite unusual in a caravan or on a boat. Here we describe how you can make one. So if you would like to be able to adjust the mood when you’re entertaining friends and acquaintances, then this circuit enables you to do so.

Designing a dimmer for 12 V is tricky business. The dimmers you find in your home are designed to operate from an AC voltage and use this AC voltage as a fundamental characteristic for their operation. Because we now have to start with 12 V DC, we have to generate the AC voltage ourselves. We also have to keep in mind that we’re dealing with battery-powered equipment and have to be frugal with energy.

The circuit that we finally arrived at can easily drive 6 lamps of 10 W each. Fewer are also possible, of course. In any case, the total current has to be smaller than 10 A. L1 and S1 can be adapted to suit a smaller current, if required. Note that the whole circuit will also work from 6 V.

IC1 is a dual timer. You could also use the old faithful NE556, but it draws a little more current. IC1a is wired as an astable multivibrator with a frequency of 180 Hz. IC1b is configured as a monostable and is triggered, via D2, from the positive edge of the output of IC1a. The length of the pulse that now appears at the output of IC1b is dependant on the position of P1. IC1b will be reset whenever the output of IC1a goes low, independent of the pulse duration, set with

John Dakin

**Components List**

<table>
<thead>
<tr>
<th>Resistors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 = 1MΩ</td>
</tr>
<tr>
<td>R2 = 47kΩ</td>
</tr>
<tr>
<td>R3 = 470kΩ</td>
</tr>
<tr>
<td>R4 = 12kΩ</td>
</tr>
<tr>
<td>R5 = 100Ω</td>
</tr>
<tr>
<td>P1 = 1MΩ preset</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacitors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1, C3, C5 = 10nF</td>
</tr>
<tr>
<td>C2, C4 = 6nF</td>
</tr>
<tr>
<td>C6 = 100μF 25V radial</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductors:</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1, D2 = 1N4148</td>
</tr>
<tr>
<td>D3 = zener diode 15V /1.3W</td>
</tr>
</tbody>
</table>

T1 = IRL2203, BUZ10, BUZ11, BUZ100 or BUK455 *

IC1 = TS556CN (CMOS) or NE556N (not CMOS)

Miscellaneous:

- L1 = 3µH 9A suppressor coil * (e.g., Farnell # 976-416)
- K1 = 2-way PCB terminal block, lead pitch 5mm
- S1 = on/off switch, 10A

PCB, ref. 030141-1 from The PCB Shop

* see text
P1, R4 and C4. This guarantees that the dimming is smooth, even when the brightness is set to maximum. The output of IC1b (pin 9) drives the gate of MOSFET T1. When the duration of the pulses at the gate increases, the average time that the MOSFET is in conduction will also increase. In this way the brightness of the lamps is controlled. T1 conducts about 96% of the time when the brightness is set to maximum. In this configuration, this can never be 100%, because the 4% of the time that the FET does not conduct is necessary to charge C6. If the FET were to conduct with 100% duty cycle, the power supply for the circuit would be effectively short-circuited. C6 allows the circuit to ride through the conduction period of the FET. D1 ensures that the charge cannot leak away via the FET during the ‘on’ period.

In the schematic, an IRL2203N is indicated for T1, but in principle you could use just about any power transistor (for example, BUK455, BUZ10, BUZ11 or BUZ100). The IRL2203 does however, have a very low ‘on’ resistance (RDS on) of only 7 mΩ and can switch 12-V loads up to 5 A without a heatsink. If you choose a different MOSFET (with higher RDS on) or use the circuit in a 6-V system then you will likely need a heatsink. Using the IRL2203N with six lamps rated 12 V / 10 W, T1 dissipates only 170 mW. At 6 V and 10 A this becomes 680 mW. The circuit itself consumes about 0.35 mA at maximum brightness and about 1.25 mA at minimum. The power supply is derived from the power system via D1 and C6. Zener diode D3 provides protection against voltage surges. The main purpose of R5 is to limit the current through D3, in the event it becomes active. L1 reduces interference that could be caused by the fast switching of the transistor.

We have designed a small printed circuit board for the circuit. The construction is very simple. The PCB is quite compact in order to facilitate the replacement of existing switches. Keep in mind that the CMOS parts, IC1 and T1, are sensitive to static electricity.

Low-cost LiPo Charger

The charging of Lithium-Polymer (LiPo) cells takes place very differently to that of the well known NiCd and NiMH cells. This aspect has previously been covered in Elektor Electronics. And this isn’t the first LiPo charger that we’ve published, but it is undoubtedly the smallest! Chip manufacturer Intersil has designed a LiPo charger IC that requires a minimum of external components. Since the IC itself is also extremely small (2x3 mm), the complete charger can be kept very small as well. This lets us design a charger that can easily be built into various pieces of equipment, especially when we use SMDs for all external components.

For those of you who don’t know how a LiPo cell should be charged, we’ll go a short explanation. When the cell voltage is very low (<2.5 V), it should be charged using a small current (see Figure 1). This current is typically less than 0.1 C (where C is the nominal battery capacity). When the voltage has risen sufficiently, but is still below 4.2 V, the cell is charged with a constant current. Most LiPo manufacturers specify a current of 1 C for this stage. The voltage across the cell may not exceed 4.2 V, so the charger has to keep an eye on this as well. At this constant voltage the current through the cell will slowly reduce while the charge in the cell increases. At the point when the cell voltage is 4.2 V and the charging current has dropped to 0.1 C, the cell is about 80-90% charged, depending on the manufacturer. Most chargers decide at this point that the cell is fully charged and switch to trickle charging the cell.

Our charger works in exactly the same way. There are two parameters that can
be adjusted in this charger, which are the normal charging current and the trickle charge that flows when the cell is 'full'. In the circuit of Figure 2 resistor R1 sets the charging current to about 500 mA, and resistor R2 sets the trickle charge current to about 45 mA. R3, R4, D1 and D2 are optional in this design and provide the user with status information. D1 shows when the charging process is busy and D2 indicates that the correct input voltage is present.

If you want to use different maximum and minimum charge currents you should use the following formulae for R1 and R2:

\[ R_1 = 12 \times 10^3 / \text{ref} \]
\[ R_2 = 11 \times 10^3 / \text{min} \]

Keep in mind that the accuracy of the current source at 500 mA is about 10%; this drops to about 30% at 50 mA. You should therefore be conservative in your choice of charging current so that you keep below the manufacturer's maximum recommended charging current.

DIL/SOIC/TSSOP Experimenting Boards

Wolfgang Steimle

Whenever you want to put a circuit together quickly, it will take too long to design a PCB for it first. In that case, the experimenting PCBs shown here are eminently suitable.

Three variations are available: 20-pin DIL package, 20-pin SOIC package and a 20-pin TSSOP package. If you use an IC with fewer pins, then you simply don't use some of the solder pads.

The remaining part of each PCB is filled with solder pads, which are arranged in groups of four. In between is a continuous copper pattern. By connecting this copper grid to ground, the boards are also suitable for RF designs.

The layouts for the various PCBs are shown here at a reduced scale. You can download the true scale layouts from the Elektor Electronics website (in pdf format). The file number is 040289-1.zip. They are also available ready-made from Elektor Electronics (refer to SHOP pages or website), the part numbers are 040289-1, -2 and -3.

Robin van Arem

The circuit presented here has the same functionality as the renowned LM3914, an LED driver that can control 10 LEDs. The circuit shown here can even drive 12 of them, with only 4 outputs. A necessary requirement is that low-current LEDs are used.

The audio signal is amplified by (half of) an LM358 opamp. P1 allows adjustment of the gain and therefore the sensitivity.
One input of the opamp is connected to ground so that only the positive half of the input signal is amplified and is effectively rectified at the same time. The combination of R2/C4 then performs an averaging function after which the signal is converted to a digital value by the 8-bit ADC in the Attiny15l microcontroller. Subsequently, the 12 LEDs are then controlled through a method called 'charlieplexing'. Switch S1 selects between dot and bar mode. The power supply is regulated with the usual 7805. The maximum current consumption amounts to 20 mA at 13.8 V. Power supply voltages of up to 30 V are not a problem, since the LM358 can deal with a maximum of 33 V at least (a 7805 can typically deal with 35 V). The minimum voltage at which the circuit will operate is around 7 V.

The software can be downloaded in the form of a hex file from our website at www.elektor-electronics.co.uk. The file number is 050115-1.zip. After the code has been programmed into the Attiny, it is necessary to disable the external reset with the appropriate fuse, since the reset pin in this circuit is used as an output.

Those among you who would like to know more on the subject of charlieplexing are referred to www.maxim-ic.com. The chip is also available ready-programmed as no. 050118-41.

3 V Headphone Amplifier

Ton Giesberts

Many new devices require a headphone connection, but due to the high level of integration and miniaturisation there is usually little room left. The low supply voltage and/or battery voltage also causes problems. If no special techniques are used, the output power and headroom are severely limited.

The MAX4410 mode by Maxim overcomes these problems not just by virtue of its small size, but also by including an internal supply inverter (charge-pump). This requires only two small external ceramic SMD capacitors (C6 and C7). The supply voltage to the output stage is now symmetrical and the outputs are therefore relative to ground (no DC offset). This gets round the need for large output capacitors to stop a DC voltage from reaching the headphones. A DC-coupled output can also be implemented using two bridge amplifiers, but virtually all plugs for stereo headphones are asymmetric and use 3-pole connectors (common ground), which can't be connected to a bridge output.

Each channel can be individually turned off (SHDNL and SHDNR) by jumpers JP1 and JP2. During normal operation these two inputs should be connected to the
positive supply. When both channels are turned off the charge pump is also switched off and the current consumption drops to about 6 µA.

The IC also has thermal and short-circuit protection built in. The IC switches to standby mode when the supply voltage is too low and it has a circuit that prevents power-on and off plops at the outputs. The recommended supply voltage is between 1.8 V and 3.6 V. The IC can deliver about 80 mW per channel into a 16 Ω load. The power supply should be able to output at least 200 mA. In practice this means that when you use a power supply that also powers other circuits, it should have at least 300 mA in reserve.

The amplifiers are configured in inverting mode with a gain set by the ratio of two resistors (R3/R1 or R4/R2); the input impedance is determined by R1 and R2. C1 and C2 are required to decouple any possible DC-offset from the inputs. In the MAX4410 evaluation kit these are small tantalum capacitors, but we don't recommend these for use in audio applications. Plastic film types would be much better, although they take up much more room. HF decoupling is provided by 100 pF capacitors connected in parallel with R3 and R4. These set the bandwidth of the amplifiers to just over 150 kHz. The typical distortion is 0.003%. For more details you should refer to the MAX4410 datasheet. It is also worth looking at the datasheet for the associated evaluation kit.

The choice of capacitors for decoupling etc., their positioning on the board and the overall layout are very critical and demand a lot of attention. Furthermore, the 14-pin TSSOP package (with a pin spacing of 0.65 mm) and SMDs in 0402 packages make it very difficult to construct this circuit yourself. The IC is also available in a (much more difficult to solder) UCSP 16 package (ball grid array, only 2.02 by 2.02 mm).

Servo Points

Karel Wurtlaven

Servos for model making can also be used for completely different purposes besides model airplanes, boats and cars. As an example, here a servo is used to operate a set of points for a model railway system. The points are directly actuated by a length of steel wire connected to the servo arm, and they move quietly and smoothly, so the illusion is no longer spoiled by that irritating click-clack sound. The voltage on the point tongues and nose is also switched over by the servo.

As an example for DIY construction, we have designed two small PCBs that can be attached to a servo with a bit of glue. The larger board should be glued to the case of the servo, while the smaller (round) board should be glued to the arm. Several contact strips made from phosphor bronze must be soldered to the larger board.

Phosphor bronze is a copper alloy with good spring characteristics. Almost all relay contacts arms are made from this material. It can be obtained from Conrad, among other sources, in the form of small sheets that can be cut or sawn into strips. Any desired switching scheme can be created by devising a suitable pattern of cop-
Searching for Components

Karel Walraven

This is a tip we think you'll appreciate: the large mail-order firms have a lot of information on their sites that can be quite handy even if you never order anything from them. As an example we can mention www.Farnell.com. If you're looking for a certain component, you can simply use the search menu to retrieve its most important characteristics and immediately see whether it is still generally available and approximately what it costs. The full data sheet is also usually available.

If the component is no longer available or you're looking for an alternative for some reason, you can use the 'find similar products by attributes' function to find several similar products. You can refine your choice in several steps until you finally end up with the components with the desired properties. You can't get the same type of results on a manufacturer's site, because such sites are usually limited to the manufacturer's own products, while a dealer also shows competitive products and you can directly compare their availability and prices. That means you can make things a lot easier for yourself, since it takes time to check out all the manufacturer sites, with the added risk that even if you find a suitable component it may turn out to not be available unless you plan to buy 100,000 at the same time.

Short-Wave Superregenerative Receiver

Burkhard Kainka

Superregenerative receivers are characterised by their high sensitivity. The purpose of this experiment is to determine whether they are also suitable for short-wave radio.

Superregenerative receivers are relatively easy to build. You start by building a RF oscillator for the desired frequency. The only difference between a superregenerative receiver and an oscillator is in the base circuit. Instead of using a voltage divider, here we use a single, relatively high-resistance base resistor (100 kΩ to 1 MΩ). Superregenerative oscillation occurs when the amplitude of the oscillation is sufficient to cause a strong negative charge to be applied repeatedly to the base. If the regeneration frequency is audible, adjust the values of the resistors and capacitors until it lies somewhere above 20 kHz. The optimum setting is when you hear a strong hissing sound. The subsequent audio amplifier should have a low upper cutoff frequency to strongly attenuate the regeneration signal at its output while allowing signals in the audio band to pass through.

This experimental circuit uses two transistors. A Walkman headphone with twa 32-Ohm earphones forms a suitable output device. The component values shown in the schematic diagram are proven to be suitable for the 10-20 MHz region. The coil consists of 27 turns wound on an AA battery serving as a winding form. The circuit produces a strong hissing sound, which diminishes when a sta-
The radio is so sensitive that it does not require any antenna to be connected. The tuned circuit by itself is enough to receive a large number of European stations. The circuit is usable with a supply voltage of 3 V or more, although the audio volume is greater at 9 V. One of the major advantages of a superregenerative receiver is that weak and strong stations generate the same audio level, with the only difference being in the signal to noise ratio. That makes a volume control entirely unnecessary. However, there is also a specific drawback in the short-wave bands: interference occurs fairly often if there is an adjacent station separated from the desired station by something close to the regeneration frequency. The sound quality is often worse than with a simple regenerative receiver. However, this is offset by the absence of the need for manual feedback adjustment, which can be difficult.

**Medium-Wave Modulator**

Burkhard Kaltka

If you insist on using a valve radio and listening to medium-wave stations, you have a problem: the existing broadcasters have only a limited number of records. Here there's only one remedy, which is to build your own medium-wave transmitter. After that, you can play your own CDs via the radio.

The transmitter frequency is stabilised using a 976-kHz ceramic resonator taken from a TV remote control unit. Fine tuning is provided by the trimmer capacitor. If there's another station in the background, which will probably be weak, you can tune it to a heterodyne null, such as 981 kHz. As an operator of a medium-wave transmitter, that's your obligation with respect to the frequency allocations. And that's despite the fact that the range of the transmitter is quite modest. The small ferrite coil in the transmitter couples directly into the ferrite rod antenna in the radio.

The modulator is designed as an emitter follower that modulates the supply voltage of the output amplifier. As the medium-wave band is still monochrome, the two input channels are merged. The potentiometer can be adjusted to obtain the least distortion and the best sound. The RF amplifier stage has intentionally been kept modest to prevent any undesired radiation. The quality of the output signal can also be checked using an oscilloscope. Clean amplitude modulation should be clearly visible.

The medium-wave modulator can simply be placed on top of the radio. A signal from a CD player or other source can be fed in via a cable. Now you have a new, strong station on the radio in the medium-wave band, which is distinguished by good sound quality and the fact that it always plays what you want to hear.
Filter-based 50 Hz Sinewave Generator

Myo Min

When it comes to designing a reliable 50Hz oscillator, the disadvantage of the good old Wien Bridge oscillator is the difficulty to adjust its own gain. If the gain is higher or lower than the optimum value, the Wien Bridge often fails to work properly.

The circuit shown here combines the functions of a low-pass filter and an integrator, presenting a novel approach to creating a precision 50Hz source with relatively low distortion.

The circuit is free from any kind of gain setting network. Opamp IC.1B and R3/C4/C5 act as an inverting integrator effectively converting the incoming sine wave (from IC.1A) into a square wave with a good amount of harmonics. R4, D1 and D2 divide the square wave to the desired level. For optimum switching speed, a matching number of series-connected low-power switching diodes like the ubiquitous 1N4148 may be used instead of the zener diodes. The output voltage is directly proportional to the zener diode values. The second opamp, IC.1A and its surrounding components R1, C1 acts as a two-pole low-pass filter supplying the 50Hz output signal via R5. Theoretically, the filter roll-off is at 24 Hz, which means the base frequency of 50 Hz is also attenuated to some degree. That is not too serious as long as higher harmonics are properly attenuated. The design with the component values shown here will supply an output voltage of 1.24 V at a frequency of 49.6 Hz. Current consumption was measured at less than 5 mA, while the distortion was 3.7% when using an LF353 opamp.

We performed an FFT (Fast Fourier Transform) analysis on the generator's output signal. Even-numbered harmonics were found clearly less in level than their odd-numbered counterparts. This is caused by a slight asymmetry in the generator's internal square wave. In our prototype, the FFT graph showed the 3rd harmonic at a relatively high level of -29.2 dB; the 2nd harmonic did much better at just -67.7 dB.

**COMPONENTS LIST**

- **Resistors:**
  - R1, R2, R3 = 47kΩ
  - R4 = 4kΩ
  - R5 = 100Ω

- **Capacitors:**
  - C1, C2, C3, C6, C7 = 100nF

- **Semiconductors:**
  - D1, D2 = zener diode 5.6V 400mW
  - IC1 = LF353DP

- **Miscellaneous:**
  - PCB, ref. 040093-1 from The PCBshop

<table>
<thead>
<tr>
<th>Resistor Values</th>
<th>Capacitor Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2, R3 = 47kΩ</td>
<td>C1, C2, C3, C6, C7 = 100nF</td>
</tr>
<tr>
<td>R4 = 4kΩ</td>
<td></td>
</tr>
<tr>
<td>R5 = 100Ω</td>
<td></td>
</tr>
</tbody>
</table>

- **Semiconductors:**
  - D1, D2 = zener diode 5.6V 400mW
  - IC1 = LF353DP

- **Miscellaneous:**
  - PCB, ref. 040093-1 from The PCBshop

- **Semiconductors:**
  - D1, D2 = zener diode 5.6V 400mW
  - IC1 = LF353DP

- **Miscellaneous:**
  - PCB, ref. 040093-1 from The PCBshop
Long-Delay
Stop Switch

Robert Edlinger

Presentable times for train stops in stations are indispensable if you want to operate your model railway more or less realistically according to a timetable. This circuit shows how a 555 timer can be used with a relatively small timing capacitor to generate very long delay times as necessary by using a little trick (scarce known among model railway electronic technicians): pulsed charging of the timing network. Such long delays can be used in hidden yards with through tracks, for instance.

As the timer is designed for half-wave operation, it requires only a single lead to the transformer and one to the switching track or reed contact when used with a Märklin AC system (H0 or H1). The other lead can be connected to any desired grounding point for the common ground of the track and lighting circuits.

As seen from the outside, the timer acts as a monostable flip-flop. The output (pin 3) is low in the quiescent state. If a negative signal is applied to the trigger input (pin 2), the output goes high and C4 starts charging via R3 and R4. When the voltage on C4 reaches 2/3 of the supply voltage, it discharges via an internal transistor connected to pin 7 to 1/3 of the supply voltage and the output (pin 3) goes low. The two threshold values (1/3 and 2/3) are directly proportional to the supply voltage. The duration of the output signal is independent of the supply voltage:

\[ t = 1.1 \times (R4 + R5) \times C4 \]

if the potentiometer is connected directly to the supply line (A and B joined). The maximum delay time that can be generated using the component values shown in the schematic diagram is 4.8 minutes. However, it can be increased by a factor of approximately 10 if the timing network is charged using positive half-waves of the AC supply voltage (reduced to the 10-16V level) instead of a constant DC voltage.

The positive half-waves of the AC voltage reach the timing network via D2, the transistor, and D3. Diode D3 prevents C4 from being discharged between the pulses. The total resistance of R4 and R5 should not be too high (no more than 10 MO if possible), since electrolytic capacitors (such as are needed for C4) have significant leakage currents. Incidentally, the leakage current of aluminum electrolytic capacitors can be considerably reduced by using a supply voltage well below the rated voltage. Capacitor C6 is intended to suppress noise. It forms a filter network in combination with an internal voltage-divider resistor. If a vehicle happens to remain standing over the reed switch so the magnet holds the contacts constantly closed, the timer will automatically be retriggered when the preset delay times out. In this case the relay armature will not release and the locomotive will come to the ‘end of the line’ in violation of the timetable. This problem can be reliably eliminated using R6, R7 and C5. This trigger circuit ensures that only one trigger pulse is generated, regardless of how long the reed switch remains closed.

RC network R8/C7 on the reset pin ensures that the timer behaves properly on switch-on (which is far from being something to be taken for granted with many versions of the 555 or 556 dual timer).

Reed switches have several special characteristics that must be kept in mind when fitting them. The contact blades, which are made from a ferromagnetic material, assume opposite magnetic polarities under the influence of a magnetic field and attract each other. Here the position and orientation of the magnet, the distance between the magnet and the reed
Transformerless 5-volt Power Supply

Srdjan Jankovic and Branko Milovanovic

An increasing number of appliances use a very small current from the power supply. If you need to design a mains-powered device, you could generally choose between a linear and a switch-mode power supply. However, what if the appliance's total power consumption is very small? Transformer-based power supplies are bulky, while the switchers are generally made to provide greater current output, with a significant increase in complexity, problems involving PCB layout and, inherently, reduced reliability.

Is it possible to create a simple, minimum-component mains (230 VAC primary) power supply, without transformers or coils, capable of delivering about 100 mA of 5 V output? A general approach could be to employ a highly inefficient stabilizer that would rectify AC and, utilizing a zener diode to provide a 5.1 V output, dissipate all the excess from 5.1 V (230 VAC/2) in a resistor. Even if the load would require only about 10 mA, the loss would be approximately 3 watts, so a significant heat dissipation would occur even for such a small power consumption. At 100 mA, the useless dissipation would go over 30 W, making this scheme completely unacceptable. Power conversion efficiency is not a major consideration here; instead, the basic problem is how to reduce heavy dissipation and protect the components from burning out.

The circuit shown here is one of the simplest ways to achieve the above goals in practice. A JVR varistor is used for overvoltage/surge protection. Voltage divider R1-R2 follows the rectified 230 V and, when it is high enough, T1 turns on and T3 cannot conduct. When the rectified voltage drops, T1 turns off and T3 starts to conduct current into the reservoir capacitor C1. The interception point (the moment when T1 turns off) is set by P1 (usually set to about 3 kΩ), which controls the total output current capacity of the power supply: reducing P1 makes T1

CAUTION

The circuit is not galvanically isolated from the mains. Touching any part of the circuit (or any circuitry it supplies power to) while in operation, is dangerous and can result in an electric shock! This circuit should not be built or used by individuals without proper knowledge of mains voltage procedures. Neither the authors nor Elektor Electronics magazine can be held responsible for any harm or injury resulting from use, or inability to use, the information presented in this article.
react later, stopping T3 later, so more current is supplied, but with increased heat dissipation. Components T2, R3 and C2 form a typical ‘soft start’ circuit to reduce current spikes — this is necessary in order to limit C1’s charging current when the power supply is initially turned on. At a given setting of P1, the output current through R5 is constant. Thus, load R4 takes as much current as it requires, while the rest goes through a zener diode, D5. Knowing the maximum current drawn by the load allows adjusting P1 to such a value as to provide a total current through R5 just 5 to 6 mA over the maximum required by the load. In this way, unnecessary dissipation is much reduced, with zener stabilization function preserved. Zener diode D5 also protects C1 from overvoltages, thus enabling the use of low-cost 16 V electrolytics. The current flow through R5 and D5, even when the load is disconnected, prevents T3’s gate-source voltage from rising too much and causing damage to device. In addition, T1 need not be a high-voltage transistor, but its current gain should exceed 120 (e.g. BC546B, or even BC547C can be used).

**Telephone Line Indicator**

Flemming Jensen

Many ‘busy’ indicators for use in telephone systems present undesirable loading of the telephone line. Some circuits are very simple indeed to the extent of only loading the line when it is not in use. The downside is that a (usually green) LED lights when the line is not occupied. The author feels that a LED should flash when the line is actually in use by another extension and that the circuit should present a minimal load of the line. The circuit shown here fulfills both requirements. We should, however, not forget to mention its only drawback: its needs to be powered from a battery or an energy-friendly battery eliminator (a.k.a. wall cube or mains adapter).

If a high-efficiency LED is used then the current drain from the 9-volt supply will be so small that a standard (170 mAh) 9 V PP3 battery will last for months. Considering that the LED is powered at current of 2 mA by T1, theoretically some 85 hours of ‘LED on’ time can be obtained.

**PC IrDA Port**

Luc Lemmens

Many PC motherboards (perhaps most of them, in fact) are fitted with a connector for an infrared communication port. That connector is generally not used, since IrDA never became truly successful and has probably already seen its best days. Still, quite a few modern devices that can use this link to communicate with a PC are available, including printers, PDAs, mobile phones, and laptops. However, the link between the above-mentioned connector on the motherboard and the outside world, the IrDA interface, is not supplied with any motherboard and is usually not available in computer shops as an accessory.

Fortunately, the necessary hardware is quite simple, and most solder artists should find it dead easy to build it as a ‘point-to-point’ construction. Selection of the IrDA IC is not critical, and just any about any type is suitable. However, you should check the size of the module when making your purchase, because quite a few types are so small that
they're difficult to solder. Naturally, the interface must be able to see outside, and it should be soldered to the front of the computer. A cover plate for a free floppy-disk or CD drive bay is quite suitable for this purpose. It's easy to remove from the case, and it should be easy to make a neat opening in it for the interface.

The connection to the motherboard is another story. Unfortunately, the motherboard manufacturers never agreed on a standard for this. That means you'll have to consult your user's manual, and if that documentation is no longer to be found, the manufacturer's website can remedy the situation in 99% of the cases, since most manuals are available as downloads. Be careful: a mistake in the connection can cause serious damage to the motherboard, so check everything thoroughly and carefully before switching on the PC. The next step is to check the BIOS settings of the PC (to verify that the IrDA port is enabled) and install the drivers. What this involves varies from one PC to the next, and it also depends on the operating system, so there's no single recipe for it. If you aren't keen on figuring all this out for yourself, you can try searching the Internet. A highly suitable site is www.infrarport.de, which clearly explains in German and English what you have to do and has all sorts of settings, drivers and patches, including supplementary explanations and experience with various types of motherboards. That's often what takes the most time in getting this serial interface to start talking.

---

Carriage Detection for Model Railway

Karel Walraven

Model railway builders know all about this: it is a troublesome job to get a block system to function properly. We present here a simple, reliable and cheap solution on how to fit resistors between insulated wheels, as is used with the two-rail systems that operate a block detection system based on current consumption.

A block, in this case, is an isolated section of rail. It is considered occupied if a load is detected. The locomotive usually has at least some current consumption, even if it is just for the lights. Digital locomotives with a decoder always consume a few milliamps, which is also sufficient for detection. To be able to detect the rolling stock, a little more effort is required. When a single carriage is accidentally left behind in a block, the detector has to be able to sense this and indicate the block as occupied. In order to achieve this, all axles of all carriages have to be fitted with a small resistor, so that a small current can flow.

Carriages with internal lighting have additional sliding contacts (on the wheels) and a small lamp or LED as load. However, it is much too complicated to fit all carriages with additional sliding contacts. That is why it is usual for a resistor to be placed across the plastic insulating sleeve. One of the wheels is isolated with respect to the axle, otherwise the wheels would short circuit the rails. This is, of course, not the intention with a two-rail system. Axles with resistors are available read-made, but are somewhat expensive. Usually on SMD or 1/8 W type resistor is used, with a value ranging from about 4k7 to 10k. It is mechanically mounted with a little (epoxy) glue and the actual electrical connection is made with conductive glue (often containing silver particles). This will usually last for years, but regular inspection is required if carriages are subject to rough handling. In addition, conductive glue is expensive, not always available and dries out after a while.

We consider the following a better method: grab the axle with small pliers and carefully pull of the insulated wheel from the axle. Also remove the insulating sleeve. Cut a two cm piece of thin hook-up wire and remove the individual strands. They have to be thin, no more than about 0.1 mm. Put the wheel back on, but now with a 0.1 mm wire between axle and sleeve and opposite that a 0.1 mm wire between sleeve and wheel. You now have created two connections. With a little bit of dexterity you can...
solder a resistor to those wires. First prac-
tice a little on a few old axles, the example
in the pictures isn’t the newest model
either! Don’t forget to glue the resistor
down, otherwise the thin wires will cer-
tainly break after a short time.
It is also possible to first solder the wires on
an SMD resistor and then reassemble the
axle. Do it whichever way you personally
find the easiest.

Short-Wave
Regenerative Receiver

for AM and DRM

Burkhard Kainka

Is it possible to make a short-wave regen-
erative valve receiver so stable that it is
even suitable for DRM? And is it possible
to do this using a 6-V supply, so only a sin-
gle voltage is necessary for the filament
and anode supply? It looks like it might be
possible with an EL95, which has good
transconductance even at low anode volt-
ares, although it is actually an output-
age pentode instead of an RF valve.
Besides that, it draws only a modest
200 mA of heater current. Everything can
be operated from a small battery, which
eliminates any problems with 50-Hz hum.
The stability depends entirely on the tuned
circuit. Consequently, a robust coil with
20 turns of 1.5-mm wire was wound on
a PVC pipe with a diameter of 18 mm.
With short leads to the air-dielectric vari-
able capacitor, this yields an unloaded Qi
factor considerably larger than 300.
The schematic shows a regenerative
receiver with feedback via the cathode.
The amount of feedback is adjusted using
the screen grid voltage. The audio signal
across the anode resistor is coupled out
via a capacitor. No additional gain is
necessary, since the voltage level is suffi-
cient for a direct connection to the Line
input of a PC sound card. A screened
cable should be used for this connection.
A two-turn antenna coil is located at the
bottom end of the tuned circuit. It provides
very loose coupling to the antenna, which
is important for good stability.
Now it’s time to see how it works in prac-
tice. Despite the open construction, the fre-
quency drift is less than 1 Hz per minute.
That’s the way it should be if you want to
receive DRM. Quite strong feedback
should be used, so the regenerative cir-
cuit acts like a direct mixer or a self-oscil-
lating mixer stage.
Every strong DRM signal could be seen
using DREAM and tuned to 12 kHz. A
total of six different DRM frequencies
could be received in the 40-m and 41-m
bands. If no good DRM stations are avail-
able, the receiver can also pick up AM
transmitters. In this case, the amount of
feedback should be reduced. The PC can
be set aside for AM reception, since all
you need is a direct connection to an
active PC speaker.

Improved DECT
Battery Charger

Karel Walraven

After buying a number of DECT tele-
phones, we noticed that these became
quite warm while charging. That surprised
us, because the manufacturer wrote in the
manual that the batteries had to be
charged for 14 hours. That would lead
you to conclude that the batteries are
charged at 1/10th of the nominal capac-
ity. But we had the feeling that the batter-
ies were getting rather warm for such a
small charging current. That is why we
quickly reached for a screwdriver and
explored the inards of the charging sta-
tion. The accompanying schematic
reveals what is going on.
The batteries are ‘simply’ charged from a
9-V mains adapter. In series with the out-
put are a diode and a resistor. A quick
calculation shows that a current of about
160 mA will flow and this was indeed the case when measured with a multimeter. That means that, far the AAA cells used here, rated at 650 mAh, the charging current isn't \( \frac{1}{10} \) C, but \( \frac{1}{4} \) C. This is rather high and certainly not good for the life expectancy of the batteries. The remedy is simple: increase the value of the 25 \( \Omega \) series resistor so that the charging current will be less. We choose a value of 68 \( \Omega \), resulting in a charging current of about 60 mA.

You may ask what the purpose of the remainder of the circuit is. This is all required to turn on the LED, which indicates when charging is taking place. During charging, there is a voltage drop of about 4 V across R1. T1 will then receive base current via R2 and the LED turns on. The resistor in series with the LED limits the LED current. The fact that the batteries are charged with an unregulated supply is not such a problem. The mains voltage will vary somewhat, but with a maintenance charge such as in this application it is not necessary to charge with an accurate constant current, provided that the current is not too high. For the curious, here is the calculation for the charging resistor: three cells are being charged. The charging voltage of a NiMH cell is about 1.4 V. The voltage drop across D1 is about 0.7 V. That leaves a voltage across the resistor of:

- 9 V mains adapter - 4.2 V batteries - 0.7 V diode = 4.1 V

Therefore, there flows a current of \( \frac{4.1}{25} = 164 \) mA.

---

**1:800 Oscillator**

Bernd Ohlerking

Oscillators are ten a penny, but this one has something special. Its frequency can be adjusted over a range of 800:1, it is voltage controlled, and it switches off automatically if the control voltage is less than approximately 0.6 V.

As can be seen from the chart, the characteristic curve \( f = f(U_e) \) is approximately logarithmic. If the input voltage is less than 0.7 V, T1 and T3 are cut off. The capacitor then charges via the 10 k\( \Omega \) resistor. The combination of the capacitor, the two Schmitt triggers and T2 form the actual oscillator circuit. However, T2 cannot discharge the capacitor, because T3 is cut off. In this state, a low level is present at A1 and a high level is present at A2. If the input voltage is increased, T3 starts conducting. This allows the capacitor to be discharged via T2, and the circuit starts to oscillate. If \( U_e \) is further increased, the capacitor receives an additional charging current via T1 and the 100-\( \Omega \) resistor. That causes the oscillator frequency to increase. In situations where the duty cycle of the output signal is not important (such as when the circuit is used as a clock generator), this circuit can be used as a voltage-controlled oscillator (VCO) with a large frequency range and shutdown capability.
MP3 Adapter for TV

Ton Giesberts

Nowadays there are many ways in which you can listen to music. A portable MP3 player with headphones is often used while on the move. But when you need to stay in a hotel and would like to listen without headphones to your favourite music in your hotel room, things become more difficult. Most hotel rooms have a TV, but rarely a music centre.

We have designed a fairly compact adapter that lets you connect an MP3 player (or any other portable device) to the SCART socket of a TV. It is obvious that this will only work if the TV has a SCART socket! The board directly feeds the headphone signals to the correct SCART pins. If the TV only has mono sound, then the left input signal is probably used. The connection between the adapter and TV is made with a SCART cable. It is best to make your own lead for the connection of the headphone signals. There are three pins on the board for the signal connections (L, R and ground). Unfortunately, this alone is not enough in practice. Most TVs expect a correct video signal on an external connection; otherwise the input is turned off (muted). To get
round this problem we used a programmable logic device (IC1, on EPM7064 mode by Altera) to generate a video sync signal. More detailed information can be found in the sync generator article elsewhere in this issue. It is sufficient to state that this IC generates a sync signal according to the PAL/SECAM specification. Several outputs are connected in parallel to give a stronger output signal. Potential divider R5/R6 produces a signal that is slightly bigger than a normal video signal (normally 30% of Vpp into 75 Ω). The signal is now a bit under 0.5 Vpp into 75 Ω. The output impedance of R5/R6 is 75 Ω, which reduces reflections should the cable be incorrectly terminated. ISP connector K2 has been included for those of you who would like to experiment with this circuit (see www.olfero.com).

The TV can be automatically switched to an external source using the video-status signal (pin 8). Modern widescreen TVs use this signal to switch between two display modes. A voltage between 9.5 and 12 V results in a 4:3 display and a voltage between 4.5 and 7 V switches to a widescreen format. jumper JP1 can be used to control this function of the TV. For older TVs the jumper should be in the 4:3 position. In all cases the display remains dark though.

A supply voltage is required for IC1 as well as the video-status signal. This is provided by a mains adapter with a stabilised 12 V output, preferably modern switch-mode supply. Voltage regulator IC2 provides a stable 5 V to IC1 and K2. LED D1 indicates that the circuit is powered up. The current consumption is mainly determined by IC1 and is about 80 mA.

![Image of the circuit](image.png)

**Components List**

<table>
<thead>
<tr>
<th>Resistor Values</th>
<th>Capacitor Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1, R2 = 1kΩ</td>
<td>C1, C2 = 22pF</td>
</tr>
<tr>
<td>R3, R4 = 2kΩ</td>
<td>C3-C7 = 100nF ceramic, lead pitch 5mm</td>
</tr>
<tr>
<td>R5 = 270Ω</td>
<td>C8, C9 = 10µF 63V radial</td>
</tr>
<tr>
<td>R6, R7 = 100kΩ</td>
<td>C10 = 22µF 25V radial</td>
</tr>
</tbody>
</table>

**Semiconductors:**

- D1 = LED, low-current
- D2 = IN4002
- IC1 = EPM7064SC44-10 PLC44 with code 054035-31
- IC2 = 7805

**Miscellaneous:**

- JP1 = 3-way SIL header with jumper
- K1 = SCART socket (female), PCB mount, angled
- K2 = 10-way boxheader
- X1 = 10MHz quartz crystal
- PCB, Publisher's order code 054035-1

**Miscellaneous (cont):**

- Disk, EPM7064 code, Publisher's order code 054035-11 or Free Download *

* See Elektor SHOP pages or [www.elektor-electronics.co.uk](http://www.elektor-electronics.co.uk)

---

**Solar-powered SLA Battery Maintenance**

**Myo Min**

This circuit was designed to "babysit" SLA (sealed lead-acid or 'gel') batteries using freely available solar power. SLA batteries suffer from relatively high internal energy loss which is not normally a problem until you go on holidays and disconnect them from their trickle current charger. In some cases, the absence of trickle charging current may cause SLA batteries to go completely flat within a few weeks. The circuit shown here is intended to prevent this from happening. Two 3-volt solar panels, each shunted by a diode to bypass them when no electricity is generated, power a MAX762 step-up vage converter IC. The '762 is the 1.5-volt output version of the perhaps more familiar MAX761 (12 V out) and is used here to boost 6 V to 15 V. C1 and C2 are capacitors that suppress high and low frequency spurious components produced by the switch-mode regulator IC. Using Schottky diode D3, energy is stored in inductor L1 in the form of a magnetic field. When pin 7 of IC1 is open-circuited by the internal switching signal, the stored energy is diverted to the 15-volt output of the circuit. The V+ (sense) input of the MAX762, pin 8, is used to maintain the output voltage at 15 V. C4 and C5 serve to keep the ripple on the output voltage as small as possible. R1, LED D4 and pushbutton S1 allow you to check the
presence of the 15-V output voltage. D5 and D6 reduce the 15-volts to about 13.6 V which is a frequently quoted nominal standby trickle charging voltage for SLA batteries. This corresponds well with the IC's maximum, internally limited, output current of about 120 mA.

The value of inductor L1 is not critical — 22 μH or 47 μH will also work fine. The coil has to be rated at 1 A though in view of the peak current through it. The switching frequency is about 300 kHz. A suggestion for a practical coil is type M from the WE PD series supplied by Würth (www.wue-online.com). Remarkably, Würth supply one-off inductors to individual customers. At the time of writing, it was possible, under certain conditions, to obtain samples, or order small quantities, of the MAX762 IC through the


Gregor Kleine

A window comparator that monitors whether its input voltage $U_{in}$ lies within a defined voltage window can be built using only a few components.

The circuit shown in Figure 1 is a version that operates with complementary supply voltages. Two diode pairs are connected across the inputs of the comparator IC and supplied with bias currents via R1 and R2. If the input of the circuit is open, the current flowing through diode pair D2c and D2b (whose common terminal is connected to ground) causes the inverting input of the comparator to be at +0.7 V and the non-inverting input to be at -0.7 V. The comparator output is thus at the $-U_b$ level, since the differential voltage at the comparator input is negative. The differential voltage is equal to the voltage on the non-inverting input minus the voltage on the inverting input.

If a positive input voltage is applied, diode D1b conducts and the voltage on the non-inverting input rises. This voltage is always 0.7 V lower than the input voltage. Diode D2b is cut off if the input voltage is positive. If the voltage at the circuit input rises to somewhat more than +1.4 V, the voltage on the non-inverting input will be slightly higher than the voltage on the inverting input, which is held to 0.7 V. The differential voltage between the comparator inputs will thus be positive, and the comparator output will switch to the $+U_b$ level.
The behaviour of the circuit is similar with a negative input voltage, with the difference being that the roles of the two diodes are swapped. In this case, the non-inverting input of the comparator remains at -0.7 V. If the input voltage drops below -1.4 V, the differential voltage between the comparator inputs again becomes positive, and the comparator output again switches to the +U level. Note that the 'low' output level of the window comparator is -U, instead of ground, due to the complementary supply voltages.

A version of the window comparator that works with a single supply voltage can be implemented by tying the common terminal of the diodes to a freely selectable intermediate voltage. The schematic diagram for such an arrangement is shown in Figure 2, where opamp IC2 acts as a low-impedance source of reference voltage U center. The voltage at the centre of the window can be adjusted to the desired value using the trimpot.

The width of the voltage window is determined by the diodes alone and amounts to twice the forward voltage drop (0.7 V) of a single diode. The width of the window can easily be enlarged by connecting additional diodes in series with D1 and D2. That can be done symmetrically, but it can also be done asymmetrically, such as by only wiring an additional diode in series with each of D1b and D2b. In the latter case, the window will not be symmetric about voltage U center (U center = ±0.7 V), but will instead extend from U center - 0.7 V to U center + 1.4 V. The circuit works with practically any type of comparator, such as the familiar LM399 or LP399 (low-power quad) comparator IC with supply voltages between ±2 V and ±18 V. IC2 in Figure 2 must be a rail-to-rail type (such as the LM7301) that is rated for the same supply voltage range as the comparator.

---

**Simple Stepper Motor Driver**

Paul Goossens

There is hardly any field in the world of electro-mechanics that has not found an application for the stepper motor. They are used extensively in the world of model making and as actuators in remote control equipment. In industry, picture scanners and printers are probably the most obvious devices that simply would not function without them, so no excuse is needed to include this very simple 4-phase stepper motor driver design in this collection of circuits. The circuit clock generator is formed from two exclusive OR (XOR) gates IC2A and IC2B together with C1 and P1. A logic '0' on the ENABLE input enables the clock generator and its output frequency is defined by:

1.4 P1C1

The output signal from the clock generator is connected to the clock inputs of the two D-type flip-flops IC1.A and IC1.B. These two flip flops are connected together in a ring to form a 2-bit shift register so that the Q output of IC1.B is fed back to the D input of IC1.A and the Q output of IC1.A is fed into the D input of IC1.B. This configuration supplies the 4 phase impulses necessary to provide motor rotation. When the DIRECTION input is changed to logic zero IC2C and IC2D operate as non-inverting gates, reversing the phase sequence of the output signals and making the motor spin in the opposite direction. The actual rotation direction will depend on the sense of the motor windings.

Swapping the outer two coil connections on one of the windings will reverse the direction if this is necessary. With the components specified the circuit oscillates at a frequency of 10 Hz. The clock frequency can be adjusted between 0.2 and 100 Hz by substituting different values for P1 and C1. It is important to ensure that power drawn by the stepper motor is within the power handling capability of the driver transistors T1 to T4. Diodes D1 to D4 are necessary to conduct away the back-EMF produced each time a drive impulse is applied to each of the motor coils is switched off.
Extension for LiPo Charger

The 'Simple LiPo Charger' published in Elektor Electronics April 2005 is a small and handy circuit that allows you to quickly charge two or three LiPo cells. Especially in the model construction world are LiPo batteries used a lot these days, particularly model aeroplanes. It is usual to use a series connection of three cells with these models. Since working with these model aeroplanes usually happens in the field, it would be nice if the batteries could be charged from a car battery. We therefore designed a voltage converter for the LiPo charger concerned, which makes it possible to charge three cells in series. The voltage per cell increases while charging to a value of about 4.2 V, which gives a total voltage of 12.6 V. The converter, therefore, raises the 12 V voltage from the car battery to 16.5 V, from which the LiPo charger can be powered.

A step-up controller type MAX1771 in combination with an external FET carries out the voltage conversion. The IC operates at a moderately high switching frequency of up to 300 kHz, which means that quite a small coil can be used. Because the IC uses pulse frequency modulation (PFM) it combines the advantages

**COMPONENTS LIST**

**Resistors:**
- R1 = 25mΩ (e.g., Digikey # 2FR025-ND)
- R2 = 100kΩ
- R3 = 10kΩ

**Capacitors:**
- C1, C4, C8 = 100nF
- C2, C3 = 47µF 25V radial
- C5, C7 = 100µF 25V radial
- C6 = 100pF

**Semiconductors:**
- D1 = 31DG05 (e.g., Digikey # 31DG05-ND)
- IC1 = MAX1771-CPA (e.g., Digikey # MAX1771EPA-ND)
- T1 = IRFUS708 (e.g., Digikey # IRFUS708-ND)

**Miscellaneous:**
- K1, K2 = 2-way PCB terminal block, lead pitch 5mm
- L1 = 47µH high current suppressor coil, (e.g., Digikey # M9889-ND)
- PCB, ref. 054012-1 from The PCBShop
of pulsewidth modulation (high efficiency at high load) with very low internal current consumption (110 μA). The IC is configured here in the so-called non-bootstrapped mode, which means that it is powered from the input voltage (12 V). The output voltage is adjusted with voltage divider R2/R3. This can be set to any required value, provided that the output voltage is greater than the input voltage.

Finally, sense resistor R1 determines the maximum output current that the circuit can deliver. With the 25 mΩ value as indicated, this is 2.5 A.

**Transistor Dip Meter**

Burkhard Kaina

The dip meter consists of a tunable RF oscillator whose resonant circuit is held in the vicinity of a resonant circuit to be checked. If the frequencies of the two circuits match, the circuit being measured draws energy from the oscillator circuit. This can be measured. This type of meter is also called a 'grid dip meter', since it was originally built using a valve. The amplitude of the voltage on the tuned circuit could be measured from the grid leakage current. Such meters typically have a set of interchangeable coils and several frequency scales.

A meter that can manage with a low voltage of only 1.5 V can be built using a circuit with two transistors. In addition, a coil tap is not required in this design. That makes it easy to connect many different coils to cover a large number of frequency bands.

If a sufficiently sensitive moving-coil meter is not available, an acoustic signal can be used instead of a pointer display. This involves a sound generator whose frequency increases when its input voltage rises. A resonance dip is then indicated by a falling tone. This acoustic indicator draws less current from the measurement rectifier than a moving-coil instrument. That allows the amplitude of the oscillation to be decreased slightly by reducing the emitter current. This increases the sensitivity, so the dip meter can measure resonant circuits at greater distances.

**Three-component Li-ion Charger**

Gregor Klein

The LTC4054 from Linear Technology (www.linear.com) is a very simple device for charging 4.2 V Li-ion batteries. This SMD IC comes in a five-pin SOT-23 package and needs just two external components (the LED is not absolutely essential): a decoupling capacitor of at least 1 μF and a resistor connected to pin 5 (PROG) to set the charging current. The value of 1.62 kΩ shown here gives a charging current \( I_{\text{CELL}} \) of 600 mA when the device is in constant current mode. The formula

\[ I_{\text{CELL}} = \frac{1000 \cdot V_{\text{PROG}}}{R_{\text{PROG}}} \]

where \( V_{\text{PROG}} = 1 \text{ V} \), gives the charging current in terms of \( R_{\text{PROG}} \).

The device works from a supply voltage of between 4.25 V and 6.5 V and is therefore suitable for connection to a USB port on a computer. To avoid risk of damage to the cells, the charging process is divided into three stages. In the first stage, which is brief, a constant power is delivered to the cell. In the next stage a constant current is delivered, and the cell voltage rises linearly. Finally the devices
switches to a constant voltage mode, and the current drops off sharply.

The LTC4054 goes into a high-impedance state when the input voltage falls below a set value to ensure that the battery does not get discharged. The CHARGE pin (pin 1) indicates the charging state. It is an open drain output which is pulled down to ground via a low impedance during charging, allowing an LED to be connected. The pin sinks approximately 20 μA to ground when the Li-ion cell voltage is between 2.9 V and 4.05 V; this is the standby state. If the cell voltage falls below 2.9 V, the LTC4054 begins charging again. CHARGE goes into a high-impedance state if the input voltage is not at least 100 mV higher than the cell voltage. The undervoltage lockout circuit is then activated, with less than 2 μA being drawn from the cell.

**DRM Double Superhet Receiver**

**Using an EF95/6AK5**

Burkhard Kalinka

This receiver arose from the desire to demonstrate that valves are fully capable of holding their own against modern semiconductor devices. Valves often have better large-signal characteristics and less noise. The decisive difference is that the circuit must be designed with higher input and output impedances.

This circuit is built using four EF95 (US equivalent: 6AK5) valves, since this type of valve is small and has proved to operate well with low anode voltages. All four heaters are connected in series and operated from a 24-V supply. That makes it attractive to use the same supply for the anode voltage. The achievable gain is fully adequate.

The receiver is designed for the RTL DRM channel at 6095 kHz. It consists of two mixer stages with two crystal oscillators. A steep-edged ceramic filter (type CFW45SF with a bandwidth of 12 kHz) provides good IF selectivity. Thanks to the high-impedance design of the circuit, the valves achieve a good overall gain level.

The receiver performance is comparable to that of the Elektor Electronics DRM receiver design published in the March 2004 issue, and it can even surpass the performance of the latter circuit with a short antenna, since the tuned input circuit
allows better matching to be obtained. The key difficulty is obtaining a suitable crystal with a frequency of 6.550 kHz. Old-style FT243 crystals with exactly this frequency are available from American army radio units. However, it takes a bit of luck to obtain a crystal with exactly the right frequency. It's also possible to use a standard crystal with a frequency of 6553.6 kHz, which yields an IF that is 3.6 kHz too high. However, that shouldn't be a problem if a relatively widebandwidth ceramic filter is used. One possibility is the CFW455C, which has a bandwidth of 25 kHz. If the frequency of the second crystal oscillator remains unchanged, the DRM baseband signal will appear at around 9 kHz, approximately 3 kHz below the nominal value. Nevertheless, the signal can easily be decoded by the DREAM software, since it does not depend on the signal being at 12 kHz. Another possibility would be to use the programmable crystal oscillator design published in the March 2005 issue of Elektor Electronics.

Simulator for Bridge Measurements

Bernd Schaedler

The arrangement of resistors shown here can be used to test bridge amplifiers with differential inputs. Such amplifiers are used in conjunction with strain gauges, for example, or in measuring inductances or capacitances. Because of their symmetrical construction, bridges allow the finest variations in the quantity in question (for example, resistance) to be amplified without resorting to complex compensation techniques.

The circuit here simulates small variations in one of the resistors that forms the bridge, as happens in the example of strain gauges. Since only standard metal film resistors are used, it is suitable only for general testing of the connected amplifier. Strain gauges typically have a sensitivity of 2 mV/V. This means that if the supply voltage to the bridge is 10 V, the maximum variation in differential voltage taken from the bridge to the differential amplifier is 20 mV. The resistance of this circuit is rather greater than the 350 Ω typical of strain gauges, but in practice this is not important.

Calibrating the bridge simulator

Ensure that the power supply voltages connected to the positive and negative supply inputs have exactly equal magnitude (+5000 V and -5000 V). Now connect a voltmeter between the negative output and ground and adjust P1 so that the meter reads close to 0 mV as possible. Now connect the voltmeter across the two outputs and set S1 to '0 %'. Adjust P2 until the voltmeter reads close to 0 mV as possible.

Finally, switch S1 to the '25 %', '50 %', '75 %' and '100 %' positions in turn and adjust the corresponding trimmer potentiometers P4 to P7 to obtain voltages of 5 mV, 10 mV, 15 mV and 20 mV respectively, with the voltmeter still connected between the positive and negative outputs. If the variable output is used instead of the positive output, the voltage can be varied continuously over the full positive and negative range using potentiometer P3. Switch S2 allows the polarity of the supply voltage to be reversed.

(3522-1-3)
Code Lock with One Button

Zorislav Miljak

The unusual feature of this code lock is that it can be operated with just one push-button. In situations where a tamper-proof solution is required this circuit has a great financial advantage: only one robust pushbutton needs to be bought. The disadvantage of this solution is that it takes a little longer to enter the code.

The operation of the code lock is as follows. After pressing the button, the PIC16F84 starts to count at a rate of one hertz. The numbers are visible on the LED display. The button is released once the correct number is displayed. This operation is repeated for the other digits in the code. The time between releasing the button and pressing it again for the next digit may not be more than 15 seconds. After the last digit, the letter ‘E’ (Enter) needs to be entered. If the entered code is incorrect, the display will show on ‘F’ (Fault) for 1.5 sec-

COMPONENTS LIST

Resistors:
R1-R8, R11 = 1kΩ
R9 = 100Ω
R10 = 6kΩ

Capacitors:
C1 = 100nF

Semiconductors:
D1 = LED, green, low-current
D2 = 1N4148
IC1 = PIC16F84 [programmed, order code 040481-41*]
LD1 = 7-segment display, red, common-anode [e.g., Kingbright Sc56-11SRWA]
T1 = BC547B

Miscellaneous:
JP1 = 3-way SIL pinheader with jumper
K1 = 3-way PC8 terminal block, lead pitch 5mm
Re1 = relay, 5V coil, [e.g., Omron G6A-234P-ST-US-DC5]
S1 = switch, 1 make contact, tamper proof [see text]
X1 = 4MHz ceramic resonator
PCB, ref. 040481-1 from The PCBShop Disk, source and hex code, order code 040481-11*

* see Elektor SHOP pages or www.elektor-electronics.co.uk
On-demand WC Fan

Ton Giesberts

In most WC's with an extractor the fan is connected to the lighting circuit and is switched on and off either in sympathy with the light or with a short delay. Since toilets are sometimes used for washing the hands or just for a quick look in the mirror, it is not always necessary to change the air in the smallest room in the house. The following circuit automatically determines whether there really is any need to run the fan and reacts appropriately. No odour sensor is needed; we just employ a small contact that detects when and for how long the toilet seat lid is lifted. If the seat lid is left up for at least some presettable minimum time \( t_1 \), the fan is set running for another presettable time \( t_2 \). In the example shown the contact is made using a small magnet on the lid and a reed switch mounted on the cistern. The rest is straightforward: IC2, the familiar 555, forms a timer whose period can be adjusted up to approximately 10 to 12 minutes using P2. This determines the fan running time. There are three CMOS...
NAND gates (type 4093) between the reed switch and the timer input which generate the required trigger signal. When the lid is in the ‘up’ position the reed switch is closed. Capacitor C1 charges through P1 until it reaches the point where the output of IC1a switches from logic 1 to logic 0. The output of IC1b then goes to logic 1. The edge of the 0-1 transition, passed through the RC network formed by C2 and R2, results in the output of IC1c going to logic 0 for a second. This is taken to the trigger input on pin 2 of timer IC2, which in turn switches on the relay which causes the fan to run for the period of time determined by P2.

The circuit is powered from a small transformer with a secondary winding delivering between approximately 8 V and 10 V. Do not forget to include a suitable fuse on the primary side. The circuit around IC1b and IC1c ensures that the fan does not run continuously if the toilet seat lid is left up for an extended period.

The time constant of P1 and C1 is set so that the fan does not run as a result of lavatorial transactions of a more minor nature, where the lid is opened and then closed shortly afterwards, before C1 has a chance to charge sufficiently to trigger the circuit.

Simple Microphone Preamplifier

for Radio Amateurs

Ludwig Libertin

The technical demands on microphones used with radio equipment are not stringent in terms of sound quality: a frequency response from around 50 Hz to 5 kHz is entirely adequate for speech. For fixed CB use or for radio omoteurs sensitivity is a more important criterion, so that good intelligibility can be achieved without always having to hold the microphone directly under your nose. Good microphones with extra built-in amplifiers can be bought, but, with the addition of a small preamplifier, an existing microphone will do just as well. The project described here uses only a few discrete components and is very undemanding. With a supply voltage of between 1.5 V and 2 V it draws a current of only about 0.8 mA. If you prefer not to use batteries, the adopter circuit shown, which uses a 10 kΩ resistor, three series-connected diodes and two 10 μF electrolytic smoothing capacitors, will readily generate the required voltage from the 13.8 V supply that is usually available.

There is little that need be said about the amplifier itself. Either an ordinary dynamic microphone or a cheaper electret capsule type can be connected to the input. In the latter case a 1 kΩ resistor needs to be connected between the 1.5 V supply volt-
9-in-1 Logic Glue / Level Translators

Dirk Gehke

Two logic devices from revered Texas Instruments, the SN74AUP1T97 and '98 are logic glue components in tiny SOT23 cases. As shown in the diagrams, both the AUP1T97 and its inverting counterpart the AUP1T98 can be configured as voltage level translators with nine different logic functions marked by Schmitt trigger inputs. Apart from their logic function, these devices can also act as voltage level translators between low-voltage logic systems, as follows:

<table>
<thead>
<tr>
<th>In</th>
<th>Out</th>
<th>at Vcc</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 V</td>
<td>3.3 V</td>
<td>3.3 V</td>
</tr>
<tr>
<td>2.5 V</td>
<td>3.3 V</td>
<td>3.3 V</td>
</tr>
<tr>
<td>1.8 V</td>
<td>2.5 V</td>
<td>2.5 V</td>
</tr>
<tr>
<td>3.3 V</td>
<td>2.5 V</td>
<td>2.5 V</td>
</tr>
</tbody>
</table>

An example of a level translator could be one converting from 1.8 V LVCMOS to 3.3 V LVITL or LVCMOS. The devices, says TI, are tolerant to slow input transitions and noisy signals.

somewhat cavalier attitude towards distortion: for speech radio the 'f' does not need to be 'h'. Quite the reverse, in fact: the harmonics involved in a few percent of distortion can actually improve intelligibility — it's not a bug, it's a feature!
Universal I/O for Power Amps

Ton Giesberts

This two-part circuit was designed as an addition to the ‘Compact 200 W Output Stage’ in this issue. But it is also suitable for use with IC amplifiers that don’t have their own power-on delay.

The circuit consists of an input stage (nothing more than a resistor and capacitor) and a power-on delay with a relay for the amplifier output.

A small PCB has been designed for the input signal. This board contains a phono socket, capacitor and a resistor that is connected directly across the input. This resistor keeps the input side of the capacitor at ground level. It prevents any offset voltage at the amplifier input from appearing at the input of this circuit when there is no connection. This would otherwise cause a loud bang from the loudspeaker when a connection was made. We have taken account of the larger size of MKP and MKT capacitors. There are several mounting holes on the board to cater for the various sizes of capacitor. The maximum size is 18x27.5x31.5 mm (WxHxL).

To protect a loudspeaker from a DC offset during the switch-on period a relay needs to be connected in series that turns on after a short delay. This circuit also makes use of the falling supply voltage of the amplifier when it is switched off. This concept also makes this circuit suitable to protect against overloads.

The circuit itself is relatively straightforward. MOSFET T1 turns on relay RE1 when the gate-source voltage rises above 2.5 V. The gate voltage is derived directly from the amplifier supply via potential divider R3/R4/P1. P1 is used to adjust the exact level at which the relay turns on.
This is also used to compensate for the tolerance in the MOSFET threshold voltage. The relay operating voltage is limited to about 24 V by resistor R2. D2 restricts the voltage across T1 from rising above 24 V, stopping this voltage from rising too much when the relay is not actuated. It also keeps the voltage at 24 V when a relay with a higher coil resistance is used (see parts list). When a relay with a lower coil resistance is used, the value of R2 needs to be adjusted accordingly. To calculate the value for R2 you should take the minimum acceptable supply voltage, subtract 24 V and divide the result by the current through the relay. This value should then be rounded to a value in the E12 series.

There is room on the PCB for a vertically mounted 5W resistor for R2, so it's even possible to use a 12 V relay (D2 should then be changed to a 12 V type as well). D1 protects T1 from induced voltages when the relay is turned off. The voltage at the gate only reaches its end value slowly due to the addition of D3 and C3. D3 prevents C3 from keeping the MOSFET conducting when the voltage drops. When the voltage has fallen below half the normal supply voltage, C3 starts to discharge via D4. In this way the switch-on delay is at a maximum even when the power is turned off and on repeatedly.

It should be clear that this circuit can only be used with amplifiers that are stable until the threshold voltage is reached and hence do not create an offset at the output before the relay turns off.

Modifying Stripboard for SO Packages

Dirk Gehrke

This technique for modifying standard predrilled prototyping stripboard ('perf-board' or veraboard') to accept SO IC packages is intended to be used for inexpensive breadboard constructions. It provides an economical alternative to using special circuit boards that accept SO packages and increase the lead spacing from 1.27 mm to the 2.54 mm grid spacing. The standard dimensions of SO and plastic DIP packages are shown for comparison in Figure 1 (with metric dimensions in parentheses).

The grid spacing of predrilled stripboard is 2.54 mm. Preadrilled stripboard is available in various sizes with glass-epoxy or paper-phenolic substrate material. It is commonly sold in Eurocard format with dimensions of 100 x 160 mm. To allow an IC in a SO package to be soldered to the predrilled stripboard, a utility knife is used to separate a section of a strip down the middle through the holes, thus reducing the grid spacing from 2.54 mm to 1.27 mm. After being prepared in this manner, the board can accept SO packages. Figure 2 shows a diagram of simple example application using a TL5001 in a SO package. Here the green points and lines represent cuts that must be made using a strip cutter and/or a utility knife.

Components List

| Resistors: |
| R1 = 270kΩ |
| R2 = 1kΩ |
| R3, R4 = 1MΩ |
| P1 = 250kΩ preset |

| Capacitors: |
| C1 = 4μF Mkt or MKP (see text) |
| C2 = 47nF |
| C3 = 10μF 63V radial |

| Semiconductors: |
| D1, D3 = 1N4148 |

| Miscellaneous: |
| K1 = cinch socket, PCB mount, e.g. Monocor / Monarch T1709G |
| K2, K3 = spade terminal, PCB mount, vertical, 2 pins |
| RE1 = PCB relay 24 V/16 A (e.g., Omron G2K-124, 1100 Ω, or Schrack RT314024, 1440 Ω) |
| PCB, ref. 054010-1 from The PCBShop |
| D2 = zener diode 24V 1.3W |
| D4 = 1N4002 |
| T1 = BS170 |

Parts List (24V): K1 = cinch socket, PCB mount, e.g. Monocor / Monarch T1709G, K2, K3 = spade terminal, PCB mount, vertical, 2 pins, RE1 = PCB relay 24 V/16 A (e.g., Omron G2K-124, 1100 Ω, or Schrack RT314024, 1440 Ω), PCB, ref. 054010-1 from The PCBShop, D2 = zener diode 24V 1.3W, D4 = 1N4002, T1 = BS170.
Remote Control Extension using RF

Transmitter

Ton Giesberts

We have, over the years, published numerous variations of remote control extenders in Elektor Electronics, but not yet one using RF. These days, transmit-and-receive modules that operate on the well-known 433-MHz licence-free frequency are reasonably cheap and freely available at electronics stores. The circuit described here makes use of the transmitter/receiver combination available from Conrad Electronics, which stands out because of its low price.

A disadvantage with this setup is the available bandwidth. At 2 kHz this is quite limited, but still sufficient for our purpose.

We assume that the RC5 remote control system from Philips is being used. It is now a little dated but still has many applications, particularly for your own designs.

The minimum pulse width of RC5 amounts to 0.89 ms. The maximum frequency is therefore 562 Hz \( \left( \frac{1}{2 \times 0.89 \times 10^{-3}} \right) \). This still passes reasonably well through the RF link. However, at the receiver some pulse stretching is required.

The transmitter is simplicity itself. IC1 is an IR receiver for remote control systems. The output signal is active low. The pulses at the output, with RC5, have a minimum length of 0.89 ms. The transmitter is activated with an active high signal that is supplied by T1. When IC1 receives a pulse, T1 will leave conduction and the transmitter is turned on via R2.

The little transmitter module has 4 connections: ground, power (3 to 12 V), data input and antenna output. The transmitter module is mounted on our PCB and connected with four pieces of wire. The overlay makes incorrect assembly just about impossible. You can use a piece of wire of about 15.5 cm long (1/4 λ) as the antenna.

Current consumption in the idle state is about 4 mA and about 5.3 mA while transmitting. For the protection of IC1, a 5.1 V zener diode is connected in parallel with its power supply connections. An excessive power supply voltage is then turned into heat via decoupling resistor R1. That means that a power supply voltage of up to 10 V can be connected to the circuit without any problems (with a

COMPONENTS LIST

Resistors:
- R1 = 100Ω
- R2 = 4kΩ

Capacitors:
- C1, C3 = 100μF 10V radial
- C2 = 100nF ceramic

Inductors:
- L1 = 10μH

Semiconductors:
- D1 = zener diode 5V 0.5W
- T1 = BC547B
- IC1 = SFH5110-36

Miscellaneous:
- S1 = miniature slide switch SX254 (Hartmann) (Conrad Electronics # 708062) or 3-way pinheader with jumper
- MOD1 = 433.92 MHz AM transmitter module from Conrad Electronics set, # 130428
- PCB, ref. 054013-1 from The PCBShop
power rating of at least 0.25 W for R4). A disadvantage is that the circuit draws a little less than 50 mA additional current. You can increase the value of R1, of course, when the power supply voltage is always at the high end of the range. The transmitter module can deal with 3 to 12 V and that limits the maximum supply voltage to 12 V.

According to the datasheet, the current consumption of IC1 is 5 mA. In our prototype the current consumption was actually lower, less than 3 mA. R1 is then roughly (U-5.1)/3.5-10^3. However, just to be sure, measure the voltage across the IR receiver and check that it is correct. You can use other devices for IC1, but keep in mind the current consumption and the pinout of the terminals. Another requirement is that the alternative IR-receiver has an active low output and an internal pull-up resistor. C1, L1 and C2 provide additional decoupling and C3 decouples the common power supply. In place of S1 you could just fit a wire link or a 3-way pin header with a jumper. The switch is really only useful when the circuit is powered from batteries. It is likely that the circuit will be placed in a fixed location and a regulated mains adapter as a power supply is more appropriate. On the PCB there is enough space so that IC1 can be fitted horizontally. The electrolytic capacitors can also be placed horizontally, so that the entire assembly can be quite thin, so that it can easily be mounted between, behind or in something.

Cheap Dot-mode Bargraph Display

Rev. Thomas Scarborough

The five-stage linear dot-mode bargraph display shown in here has a number of distinct advantages, which may be summarized as:
- the resistor chain is fully customizable;
- IC1's high input impedance results in minimal loading on circuits;
- IC1 and IC2 have a wide supply voltage range, between 3V and 15V;
- If a higher supply voltage is used, all colour LEDs may be employed with a single ballast resistor R3.

Four op-amp comparators are used to provide a five-stage output, as follows: as the voltage at the signal input rises, so the outputs of comparators IC1A to IC1D go High in succession. This creates the sequence at IC2's binary channel select and output channels shown in the Table. The last binary number in this sequence is created as IC1.D goes High, thus pulling IC2 binary input 1 Low through T1. In this way, five of the (IC2) 8-to-1 analogue multiplexer/demultiplexer output channels are utilized to produce a five-stage linear dot-mode bargraph display. The signal input voltage required to switch any one of IC1's four outputs may be calculated by dividing the supply voltage by the values in the resistor chain. For example, if the supply voltage is 12 V, and all of the resistors in the chain are 10 kΩ, then IC1.C's output pin 8 (and IC2's output channel 6) will swing High as the voltage of the signal input exceeds 12 V x ([R3+R4+R5] x [R1+R2+R3+R4+R5]) = 7.2 V

The only aspect of the circuit which might require special clarification is T1. T1 pulls IC2's binary channel select input 1 Low by

<table>
<thead>
<tr>
<th>IC2 Channel Select</th>
<th>IC2 Output Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 1 0</td>
<td>0 0 0</td>
</tr>
<tr>
<td>0 1 0</td>
<td>1 1 0</td>
</tr>
<tr>
<td>1 1 1</td>
<td>1 0 1</td>
</tr>
</tbody>
</table>

whatever LEDs you have available for the readout. Since the output current of 4000 series CMOS ICs needs to be observed, it is a good idea to use high-efficiency LEDs of the 2-mA class. The value of R3 is calculated from

R3 = (Vb - 2) volts / 3

where the result is in kilo-ohms.
RF Remote Control Extender: Receiver

Ton Giesberts

This circuit works together with a transmitter described elsewhere in this issue to form a remote-control extender. Due to its limited bandwidth, the output of the RF receiver module does not exactly reproduce the original pulses from the IR receiver. That problem is remedied here by the circuit around T1. The modulator circuit for the data received from this stage is active low, so the primary function of T1 is to invert the received signal. However, the stage built around T1 also acts as a pulse stretcher in order to restore the original pulse length. Capacitor C2, which is connected in parallel with P1, charges quickly. The maximum current is limited by R3 to protect T1. The discharge time is determined by P1 and C2, and P1 can be adjusted to compensate for various deviations and tolerance errors. The timing should be matched to the RC5 code with P1 set to approximately its midrange position. In practice, the pulse length also proved to be slightly dependant on the signal strength.

T1 provides the reset signal for a 74HC4060 IC (14-stage binary ripple counter with built-in oscillator). This counter restores the original modulation with a frequency of 36 kHz. Each received pulse starts the oscillator, and a frequency of exactly 36 kHz is present on pin 13 (division factor 2) if the crystal frequency is 18.432 MHz. Other oscillator frequencies can also be selected using J1, and various combinations are possible using other division factors (for 36 kHz, connect a jumper between pins 11 and 12 of J1). At frequencies below 12 MHz, C5 must be replaced by a resistor with a value of 1-2.2 kΩ (fitted vertically). The main reason for including J1 is to allow the remote control extender to be used with other modulation frequencies. The counter output drives a transistor stage (T2) with two IR diodes (type LD271, but other types can also be used). The current through LEDs D1 and D2 is limited to approximately 90 mA by R18. R6 and R7 are connected in parallel with D1 and D2, respectively, to reduce the turn-off time. A normal LED (D3) is connected in parallel with the IR LEDs to provide a supplementary visible indication of a transmitted signal (IR or RF).

The circuit needs nice stiff 5-V supply,
which means that battery operation is not suitable (unless a hefty electrolytic capacitor is connected across the supply terminals). L1 and L2 ensure that the supply voltage for the receiver module is as clean as possible. The quiescent current consumption is approximately 1.3 mA, and it increases to around 8 mA on average with a good received signal level.

Assembling the circuit board (see Figure 2) is straightforward. Naturally, a wire bridge can be used in place of J1 if you only want to use a single IR code. The receiver module is supplied with quite long connection leads and a pre-fitted antenna. It's a good idea to shorten the antenna slightly. With our modules, the length was nearly 18 cm. In practice, a length of 15.5 cm is more suitable at a frequency of 433.92 MHz.

The circuit board is designed to allow the receiver module to be fitted to the board, but we chose to fit it next to the board (along its long axis). That puts the receiver a bit further away from the noise generated by the IR LEDs and the counter, which reduces the interference to signal reception. The module leads are long enough for this. You will also have to experiment with the orientation of the module and the antenna, since the arrangement proved to be critical in practice (the RF aspects, that is).

Simple Cable Tester

Bert Vink

This cable tester allows you to quickly check audio cables for broken wires. Because of the low power supply voltage, batteries can be used which makes the circuit portable, and therefore can be used on location. The design is very simple and well organised: using the rotary switch, you select which conductor in the cable to test. The corresponding LED will light up as indication of the selected conductor. This is also an indication that the power supply voltage is present. If there is a break in the cable, or a loose connection, a second LED will light up, corresponding to the selected conductor. You can also see immediately if there is an internal short circuit when other than the corresponding LEDs light up as well.

You can also test adapter and splitter cables because of the presence of the different connectors. Two standard AA- or AAA-batteries are sufficient for the power supply. It is recommended to use good, low-current type LEDs. It is also a good idea not to use the cheapest brand of connectors, otherwise there can be doubt as to the location of the fault. Is it the cable or the connector?

COMPONENTS LIST

Resistors:
- R1, R2 = 10 kΩ
- R3 = 47 kΩ
- R4 = 1 MΩ
- R5 = 18 kΩ
- R6, R7 = 100 kΩ
- R8 = 470 kΩ
- R9 = 10 kΩ preset

Capacitors:
- C1, C7, C8 = 100 nF ceramic
- C2 = 100 nF MFK
- C3, C4 = 33 pF
- C5 = 1.5 pF
- C6 = 220 µF 25 V radial
- C9 = 100 µF 10 V radial

Inductors:
- L1 = 10 µH
- L2 = 47 µH

Semiconductors:
- D1, D2 = 1D271
- D3 = LED, red, high-efficiency
- T1 = BC547B
- T2 = BC639
- IC1 = 74HC4060

Miscellaneous:
- J1 = 14 (2x7) way pinheader + 1 jumper
- X1 = 18.432 MHz quartz crystal
- MOD1 = 433.92 MHz AM receiver (RX) module from set, Conrad Electronics # 130428
- PCB, ref. 054014-1 from The PCB Shop

(042250-1)
1 MHz

Frequency Counter

H. Breitzke

The XR 2206 function generator chip is a very popular device and forms the basis of many analogue function generator designs. A disadvantage of this chip is that in its most basic configuration the output frequency is adjusted manually by rotating an output frequency control knob and lining it up on a printed scale. Without a frequency counter it is difficult to tell the value of the output frequency, especially at the high end of the scale. The frequency counter design presented here offers a low cost solution to this problem and achieves good accuracy. Power for the circuit is derived from the dc power supply of the existing function generator. The input signal to the counter is taken in parallel from the TTL output of the XR2206. The frequency counter circuit contains an Atmel AT90S2313 microcontroller together with an LCD display. The frequency counter program is written in Basic.

The fundamental components needed to build a frequency counter are a timer, which is used to time an accurate measurement window and a counter to count the number of transitions that the input signal makes during the measurement window period. The microcontroller contains two internal hardware counters of 8 and 16 bit length and these can be configured as either a timer or counter. Operating with a crystal frequency of \(8.388608\) MHz the counter achieves an accuracy of 1 Hz at 1 MHz or with a more readily available 4.194304 MHz crystal the accuracy will be 1 Hz with a 500 kHz input signal.

The 16-bit counter is configured as the frequency counter and the input signal is connected to pin 9 of TTL logic levels. A 16-bit counter can only count to a maximum value of 65536 so to extend its range it software keeps note of the number of counter timer overflow interrupts that occur during the measurement window. At the end of the measurement window it multiplies this value by 65536 and adds it to the current value of the counter:

\[ F \text{ = } \text{int} \times 65536 + \text{Timer} \]

The interrupt rate restricts the maximum input to 1.5 MHz and at this frequency the display will exhibit a jitter of 4 Hz i.e. the displayed frequency will 'wander' by 4 Hz. All input frequencies below 200 kHz should not display any jitter.
The program is written in AVR Basic and is small enough to be compiled and downloaded to the microcontroller by the free demo version of the BASCOM AVR compiler [Download from: www.mcseltec.com]. The single line LCD display interface is designed for a Hitachi 1x6x1 or compatible display. Preset R1 allows adjustment of the display contrast. IC1 provides a regulated 5 V for the microcontroller and display.

The frequency counter accuracy depends on the precision of the crystal and its frequency stability together with capacitors C1 and C2. PAL crystals generally are produced to close tolerances and exhibit low drift. During testing the crystal showed on offset of 60 ppm, which would produce a display error of 60 Hz on a 1 MHz signal. Adjustment of the capacitive loading [C1 and C2] on the crystal was able to ‘pull’ the crystal frequency and reduce the error to zero. At audio frequencies the counter measures to an accuracy of 1 Hz across the entire audio spectrum without any need for circuit alignment.

COMPONENTS LIST

**Resistors:**
- R1 = 10kΩ
- P1 = 1kΩ preset

**Capacitors:**
- C1, C2 = 27pF
- C3 = 1µF / 16V radial
- C4, C6 = 100nF

**Semiconductors:**
- IC1 = 78L05

**IC2 = AT90S2313-10PI, programmed, order code 030045-41**

**Miscellaneous:**
- X1 = 4.194304MHz or 8.388608MHz quartz crystal (see text)
- LCD1 = LCD Module, 1 line, 16 characters
- PCB, ref. 030045-1 from The PCBShop Disk, project software, order code 030045-11 * or Free Download

* see Elektor SHOP pages or www.elektor-electronics.co.uk

---

**High Voltage Regulator**

**Tom Giesberts**

The LR12 made by Supertex Inc. is a good choice for applications where a supply voltage of more than 35 to 40 V needs to be stabilised. This small regulator can cope with input voltages of up to 100 V, when the output voltage can be adjusted between 1.2 and 88 V. A small disadvantage is that the input voltage needs to be at least 12 V more than the output voltage.

The regulator keeps the voltage between the output and adjust pin constant at 1.2 V. With a potential divider the output voltage can be set using the following equation:

\[ V_{out} = 1.2 \times (R2 / R1 + 1) + I_{adj} \times R2. \]

The circuit shows a standard application where the LR12 is used as a 5 V regulator. C1 decouples the input voltage. Its value and working voltage depend on the input voltage and the current consumption. The bypass capacitor (C2) is required to keep the LR12 stable. In cases where the voltage at the input may be smaller than at the output an extra protection diode is required, for example a 1N4004.

The output current of the IC needs to be at least 0.5 mA. In the circuit shown here the potential divider made by R1/R2 already draws 0.2 mA. This means that with a 5 V output the load resistor needs to be less than 16 kΩ.

Higher, the total output current drops below the required value of 0.5 mA. The output current of the LR12, with a 12 V difference between input and output, is limited to 100 mA (max. dissipation of a TO92 package: 0.6 W at 25 °C). The ripple suppression is at least 50 dB. The current consumption of the IC itself is very low at only 5 to 15 µA.
Klaus-Jürgen Thiesler

This pulse generator, which offers a mark-space ratio that is adjustable in exponentially increasing steps, is a novel use for a familiar IC. It can come in handy in a range of situations: for example, when testing the dynamic regulation characteristics of a power supply. In this test a load is applied to a power supply that draws a square-wave, rather than constant, current. An oscilloscope can then be used to check how quickly the regulator in the power supply responds and to observe any undesirable artefacts in the output such as overshoots or oscillation. A disadvantage of such an arrangement is that the dynamic characteristics of the power supply are only measured at one average current, determined by the mark-space ratio of the current and by its maximum value. Modern computers, for example, draw varying amounts of current depending on what they are doing, and the current can vary over very short timescales. A modern PC power supply must therefore deliver accurate and stable voltages not only under high and intermediate load, but also at low load (in standby mode).

The PDM pulse generator is ideal for this situation. As can be seen from the table, S1 allows the mark-space ratio to be adjusted from 1:17 to 1:2. The frequency varies from 566 Hz to 302 Hz, making it suitable for testing PC power supplies. The variation in frequency with mark-space ratio is a consequence of how the circuit works.

At the heart of the circuit is our old friend the CMOS 4060. This includes an RC oscillator circuit and a 14 bit binary counter. The basic clock frequency, which can be calculated using the formula shown, is around 77 kHz for the given values of R1 and C1. The space time is constant at around 1660 μs. When the IC is reset, all outputs are initially low. Consider now the voltage at the gate of T1. If it were not for D1, when Q7 goes high after the 128th clock pulse (the divide-by-2^8 output spends 128 clock periods low and then 128 periods high) IC1 would be reset immediately via R3, T1, and therefore the load, would thus receive extremely short pulses with long pauses between. Because of the switching speed of the IC, the width of the pulses would only be of the order of the ten nanoseconds. A low level via D1 and S1, however, delays the resetting of the IC for exactly as many clock periods as it takes for the output selected by S1 to go high. For example, if Q3 is selected, this happens after a further eight periods. The cycle time is then 128 + 8 clock periods, of which 128 clock periods are space and just eight are mark. This gives a duty cycle, as shown in the table, of 8/136 or 1/17. If Q6 were used the pulse would be 0.5 x 2^7 = 64 clock periods wide with...

---

**Table 1. Pulse width in exponentially increasing steps**

<table>
<thead>
<tr>
<th>Switch position</th>
<th>CLR pin connected to</th>
<th>Duty cycle as percentage</th>
<th>Duty cycle as a fraction **</th>
<th>Frequency * Hz</th>
<th>Period * ps</th>
<th>Pulse width * ps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Q 3</td>
<td>5.9 % approx.</td>
<td>1/17</td>
<td>566</td>
<td>1765</td>
<td>103</td>
</tr>
<tr>
<td>2</td>
<td>Q 4</td>
<td>11 1/4 %</td>
<td>1/9</td>
<td>535</td>
<td>1868</td>
<td>207</td>
</tr>
<tr>
<td>3</td>
<td>Q 5</td>
<td>20,0 %</td>
<td>1/5</td>
<td>480</td>
<td>2082</td>
<td>415</td>
</tr>
<tr>
<td>4</td>
<td>Q 6</td>
<td>33 1/3 %</td>
<td>1/3</td>
<td>401</td>
<td>2495</td>
<td>830</td>
</tr>
<tr>
<td>5</td>
<td>GH9</td>
<td>50,0 %</td>
<td>1/2</td>
<td>302</td>
<td>3320</td>
<td>1660</td>
</tr>
</tbody>
</table>

* = measured to ±1 in last digit

** = see text (duty cycle is mark time as a proportion of period, a dimensionless quantity)
the same space period of 128 clocks. The duty cycle in this case is 1/3. If the cathode of D1 is tied to ground, the IC does not receive a reset signal and so a symmetrical square wave with a 128-clock mark and 128-clock space is produced. T1 functions as a power switch. Load R4 is chosen so that the maximum rated current of the power supply flows when T1 conducts. The average load on the power supply can be calculated using the duty cycle values given in the table. It should go without saying that the current drawn must be within the specification of the power supply, and that R4 must be capable of the necessary power dissipation. At higher currents a heatsink is recommended for T1. It can pass a maximum of 60 A and although it has a very low resistance in the conducting state (just 18 mΩ) it is no superconductor! At currents above about 10 A it starts to get warm. The oscilloscope trace shows the circuit operating at one of the possible mark-space ratios. The upper trace is the basic clock on pin 11 of IC1, and the lower trace shows the signal at test point A, which has a duty cycle of 1/5.

Low-cost Step-down Converter

with Wide Input Voltage Range

Dirk Gehrke

The circuit described here is mostly aimed at development engineers who are looking for an economical step-down converter which offers a wide input voltage range. As a rule this type of circuit employs a step-down converter with integrated switching element. However, by using a more discrete solution it is possible to reduce the total cost of the step-down converter, especially when manufacturing in quantity. The TLS001A is a low-cost PWM controller which is ideal for this project.

The input voltage range for the step-down converter described here is from 8 V to 30 V, with an output voltage of 5 V and a maximum output current of 1.5 A.

When the input voltage is applied the PWM output of IC1 is enabled, taking one end of the voltage divider formed by R1 and R2 to ground potential. The current through the voltage divider will then be at most 25 mA; this value is obtained by dividing the maximum input voltage (30 V) minus the saturation voltage of the output driver (2 V) by the total resistance of the voltage divider (1.1 kΩ). T1 and T3 together form an NPN/PNP driver stage to charge the gate capacitance of P-channel MOSFET T2 as quickly as possible, and then, at the turn-off point, discharge it again.

The base-emitter junction of T3 goes into a conducting state when the PWM output is active and a voltage is dropped across R2. T3 will then also conduct from collector to emitter and the gate capacitance of T2 will be discharged down to about 800 mV. The P-channel MOSFET will then conduct from drain to source. If the open-collector output of the controller is deactivated, a negligibly small current flows through resistor R2 and the base of T1 will be raised to the input voltage level. The base-emitter junction of T1 will then conduct and the gate capacitance of T2 will be charged up to the input voltage level through the collector and emitter of T1. The P-channel MOSFET will then no longer conduct from drain to source. This driver circuit constructed from discrete components is very fast, giving very quick switch-over times.

Diodes D2 and D3 provide voltage limiting for the P-channel MOSFET, whose maximum gate-source voltage is 20 V. If the Zener voltage of diode D2 is exceeded it starts to conduct; when the forward voltage of diode D3 is also exceeded, the two diodes together clamp the gate-source voltage to approximately 19 V.

The switching frequency is set at approximately 100 kHz, which gives a good compromise between efficiency and component size. Finally, a few notes on component selection. All resistors are 1/16 W, 1%. Apart from electrolytic C1 all the capacitors are ceramic types. For the two larger values (C2 and C5) the following are used:

- **C2** is a Murata type GRM21BR71C105KA01 ceramic capacitor, 1 µF, 16 V, X7R, 10%.
- **C5** is a Murata type GRM32ER60J476ME20 ceramic capacitor, 47 µF, 6.3 V, X5R, 10%.

**D1** (Fairchild type MBR340T3) is a 40 V/3 A Schottky diode. Coil L1 is a Wirth WEPD power choke type 744771417, 47 µH, 2.21 A, 75 mΩ.

**T1** (BC846) and **T3** (BC856) are 60 V, 200 mA, 310 mW complementary bipolar transistors from Vishay. The TLS001A/ID (IC1) is a low-cost PWM controller with an open-collector output from Texas Instruments.
Noise Suppression for R/C Receivers

Paul Goossens

Receiver interference is hardly an unknown problem among model builders. Preventive measures in the form of ferrite beads fitted to servo cables are often seen in relatively large models and/or electrically driven models, to prevent the cables from acting as antennas and radiating interference to the receiver.

If miniature ferrite beads are used for this purpose, the connector must be first be taken apart, after which the lead must be threaded through the bead (perhaps making several turns around the core) and then soldered back onto the connector. An interference source can also cause problems in the receiver via the power supply connection. The battery is normally connected directly to the receiver, with the servos in turn being powered from the receiver. The servos can draw high currents when they operate, which means they can create a lot of noise on the supply line. This sort of interference can be kept under control by isolating the supply voltage for the receiver from the supply voltage for the servos.

All of these measures can easily be implemented 'loose' in the model, but it's a lot nicer to fit everything onto a single small circuit board. That makes everything look a lot tidier, and it takes up less space. The schematic diagram is shown in Figure 1. Connectors K1–K8 are located at the left. They are the inputs for the servo signals, which are connected to the receiver by the servo leads. The outputs (K9–K16) are located on the right. That is where the servos are connected. Finally, the battery is connected to K17.

Interference on the supply voltage line due to the motors and servos is suppressed by a filter formed by L10, R1, C1 and C2. L10 is a ferrite-core coil with an impedance of 2000 ohms at 30 MHz. In combination with C1 and C2, it forms a substantial barrier to interference in the 35-MHz R/C band. Signals with frequencies close to the 10.4-MHz intermediate frequency (which is used in many receivers) are also effectively blocked by this filter.

L9 filters out common-mode noise on the supply line for the servos, which effectively means that it prevents the supply lines to the servos from acting as antennas. Finally, high-frequency currents on the servo signals are filtered out by ferrite beads in order to limit the antenna effects of these connection lines.
COMPONENTS LIST

Resistor:
R1 = 1Ω

Capacitors:
C1 = 100nF
C2 = 22pF

Miscellaneous:
L1-L8, L10 = ferrite inductor, SMD
1206 (e.g. Digkey # PMC1206-202-ND)
L9 = common-mode coil (e.g., Digkey
# CM1011-254-ND)
K1-K8 = servo cable
K9-K17 = 3-way SIL pinheader
PCB, ref. 054018-1 from ThePCBShop

EE-ternal Blinker

Burkhard Koinka

You occasionally see advertising signs in shops with a blinking LED that seems to
blink forever while operating from a single
battery cell. That's naturally an irre-
sistible challenge for a true electronics
hobbyist...

And here's the circuit. It consists of an
astable multivibrator with special proper-
ties. A 100µF electrolytic capacitor is
charged relatively slowly at a low current
and then discharged via the LED with a
short pulse. The circuit also provides the
necessary voltage boosting, since 1.5 V
is certainly too low for an LED.

The two oscillograms demonstrate how the
circuit works. The voltage on the collector
of the NPN transistor jumps to approxi-
mately 1.5 V after the electrolytic capacitor
has been discharged to close to 0.3V at this
point via a 10kΩ resistor. It is charged to
approximately 1.2 V on the other side. The
difference voltage across the electrolytic
capacitor is thus 0.9 V when the blink pulse
appears. This voltage adds to the battery
voltage of 1.5 V to enable the amplitude of
the pulse on the LED to be as high as 2.4 V.
However, the voltage is actually limited to
approximately 1.8 V by the LED, as shown
by the second oscillogram. The voltage
across the LED automatically matches the
voltage of the LED that is used. It can theo-
retically be as high as 3 V.

The circuit has been optimised for low-
power operation. That is why the actual
flip-flop is built using an NPN transistor
and a PNP transistor, which avoids wast-
ing conduction current. The two transis-
tors only conduct during the brief interval
when the LED blinks. To ensure stable
operating conditions and reliable oscilla-
tion, an additional stage with negative
DC feedback is included. Here again,
especially high resistance values are used
to minimise current consumption.

The current consumption can be estimated
based on the charging current of the electro-
lytic capacitor. The average voltage
across the two 10kΩ charging resistors
is 1 V in total. That means that the aver-
age charging current is 50 µA. Exactly
the same amount of charge is also drawn
from the battery during the LED pulse. The
average current is thus around 100 µA.
If we assume a battery capacity of
2500 mAh, the battery should last for
around 25,000 hours. That is more than
two years, which is nearly an eternity. As
the current decreases slightly as the bat-
tery voltage drops, causing the LED to
blink less brightly, the actual useful life could be
even longer. That makes it more than
(almost) eternal.
**Slave Flash with Red-Eye Delay**

Paul Goossens

Digital cameras are becoming more and more affordable. At the economy end of the market, cameras are usually equipped with a small built-in flash unit that is ideal for close-ups and simple portraiture. The power rating of the built-in flash unit is quite low so that any subject further away than about 2 to 3 metres (maybe 4 m if you are lucky) tends to disappear into the glaam. You soon become aware of the limitations if you need to photograph a larger group of people say at a function under artificial light in a large hall or outdoors. The majority of these cameras are not fitted with an accessory socket so it is not possible to simply connect a second flash unit to increase the amount of light. Single lens reflex cameras also need additional lighting (e.g. fill-in flash) to reduce the harsh contrast produced by a single light source. For all these cases an additional slave flashgun is a useful addition to the equipment bag. Rather than shelling out lots of cash on a professional slave flashgun, the circuit here converts any add-on flashgun into a slave flash unit triggered by light from the camera flash. Simple slave flash circuits can have problems because most modern cameras use a red eye reduction pre-flash sequence. This pre-flash is useful for portraiture. It is designed to allow time for the subjects pupils to contract so that the red inner sur-

**COMPONENTS LIST**

- **Resistors:**
  - R1, R3 = 100kΩ
  - R2 = 100Ω
  - R4, R5 = 220kΩ
  - R6 = 1kΩ

- **Capacitors:**
  - C1, C3 = 10pF 16 V radial
  - C2, C4 = 100nF
  - C5 = 47nF

**Semiconductors:**
- D1 = TLRH180P (Farnell # 352-5451)
- D2, D3 = BAT85
- IC1 = 4538P
- IC2 = MOC3020
- T1 = BC547B

**Miscellaneous:**
- B1 = two 1.5V batteries (LR44) with PCB mount holder
- S1 = 3-position slide switch
- PCB, ref. 0400701 from the PCBShop
- Cable or adaptor for external flasher

---

![Diagram of the circuit](image-url)
era flash will trigger both monolops IC1a and IC1b. The output of IC1.A does not perform any useful action in this mode because the logic level on the other side of resistor R4 is pulled high by D3. The output of IC1.B will go high for approximately 10 ms switching T1 on and causing the triac to conduct and trigger the slave flash. The use of a triac optocoupler here has the advantage that the circuit can be used with other types of flashgun triggered by switching a voltage of around 100 V as well as newer types that require only a few volts to be switched.

With switch S1 in the delay position the first flash will trigger IC1.A and its output will enable IC1.B but the low pass characteristics of the filter formed by R4 and C5 slow the rising edge of this waveform so that IC1.B will only be enabled 10 ms after the first flash is detected. IC1.B is now enabled for a period of about 1 s (governed by R1 and C3). When the main flash occurs in this time window it will immediately trigger IC1.B and the triac will be switched as described above. The circuit requires a supply of 3 V and draws very little current from the two 1.5 V button cells. It will run continuously for quite a few days, should it be accidentally left on. Switch S1 can be either a three-position toggle or slider type.

Circuit construction is greatly simplified and the finished unit looks much neater if it is built on the available PCB. Space is also provided to fit the PCB mounted battery holders. A suitable flash extension cable or adapter can be found in most photo shops.

---

**Short-Wave Converter**

**Burkhard Kainka**

This short-wave converter, which doesn't have a single coil requiring alignment, is intended to enable simple medium-wave receivers to be used to listen to short-wave signals. The converter transforms the 49-m short-wave band to the medium-wave frequency of 1.6 MHz. At the upper end of the medium-wave band, select an unoccupied frequency that you want to use for listening to the converted short-wave signals. Good reception performance can be obtained using a wire antenna with a length of one to two metres.

The converter contains a free-running oscillator with a frequency of around 4.4 MHz, which is tuned using two LEDs (which act as variable-capacitance diodes) and a normal potentiometer. The frequency range is set by adjusting the emitter current using a 1-kΩ trimpot. The oscillator frequency depends strongly on the operating point. This is due to the combination of using an audio transistor and the extremely low supply voltage. Under these conditions, the transistor capacitances are relatively large and strongly dependent on the operating point.

The second transistor forms the mixer stage. If you calculate the resonant frequencies of the tuned circuits, you will obtain 6.7 MHz for the antenna circuit and 1.7 MHz for the output circuit. Additional transistor capacitances and the effects of the coupling capacitors shift each of the resonant frequencies downward. The tuned circuits are relatively heavily damped to obtain bandwidths that are large enough to allow the circuit to be used without any specific alignment. The results are good despite the low collector-emitter voltage of around only 0.6 V, due to the fact that only a modest amount of mixer gain is necessary. The entire circuit also draws less than 1 mA.
Elektor’s online services have been restyled and extended within a brand new easy to use website. Now featuring Elektor News Service, Forum, Marketplace, Online Shop and several download options.

MAGAZINE

• indexed article archive back to 1998
• summary for easy recognition
• search articles by volume or keyword

restyled and extended

www.elektor-elektronics.com
An efficient and economical method to control the power into a load (for example the speed of a motor or the temperature of a heating element) is to use PWM (Pulse Width Modulation). But things are a little bit more involved if we want an accurate adjustment from 0 to 100 % and an indication of the power.

A little 8-pin microcontroller can do these tasks easily: generating a PWM signal and indicating the power via a 4017 (see schematic).

This configuration of the microcontroller does not require an external reset circuit (so that there is a spare pin), because we use the automatic internal one. A quartz crystal is not required either, since we’re using the integrated 4-MHz oscillator, which despite being based on an RC network, is accurate to 1 % thanks to the calibration carried out at the factory.

Once the microcontroller has been provided with a suitable program, it can carry out the instructions from the user by
means of two pushbuttons. A PWM signal with a frequency of 100 Hz is generated, while the power is indicated with a classical 4017.

The circuit can be kept very simple because the microcontroller carries out all the complicated tasks. A 78105 provides the power supply, a 4017 for the indicator and a pair of MOSFETs for the power stage.

Connector K1 receives the input power supply voltage (9 to 12 V at 1 to 5 A). The load to be controlled is connected to K2.

With 2 pushbuttons we can control the power in steps of 10%. To stop immediately, both need to be pressed at the same time. That concludes the user manual.

A special feature of the circuit is the power indication with the 4017 and 10 LEDs. When first powered up, a back-and-forth running light indicates that the circuit is powered but the output is not active. As soon as the load is switched on with pushbutton S1, the first LED (10%) will light up. The correct operation of the circuit is indicated in an eye-catching manner by flashing the LED that indicates the power, using pin 3 of the controller.

The program is of a very simple design and the source code together with the hex file are available from the Elektor Electronics website or on a floppy disk (order code 050056-11). You are free to add improvements, because there is plenty of space left in the program memory of the controller.

To compile the code (written in C) you can use the evaluation version of the CCSX-compiler (limited to 1024 words, which in our case is more than enough). This is available from the website www.blend.com/cc5x [choose the Free Edition]. Another handy piece of freeware is the ComText editor. It can be found at www.comtext.cx.

If you would like to experiment with the circuit, it is recommended to use the reprogrammable 12F529. In this case R3 is required. It is not necessary when a 12x508 is used.

When programming, don’t forget to check that all the fuses are configured correctly:

- Oscillator: Internal RC
- WatchDog Timer: ON
- Master_Clear_Enable: Internal Code_Protect: OFF

This is particularly important when using the 12C508, because this is an OTP-type (can be programmed only once).

---

**COMPONENTS LIST**

**Resistors:**
- R1 = 100 kΩ
- R2, R3 = 4 kΩ
- R4 = 220 kΩ

**Capacitors:**
- C1 = 220μF 25V
- C2 = 10μF 25V
- C3-C6 = 100 nF

**Semiconductors:**
- D1 = 1N5408
- D2 = 1N4148
- D3-D7 = LED, 3 mm, green
- D8-D12 = LED, 3 mm, red
- T1 = IRFZ34N
- T2 = BS170
- ICl = 78105
- IC2 = PIC 12C508-I/P
- IC3 = CD 4017

**Miscellaneous:**
- K1,K2 = 2-way PCB terminal block, lead pitch 5 mm
- S1, S2 = pushbutton, 1 make contact, 0.5 mm
- F1 = 2 AT (time lag) fuse with PCB mount holder
- Heatsink type SK104 (Fischer)
- PCB, ref. 050056-1 from The PCBshop
- Disk, PIC source and hex code: order code 050056-11 or Free Download
The PAL, NTSC and SECAM television standards are all several decades old. Even in this digital era, most people still have television sets that use complex analogue signals complying with these standards.

Nevertheless, the end is nigh for these standards. The DVI standard is on its way to becoming the new standard for transmitting video information. The most important property of this interface is that the information is transferred in digital form (24-bit words) instead of in the form of analogue signals.

Figure 1 shows how the required signals are divided into three data streams in a single-link interface, along with a clock signal. In DVI terminology, the clock signal is called 'Channel C'. A double-link interface with three additional information channels has also been specified to double the bandwidth. Whether these three additional channels are actually used depends on the selected resolution and repetition rate. Each channel consists of a differential signal pair. That makes this interface significantly less sensitive to interference. The technology behind these differential signal pairs is called 'transition-minimized differential signalling', or TMDS for short. Figure 2 shows how the signals are generated in electronic terms. The connector and associated signal names are shown in Figure 3 and Table 1. Besides the six TMDS signal pairs and clock signal (seven pairs in total), there are several other signals on the connector. DDC Clock and DDC Data allow a connection to be established in accordance with the DDC protocol. That protocol allows a connected device to determine which resolutions and frequencies the monitor can handle. The Hot Plug Detect signal makes it easy to recognise whether a monitor is connected. The +5-V line naturally does not need much explanation. Besides all these digital signals, the (old-fashioned) analogue RGB signals and associated sync signals are still present. Unfortunately, the illustrated connector is not the only type that is available. The illustrated connector is a DVH connector. It can transport both analogue and digital signals. There is also a DVI-D (digital only) and DVI-A (analogue only) connector. With the digital version, when you acquire a monitor or playback equipment you have to check both types of equipment to see whether they use a double-link interface (six data channels) or a single-link interface (three data channels).

The DVI 1.0 standard supports several different resolutions. They are listed in Table 2. Each resolution can also be

---

**Table 1. DVI interface connector pin assignments**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Pin</th>
<th>Signal</th>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TMDS Data2 –</td>
<td>9</td>
<td>TMDS Data 1 –</td>
<td>17</td>
<td>TMDS Data 0 –</td>
</tr>
<tr>
<td>2</td>
<td>TMDS Data2 +</td>
<td>10</td>
<td>TMDS Data 1 +</td>
<td>18</td>
<td>TMDS Data 0 +</td>
</tr>
<tr>
<td>3</td>
<td>TMDS Data2/4 shield</td>
<td>11</td>
<td>TMDS Data 1/3 shield</td>
<td>19</td>
<td>TMDS Data 0/5 shield</td>
</tr>
<tr>
<td>4</td>
<td>TMDS Data 4 –</td>
<td>12</td>
<td>TMDS Data 3 –</td>
<td>20</td>
<td>TMDS Data 5 –</td>
</tr>
<tr>
<td>5</td>
<td>TMDS Data 4 +</td>
<td>13</td>
<td>TMDS Data 3 +</td>
<td>21</td>
<td>TMDS Data 5 +</td>
</tr>
<tr>
<td>6</td>
<td>DDC clock</td>
<td>14</td>
<td>+5 V supply</td>
<td>22</td>
<td>TMDS clock shield</td>
</tr>
<tr>
<td>7</td>
<td>DDC data</td>
<td>15</td>
<td>Ground</td>
<td>23</td>
<td>TMDS clock +</td>
</tr>
<tr>
<td>8</td>
<td>Analog Vertical Sync</td>
<td>16</td>
<td>Hot Plug Detect</td>
<td>24</td>
<td>TMDS clock –</td>
</tr>
<tr>
<td>C1</td>
<td>Analog Red</td>
<td>C2</td>
<td>Analog Green</td>
<td>C3</td>
<td>Analog Blue</td>
</tr>
<tr>
<td>C4</td>
<td>Analog Horizontal Sync</td>
<td>C5</td>
<td>Analog ground</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Paul Goossens

eluktor - 7/8/2005

DVI Interface

---

Associated sync signals are still present. With the digital version, when you acquire a monitor or playback equipment you have to check both types of equipment to see whether they use a double-link interface (six data channels) or a single-link interface (three data channels). The DVI 1.0 standard supports several different resolutions. They are listed in Table 2. Each resolution can also be
used with a variety of repetition rates, which are 60 Hz, 75 Hz and 85 Hz. That's a good selection of options, which (unfortunately) also makes for a good chance of confusion among consumers.

**CCO Metal Detector**

Rev. Thomas Scarborough

To the best of the author's knowledge, the metal detector shown here represents another new genre. It is presented here merely as an experimental idea, and operates in conjunction with a Medium Wave radio.

If a suitable heterodyne is tuned in on the medium waves, its performance is excellent. An old Victorian penny, at 180 mm, should induce a shift in frequency of one tone through the radio speaker. This suggests that the concept will match the performance of induction balance (IB) detector types, while employing a fraction of the components.

In principle, the circuit is loosely based on a transformer coupled oscillator (TCO), a well known oscillator type. This essentially consists of an amplifier which, by means of a transformer, feeds the output back to the input, thus sustaining oscillation. On this basis, the author has named the detector a Coil Coupled Operation (CCO) Metal Detector.

In fact the circuit would oscillate even without L2 and C1. However, in this case one would have nothing more than a beat frequency operation (BFO) detector. Coil L2 is added to bring the induction balance principle into operation, thus modifying the signal which is returned to the output, and greatly boosting performance.

This does not mean, however, that we are dealing strictly with an IB detector type, since the design requires a beat frequency oscillator for detection. Also, unlike IB, its Rx section (L2) is active rather than passive, being an integral part of a TCO. Nor is this strictly a BFO type, since its performance for outstrips that of BFO, and of course it uses two coils.

Search oscillator IC1 oscillates at around 480 kHz, depending on the positioning of the coils on the search head. The presence of metal induces changes both in the inductance and coupling of the two coils, thereby inducing a shift in oscillator IC1's frequency.

The output (pin 6) is taken via a screened cable to a Medium Wave radio aerial. A crocodile clip termination would make a convenient connection.

The two coils are each made of 50 turns 30swg [0.315mm] enamelled copper wire, wound on a 120mm diameter former. Each has a Faraday shield, which is connected to OV as shown. A sketch of the coil is shown in the separate drawing. The coils are positioned on the search head to partly overlap one another, in such a way as to find a low tone on the best heterodyne, which should match the performance mentioned above.

Oscillator IC1 will sustain oscillation no matter which way the coils are orientated — however, orientation significantly affects performance. The correct orientation may be determined experimentally by flipping one of the coils on the search head. Ideally, the coils will eventually be potted in polyester resin.

The CCO Metal Detector's search head offers a wide area of sensitivity, so that it is better suited to sweeping an area than pinpointing a find. As with both BFO and IB, it offers discrimination between ferrous and non-ferrous metals, making it well suited to 'treasure hunting'. And if you get fed up with searching, there's always the radio to listen to.
Balancing LiPo Cells

Paul Goossens

Things change fast in the electronics world, and that's also true for rechargeable batteries. The rate of development of new types of rechargeable batteries has been accelerated by the steadily increasing miniaturisation of electronic equipment.

LiPo cells have conquered the market in a relatively short time. Their price and availability have now reached a level that makes them attractive for use in DIY circuits.

Unlike its competitors Elektor Electronics has already published several articles about the advantages and disadvantages of LiPo batteries. One of the somewhat less well-known properties of this type of rechargeable battery is that the cells must be regularly 'balanced' if they are connected in series. This is because no two cells are exactly the same, and they may not all have the same temperature. For instance, consider a battery consisting of a block of three cells. In this case the outer cells will cool faster than the cell in the middle. Over the long term, the net result is that the cells will have different charge states. It is thus certainly possible for an individual cell to be excessively discharged even when the total voltage gives the impression that the battery is not fully discharged. That requires action - if only to prolong the useful life of the battery, since LiPo batteries are still not all that inexpensive.

One way to ensure that all of the cells have approximately the same charge state is limit the voltage of each cell to 4.1 V during charging. Most chargers switch over to a constant voltage when the voltage across the battery terminals is 4.2 V per cell. If we instead ensure that the maximum voltage of each cell is 4.1 V, the charger can always operate in constant-current mode.

When the voltage of a particular cell reaches 4.1 V, that cell can be discharged until its voltage is a bit less than 4.1 V. After a short while, all of the cells will have a voltage of 4.1 V, with each cell thus having approximately the same amount of charge. That means that the battery pack has been rebalanced.

The circuit (Figure 1) uses an IC that is actually designed for monitoring the supply voltage of a microcontroller circuit.

The IC (IC1) normally ensures that the microcontroller receives an active-high reset signal whenever the supply voltage drops below 4.1 V. By contrast, the output goes low when the voltage is 4.1 V or higher.

In this circuit the output is used to discharge a LiPo cell as soon as the voltage rises above 4.1 V. When that happens, the push-pull output of IC1 goes low, which in turn causes transistor T1 to conduct. A current of approximately 1 A then flows via resistor R1. LED D2 will also shine as a sign that the cell has reached a voltage of 4.1 V.

The function of IC2 requires a bit of explanation. The circuit built around the four NAND gates extends the 'low' interval of the signal generated by IC1. That acts as a sort of hysteresis, in order to prevent IC1 from immediately switching off again when the voltage drops due the internal resistance of the cell and the resistance of the wiring between the cell and the circuit. The circuitry around IC2 extends the duration of the discharge pulse to at least 1 s.

Figure 2 shows how several circuits of this type can be connected to a LiPo battery. Such batteries usually have a connector for a balancing device. If a suitable connector is not available, you will have to open the battery pack and make your own connections for it. The figure also clearly shows that a separate circuit is necessary for each cell.
Plant Growth Corrector

Paul Goossens

House plants can make things more pleasant and cheerful. However, they have the drawback that they require a fair amount of care, since otherwise their life expectancy is usually quite short. This care is not limited to watering them and occasionally adding a bit of fertilizer to the soil. The problem is that sun-loving plants always try to grow toward the source of sunlight. Regular rotation of these plants can prevent them from growing crooked.

That’s not especially difficult with small plants, but it can be a highly unpleasant (and difficult) task with large types, which often have large pots as well.

It’s even worse if the plants are located in the garden. These plants always try to grow toward the south (or far readers located south of the equator, toward the north; readers located close to the equator don’t have to worry about this!).

One solution is to place a light source on the side of the plant that receives the least amount of sunlight. As the selected light source must be energy-efficient, a standard grow lamp is out of the question. LEDs, by contrast, are a very good choice for this application. Plants contain three different substances that can extract energy from incident light. From Figure 1, it can be seen that blue light can be used as a source of energy by all three substances. Red light can only be used by chlorophyll a and chlorophyll b. From this, it can be deduced that blue light is the most suitable source of light for plants, but red light is also quite usable. That’s quite fortunate, because red LEDs are a lot cheaper than blue LEDs.

The circuit shown in Figure 2 can be used as a guide for building your own plant lamp. The AC voltage at the transformer output is converted into a DC voltage by bridge rectifier B1. C1 smoothes this voltage to produce a more constant voltage across the resistor and LEDs. R1 ensures that the proper current flows through the LEDs. These LEDs emit energy in the form of red light. No component values are given here, since suitable values must be selected according to your particular wishes.

The first thing you need to know is the nominal current rating of the LEDs and the voltage across each LED at the nominal current. The total voltage across the LEDs is then:

\[ V_{LED\text{total}} = V_{LED} \times \text{(number of LEDs)} \]

You should ensure that at least 5% of this voltage appears across R1, which means that:

\[ V_{R1\text{min}} = 0.05 \times V_{LED\text{total}} \]

The voltage across C1 is approximately 1.4 times the output voltage of the transformer, so the secondary voltage of the transformer must be

\[ V_{ac} = \left( V_{R1\text{min}} + V_{LED\text{total}} \right) + 1.4 \]

Select a transformer that can provide at least this voltage at the desired nominal current.

Now you can calculate the actual voltage across R1:

\[ V_{R1} = (1.4 \times V_{\text{ac min}}) - V_{LED\text{total}} \]

Finally, calculate the value of R1:

\[ R_1 = V_{R1} \div I_{\text{nominal}} \]

R1 also has to dissipate a certain amount of power, so you have to first calculate this in order to determine what type of resistor to use for R1:

\[ P_{R1} = V_{R1} \times I_{\text{nominal}} \]

The value of C1 is not especially critical. Something between 100 µF and 1000 µF is a good guideline value. Ensure that the capacitor is suitable for use with the selected supply voltage.
DON'T LOSE YOUR TEMPER

Before phoning us - if you are looking for a hard-to-find part. We have over 20,000 items in stock - including obsolete and up-to-date parts.

WHY NOT VISIT OUR WEBSITE
www.cricklewoodelectronics.com

CD-ROM Robotics

A large collection of data-sheets, software tools, tips, tricks and internet links to assorted robot constructions and general technical information. All aspects of modern robotics are covered, from sensors to motors, mechanical parts to microcontrollers, not forgetting matching programming tools and libraries for signal processing. Robots built from LEGO® bricks also get a fair amount of attention.

See also www.elektor-electronics.co.uk

Forest Electronics - PIC and AVR C Compiler Products

FED's ANSI C Compiler for PIC or AVR processors
- Fully integrated editor with syntax highlighting, multiple pages etc.
- Full project support - include and manage multiple source files, simulator, assembler files and notes/comments within one project
- Fully integrated simulator and waveform analyser step from C line to C line, or examine code in assembler form. View device pins using a logic analyser application.
- Simulator supports LCD modules, keypad, buttons, LED's, displays, analogue inputs, serial and asynchronous data and more.
- Designed to ANSI C standards
- PIC - Supports 18xxx, 16xxx. 1200 series 14 and 16 bit core processors
- AVR - Supports standard and MEGA core processors
- Generates MPLAB/AVR Studio projects and source files and completely standard hex output files.

WIZ-C / AVIDICY

Drag and Drop rapid application development using ANSI C for PIC and AVR
- Rapid Application Development for the PIC or AVR microcontroller using the C language (WIZ-C for the PIC, AVIDICY for the AVR)
- Drag and drop your software component selections onto your design
- Included components support timers, serial interfaces, I2C, LCD, 7 Seg displays, keypads, switches, port controls, many bus interfaces including IIC and Dallas iButton, AVR/PIC Hardware, and more.
- Connect software components to MCU pins by point & click
- Parameters set from drop down list boxes, check boxes, or text entry
- Links your code automatically into library events (e.g. Button Pressed, Byte Received etc.)

Forest Electronic Developments
01590-681511 (Voice/Fax)
www.fored.co.uk

Also programmers, ICE, & development systems
Easy-PC version 9 just gets better
Winning accolades the world over, Easy-PC for Windows V9 is another major milestone in the evolution of this extremely popular software tool. Try a demonstration copy of Easy-PC and prepare to be amazed at the power, versatility and remarkable value for money.

Fully integrated Schematics & PCB layout in a single application complete with forward and back annotation. Design and rules checks at all stages ensure integrity at all times. Professional manufacturing outputs allow you to finish the design process with ease.

Stop press... Stop press... Stop press... Stop press...
Easy-PC imports Eagle files as well as Tsienn Boardmaker 2 files

call for a brochure, prices & CD on +44 (0)1684 773662
or e-mail sales@numberone.com
you can also download a demo from
www.numberone.com

For rapid development of electronic systems...

E-blocks are small circuit boards each of which contains a block of electronics typically found in an electronic system. E-blocks can be programmed in C, Assembly and are tightly integrated with flowcharts - which instantly converts flow charts into PICmicro code.

Low cost USB PIC programmers
(Starting at £97, model shown £39)

...plus a wide range of add-on boards and accessories...

...plus incredibly easy to use software based on flow charts...

...equals extremely rapid system development like this mobile text messaging system built from E-blocks.

...and solutions for learning and development...

Hands on training courses

Resources for learning CPLD programming

Complete courses in electronics and programming

Equipment for data logging, control and PC 'scopes

...see www.matrixmultimedia.co.uk
Valve Sound Converter

Stefan Dellemann

"Valve sound" is not just an anachronism: there are those who remain ardent lovers of the quality of sound produced by a valve amplifier. However, not everyone is inclined to splash out on an expensive valve output stage or complete amplifier with a comparatively low power output. Also, for all their aesthetic qualities, modern valve amplifiers burn up (in the full sense of the word) quite a few watts even at normal listening volume, and so are not exactly environmentally harmless.

This valve sound converter offers a cunning way out of this dilemma. It is a low-cost unit that can be easily slipped into the audio chain at a suitable point and it only consumes a modest amount of energy. A valve sound converter can be constructed using a common-or-garden small-signal amplifier using a readily-available triode. Compared to using a pentode, this simplifies the circuit and, thanks to its less linear characteristic, offers even more valve sound. For stereo use a double triode is ideal. Because only a low gain is required, a type ECC82 (12AU7) is a better choice than alternatives such as the ECC81 (12AT7) or ECC83 (12AX7). This also makes things easier for homebrewers only used to working with semiconductors, since we can avoid any difficulties with high voltages, obscure transformers and the like: the amplifier stage uses an anode voltage of only 60 V, which is generated using a small 24 V transformer and a voltage doubler (D3, D4, C4 and C5). Since the double triode only draws about 2 mA at this voltage, a 1 VA or 2 VA transformer will do the job. To avoid ripple on the power supply and hence the generation of hum in the converter, the anode voltage is regulated using Zener diodes D1 and D2, and T1. The same goes for the heater supply: rather than using AC, here we use a DC supply, regulated by IC1. The 9 V transformer needs to be rated at at least 3 VA. As you will see, the actual amplifier circuit is shown only once. Components C1 to C3, R1 to R4, and P1 need to be duplicated for the second channel. The inset valve symbol in the circuit diagram and the base pinout diagram show how the anode, cathode and grid of the other half of the double triode (V1.B) are connected. Construction should not present any great difficulties. Pay particular attention to screening and cable routing, and to the placing of the transformers to minimise the hum induced by their magnetic fields.

Adjust P1 to set the overall gain to 1 (0 dB). The output impedance of 47 kΩ is relatively high, but should be compatible with the inputs of most power amplifiers and preamplifiers.

For a good valve sound, the operating point of the circuit should be set so that the audio output voltage is in the region of a few hundred millivolts up to around 1.5 V. If the valve sound converter is inserted between a preamplifier and the power amplifier, it should be before the volume control potentiometer as otherwise the sound will change significantly depending on the volume. As an example, no modifications are needed to an existing power amplifier if the converter is inserted between the output of a CD player and the input to the amplifier.

118
THD: Sallen-Key versus MFB

There are various types of active filters, and the Sallen-Key version is probably the most commonly used type. A voltage follower is usually used for such filters, although gain can also be realised using two additional resistors. A disadvantage of this type of filter is its relatively high sensitivity to component tolerances. Measurements made on such filters have shown that component variations affect not only the filter characteristic but also the amount of distortion. However, an advantage is that filters more complex than third-order types can also be realised using a single amplifier stage, although severe requirements are placed on the component values in such cases.

One of the alternatives to the Sallen-Key filter is the ‘multiple feedback’ (MFB) filter. It owes its name to the fact that the feedback occurs via two paths. The inverting architecture can perhaps be regarded as a slight disadvantage, but that is offset by the fact that non-unity gain can be obtained without using extra components. In addition, the filter is less sensitive to component tolerances. Another drawback is that the implementation is restricted to third-order filters, so additional stages (and thus opamps) are necessary for higher-order filters.

That’s all very nice, you might think, but how can multiple-feedback filters be calculated? That’s practically impossible to do by hand. Fortunately, various software programs have been developed to do this for you, such as the quite usable FilterPro program from Texas Instruments, which can even calculate component values that exactly match the various E series. For both types of filter, we designed a 20-kHz low-pass Butterworth bandpass filter using a standard TL081 IC (Figures 1 and 2) and then measured the distortion in the output signal for an input signal of 5 Vrms. Standard polyester (MKT) capacitors were used in the circuits. To make the ultimate result more distinct, we intentionally used a simple opamp (TL081) and avoided using expensive polypropylene, polystyrene or silver-mica capacitors.

The results of the measurements can be characterised as astonishing. The multiple-feedback filter proved to generate considerably less distortion than the Sallen-Key architecture. Figure 3 shows the measurements for the two filters, which speak for themselves. The amplitude curves were the same within a few tenths of a dB. The Sallen-Key filter clearly generates up to more than ten times as much distortion at certain frequencies. With the Sallen-Key architecture, better results can be obtained by using better capacitors and opamps (such as an OPA627). From the results, it is clear the multiple-feedback architecture is less sensitive to the components used in the filter.

FilterPro:
https://focus.ti.com/docs/toolsw/folders/print/filterpro.html

Ton Giesberts

![Diagram of Sallen-Key and Multiple-Feedback filters](image_url)
An Electronic Watering Can

Robert Edlinger

Summertime is holiday time but who will be looking after your delicate houseplants while you are away? Caring for plants is very often a hit or miss affair, sometimes you underwater and other times you overwater. This design seeks to remove the doubt from plant care and keep them optimally watered.

The principle of the circuit is simple: first the soil dampness is measured by passing a signal through two electrodes placed in the soil. The moisture content is inversely proportional to the measured resistance. When this measurement indicates it is too dry, the plants are given a predefined dose of water. This last part is important for the correct function of the automatic watering can because it takes a little while for the soil to absorb the water dose and for its resistance to fall. If the water were allowed to flow until the soil resistance drops then the plant would soon be flooded. The circuit shows two 555 timer chips IC1 and IC2. IC1 is an astable multivibrator producing an ac coupled square wave at around 500 Hz for the measurement electrodes F and F1. An ac signal reduces electrode corrosion and also has less reaction with the growth-promoting chemistry of the plant. Current flowing between the electrodes produces a signal on resistor R13. The signal level is boosted and rectified by the voltage doubler produced by D2 and D3. When the voltage level on R13 is greater than round 1.5 V to 2.0 V transistor T2 will conduct and switch T3. Current flow through the soil is in the order of 10 μA. T2 and T3 remain conducting providing the soil is moist enough. The voltage level on pin 4 of IC2 will be zero and IC2 will be disabled. As the soil dries out the signal across R13 gets smaller until eventually T2 stops conducting and T3 is switched off. The voltage on pin 4 of IC2 rises to a '1' and the chip is enabled. IC2 oscillates with an 'on' time of around 5 s and an 'off' time (adjustable via P2) of 10 to 20 s. This signal switches the water pump via T1. P1 allows adjustment of the minimum soil moisture content necessary before watering is triggered.

The electrodes can be made from lengths of 1.5 mm² solid copper wire with the insulation stripped off the last 1 cm. The electrodes should be pushed into the earth so that the tips are at roughly the same depth as the plant root ball. The distance between the electrodes is not critical; a few centimetres should be sufficient. The electrode tips can be tinned with solder to reduce any biological reaction with the copper surface. Stainless steel wire is a better alternative to copper, heat shrink sleeving can used to insulate the wire with the last 1 cm of the electrode left bare. Two additional electrodes (F1) are con-
connected in parallel to the soil probe electrodes (F). The F1 electrodes are far safety to ensure that the pump is turned off if for same reason water collects in the plant pot saucer. A second safety measure is a float switch fitted to the water reservoir tank. When the water level falls too low a floating magnet activates a reed switch and turns off the pump so that it is not damaged by running with a dry tank. Water to the plants can be routed through closed end plastic tubing (with an internal diameter of around 4 to 5 mm) to the plant pots. The number of 1 mm to 1.5 mm outlet holes in the pipe will control the dose of water supplied to each plant. The soil probes can only be inserted into one flowerpot so choose a plant with around average water consumption amongst your collection, increasing or decreasing the number of holes in the water supply pipe will adjust water supply to the other plants depending on their needs. A 12 V water pump is a good choice for this application but if you use a mains driven pump it is essential to observe all the necessary safety precautions.

Last but not least the electronic watering can is too good to be used just for holiday periods, it will ensure that your plants never suffer from the blight of over or under-watering again; provided of course you remember to keep the water reservoir topped up...

**Precision Headphone Amplifier**

Hergen Breitzke

Designs for good-quality headphone amplifiers abound, but this one has a few special features that make it stand out from the crowd. We start with a reasonably conventional input stage in the form of a differential amplifier constructed from dual FET T2/T3.

A particular point here is that in the drain of T3, where the amplified signal appears, we do not have a conventional current source or a simple resistor. T1 does indeed form a current source, but the signal is coupled out to the base of T5 not from the drain of T3 but from the source of T1. Notwithstanding the action of the current source this is a low impedance point for AC signals in the differential amplifier. Measurements show that this trick by itself results in a reduction in harmonic distortion to considerably less than -80 dB (much less than 0.01 %) at 1 kHz.

T5 is connected as an emitter follower and provides a low impedance drive to the gate of T6; the gate capacitance of HEXFETs is far from negligible. IC1, a voltage regulator configured as a current sink, is in the load of T6. The quiescent current of 62 mA (determined by R11) is suitable for an output power of 60 mW in to an impedance of 32 Ω, a value typical of high-quality headphones, which provides plenty of volume. Using higher-impedance headphones, say of 300 Ω, considerably more than 100 mW can be achieved.

The gain is set to a useful 21 dB (a factor of 11) by the negative feedback circuit involving R10 and R8. It is not straightforward to change the gain because of the single-sided supply: this voltage divider also affects the operating point of the amplifier. The advantage is that excellent audio quality can be achieved even using a simple unregulated mains supply. Given the relatively low power output the power supply is considerably overspecified. Noise on hum thus remain more than 90 dB below the signal (less than 0.003 %), and the supply can also power two amplifiers for stereo operation.

The bandwidth achievable with this design is from 5 Hz to 300 kHz into 300 Ω, with an output voltage of 10 V p-p. The damping factor is greater than 800 between 100 Hz and 10 kHz. A couple of further things to note: somewhat better DC stability can be achieved by replacing D1 and D2 by low-current red LEDs (connected with the right polarity). R12 prevents a click from the discharge of C6 when headphones are plugged in after power is applied. T6 and IC1 dissipate about 1.2 W of power each as heat, and so cooling is needed. For low impedance headphones the current through IC1 should be increased. To deliver 100 mW
Myo Min

Power shortage problems arise when too many USB devices connected to PC are working simultaneously. All USB devices, such as scanners, modems, thermal printers, mice, USB hubs, external storage devices and other digital devices obtain their power from PC. Since a PC can only supply limited power to USB devices, external power may have to be added to keep all these power hungry devices happy.

This circuit is designed to add more power to a USB cable line. A sealed 12V 7.50 mA unregulated wall cube is cheap and safe. To convert 12V to 5V, two types of regulators, switching and linear, are available with their own advantages and drawbacks. The switching regulator is more suitable to this circuit because of high efficiency and compactness and now most digital circuits are immune to voltage ripple developed during switching. The simple switching type LM2575-5 is chosen to provide a stable 5V output voltage. This switcher is so simple it just needs three components: an inductor, a capacitor and a high-speed or fast-recovery diode. Its principle is that internal power transistor switch on and off according to a feedback signal. This chopped or switched voltage is converted to DC with a small amount of ripple by D1, L1 and C2. The LM2575 has an ON/OFF pin that is switched on by pulling it to ground. T1, R2, and R1 (pull-up resistor) pull the ON/OFF pin to ground when power signal from PC or +5 V is received. D2, a red LED with current resistor R3, serves to indicate 'good' power condition or stable 5 V. C3 is a high-frequency decoupling capacitor. The author managed to cut a USB cable in half without actually cutting data wires. It is advisable to look at the USB cable pin assignment for safety.

Dual Oscillator for μCs

Tan Giesberts

The MAX7378 contains two oscillators and a power-on reset circuit for microprocessors. The Speed input selects either 32.768 kHz (LF) or a higher frequency, which is pre-programmed. The type number corresponds to the standard pre-programmed value and the value of the reset threshold. There is a choice of two threshold values: 2.56 V and 4.29 V. Both thresholds are available with all standard frequencies, which are 1 MHz, 1.8432 MHz, 3.39545 MHz, 3.6864 MHz, 4 MHz, 4.1943 MHz, and 8 MHz. However, any frequency between 600 kHz and 10 MHz is also possible. An internal synchronisation circuit ensures that no glitches occur when switching between the two oscillators. The Reset output of the MAX7378 is available in three different options. Two of the options are push-pull types, either active low or active high. The third option is open drain, which thus requires an external pull-up resistor. That is the only standard option (which is why a resistor in dashed outline
Step-up Converter for 20 LEDs

Dirk Gehrke

The circuit described here is a step-up converter to drive 20 LEDs, designed to be used as a homemade ceiling night light for a child's bedroom. This kind of night light generally consists of a chain of Christmas tree lights with 20 bulbs each consuming 1 W, for a total power of 20 W. Here, in the interests of saving power and extending operating life, we update the idea with this simple circuit using LEDs.

Power can be obtained from an unregulated 12 V mains adaptor, as long as it can deliver at least about 330 mA. The circuit uses a low-cost current-mode controller type UCC3800N, reconfigured into voltage mode to create a step-up converter with simple compensation. By changing the external components the circuit can easily be modified for other applications.

To use a current-mode controller as a voltage-mode controller it is necessary to couple a sawtooth ramp (rising from 0 V to 0.9 V) to the C5 (current sense) pin, since this pin is also on input to the internal PWM comparator. The required ramp is present on the RC pin of the IC and is reduced to the correct voltage range by the voltage divider formed by R3 and R2. The RC network formed by R4 and C6 is dimensioned to set the switching frequency at approximately 525 kHz. The comparator compares the ramp with the divided-down version of the output
voltage produced by the potential divider formed by R6 and R7. Trimmer P1 allows the output voltage to be adjusted. This enables the current through the LEDs to be set to a suitable value for the devices used.

The UCC3800N starts up with an input voltage of 7.2 V and switches off again if the input voltage falls below 6.9 V. The circuit is designed so that output voltages of between 20 V and 60 V can be set using P1. This should be adequate for most cases, since the minimum and maximum specified forward voltages for white LEDs are generally between 3 V and 4.5 V. For the two parallel chains of ten LEDs in series shown here a voltage of between 30 V and 45 V will be required. The power components D1, T1 and L1 are considerably overspecified here, since the circuit was originally designed for a different application that required higher power.

To adjust the circuit, the potentiometer should first be set to maximum resistance and a multimeter set to a 200 mA DC current range should be inserted in series with the output to the LEDs. Power can now be applied and P1 gradually turned until a constant current of 40 mA flows. The step-up converter is now adjusted correctly and ready for use.

Gregor Kleine

The switching threshold of the MAX6509 temperature switch from Maxim ([www.maximic.com](http://www.maximic.com)) can be programmed over a range of −40 °C to +125 °C using an external resistor. The IC needs only two external components (see Figure 1). A hysteresis value of 2 °C (typical) or 10 °C (typical) can be selected by connecting the HYST pin to ground or Vcc, respectively.

The standard version of the IC is the MAX6509C, which pulls its open-drain output to ground when the temperature is below the threshold value set using the resistor. As shown in Figure 2, this version of the IC can be used to control a fan via an external MOSFET. The MAX6509H version has an inverted output, which means it is switched to ground when the temperature is above the threshold. A possible application for this version is switching on a heater in an oven when the temperature drops below the set point. The IC is housed in a SOT232 SMD package (Figure 3). The MAX6509 operates over a supply voltage range of +2.7−5.5 V with a supply current of only approximately 40 µA. The resulting self-heating is small enough to avoid corrupted temperature measurements (as long as the output transistor is not required to switch high currents to ground). The table lists suitable values of resistor RSET for various threshold temperatures.

The companion MAX6510 has an output stage that can be configured via a separate pin. The options are active high, active low, and open drain with an internal pullup resistor. Like the MAX6510, MAX6510 is available in a −C version (open drain when the threshold temperature is exceeded) and an −H version (output pulled to ground when the threshold temperature is exceeded).

---

**Figure 1**

**Resistor-Programmable Temperature Switch**

---

<table>
<thead>
<tr>
<th>T in °C</th>
<th>RSET</th>
<th>T in °C</th>
<th>RSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>−40</td>
<td>150 kΩ</td>
<td>35</td>
<td>62 kΩ</td>
</tr>
<tr>
<td>−30</td>
<td>136 kΩ</td>
<td>40</td>
<td>57.6 kΩ</td>
</tr>
<tr>
<td>−20</td>
<td>122 kΩ</td>
<td>45</td>
<td>53.3 kΩ</td>
</tr>
<tr>
<td>−10</td>
<td>108 kΩ</td>
<td>50</td>
<td>49.2 kΩ</td>
</tr>
<tr>
<td>−5</td>
<td>102 kΩ</td>
<td>60</td>
<td>41.3 kΩ</td>
</tr>
<tr>
<td>0</td>
<td>96.5 kΩ</td>
<td>70</td>
<td>33.9 kΩ</td>
</tr>
<tr>
<td>5</td>
<td>92 kΩ</td>
<td>80</td>
<td>27 kΩ</td>
</tr>
<tr>
<td>10</td>
<td>86.2 kΩ</td>
<td>90</td>
<td>20.4 kΩ</td>
</tr>
<tr>
<td>15</td>
<td>81 kΩ</td>
<td>100</td>
<td>14.1 kΩ</td>
</tr>
<tr>
<td>20</td>
<td>76 kΩ</td>
<td>110</td>
<td>8.2 kΩ</td>
</tr>
<tr>
<td>25</td>
<td>71 kΩ</td>
<td>120</td>
<td>2.6 kΩ</td>
</tr>
<tr>
<td>30</td>
<td>66.5 kΩ</td>
<td>125</td>
<td>0</td>
</tr>
</tbody>
</table>

---

**Figure 3**

---

**Figure 2**

---

[www.maximic.com](http://www.maximic.com)
Paul Goossens

Many new PCs now came equipped with one or more PCI Express slots on the motherboard. Eventually, PCI Express will make the old PCI standard obsolete, but for now most expansion cards still use the (old) PCI standard.

The old standard (PCI 1.0) had a maximum bandwidth of 133 MB per second. In the meantime there have been many developments in the computer industry. We can now watch videos over the Internet, as well as listen to the radio. MP3s (also unheard of then) are decoded in real-time, while we might also watch a DVD in another window.

All these applications place a big demand on the PC hardware. To process these data streams efficiently, contemporary PCs have a separate memory bus, another bus for the graphics card (AGP) and yet another bus (PCI) that lets the processor communicate with expansion cards.

There have been several enhancements to the PCI bus (e.g. the 66 MHz PCI bus, 64 bit versions, etc.), but the time has come for a complete overhaul. The result is PCI Express. The x1 version has a bandwidth of 250 MB/s, but other versions are waiting in the wings (including a x16 version) to provide even greater bandwidths.

One way in which the data rate can be increased is to increase the number of bits that are moved at the same time. This technique has already been used in processors to increase their speed. For PCI Express however, a serial transport mechanism was chosen (as with SATA, USB, firewire, etc.).

The slowest version of PCI Express uses a connector with only 26 connections. The connection details for the PCI Express connector are shown in Table 1.

There are only four signals on this connector that take care of the actual data transmission via the PCI Express protocol. These are the signal pairs PETn0/PETp0 and PERn0/PERp0. Signal pair PETx0 (PCI Express Transmit 0) moves data from the host (PC) to the slave (slot), while PERx0 (PCI Express Receive 0) moves the data in the opposite direction. The small letter p or n denotes the polarity (positive or negative).

The data has to be in step with a clock signal, provided by the signal pair CLK+ and CLK-.

The rest of the connections are for the supply, plus a few more signals for housekeeping tasks. It is noteworthy that the connector also has a USB port and an SMBus (a type of I2C bus). This bus is used in PCs for power management and system monitoring. PCI Express cards could, for example, return measurements of the supply voltage and temperature. The PC could also put the expansion card into standby mode while it wasn’t needed.

Faster versions of PCI Express make use of multiple transmit and receive channels, (hence the ‘0’ in, for example, PERn0). In this way a form of parallelism is still used to provide a speed increase.

---

**Table 1**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>From</th>
<th>To</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
<td>N/A</td>
<td></td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>USBD-</td>
<td></td>
<td></td>
<td>USB signals</td>
</tr>
<tr>
<td>3</td>
<td>USBD+</td>
<td></td>
<td></td>
<td>SMBus clock</td>
</tr>
<tr>
<td>4</td>
<td>CPUSB</td>
<td>slave</td>
<td>host</td>
<td>+1.5V supply voltage</td>
</tr>
<tr>
<td>5</td>
<td>reserved</td>
<td></td>
<td></td>
<td>+3.3V supply voltage</td>
</tr>
<tr>
<td>6</td>
<td>reserved</td>
<td></td>
<td></td>
<td>+3.3V supply voltage</td>
</tr>
<tr>
<td>7</td>
<td>SMBClk</td>
<td>bidirectional</td>
<td>SMBus data</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>SMBDATA</td>
<td></td>
<td></td>
<td>Wake-up signal for host</td>
</tr>
<tr>
<td>9</td>
<td>+1.5V</td>
<td>N/A</td>
<td></td>
<td>Reset signal</td>
</tr>
<tr>
<td>10</td>
<td>+1.5V</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>WAKE</td>
<td>slave</td>
<td>host</td>
<td>Clock request</td>
</tr>
<tr>
<td>12</td>
<td>+3.3V</td>
<td>N/A</td>
<td></td>
<td>PCI Express detection</td>
</tr>
<tr>
<td>13</td>
<td>PERST</td>
<td>host</td>
<td>slave</td>
<td>Differential clock signal pair</td>
</tr>
<tr>
<td>14</td>
<td>+3.3V</td>
<td>N/A</td>
<td></td>
<td>synchronised with data</td>
</tr>
<tr>
<td>15</td>
<td>+3.3V</td>
<td>N/A</td>
<td></td>
<td>Ground</td>
</tr>
<tr>
<td>16</td>
<td>CLKREQ</td>
<td>slave</td>
<td>host</td>
<td>Differential data signal pair</td>
</tr>
<tr>
<td>17</td>
<td>CPPE</td>
<td>slave</td>
<td>host</td>
<td>from slave to host</td>
</tr>
<tr>
<td>18</td>
<td>REFCLK-</td>
<td>host</td>
<td>slave</td>
<td>Ground</td>
</tr>
<tr>
<td>19</td>
<td>REFCLK+</td>
<td>host</td>
<td>slave</td>
<td>Differential data signal pair</td>
</tr>
<tr>
<td>20</td>
<td>GND</td>
<td>N/A</td>
<td></td>
<td>from host to slave</td>
</tr>
<tr>
<td>21</td>
<td>PERn0</td>
<td>slave</td>
<td>host</td>
<td>Ground</td>
</tr>
<tr>
<td>22</td>
<td>PERp0</td>
<td>slave</td>
<td>host</td>
<td>Differential data signal pair</td>
</tr>
<tr>
<td>23</td>
<td>GND</td>
<td>N/A</td>
<td></td>
<td>from slave to host</td>
</tr>
<tr>
<td>24</td>
<td>PETn0</td>
<td>host</td>
<td>slave</td>
<td>Ground</td>
</tr>
<tr>
<td>25</td>
<td>PETp0</td>
<td>host</td>
<td>slave</td>
<td>Differential data signal pair</td>
</tr>
<tr>
<td>26</td>
<td>GND</td>
<td>N/A</td>
<td></td>
<td>from host to slave</td>
</tr>
</tbody>
</table>
Passive 9th-order Elliptical Filter

Ton Giesberts

Steep filters can be realised in many different ways, for example by connecting active 2nd to 5th-order sections in series and calculating the component values for the higher order. They can also be made passive, but in practice this has a few difficulties associated with it. You cannot avoid the need for inductors with values that deviate from the standard series. You will have to wind them yourself on a specially selected core. The filter presented here was originally designed to enable measurements to be made on the Class-D Amplifier (yes indeed, the one in Elektor Electronics, June 2004).

When designing and testing audio equipment, we use a System Two Cascade Plus Analyzer made by Audio Precision. The accuracy of the measurements with this instrument is reduced if frequency components above 200 kHz are present at significant levels. This is the case with our amplifier, particularly at low signal levels. We immediately went for large artillery, namely a 9th-order elliptical filter. During the design of the filter we made use of normalised tables. In the end it became a filter with identical termination impedances, which unfortunately means an attenuation of two times within the pass band. When converting to realistic values we selected pure E12-series values for C1±C2. All capacitors are arranged as two in parallel in order to closely approximate the calculated value. This applies to the resistors as well. With the inductors there is no way to avoid 'funny' values and series or parallel connections don’t make much sense because to achieve a certain quality, standard coils are not appropriate. So we had to think of a solution ourselves. The input and output impedance are theoretically 1.060 kΩ and are approximated quite well with components in parallel (1.05996 kΩ). By making use of a voltage divider it becomes possible for R3 to handle a higher voltage (otherwise note the dissipation of R11). Any voltage divider needs to have an output impedance of 1.06 kΩ (R1/R2/R3). In the last section, the parasitic capacitance of the connecting cable and input impedance of the analyzer has been taken into account. Trimmer C19 can be used to compensate the attached capacitance and R5 can be omitted if the input impedance is about 100 kΩ. A deviation of about 50 pF makes little difference to the amplitude characteristic in the pass-band. The advantage of an elliptical filter compared to, for example a Chebyshev filter, is to trade off a limited attenuation in the stop-band to a much steeper transition from pass-to stop-band. It suffices to mention that the curve from 180 kHz to 200 kHz falls by more than 60 dB, quite steep and certainly not bad for a passive filter! In practice the attenuation in the stop-band at -63 dB was a little lower than the theoretical value of 60.2 dB, which was the design value.

Frequency characteristic A shows mainly the stop-band and the characteristic behaviour of an elliptical filter can be clearly seen. Frequency characteristic B shows an enlarged version of the ripple in the pass-band, which also shows the phase behaviour of the filter (scale on the right). At 20 kHz the attenuation is only 0.1 dB and the phase shift only -3°. The first dip of only -0.263 dB occurs at about 46 kHz and the attenuation at 100 kHz is only 0.276 dB. Above that, the non-ideal behaviour of the components becomes noticeable and the curve starts to drop a little too soon, but the characteristic elliptical behaviour is still clearly visible at 180 kHz.

The filter proved to be quite useful in filtering the PWM signal and analyse the LF-amplitude. The only disadvantage is the increasing distortion at 20 kHz (from 0.5 V input signal) so that good THD+N measurements can only be done at 1 kHz. This can be seen clearly in Graph C. With 1 W into 8 Ω (2.828 V) the distortion at 1 kHz is less than 0.001%, but at 20 kHz the distortion is
COMPONENTS LIST

Resistors:
R1, R4 = 1 kΩ
R2, R5 = 113 kΩ
R3 = not fitted

Capacitors:
C1, C14 = not fitted
C2, C5, C11, C13 = 1 nF 500V 1%
silvered mica (Farnell 868-012)
C3, C8, C12 = 120 pF 500V 1%
silvered mica (Farnell 867-901)

Inductors:
L1 = 1mH, 115 turns of 0.5 mm dia.
ECW on core TN23/14/7-4C65 from

Miscellaneous:
K1, K2 = cinch socket, PCB mount, e.g., 709G (Monaco/Monarch)
PCB, available from The PCB Shop

* see text

Theoretical component values
R1//R2 = 1 060 kΩ
R4//R5 = 1 060 kΩ
C1+C2 = 1 000 nF
C3+C4 = 128.0 pF
C5+C6 = 1 277 nF
C7+C8 = 809.0 nF
C9+C10 = 860.4 nF
C11+C12 = 1 125 nF
C13+C14 = 996.8 pF
C15+C16 = 492.7 nF
C17+C18+C19 = 7 42.4 pF
L1 = 1 148 mH
L2 = 693.3 μH
L3 = 556.4 μH
L4 = 809.6 μH

20 times larger. In this measurement the maximum input signal was 13.33 V (maximum from the analyser).
For those who like to experiment and wind inductors, we have also designed a PCB.
A low permeability core material (TN23/14/7-4C65) was selected for the inductors, so that saturation and material properties are less of a problem. Unfortunately this results in a higher number of turns, but also means that the inductor value can be made more accurate. A larger core may have resulted in a lower distortion, but it would have been harder to obtain an accurate value. Toroids were selected to minimise mutual coupling — that this was successful is shown in Graph A. It is easiest when winding the cores to calculate the amount of wire required beforehand and then add 10 or more centimetres. You have to wind tightly and put the turns close together to prevent the second layer dropping in between the first layer. This applies to the inside of the ring core. When using 0.5 mm enamelled wire the second layer turns easily fit between the first layer turns. The PCB has been designed such that connections can be made in several places (inside a quarter circle). The capacitors are 1% silvered mica types with an operating voltage of 500 V. That way even extreme voltage peaks will not cause any harm. There is also room for 1% tolerance ‘Stratflex’ (polystyrene) capacitors from Siemens (that are not made any more), which we have used in the past. Other manufacturers also use this shape.
The circuit shown here can be used to convert a digital input signal having any desired duty cycle into an output signal having a duty cycle that can be adjusted between 10% and 80% in steps of 10%. The circuit is built around a 74HC4017 decade Johnson counter IC. Individual pulses appear on the ten outputs (Q0-Q9) of this IC at well-defined times, depending on the number of input pulses (see the timing diagram).

This characteristic is utilized in the circuit. The selected output is connected via a jumper to the Reset input (MR, pin 2) of a 74HC390 counter. A High level resets the output signals of the 74HC390 counter. Q9 of the 74HC4017 is permanently connected to the CPO input of the counter to set the Q0 output of the 74HC390 (pin 3) High on its negative edge. As can be seen from the timing diagram, which shows the signals for a duty cycle of 30% as an example, this produces a signal with exactly the desired duty cycle.

The circuit cannot be used to produce a duty cycle of 10% (which would be equivalent to taking the signal directly from the Q0 output of the 74HC4017) or 90%. In both cases, the edges of the pulses used for the count input (CPO) and the asynchronous reset input (MR) of the 74HC390 would coincide, with the result that the output state of the 74HC390 would not be unambiguously defined. The input frequency must be ten times the desired output frequency. If the second half of the 74HC390 is wired as a prescaler, a prescaling factor of 2, 5 or 10 can be achieved, thus allowing the ratio of the input frequency to the output frequency to be 20, 50 or 100.

If the circuit is built using components from the 74HC family, it can be operated with supply voltages in the range of 3-5 V.

Gregor Klein

Adjustable Duty Cycle
**Bridge-Rectifier LED Indicator**

**Karol Wawraven**

Using a few diodes and a LED, you can make a nice indicator as shown in associated schematic diagram that can be used for a lot of applications (with a bit of luck). It's quite suitable for use in series with a doorbell or thermostat (but don't try to use it with an electronically controlled central-heating boiler). This approach allows you to make an attractive indicator for just a few pennies. The AC or DC current through the circuit causes a voltage drop across the diodes that is just enough to light the LED. As the voltage is a bit on the low side, old-fashioned red LEDs are the most suitable for this purpose. Yellow and green LEDs require a somewhat higher forward voltage, so you'll have to first check whether it works with them. Blue and white LEDs are not suitable. You also don't have to use modern high-efficiency types (sometimes called '2-mA LEDs' or '3-mA LEDs'). If a DC current flows through the circuit and the LED doesn't light up, reverse the plus and minus leads.

When building the circuit, you'll notice that despite its simplicity it involves fitting quite a few components to a small printed circuit board or a bit of prototyping board. That's why we'd like to give you the tip of using a bridge rectifier, since that allows everything to be made much more compact, smaller and more tidy, and it eliminates the need for a circuit board to hold the components. Besides that, you can surprise friend and foe alike, because even an old hand in the trade won't understand the trick at first glance and will likely mutter something like "Huh? That's impossible."

A bridge rectifier contains four diodes, which is exactly what you need. If you short the + and - terminals of the bridge, you create a circuit with two pairs of diodes connected in parallel with opposite polarity.

Select a bridge rectifier that can handle the current that will flow through it. In the case of a doorbell, for example, that can easily be 1 A. Select a voltage of 40 or 80 V. Never use this circuit in combination with mains voltage, due to the risk of contact with a live lead.

---

**Stable USB Power Supply**

A common problem when an AC mains adapter is used to power a USB device is that the voltage does not match the nominal 5 V specified by the USB standard. The circuit shown here accepts an input voltage in the range of 4–9 V and converts it into a 6-V output voltage, which is then stabilised to a clean 5-V level by a series regulator. The combined boost/buck converter used here operates on the SEPIC principle. That principle is quite similar to the operating principle of the Cuk converter (see the January 2005 issue of *Elektor Electronics*), but without the disadvantage of a negative output voltage.

The circuit is built around a MAX668, which is intended to be used as a controller for boost converters. The difference between a SEPIC converter and a standard boost (step-up) converter is that the former type has an additional capacitor (in this case C2) and a second inductor (in this case, the secondary winding of transformer L1). If C2 is replaced by a wire bridge and the secondary winding of L1 is left open, the result is a normal boost converter. In that case, a current can always flow from the input to the output via L1 and D1, even when the FET is not driven by IC1. Under these condi-
tions, the output voltage can never be less than the input voltage less the voltage drop across the diode.

The operation of a SEPIC converter can be explained in simple terms by saying that C2 prevents any DC voltage on the input from appearing at the output, so the output voltage can easily be made lower than the input voltage. The second coil causes a defined voltage to be present at the onode of D1. It is also possible to replace the transformer by two separate coils that are not magnetically coupled. However, the efficiency of the circuit is somewhat higher if coupled coils are used as shown here.

The value of resistor R4 is chosen to limit the maximum current to 500 mA, which is also the maximum current that a USB bus can provide according to the specifications. Resistors R1 and R2 cause the voltage across C3 and C7 to be regulated at a value of around 6 V. A low-drop regulator (LM2940) is used to generate a stabilised 5 V from the 6-V output (with ripple voltage). The efficiency should be somewhere between 60% and 80%.

Efficient Current Source for High-power LEDs

Juergen Heidbreder

To get the maximum brightness and working life out of a high-power LED, it needs to be driven at the optimum specified current. Allowing the current to exceed the permitted value is to be avoided at all costs, since it will severely affect the life of the device. A power supply or a battery with a small current-limiting resistor is not really an ideal solution, since not only is energy wasted in heating the resistor, but, if a small value is chosen to minimise this wastage, small changes in the applied voltage will lead to large changes in the current that flows. It is well known that LEDs have a small dynamic resistance in the neighbourhood of their optimal operating point. We will therefore need more in the way of electronics than a simple series resistor to meet our requirements.

The most direct way to provide a highly constant current in the face of relatively small changes in supply voltage is to use a conventional regulated current source. Unfortunately this type of circuit unnecessarily wastes energy in its series transistor, which rather detracts from the charm of using a semiconductor-based circuit. The inefficiency can be mitigated by using a modern device such as a power MOSFET as the series component. Power loss is then limited to that in any current sense resistor that might be used and the dissipation in the relatively small 'on' resistance of the switching transistor.

The circuit suggested here drives a commercially-available Luxeon LED using a BUZZ1. The 5 W version of this LED draws 0.7 A. This means that 0.175 V is dropped across R9, making for a power dissipation of 122 mW. T1 has a typical resistance in the 'on' state of 85 mΩ. In the ideal scenario this means that about 60 mV is dropped across it, for a dissipation of at least 42 mW. The supply voltage therefore needs to be about 230 mV higher than the nominal voltage
Simple Overcurrent Indicator

Myo Min

This circuit eventually surfaced while pander- dering over the design of a current indi- cator for a small power supply. Fortunately, it proved possible to employ the supply voltage as a reference by dividing it down with the aid of R1 and R2. C1 is an essential capacitor to suppress noise and surges. The half supply voltage level is applied to the non-inverting pin of opamp IC1. The value of the R3 deter- mines the trip level of the indicator, according to

$$R_3 = 0.4 \times \text{[desired voltage drop]} / \ t_{\text{trip}}$$

Actually this is high side sensing but the method can be used as low side sensing, too! The desired voltage or sense voltage can be any value between 0.35 V and 0.47 V. If currents greater than about 1 A are envisaged, you should not forget to calculate R3’s dissipation on penalty of smoke & smells.

Now to how it works. D1 acts as a reference, with a voltage of 2.5 V being dropped across it. IC1b, together with T1, form a current source, whose current can be set between 360 mA and 750 mA using P2. The otherwise unused opamp IC1a is connected to form an undervoltage cutout switch which prevents a con- nected battery from being discharged too deeply. The threshold point is set using P1. IC1a is configured as a comparator with a small hysteresis. If its output is high, IC1b is fooled into thinking that the cur- rent through R9 is too high, whereupon it switches off the LED. The same happens if R1 is not shorted by a switch. For the purposes of this circuit only opamps with input stages constructed using PNP trans-istors should be used.

One last look at the energy budget: if six cells are used, the average voltage during dis-charge will be around 7.4 V. Subtract the nominal voltage of the LED and 0.55 V is left to be converted into heat. About 0.4 W will be dissipated by T1, which therefore will not require cooling. Efficiency is very good, at over 90%.

Low-drop Regulator

Karel Walraven

Even today much logic is still powered from 5 volts and it then seems obvious to power the circuit using a standard regu- lator from a rectangular 9-V battery. A dis- advantage of this approach is that the capacity of a 9-V battery is rather low and the price is rather high. Even the NiMH revolution, which has resulted in considerably higher capacities of (pen- light) batteries, seems to have escaped the 9-V battery generation.

It would be cheaper if 5 volts could be
Derived from 6 volts, for example. That would be 4 'normal' cells or 5 NiMH cells. Also the 'old fashioned' sealed lead-acid battery would be appropriate, or two lithium cells.

Using an LP2951, such a power supply is easily realised. The LP2951 is an evergreen from National Semiconductor, which you will have encountered in numerous Elektor Electronics designs already. This IC can deliver a maximum current of 100 mA at an input voltage of greater than 5.4 V. In addition to this particular version, there are also versions available for 3.3 and 3 V output, as well as an adjustable version.

In this design we have added a battery indicator, which also protects the battery from too deep a discharge. As soon as the IC has a problem with too low an input voltage, the ERROR output will go low and the regulator is turned off via IC2d, until a manual restart is provided with the RESET-pushbutton.

The battery voltage is divided with a few resistors and compared with the reference voltage (1.23 V) of the regulator IC. To adapt the indicator for different voltages you only need to change the 100k resistor. The comparator is an LP339. This is an energy-friendly version of the LM339. The LP339 consumes only 60 µA and can sink 30 mA at its output. You can also use the LM339, if you happen to have one around, but the current consumption in that case is 14 times higher (which, for that matter, is still less than 1 mA).

Finally, the LP2951 in the idle state, consumes about 100 µA and depending on the output current to be delivered, a little more.

(National Semiconductor application note)

**Navigator Assistant**

These days it is quite common that a hand-held computer (PDA) is used in a car as a navigation system. The author uses, for example, a Dell Axim X5 with TomTom navigator. The PDA is installed in a holder.
in such a way that the screen is clearly visible to the driver. Such holders do not normally have power and audio connections for the PDA. This circuit offers a solution to both problems: a regulated power supply and an audio power amplifier.

The author originally used an LM3350 IC, but it proved to be barely capable of coping with the dissipation when the battery was nearly completely discharged. That is why, in the end, a switching power supply was used. The power supply is designed around an LT1074, a bipolar switching regulator that contains just about all the components required for a so-called buck-regulator. The IC operates at a switching frequency of 100 kHz and can deliver up to 5 A. Call L1 and diode D3 form part of the flyback circuit. Make sure that these are capable of dealing with the maximum desired output current. Potentiometer P1 is used to adjust the output voltage to the value that is optimum for the PDA that is being used. LED D2 indicates the presence of the input power supply. The second part, the audio amplifier, is an equally simple design. The circuit really speaks for itself. This is on LM386 in a standard configuration. P2 adjusts the volume.

The amount of power that the LM386 can deliver is about 300 mW. The best results are obtained if you use a special communication loudspeaker. The navigation messages are then very easy to understand. The gain of IC2 is set to 20. This will usually be sufficient, but you can also increase the amplification. At a gain of 50, it is necessary to connect a series network consisting of a 1k2 resistor and 10-μF electrolytic between pins 1 and 8 of the LM386 (the negative of the capacitor connects to pin 8).

Finding the correct power supply connector for the PDA can be a bit of a problem. So look for a suitable connector before you start to build this circuit. Also be very careful about the correct polarity of the connector.

The circuit can be wired directly to the car’s power circuit or connected to the cigarette-lighter socket. In either case a fuse (F1) can be connected in the power supply lead or the plug.

See your design in print!

Elektor Electronics (Publishing)

are looking for

Freelance Technical Authors/Designers

If you have

* an innovative or otherwise original design you would like to see in print in Europe’s largest magazine on practical electronics
* above average skills in designing electronic circuits
* experience in writing electronics-related software
* basic skills in complementing your design with an explanatory text
* a PC, email and Internet access for efficient communication with our in-house design staff

then do not hesitate to contact us for exciting opportunities in getting your designs published on a regular basis.

Elektor Electronics
K. Walraven, Head of Design Dept.
P.O. Box 75, NL-6190-AB Beek, The Netherlands, Fax: (+31) 46 4370161
Email: k.walraven@segment.nl

7/8/2005 - elektor electronics
In line with this month's Summer Circuit edition of the magazine we once again present a circuit design problem. Figure 1 shows the circuit diagram of an amplifier. A 1 kHz, 12 mVpp input signal produces an output signal of 2 Vpp. Consequently the ac signal gain works out at about 170. This is surprising, because the signal does not seem to have a way of reaching the output in the first place, because the collector of T1 is heavily decoupled by capacitor C1, hence cannot reach IC1 either, let alone its output. If you don't believe it, feel free to convince yourself (and your friends) with a practical realisation of the circuit like the one pictured in Figure 2.

This month's question is: How can the AF signal from T1 reach IC1 in spite of the collector of T1 being grounded for alternating voltages?

Quizz'away and win!

Send in the best answer to this month's Quizz'away question and win one of 10 Design Guide: Trilogy of Inductors books sponsored by Würth Electronics (www.wuerth-elektronik.com). The book combines a unique reference work with a compilation of design notes and practical applications of ferrites and inductive components.

All answers are processed by Martin Ohsmann in co-operation with Elektor editorial staff. Results are not open to discussion or correspondence and a lucky winner is drawn in case of several correct answers.

Please send your answer to this month's Quizz'away problem, by email, fax or letter to: Quizz'away, Elektor Electronics, PO Box 190, Tunbridge Wells TN5 7WY, England. Fax (+44) (0)1580 200616. Email: editor@elektor-electronics.co.uk, subject: 'quizzaway 7-05'.

The closing date is 30 July 2005 (solution published in the October 2005 issue). The outcome of the quiz is final. The quiz is not open to employees of Segment b.v., its business partners and/or associated publishing houses.
As of the September 2004 issue Quizz’away is a regular feature in Elektor Electronics.
The problems to solve are supplied by Professor Martin Ohsmann of Aachen Technical University.

**Hint:**
The TL431 is a so-called ‘shunt voltage regulator’, its inner structure is shown in Figure 3. To be able to solve this month’s problem you will first need to consider how the amplifier works without the action of C1, then try to reason why C1 has hardly any effect. Initially, it is convenient to assume that the opamp inside the TL431 acts as an ideal device.

**Solution to the Mai 2005 problem**

(p. 78; ‘Blown Transistor’)

To everyone’s amazement, the circuit will eventually produce a negative voltage $U_1$. Typical values obtained from experiments range from $U = -0.25 \text{ V}$ to $U = -0.4 \text{ V}$. How can we explain a single transistor reversing a direct voltage? The question and the answer are found in the literature references below.

The base-emitter junction of the transistor is reverse-biased (via a 1k resistor, see Figure 4). The electrolytic capacitor has about 15 V on it. At this voltage, the base-emitter junction usually breaks down, the diode starting to act as a zener and emit light (usually in the infrared range). The light is incident on the collector, base junction, where the photoelectric effect causes a small but reversed (negative) voltage between terminals A and B.

**Literature:**

---

**Figure 3.** Inside the TL431.

**Figure 4.** Blown transistor as an unexpected optocoupler/voltage inverter.

---

**Prototypes and small series up to 1000 pcs**

**Value for Money**
Up to 6 layer boards
Always Available
Attractive price

**On-line** Printed Circuit Boards

**www.ThePCBShop.com**

**Double Sided, 1.6 mm,**
Plated Through,
Green Solder mask,
Hot Air Level,
1 White Legend.
Price including
tooling + plotting + VAT
100 mm x 160 mm
1 pc = 45.74 Euro
100 mm x 80 mm
5 pcs = 68.97 Euro

7-8/2005 - elektor electronics
<table>
<thead>
<tr>
<th>Company Name</th>
<th>Website</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allgood Technology</td>
<td><a href="http://www.allgoodtechnology.com">www.allgoodtechnology.com</a></td>
<td>Low-medium volume sub-contract assembly. SMT specialist since 1990. Customers include military, aerospace etc. 0402 to BGA capabilities, automatic assembly and hand built prototypes.</td>
</tr>
<tr>
<td>Future Technology Devices</td>
<td><a href="http://www.fdtichip.com">http://www.fdtichip.com</a></td>
<td>FTDI designs and sells USB-UART and USB-FIFO interface I.C.'s. Complete with PC drivers, these devices simplify the task of designing or upgrading peripherals to USB.</td>
</tr>
<tr>
<td>Audioxpress</td>
<td><a href="http://www.audioxpress.com">www.audioxpress.com</a></td>
<td>The premier do-it-yourself audio magazine for 35 years. • Hands-on projects • Helpful articles • Expert advice • New technologies Full range of books, back issues on CD</td>
</tr>
<tr>
<td>EasySync</td>
<td><a href="http://www.easysync.co.uk">http://www.easysync.co.uk</a></td>
<td>EasySync Ltd sells a wide range of single and multi-port USB to RS232/RS422 and RS485 converters at competitive prices.</td>
</tr>
<tr>
<td>Danbury Electronics</td>
<td><a href="http://www.livinginthepast.demon.co.uk">http://www.livinginthepast.demon.co.uk</a></td>
<td>Here you will find our mains and output transformers in Mike Holme's range of valve/tube amplifiers (PP &amp; SE). Also circuits, parts lists, chassis, advice.</td>
</tr>
<tr>
<td>ElneC</td>
<td><a href="http://www.elne.com">www.elne.com</a></td>
<td>• device programmer manufacturer • selling through contracted distributors all over the world • universal and dedicated device programmers • excellent support and after sale support • free SW updates • reliable HW • once a months new SW release • three years warranty for most programmers</td>
</tr>
<tr>
<td>Burn Technology Ltd</td>
<td><a href="http://www.burneltec.com">http://www.burneltec.com</a></td>
<td>Test &amp; Measurement Equipment Distributors • Anemometers • Clamp Meters • Light Meters • LCR Meters • Sound Meters • Multimeters • Device Programmers Burn Technology Limited, Winfrith Technology Centre, Dorchester, Dorset, DT2 8DN Tel: (01305) 852090 Fax: (01929) 463214</td>
</tr>
<tr>
<td>Elnective Electronics</td>
<td><a href="http://www.ilectronics.com">www.ilectronics.com</a></td>
<td>Suppliers of electrical / electronic parts and consumables. Including: • Cable ties / bases • Tools / hardware • Bootlace ferrules • Connectors • Solvent sprays &amp; cleaners • PVC Tape • Heat Sink compound</td>
</tr>
<tr>
<td>JLB Electronics</td>
<td><a href="http://www.jlbelectronics.com">www.jlbelectronics.com</a></td>
<td>Learn how to design a PCI card, and write a PCI device driver. We lead you step by step with practical PCI projects you build.</td>
</tr>
<tr>
<td>Komcard</td>
<td><a href="http://www.komcard.com">http://www.komcard.com</a></td>
<td>Learn how to design a PCI card, and write a PCI device driver. We lead you step by step with practical PCI projects you build.</td>
</tr>
</tbody>
</table>
SHOWCASE YOUR COMPANY HERE

Elektor Electronics has a feature to help customers promote their business, Showcase - a permanent feature of the magazine where you will be able to showcase your products and services.  For just £220 + VAT (£20 per issue for eleven issues) Elektor will publish your company name, website address and a 30-word description.

I wish to promote my company, please book my space:

- Text insertion only for £220 + VAT
- Text and photo for £330 + VAT

NAME: ________________________________ ORGANISATION: ________________________________

JOB TITLE: ________________________________

ADDRESS: ________________________________________________________________

______________________________________________________________________________

TEL: ________________________________

PLEASE COMPLETE COUPON BELOW AND FAX BACK TO 00 44 (0) 1932 56 4998

COMPANY NAME: ________________________________

WEB ADDRESS: ________________________________________________________________

30-WORD DESCRIPTION: ________________________________________________________

MQP ELECTRONICS
http://www.mqp-electronics.co.uk

Leaders in Device Programming Solutions.
- Online shop
- Low Cost Adapters for all Programmers
- Single Site and Gang Programmers
- Support for virtually any Programmable Device

NEW WAVE CONCEPTS
http://www.new-wave-concepts.com

Software for hobbyists:
- Livewire circuit simulation software, only £29.36
- PCB Wizard circuit design software, only £29.36

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

PICDOS™
http://www.picdos.com

Hard disk, DOS & files on PIC16F877. SmartMediaTM based. No complex hardware just wires. Run-Debug existing PIC code & interrupts. Free schematics, software, debugger

PHYZX
http://www.phyzx.co.uk

Automatically Plot and Drill PCB's
- Accurately
- Repeatably
- Mains operated
- Robust Steel Construction
- Gerber RS274X compatible
- Full XY2 RS32 Control
- Including Accessories
- Complete system Under £500.

QUASAR ELECTRONICS
www.quasar-electronics.com

Over 300 electronic kits, projects and ready built units for hobby, education and industrial applications including PIC/ATMEG programming solutions. Online ordering facilities.

Tel: +44 (0) 870 248 1826
Fax: +44 (0) 870 460 1045
Email: sales@quasar-electronics.com

ROBOT ELECTRONICS
http://www.robot-electronics.co.uk

- Ultrasonic rangefinders
- Motor H-Bridge controllers
- Magnetic Compasses
- RC servos and controllers
- PIC programmers and components
- Electronic Design/Development and Manufacturer to industry

ULTRALEDS
http://www.ultraleds.co.uk

Large range of low cost Ultra bright leds and Led related lighting products. Major credit cards taken online with same day dispatch.

USB INSTRUMENTS
http://www.usb-instruments.com

USB Instruments specialises in PC based instrumentation products and software such as Oscilloscopes, Data Loggers, Logic Analysers which interface to your PC via USB.

VIEWCOM
http://www.viewcom.f9.co.uk

Tel: 020 8471 9338 fax: 020 8552 0946
- Mail Order supplier of:
- Integrated Circuits and Components.
- Kit and parts for Elektor projects.
- Transistors, FETS, Capacitors, Resistors, Crystals, etc and hard to find devices.

VIEWCOM Electronics, 77 Upperton Road West, Palletow, London E13 9LT

VIRTINGS TECHNOLOGY
http://www.virtings.com

PC based virtual instrument for electronics enthusiasts, students and professionals, including full-featured sound card real time Oscilloscope, Spectrum, Analyzer and Signal, Generator, Download and try.
The DiskMirror utility on this CD-ROM allows your earlier Elektor year volume CD-ROMs (1997-2003) to be added to a large archive on hard disk for fast access and easy reference. A built-in search function allows you to find references in any article from the archive on hard disk, or from individual year volume CD-ROMs you have available.

**Audio Collection 2**
A unique CD-ROM for the true audio lover, containing no fewer than 75 audio designs from the past five years volumes of Elektor Electronics magazine. The articles on the CD-ROM cover test & measurement equipment, amplifiers, digital audio and loudspeaker technology. Highlights include the Crescendo Millennium Edition, Audio-DAC 2000, Audio-ADC 2000 and the IR-S/PDF Transmitter and Receiver. Using the included Acrobat Reader you are able to browse the articles on your computer, as well as print texts, circuit diagrams and PCB layouts.

**ECD**
Elektor's Components Database gives you easy access to design data for over 5,700 ICs, more than 35,000 transistors, FETs, thyristors and triacs, just under 25,000 diodes and 1,800 optocouplers. All database applications are fully interactive, allowing the user to add, edit and complete component data.
Electrosmog Tester
(June 2005)

Ready-built PCB
(excl. enclosure)

050008-91
£ 50.00 / $ 94.25

Matching enclosure

050009-71
£ 10.25 / $ 19.30

OBD-2 Analyser
(July/August 2005)

Kit of parts including PCB, programmed controller, components and OBD cable. Enclosure also included.

050008-71
£ 54.15 / $ 102.05

Further products from Elektor Electronics:

READY-BUILT PROJECTS

Clarity 300-W Class-T Amplifier

030217-91 Amplifier board with 300-W output, L1 & L2 34.50 55.70

Flash Microcontroller Starter Kit

010099-01 Flash microcontroller PCB, extension board & related articles 69.00 112.50

Gameboy Digital Sampling Oscilloscope (GBDSO)

990002-91 ready-assembled board incl. the PC software and related articles 100.00 160.00

LPC210x ARMee Development System

040444-91 Programmed board, ready-assembled and tested 25.50 38.05

Micro Webserver with MSC1210 Board

030000-91 Microcontroller Board, ready-assembled 75.50 142.25

040230-01 NDK9206E Development Board, ready-assembled 44.00 63.05

040255-91 Combined package (040255-91 & 040255-91 & related articles) 117.50 220.50

EVERGREENS

Elektor Electronics Help Disk

050022-01 Disk, Windows version 8.15 13.45

Elektor Electronics Item Tracer 1985-2003

040500-11 contents database (disk, Windows version) 8.15 13.45

Universal Prototyping Boards

UP31-2 PCB 3.45 5.50

UP32-2 2 PCBs 4.10 6.50

UP33-4 4 PCBs 6.55 11.35

No. 345 JULY/AUGUST 2005

1 MHz Frequency Counter

030045-11 DIY design, parts list 5.00 8.35

030045-41 DIY002531 & related programmed 5.50 9.35

Code Lock with One Button

040481-11 Disk, software & files 5.26 9.75

040481-41 PIC16F84A programmed 6.65 12.25

Digital Voltmeter

050116-11 DIY design, software 5.20 9.75

050116-41 DIY design, programmed 3.40 6.25

DIL/SOIC/TSSOP Adapter Boards

040289-1 PCB for TSSOP, DIL IC 8.75 15.20

Kits & Modules

GPS Receiver on USB
(June 2005)

Complete kit with Lassen iQ receiver, extra long cable and waterproof antenna case

030264-71
£ 62.05 / $ 116.95

Temperature Logger
(June 2005)

Complete kit of parts including components, PCB and programmed controller (available from mid May 2005)

030347-71
£ 25.85 / $ 48.75

Further products from Elektor Electronics:

READY-BUILT PROJECTS

MP3 Adaptor for TV

040105-1 PCB, bare 3.55 5.50

050388-11 Disk, project software 3.00 5.05

040035-31 PIC16F84A, C446-16, programmed 27.50 51.95

OBD-2 Analyser

050092-1 PCB, bare 8.05 13.55

No. 345 JUNE 2005

Electrosmog Tester
050001-01 PCB, bare 5.15 9.75
050008-31 PCB, ready built and tested, check our website 50.00 94.25

GPS Receiver on USB
040502-1 PCB, bare 6.75 12.05
040504-71 Kit of parts 25.50 44.50

Temperature Logger
030147-1 PCB, bare 3.60 6.05
030447-11 Disk, project software 5.00 9.75
030147-41 PIC16F84, programmed 6.50 10.55
030147-71 Kit of parts 32.00 58.00

Tune in to Electrosmog
040482-1-1 PCB 3.40 6.55

No. 345 MAY 2005

Glow Plug Heater
040239-11 DIY design, parts list 5.00 9.75
040239-41 STPFLITE20, programmed 16.00 29.00

Magnetic Flux Density Meter
040258-11 DIY design, software 5.20 9.75
040258-41 PIC16F84A, 8051 MP, programmed 16.55 31.15

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

home construction = fun and added value
INFO & MARKET  

SNEAK PREVIEW

USB Oscilloscope Test

The 10 or so instruments we're examining next month are small add-on boxes that effectively turn your PC into an oscilloscope. All contain a fast A/D converter and a state of the art USB connection for easy connection to the PC. As with our previous tests of oscilloscopes and power supplies, the instruments will be critically evaluated for hardware & software performance, price and ease of use.

Also...

USB-R5232 Hurdle Race, Barometer/Altimeter, Commercial Break Silence, Ez80Acclaim.

RESERVE YOUR COPY NOW!

The September 2005 issue goes on sale on Saturday 20 August 2005 (UK distribution only). Article titles and magazine contents subject to change.

NEWSAGENTS ORDER FORM

SHOP SAVE / HOME DELIVERY

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

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

INDEX OF ADVERTISERS

Allgood Technology, Showcase  
www.allgoodtechnology.com  
136

Audipress, Showcase  
www.audipress.com  
136

Avit Research  
www.avitresearch.co.uk  
49, 136

Black&Decker  
www.blackanddecker.co.uk  
136

PowerMAC  
www.powermacsystems.co.uk  
136

Clevis  
www.clevis.com  
136

Compuserve  
www.compuserve.com  
136

Conformal Electronics, Showcase  
www.conformaltec.co.uk  
136

Cricketped  
www.cricketpedelectronics.com  
116

Danby, Showcase  
www.danby.co.uk  
136

Display Electronics  
www.displaytech.co.uk  
58

Eltech Systems, Showcase  
www.eltechsystems.co.uk  
17, 136

Elec, Showcase  
www.elec.com  
136

Electrocircuit  
www.electro circuits.com  
135

ExpressPCB  
www.expresspcb.com  
7

Fast Components  
www.fastcomponents.co.uk  
59

Fasttrax  
www.fasttrax.co.uk  
116, 136

Future Technology Devices, Showcase  
www.futuretech.co.uk  
136

Futurelec, Showcase  
www.futurelec.co.uk  
136

HiRes  
www.hires.co.uk  
59

ILP Electronics Limited, Showcase  
www.ilpel ectr onics.com  
80136

Ipeva Limited, Showcase  
www.ipeva.com  
136

Jaycar Electronics  
www.jaycarelectronics.co.uk  
2

J.B. Electronics, Showcase  
www.jbel ectr onics.com  
136

Kometron, Showcase  
www.kometron.com  
136

Labcenter  
www.labcenter.co.uk  
144

Levin Electronics, Showcase  
www.levin.org.uk  
136

Matrix Multimedia Ltd  
www.matrixmultimedia.co.uk  
117

MGP Electronics, Showcase  
www.mgpelectronics.co.uk  
137

New Wave Concepts, Showcase  
www.new-wave-concepts.co.uk  
137

Number One Systems  
www.numberone.co.uk  
117

Osem Networks  
www.osemresalesation.com  
59

PCB World, Showcase  
www.pcbworld.org.uk  
137

PicoX, Showcase  
www.picox.co.uk  
137

Picksus, Showcase  
www.picksus.com  
137

Pika  
www.pikatch.com  
49

Qasar Electronics, Showcase  
www.qasarelectronics.com  
30, 137

RD Research  
www.rdresearch.co.uk  
3

Robot Electronics, Showcase  
www.robotelectronics.co.uk  
137

Showcase  
136, 137

Sonus, Showcase  
www.sonus.com  
137

Total Electronics  
www.total-electronics.com  
7

Ultradex, Showcase  
www.ultradex.co.uk  
137

University of Manchester  
www.unimetro.co.uk  
6

USB instruments, Showcase  
www.usb-instruments.com  
137

Wavelength, Showcase  
www.wavelength.co.uk  
137

Virtech, Showcase  
www.virtech.co.uk  
137

Virtex Technology, Showcase  
www.virtex.co.uk  
137

Advertising space for the issue of 20 September 2005 may be reserved not later than 23 August 2005

with Husan International Media - Cambridge House - Gogmora Lane - Chertsey, Surrey KT16 9AP - England - Telephone 01932 564 999 - Fax 01932 564998 - e-mail:elpar@husanmedia.com To whom all correspondence, copy instructions and artwork should be addressed.
Yes, I am taking out an annual subscription to Elektor Electronics and receive a free 128 MB USB 2.0 Flash drive.

I would like:

☐ Standard Subscription (11 issues)
☐ Subscription-Plus
  (11 issues plus the Elektor Volume 2005 CD-ROM)

* Offer available to Subscribers who have not held a Subscription to Elektor Electronics in the last 12 Months. Offer Subject to Availability. See reverse for rates and conditions.

Title (Dr/Mr/Mrs/Ms*)  Initials  Surname

Name

Address

Post code

Email

Date  -  2005  Signature

* Cross out what is not applicable

EL0708
HOW TO PAY

Unless you have an approved credit account with us, all orders must be accompanied by the full payment, including postage and packing charges as stated above. Payment may be made by cheque drawn on a London clearing bank (but see para. 4 below), postal order, Visa, Access, MasterCard or EuroCard (when paying by credit card, the order must go to the cardholder’s address). Do not send cash through the mail. Cheques and postal orders should be crossed and made payable to "Elektor Electronics (Publishing)". Payment may also be made by direct transfer from a private or business Giro account to our Giro account No. 34-152-3801 by completing and sending to the National Giro Centre, in a National Giro post-age paid envelope, a National Giro transfer/deposit form. Do not send Giro transfers direct to us, as this will delay your order. If you live outside the UK, payment may also be made by Bankers’ sterling draft drawn on a London clearing bank, Eurocheques made out in pounds sterling (with holder’s guarantee card number written on the back), or US or Canadian dollar cheque drawn on a US or Canadian bank. If a Bankers’ sterling draft, make clear to the issuing bank that your full name and address MUST be communicated to the London clearing bank. Our bankers are NAT WEST PLC, 1 St James’s Square, Wadhurst, East Sussex TN5 6BH, England. Our account number is 3512 5225, Sorting Code 69-22-15, IBAN code: GB40 NWB K6 022 15 3512 5225 BIC code: NWB KGB 2L

COMPONENTS

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

TERMS OF BUSINESS

Delivery Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we cannot guarantee this time scale for all orders. Returns Faulty goods or goods sent in error may be returned for replacement or refund, but not before obtaining our permission. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number. If the goods are returned because of a mistake on our part, we will refund the return postage. Damaged goods Claims for damaged goods must be received at our Tunbridge Wells office within 10-days (UK); 14-days (Europe) or 21-days (all other countries). Cancelled orders All cancelled orders will be subject to a 10% handling charge with a minimum charge of £5.00. Patents Patent protection may exist in respect of circuits, devices, components, and so on, described in our books and magazines. Elektor Electronics (Publishing) does not accept responsibility or liability for failing to identify such patent or other protection. Copyright. All drawings, photographs, articles, printed circuit boards, programmed integrated circuits, diskettes and software carriers published in our books and magazines (other than in third-party advertisements) are copyright and may not be reproduced or transmitted in any form or by any means, including photocopying and recording, in whole or in part, without the prior permission of Elektor Electronics (Publishing) in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature. Norwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission. Limitation of liability Elektor Electronics (Publishing) shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connection with, the supply of goods or services by Elektor Electronics (Publishing) other than to supply goods as described or, at the option of Elektor Electronics (Publishing), to refund the purchaser any money paid in respect of the goods. Law Any question relating to the supply of goods and services by Elektor Electronics (Publishing) shall be determined in all respects by the laws of England.

SUBSCRIPTION RATES FOR ANNUAL SUBSCRIPTION

<table>
<thead>
<tr>
<th>United Kingdom</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>£39.50</td>
<td>£46.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economy Mail</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>£51.30</td>
<td>£57.80</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Priority Airmail</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>£31.30</td>
<td>£37.80</td>
<td></td>
</tr>
<tr>
<td>£55.00</td>
<td>£61.50</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Airfreight</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA &amp; Canada only</td>
<td>£88.00</td>
<td>£98.00</td>
</tr>
</tbody>
</table>

Payment should be made by:
- Cheque or bankers’ draft in sterling drawn on a London clearing bank (except in the USA and Canada — see below).
- U.S. cheques drawn on a US or Canadian bank — only by subscribers in the USA or Canada.
- Direct transfer to our bank (NAT WEST PLC, 1 St James’s Square, Wadhurst, East Sussex TN5 6BH, England).
- Our account number is 3512 5225, Sorting Code 60-22-15. IBAN code: GB40 NWB K6 022 15 3512 5225 BIC code: NWB KGB 2L
- Postal order.
- Credit card: Visa, Access, Euro/MasterCard, JCB Electron or Switch.
- Transfer to our Giro account number 34 152 3801. Giro transfers should be made by completing and sending the appropriate transfer/deposit form to the National Giro Centre (UK) or to your national Giro Centre.

Cheques and postal orders should be made payable to Elektor Electronics (Publishing). Do not send cash through the mail.

SUBSCRIPTION RATES FOR 18-MONTH SUBSCRIPTION

<table>
<thead>
<tr>
<th>United Kingdom</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>£59.25</td>
<td>£69.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Economy Mail</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>£76.95</td>
<td>£86.70</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Priority Airmail</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>£78.75</td>
<td>£88.50</td>
<td></td>
</tr>
<tr>
<td>Outside Europe</td>
<td>£87.50</td>
<td>£107.25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Airfreight</th>
<th>Standard</th>
<th>Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA &amp; Canada only</td>
<td>£130.20</td>
<td>£147.00</td>
</tr>
</tbody>
</table>

SUBSCRIPTION CONDITIONS

The standard subscription order period is twelve months. If a permanent change of address during the subscription period means that copies have to be despatched by a more expensive service, no extra charge will be made. Conversely, if a refund is made, no expiry date extended, if a change of address allows the use of a cheaper service. Student applications, which qualify for a 20% (twenty per cent) reduction in current rates, must be supported by evidence of studentship signed by the head of the college, school or university faculty. A standard Student Subscription costs £31.60, a Student Subscription-Plus costs £37.60 (UK only). Please note that new subscriptions take about four weeks from receipt of order to become effective.

Cancellations of subscriptions will be subject to a charge of 25% (twenty-five per cent) of the full subscription price or £7.50, whichever is the higher, plus the cost of any issues already dispatched. Subscriptions cannot be cancelled after they have run for six months or more.

January 2005
Straight from the heart of electronics each month

This Issue:
The Summer Circuits edition 2005
More than 100 snappy projects, tips and ideas

Next Issue:
TEST AND MEASUREMENT
USB oscilloscopes on the test rack

Want to know everything each month?
Select your own annual subscription and receive a free 128 MB USB 2.0 Flash drive

Available options:
- Elektor Electronics annual subscription (standard)
  You receive 11 issues, including the July/August double issue.
- Elektor Electronics annual subscription-PLUS
  You receive 11 issues, including the July/August double issue, plus a copy of the Elektor Electronics Volume 2005 CD-ROM (normal price £16.25). Your saving: approx. £10.00!

Please fill out the Order Form with this issue.
Subscription rates and conditions may be found at the back of this issue.
**PROTEUS**
The Complete Electronics Design System

Schematic & PCB Layout

- Powerful & flexible schematic capture.
- Auto-component placement and rip-up/retry PCB routing.
- Polygonal gridless ground planes.
- Libraries of over 8000 schematic and 1000 PCB parts.
- Bill of materials, DRC reports and much more.

**Mixed Mode SPICE Circuit Simulation**

- Berkeley SPICE3F5 simulator with custom extensions for true mixed mode and interactive simulation.
- 6 virtual instruments and 14 graph based analysis types.
- 6000 models including TTL, CMOS and PLD digital parts.
- Fully compatible with manufacturers’ SPICE models.

**Proteus VSM - Co-simulation and debugging for popular Micro-controllers**

- Supports PIC, AVR, 8051, and BASIC STAMP micro-controllers.
- Co-simulate target firmware with your hardware design.
- Includes interactive peripheral models for LED and LCD displays, switches, keypads, virtual terminal and much, much more.
- Compatible with popular compilers and assemblers from Microchip, Crownhill, IAR, Keil, and others.

Call Now for Upgrade Pricing

New Features in Version 6.5

- Textual library part search.
- User defined keyboard map.
- CAD/CAM output to ZIP file.
- Bitmap import function.
- TrueType fonts on PCBs.
- Enhanced printer output.

**NEW**
ELECTRA SHAPE BASED AUTOROUTER NOW AVAILABLE

**Contact us for Free Demo CD**

Tel: 01756 753440  Fax: 01756 752857

www.labcenter.co.uk info@labcenter.co.uk

**Labcenter Electronics**
53-55 Main Street, Grassington, BD23 5AA