



elektor

electronics worldwide



Surround Light

for PC and TV

UK University Courses for Electronics & Electrical Engineering

- DIY: CAN Bus Explorer**
- DIY: LED Ringflasher for macro photography**
- Disassembled: Philips LivingColors**



9 770268 45113 5

Great Kits for Electronics Enthusiasts

Top Selling Kits

10A 12VDC Motor Speed Controller

KC-5225 £7.95 + post & packing

Ideal for controlling 12V DC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. You can also use it for headlight dimming and for running 12V DC motors in 24V vehicles. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps.

Includes PCB and all electronic components.

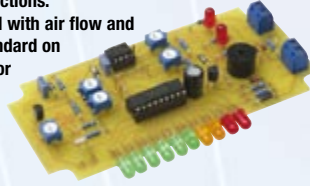


Smart Fuel Mixture Display for Fuel Injected Cars

KC-5374 £8.95 + post and packing

This kit features auto dimming for night driving, emergency lean-out alarm, and better circuit protection. Another great feature is the 'dancing' display which operates when the ECU is operating in closed loop. Kit supplied with PCB and all electronic components with clear English instructions.

* Car must be fitted with air flow and EGO sensors (standard on all EFI systems) for full functionality.



Clock Watcher's Clock

KC-5404 £41.75 + post & packing

KC-5416 £55.25 + post & packing

This amazing clock uses an AVR driven circuit, and produces a dazzling display with 60 LEDs around the perimeter. It looks amazing, but can't be properly explained here. We have filmed it in action so you can see for yourself on our website www.jaycarelectronics.com. Kit supplied with double sided

silkscreened plated through hole PCB and all board components as well as the special clock housing!

Available in Red or Blue

Red KC-5404

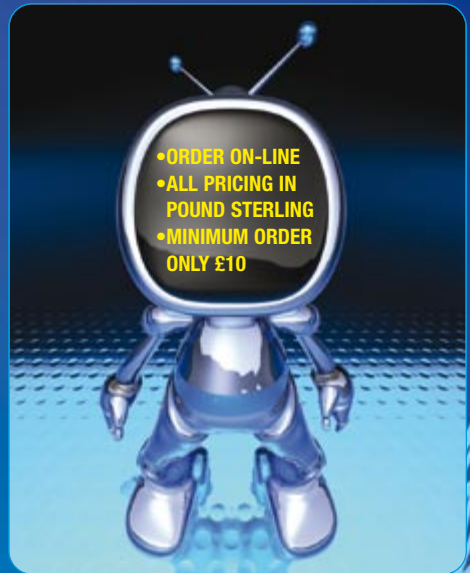
Blue KC-5416



45 Second Voice Recorder Module

KC-5454 £11.75+ post & packing

This kit can be set up to record two, four or eight different messages for random-access playback, or a single message for 'tape mode' playback. It provides clean, glitch-free line-level audio output suitable for feeding to an amplifier or PA system. It can be powered from any source of 9-14V DC. Supplied with silk screened and solder masked PCB and all electronic components.



•ORDER ON-LINE
•ALL PRICING IN POUND STERLING
•MINIMUM ORDER ONLY £10

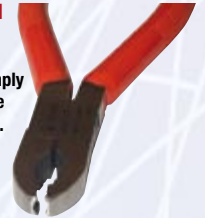
Handy Helpers

Fujiya 175mm Screw Removing Pliers

TH-2330 £7.00+ post and packing

Remove screws even with completely stripped heads. Simply grab the screw head with these Japanese made pliers and turn. Beautiful.

- 175mm long
- Soft grip handle



Waterproof (IP67) LED Lighting Modules

Each £5.75 + post and packing

Endless possibilities - backlighting signs, strip lighting in stairwells & passageways, boats, garages etc. Supplied as 10 x 3 LEDs module, 10 modules, with 500mm flying leads for termination. Each module is spaced at approximately 110mm between centres. Simply connect up a 12VDC 600mA supply and away you go.

Two types available

ZD-0490 White

ZD-0492 Blue



Audio Playback Adaptor for CD-ROM Drives

KC-5459 £19.00 + post & packing

Put those old CD-ROM drives to good use as CD players using this nifty adaptor kit. The adaptor accepts signals from common TV remote controls and operates the audio functions of the drive as easily as you would control a normal CD player. Kit features a double sided PCB, pre-programmed micro controller, and IDC connectors for the display panel. Supplied with solder masked and screen printed PCB and all required electronic components.



Build-Yourself Electronic Project Kits

Looking for a particular KIT?

Checkout Jaycar's extensive range.

We have kits and electronic projects for use in:

- Audio & Video
- Car & Automotive
- Computer
- Learning & Educational
- Lighting
- Power
- Test & Meters
- General Electronics Projects - just for fun!



430+ pages
ALL prices in PDS

Post and Packing Charges

Order Value	Cost	Order Value	Cost
£10 - £49.99	£5	£200 - £499.99	£30
£50 - £99.99	£10	£500+	£40
£100 - £199.99	£20		

Max weight 12lb (5kg). Heavier parcels POA.
Minimum order £10.

Note: Products are despatched from Australia, so local customs duty and taxes may apply.

How to order:

Phone: Call Australian Eastern Standard Time Mon-Fri on 0800 032 7241

Email: techstore@jaycarelectronics.co.uk

Post: PO BOX 6424, Silverwater NSW 1811. Australia
Expect 10-14 days for air parcel delivery

Low Voltage Battery Warning

KG-9000 £3.00 + post and packing

This circuit monitors any battery voltage between 3-15 volts.

Whenever the voltage falls below a predetermined value a Red LED lamp lights up to alert you.

Uses a tiny amount of power from the battery being monitored. Use it for monitoring all sorts of battery systems and avoiding battery damage.



Light-Sensitive Switch 240VAC 10A

AA-0326 £3.00 + post and packing

Turn a mains powered device on or off according to the ambient light level. Ideal for garden lighting or security applications. The controller is weather resistant and includes a mounting bracket. Approx 80mm high.



Check out the Jaycar range in your FREE Catalogue - logon to

www.jaycarelectronics.co.uk/elektor

or check out the range at

www.jaycarelectronics.co.uk

0800 032 7241

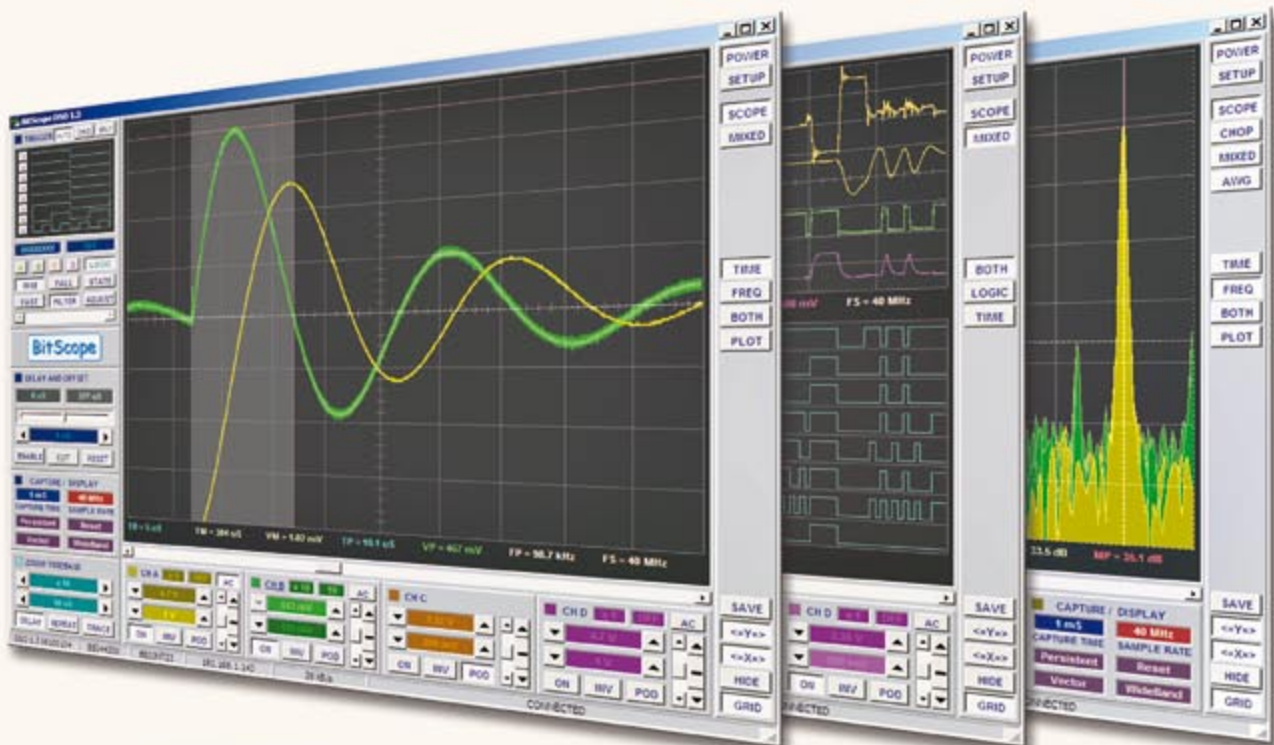
(Monday - Friday 09.00 to 17.30 GMT + 10 hours only)

For those who want to write: 100 Silverwater Rd
Silverwater NSW 2128 Sydney AUSTRALIA

Jaycar
Electronics

BitScope PC Oscilloscopes & Analyzers

DSO Test Instrument Software for BitScope Mixed Signal Oscilloscopes



4 Channel BitScope



2 Channel BitScope



Pocket Analyzer

Digital Storage Oscilloscope

- ✓ Up to 4 analog channels using industry standard probes or POD connected analog inputs.

Mixed Signal Oscilloscope

- ✓ Capture and display up to 4 analog and 8 logic channels with sophisticated cross-triggers.

Spectrum Analyzer

- ✓ Integrated real-time spectrum analyzer for each analog channel with concurrent waveform display.

Logic Analyzer

- ✓ 8 logic, External Trigger and special purpose inputs to capture digital signals down to 25nS.

Data Recorder

- ✓ Record anything DSO can capture. Supports live data replay and display export.

Networking

- ✓ Flexible network connectivity supporting multi-scope operation, remote monitoring and data acquisition.

Data Export

- ✓ Export data with DSO using portable CSV files or use libraries to build custom BitScope solutions.

BitScope DSO Software for Windows and Linux

BitScope DSO is fast and intuitive multi-channel test and measurement software for your PC or notebook. Whether it's a digital scope, spectrum analyzer, mixed signal scope, logic analyzer, waveform generator or data recorder, BitScope DSO supports them all.

Capture deep buffer one-shots or display waveforms live just like an analog scope. Comprehensive test instrument integration means you can view the same data in different ways simultaneously at the click of a button.

DSO may even be used stand-alone to share data with colleagues, students or customers. Waveforms may be exported as portable image files or live captures replayed on other PCs as if a BitScope was locally connected.

BitScope DSO supports all current BitScope models, auto-configures when it connects and can manage multiple BitScopes concurrently. No manual setup is normally required. Data export is available for use with third party software tools and BitScope's networked data acquisition capabilities are fully supported.



www.bitscope.com

Theme of the month

With trade magazines it is customary for the editorial planning for the year to be based on themes or points of focus set for each issue. However the theme planning is not just a crucial bit of information to the magazine editors — it also offers guidance to press and PR agencies, advertisers and, importantly, potential authors who will typically use the list to report a relevant article to... the editor! Elektor's theme plan for 2008 is available for all & sundry to see at www.elektor.com if you click on the Service tab.

For sure, a number of our themes can be accessed from so many angles that they can be relied on to fill the magazine pages on their own strength. The January 2008 issue had a strong focus on energy, energy savings and the environment. For this month, LEDs and LED technology form the plot, unmistakably. Immediately after releasing our theme plan, articles and projects using LEDs poured in to the extent that they could easily have filled the pages of an Elektor issue exclusively on LEDs. LEDs are hot (and 'cool') as we've noticed from the response to relevant news items on our News & New Products pages and in the Elektor E-weekly. Not a week goes by without 'breaking news' of a yet brighter or more efficient LED, or a stunning application. The light emitting diode has come a long way since its introduction in the mid 1970s. Today the full spectrum from infrared right up to ultra-violet is readily available, and white LEDs (a class of their own) get brighter and whiter all the time. Efficiency-wise LEDs have long since surpassed halogen lamps and they now look poised to match low-energy CFLs. In the automotive industry, to talk of a LED array as a replacement for xenon lights is no longer utopian. Not forgetting TFT backlighting (till now the exclusive domain of incandescent lamps) where LEDs will be seen soon — literally!

Jan Buiting
Editor

Surround Light & TV Light 16 & 24

Due to the fact that we received two circuit designs for television mood lighting and they both fit with the theme of this issue, we initiated a unique Elektor project: in this issue we present two completely different designs that produce nearly the same effect. Our French contributor Alex Vercey took the analogue approach, while Steffen Schütte from Germany went the 'microcontroller way'. See, compare, experience for yourself!



30 What University

So you were thinking of studying for an Electronics and Electrical Engineering degree or similar qualification at a UK university or other higher level educational establishment?

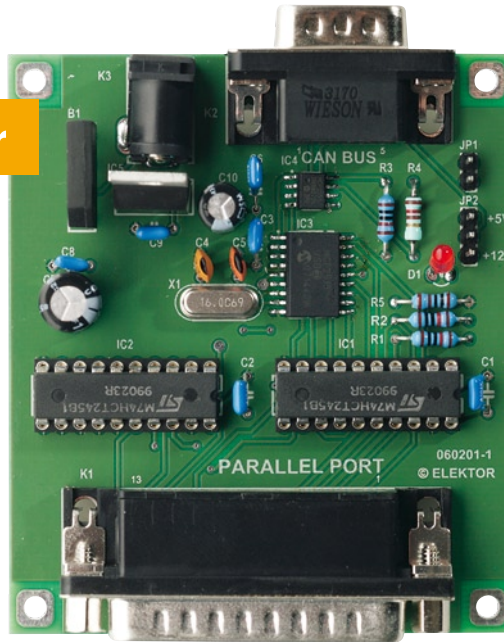
BEng., MEng., perhaps a PhD.?

Here's a 3-step primer on the subject: first get oriented; then hear opinions and finally, decide where to hang out.



38 CAN Explorer

Implementing the CAN bus network is not a trivial undertaking. This low-cost solution is a CAN board which sits between the CAN bus and a PC. Using the versatile (free) software it can monitor activity on the network and test the functioning of other nodes.



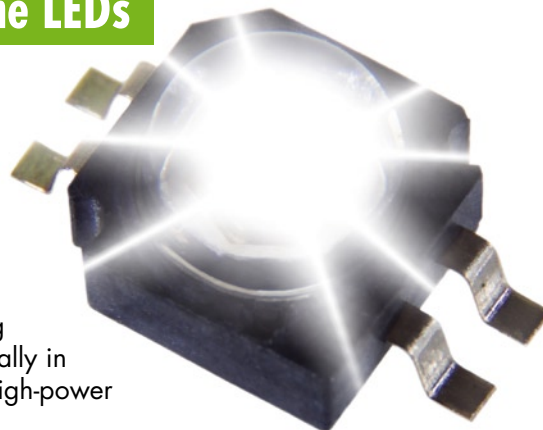
50 LED Ringflash

With macro-photography, if lighting conditions are not ideal, it will be necessary to resort to the use of flash, with the attendant risk of shadows. The solution is a ringflash – and while we're about it, why not one using LEDs?



66 Power to the LEDs

In two short picture stories we tell not only how LEDs are designed and produced (basically!), but also look at what Philips Lumileds Lighting Systems are pursuing technically in a bid at making a versatile high-power LED for mass production.



projects

- 16 Surround Light
- 24 TV Light
- 38 CAN Explorer
- 42 RGB LED Mood Lighting
- 50 LED Ringflash
- 56 E-blocks: Thermometer / Thermostat
- 60 LEDBUS System
- 73 Design Tip: 1 MHz frequency counters using AT89C2051
- 74 Frost Detector

technology

- 66 Power to the LEDs
- 70 Philips LivingColors
- 72 Vista versus LPT

info & market

- 6 Colophon
- 8 Mailbox
- 10 News & New Products
- 30 What University
- 80 Elektor SHOP
- 84 Sneak Preview

infotainment

- 76 Hexadoku
- 77 Retronics: Programmable Disco Lights Array (1984)

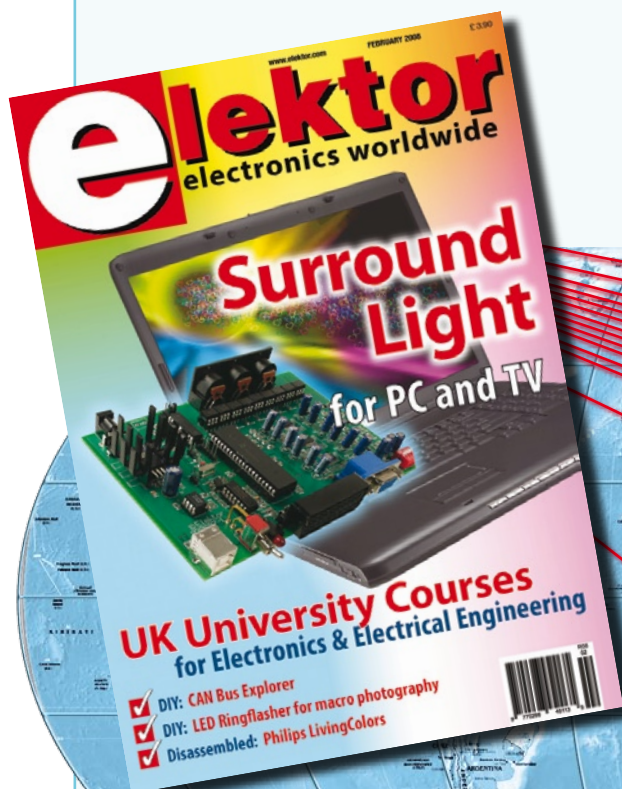
elektor international media

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

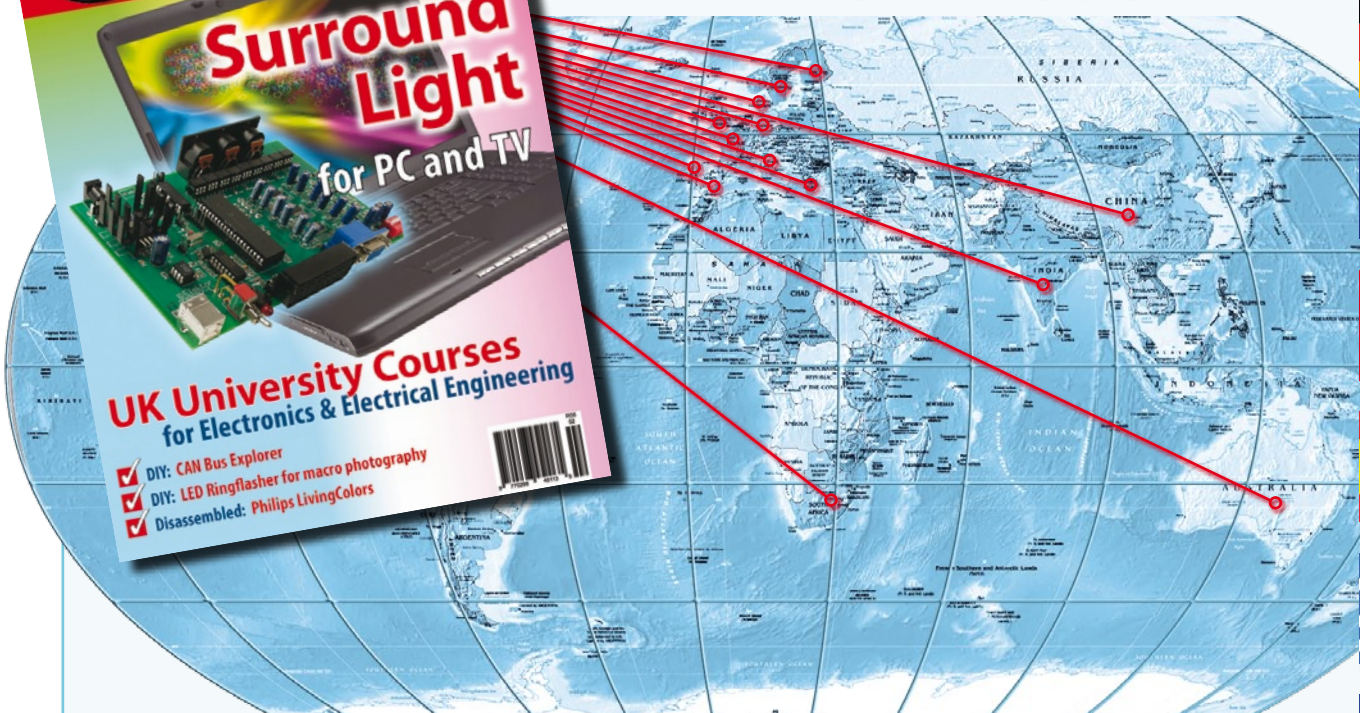
From professionals passionate about their work to enthusiasts with professional ambitions.

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

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



English
German
Dutch
French
Chinese



Greek
Spanish
Swedish
Finnish



Volume 34, Number 374, February 2008

ISSN 0268/4519

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

Publishers: Elektor International Media, Regus Brentford, 1000 Great West Road, Brentford TW8 9HH, England. Tel. (+44) 208 261 4509, fax: (+44) 208 261 4447 www.elektor.com

The magazine is available from newsagents, bookshops and electronics retail outlets, or on subscription.

Elektor is published 11 times a year with a double issue for July & August.

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

International Editor:
Wisse Hettinga (w.hettinga@elektor.nl)

Editor: Jan Buiting (editor@elektor.com)

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

Design staff: Antoine Authier, Ton Giesberts, Paul Goossens, Luc Lemmens, Jan Visser, Christian Vossen

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

Graphic design / DTP: Giel Dols, Mart Schroijen

Managing Director / Publisher: Paul Snakkers

Marketing: Carlo van Nistelrooy

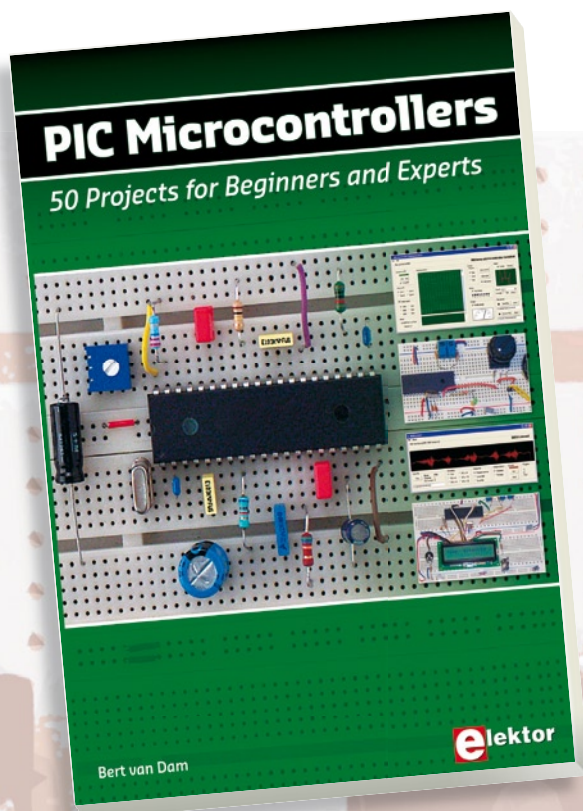
Customer Services: Anouska van Ginkel

Subscriptions: Elektor International Media, Regus Brentford, 1000 Great West Road, Brentford TW8 9HH, England. Tel. (+44) 208 261 4509, fax: (+44) 208 261 4447 Internet: www.elektor.com

PIC Microcontrollers

NEW!

➔ Silent alarm, RGB fader, poetry box,
night buzzer and more!



This hands-on book covers a series of exciting and fun projects with PIC microcontrollers. You can build more than 50 projects for your own use. The clear explanations, schematics, and pictures of each project on a breadboard make this a fun activity. You can also use it as a study guide. The technical background information in each project explains why the project is set up the way it is, including the use of datasheets. This way you'll learn a lot about the project and the microcontroller being used. Even after you've built all the projects it will still be a valuable reference guide to keep next to your PC. All software used in this book can be downloaded for free, including all of the source code, a program editor, and the JAL open source programming language.

446 pages • ISBN 978-0-905705-70-5 • £27.00 • US\$ 54.00

elektor
SHOP

Elektor
Regus Brentford
1000 Great West Road
Brentford
TW8 9HH
United Kingdom
Tel. +44 20 8261 4509

Order quickly and safe through www.elektor.com/shop
or use the Order Form near the end of the magazine

Email: subscriptions@elektor.com

Rates and terms are given on the Subscription Order Form

Head Office: Elektor International Media b.v.

P.O. Box 11 NL-6114-ZG Susteren The Netherlands
Telephone: (+31) 46 4389444, Fax: (+31) 46 4370161

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

UK Advertising: Huson International Media, Cambridge House,
Gogmore Lane, Chertsey, Surrey KT16 9AP, England.
Telephone: +44 1932 564999, Fax: +44 1932 564998

Email: p.brady@husonmedia.com

Internet: www.husonmedia.com

Advertising rates and terms available on request.

International Advertising: Frank van de Raadt, address as Head Office

Email: advertenties@elektor.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 circuits, disks, CD-ROMs, software carriers and article texts 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 or 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.

Disclaimer

Prices and descriptions of publication-related items subject to change.
Errors and omissions excluded.

© Elektor International Media B.V. 2008

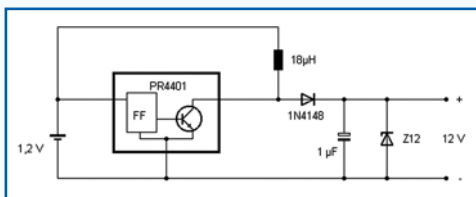
Printed in the Netherlands

Alternative and original uses for the LED driver board (September 2007 issue) (2)

12-V converter using the PR4401

Many thanks for the nice lamp driver, although the IC is almost too good for a piddly little lamp. I had a different problem in my lab: my digital multimeter (Conrad BT-555) uses an expensive 12-V photo battery. It needs a new one every few weeks, and after replacing the battery twice you have paid for the instrument twice over. I thus needed to build a voltage converter to generate 12 V from a 1.2-V source (a NiCd or NiMH cell). To do so, I fitted a 12-V zener diode to the board that came with the September 2007 issue of *Elektor*. Naturally, you can use a diode with a different zener voltage if you need a different output voltage. The 1.2-V rechargeable cell came from a 9-V battery (GF22), which consists of a flat stack of six cells. All of this fits perfectly in the multimeter. Now I can use the multimeter with renewed pleasure!

John Dyer



Hi Jan—I am considering installing it in a book reading lamp with a white LED, and a plastic diffuser sheet from a broken phone LCD panel.

I found the diffuser plastic works really well in providing a more even light distribution. It removes the contrasting rings of light dark cast from the led and there is very little loss of intensity. I tested the diffuser with a commercial LED torch and it makes the torch more usable. I believe the diffuser plastic is very similar to what Luminit manufacture using holographic technology.

www.luminitco.com/index.html

Peter Wintulich (Australia)



Residual charge converter

When I saw the *Elektor* LED driver circuit, I was immediately reminded of the following website: www.emanator.demon.co.uk/biglive/joule.htm

As you can see, an even simpler solution is possible. In theory you could also omit the 1-kΩ resistor by winding the coil with resistance wire.

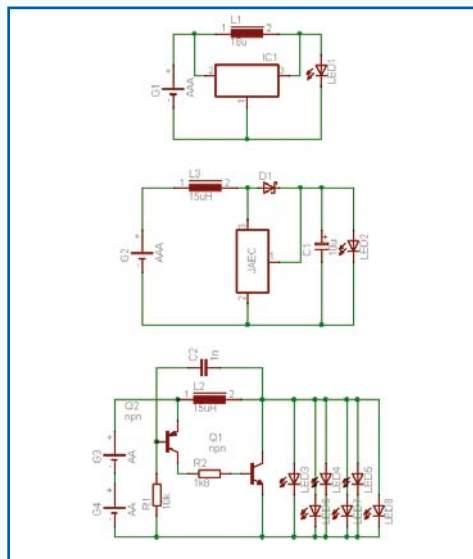
Ron Kellerman

Déjà vu

This was a sort of déjà vu experience. I discovered a three-lead LED driver around two years ago. The circuit (of which I found two versions) is used in an aluminium pocket torch with a single AAA cell, and it starts working at around 0.7 V. If you forget to switch off the torch, it keeps working down to below 0.2 V. This should also be possible with your IC. This means it could also be used with a single-cell solar module, which could then be used to recharge a mobile phone.

I also found another type of circuit in an aluminium torch from China. It consists of six discrete components and drives six white LEDs from a voltage of around 0.7 V or more. This circuit board is not much larger, since the transistors are in SOT23 packages.

Frederic Stephens



The PR4401 is not the best choice for a solar charger with only one solar cell. This would need a somewhat lower minimum input voltage, and the maximum output current would have to be somewhat higher. The TPS61200 from TI is one possible recommendation, although it is somewhat limited by its 3x3 QFN package.

What can I write about?

Hi Jan — I was a regular reader & subscriber to *Elektor India* Magazine until it was stopped a couple of years ago. I was wondering if I could contribute technical articles & projects for publication in your magazine. If so, please reply.

Venkateswaran Gopalakrishnan (India)

As opposed to a number of our competitors on the market, Elektor is open to contributions from external authors and designers. Mind you, we do have challenging requirements for articles and projects. Please have a look at our Author Guidelines and the Elektor Publishing Plan for 2008. Both documents are available for anyone to view at www.elektor.com under the 'Service' tab.

Be a good sport

Dear Jan — I have been secretly wishing for many years that *Elektor* would feel the need to cast its eye over sports and the application of electronics in aiding training and competition. I have been eagerly waiting for you to run an issue on just electronic projects for sports. I loved the Robotics issue (July/August 2007), and something along those lines would be excellent. I and many sports coaches I am sure would love to see electronic projects that could be built at a reasonable cost. Projects based on the following ideas I am certain would be a great success.

- Automated electronic timer that stores times and can be downloaded into Excel.
- An accelerometer belt that is worn by a sprinter and stores/calculates ground contact times.
- The use of super bright LED pace makers that set the pace around a track and bleep when the athlete passes them.
- A cheap alternative to a force plate that measures jump height and ground contact time and calculates power.

M. Newman (UK)

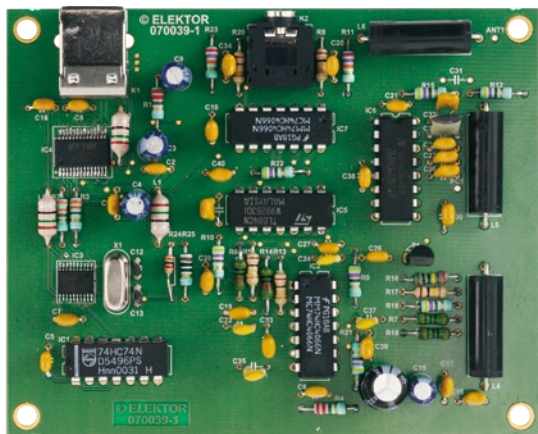
Really fine ideas which I am happy to copy into the electro-

nics design community! Please get in touch with Elektor to discuss your proposals.

Sound card for SDR receiver

Which sound card is recommended for the SDR receiver described in the May 2007 issue? You gave the minimum specifications for the sound card in a later issue, but when I search for sound cards on websites I find very little information about these specifications, so I would like to have a brand and type if possible.

Francis McGee



There are many different sound cards available, and we were not able to test all of them for use with the SDR radio. For this reason, we wrote an article on how to test your own sound card. You can download this article free of charge from the Elektor website via the following link:

www.elektor.com/magazines/2007/june/sdr-soundcard-tester.91895.lynx

Incidentally, most of the better modern sound cards are suitable for SDR reception.

USB interference with SDR

The circuit described in the May 2007 issue had poor reception characteristics. The cause of this was strong interference on the USB bus. Unfortunately, PC switch-mode power supplies are not a good source of power for sensitive analogue circuits. The only

remedy is a filter. With the SDR project, this means that capacitor C9 (4.7 µF) must be replaced by a 470 µF / 10 V type. This yields a remarkable improvement.

Using an external power supply for the circuit, as suggested by Burkhard Kainka, was not as satisfactory as replacing the capacitor, and in any case using the USB bus for power is more attractive.

Helmut DH6KR

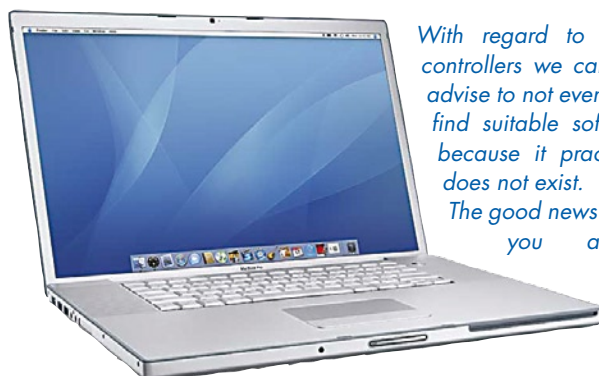
I have tested the circuit with the larger-value capacitor. It visibly cleans up the interference, but there is still some noise below around 30 Hz. I suspect that every PC has a different interference spectrum. With mine, I obtained better results with the voltage regulator. Incidentally, some readers have attempted to use the frequency range around 0 Hz directly. This yields poor results

because signals such as an AM carrier 'dry up' in that region. I set the lower frequency limit relatively high to reduce USB interference feedthrough. This is why you should use an IF of 10 to 15 kHz, since no USB interference is present there.

Burkhard Kainka

Macs and microcontrollers

I have purchased an AVR USB board, and I would like to learn how to program it. I am highly encouraged



by the easily understandable articles in your magazine, but I have a small problem. I have a new Apple Macbook with the Leopard operating system, and after long (really long) searching I have not found a single program that I can use to program the board. There are a few sites on the Internet with complicated instructions describing how this might be arranged, but most of them are rather difficult to understand. Is there any sort of software that I could use? If not, perhaps it would be a good idea to publish an article on how to do this. By that I mean something truly understandable, not the confusion propagated on the Internet.

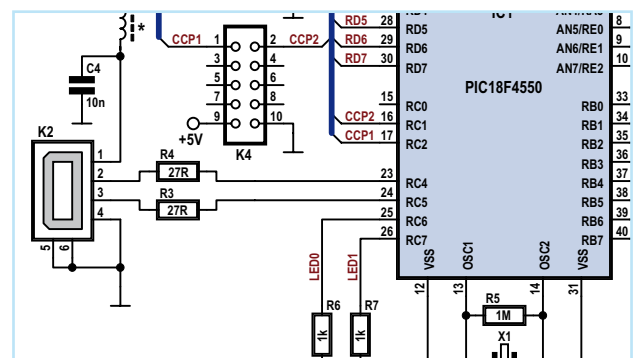
Peter Pantott (Germany)

Corrections & Updates

USB Data Acquisition Card

November 2007, p. 16-20, ref. 070148-1

In the circuit diagram, the USB+ and USB- pins on K2 should be swapped. The PCB track layout shown in the article should also be corrected. PCBs supplied through the Elektor Shop have the correct USB signal routing and are **not** affected. Although different values are indicated in the circuit diagram and the parts list, both 27 Ω and 33 Ω resistors may be used in positions R3 and R4.



the answer in your hand: the Macbook.

Simply use Bootcamp to install Windows XP (in addition to the Mac OS) in a small disk partition. For your purposes, 6 GB should be more than enough. With your Mac configured this way, you have full access to everything there is.

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.com or
Elektor, The Editor,
1000 Great West Road,
Brenford TW8 9HH, England.

Multiroom Sonocontrol Audio Transmitter

Until now, if you wanted to enjoy music from your iPod® without headphones, you had to either connect the handy MP3 player to the hi-fi system – a complicated feat – or place it in a special docking station.

Thanks to the new technology from sonostream, the music lover no longer has to let go of his iPod and can select his favourite tracks on-the-go, as usual. The hi-fi system plays them immediately with the best sound. The iPod can be placed onto the small exact-fitting Sonocontrol Audio Transmitter with one click, and it is transformed into a handy remote control for every hi-fi system.

There are special versions of the transmitter for all common iPod models (Nano G23, Classic 60/80, iPod Touch, iPhone). All of the player's functions can be con-

trolled as usual: display, menu, and information always at a glance. sonostream's transmitter-receiver system enables an interference-free and absolute loss-free digital radio transmission from the player to the stereo system and to active speakers. With further receivers or sonostream active speakers in other rooms, the system becomes a wireless multi-room system, allowing you to directly activate or shut off individual listening zones using the transmitter.

Especially practical: To charge it, the iPod and the audio transmitter, that already has its own rechargeable battery, are placed onto the docking station together so that you no longer have the bothersome switching back and forth. Accordingly, the iPod can remain docked onto the transmitter for synchroni-



sation on the computer, because the signals are looped through.

www.sonovision-digital.com

(070904-X)

VB400 and VBC Save on KWh and Energy Costs



IEPC claims to make lighting control pay with its VB400 and Vari-Ballast Control (VBC.) These lighting controls reportedly save customers money from the very first month of use, and with up to 25 to

70 percent savings in lighting energy every month, the lighting controls make existing HID and both T5 / T8 lighting systems pay. The VB400 lighting control system is meant to replace outdated, inef-

ficient, un-controlled high-bay and low-bay HID lighting fixtures. The Vari-Ballast Control (VBC) enables the use of T5 and T8 florescent ballasts. Both lighting control systems can be used with any manufacturer, wattage, bulb type and input voltage.

To save energy, many facilities managers of high-bay lighting structures switch an existing HID lighting system for a less bright, non-controllable fluorescent lighting system. The VB400 and the VBC offer more efficient, controllable and more cost-effective alternatives. IEPC provides either solution T5 / T8 or HID.

With traditional ballasts, the fixtures are spaced closely together due to inefficiencies in magnetic ballast technology. With IEPC's

lighting controls, the layout can be expanded due to higher wattage output, a power factor correction of nearly 100 percent and the ability to precisely control the lumens/fixture output. Also, traditional HID ballasts have a Watt Stopper, which can only regulate up to eight lights at a time. The VB400 and the VBC allow control of a single lamp, part of an area or an entire area with thousands of lamps from one computer.

The VB400, VB400N and the Vari-Ballast controls are available immediately through a pilot program with IEPC.

www.iepc.cc

(070904-XI)

PIC programmer for design licensing

With firmware beginning to dominate the development costs and value of electronic products, the question of how to manage it and trade it securely is becoming increasingly important. FlexiPanel Ltd tackles this issue head-on with the release of its TEAclipper range of encrypted PIC programmers. From just £ 20 (€ 30) and the size of thumbnail, they are a welcome break from the cumbersome

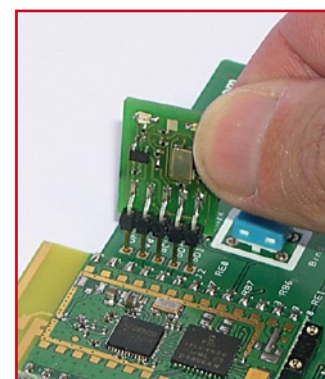
gang programmers of the past. They are plugged into the target circuit board and program the PIC in seconds.

TEAclippers were developed for businesses needing to ensure their subcontract manufacturers don't rip off their products and engineers who want to license their electronic designs. They have a limited-download feature which ensures that only a fixed number of cop-

ies may be made, and they store their firmware securely on-board for easy archiving of different versions. Customization features allow serial numbers, random numbers and configuration settings to be individually set each time a PIC is programmed.

www.flexipanel.com

(070996-1)



First Technology Transfer courses

Andrew Eliasz and Jim Davies founded First Technology Transfer (FTT) in the early 1990s with a view to providing specialist, innovative, advanced and highly tailored technical training and consultancy to organisations developing both traditional IT and embedded systems applications. Since then, it has built around the core of the company a network of consultants and technologists who collectively provide FTT with access to extensive expertise across the complete spectrum of IT and software engineering disciplines.

These consultants have had established careers within their own sectors and have seen many projects through the full life cycle. This diversity enables FTT to put together experienced multidisciplinary teams to provide mentoring, consultancy and training in a wide range of projects ranging from real time process control and laboratory automation through to net-



worked and distributed database projects.

FTT's expertise and training curriculum encompasses the following disciplines:

- Programming languages
- Embedded Linux and Unix
- Small microcontrollers
- Networking

- IPV6
- Microchip/CMX approved courses
- Service oriented architecture
- UML and OO analysis
- Windows programming
- Open source databases
- Bioinformatics

It is an inevitable fact that the use of real-time software running in

embedded devices is going to become more and more pervasive in our society. However, unfortunately, the number of experienced engineers in this area is very limited, and there is substantial demand for suitably trained staff to meet these requirements. FTT's vision, shared by it's sister company — Robotiq (focussed on educational robotics) is to encourage the young (and not so young) people to become more actively involved with technology and engineering by providing them with the training and support to equip them with the necessary skills to fulfil their ambitions.

All of FTT courses include a significant component of hands-on work. These courses can be provided either on-site at the client location or at FTT's fully equipped training centre in Carshalton, Surrey.

<http://www.ftt.co.uk>

(070996-11)

Advertisement

PCB-Soldering.co.uk

Suppliers of PCB Soldering Equipment & Rework Stations

NEW IN STOCK

328 Working Platform

<p>850A+ SMD Rework Station</p> <p>Online Price £44.95</p>	<p>932 Vacuum Pick Up Station</p> <p>Online Price £29.95</p>	<p>937+ 45W Soldering Station</p> <p>Online Price £37.95</p>	<p>Range Of Tools & Accessories</p>
<p>2738 CPU Controlled PCB Work Station</p> <p>Kit Includes: Hot Air Gun 6 x Air Nozzles 70W Soldering Iron with Fume Absorber Soldering Iron Stand Soldering Iron Tip with Heating Element Vacuum Suction Pen Heat Resistant Pad IC Removal Tool 2 x Carbon Filters</p> <p>Online Price £139.95</p>	<p>2900 70W Soldering Station</p> <p>Online Price £74.95</p>	<p>Soldering Iron Tips & Air Nozzles</p> <p>Wide Selection Available</p>	
<p>853A Quartz Infrared Preheater</p> <p>Online Price £69.95</p>	<p>950 SMD Hot Tweezers & Station</p> <p>Online Price £44.95</p>	<p>710 Infrared Welding Station</p> <p>Online Price £750.00</p>	<p>TEST-PINS.CO.UK Suppliers of Test-pins, Receptacles & Probes...</p> <p>For Test-pins & Probes Visit www.test-pins.co.uk Above discount code also applies</p>

www.pcb-soldering.co.uk

Allendale Electronics Ltd, 43 Hoddesdon Industrial Centre, Pindar Road, Hoddesdon, Hertfordshire. EN11 0FF.

T: +44 (0)1992 450780 W: www.pcb-soldering.co.uk
F: +44 (0)1992 450781 E: sales@pcb-soldering.co.uk

New PSoC® evaluation kit

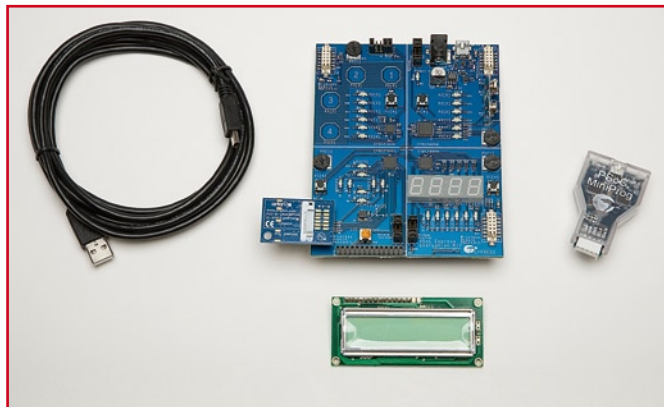
Cypress Semiconductor Corp. recently introduced a new evaluation kit for its fast-growing PSoC mixed-signal arrays. The new CY3209 ExpressEVK includes four different PSoC devices and gives designers an easy to use platform to try a multitude of designs.

The CY3209 ExpressEVK includes four sections, each of which contains a separate PSoC device. The sections can all be networked together easily via I²C interfaces to test numerous combinations of functions using the PSoC Express(tm) visual embedded design tool. The new kit offers hardware, software and design examples

to help designers implement a variety of functions, including:

- PSoC CapSense™ capacitive touch interfaces
- Wireless communication
- "Drag and drop" USB programming
- LCD and LED control
- Accelerometer, tilt or drop sensing
- Voltage monitoring

Details of the kit are at www.cypress.com/CY3209-ExpressEVK and it is available for purchase on the Cypress Online Store and through authorized distributor part-

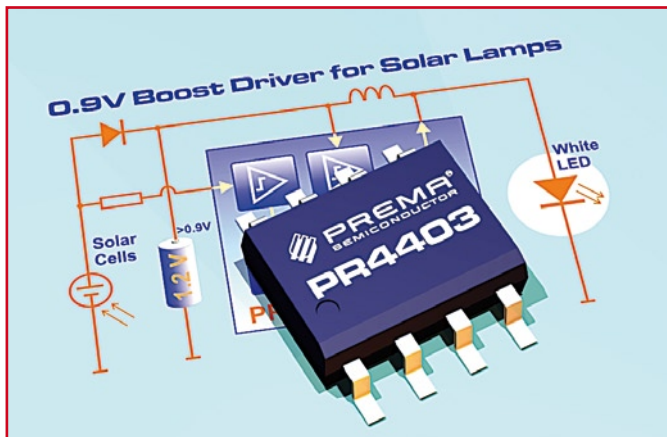


ners, including Future, Arrow, Avnet, Digikey, Mouser, P&S, and MSC. It costs \$ 129.99.

www.cypress.com

(070996-IV)

0.9V Boost LED Driver PR4403 for Solar Lamps



The new PR4403 from PREMA Semiconductor GmbH drives and controls white LEDs out of one single battery charged by solar cells. It uses the connected solar cells to detect daylight.

LED solar lamps operate with automatic LED control depending on the ambient light level. The battery is charged by solar cells. Normally this requires several components like Schottky diodes, capacitors, resistors,

two or three rechargeable battery cells and a photo resistor. In contrast to this standard solution the PR4403 saves several components, as it is able to drive the current for the white LED out of a single rechargeable battery cell. Also the expensive photo resistor is no longer needed.

A supply voltage of down to 0.9V is sufficient for the IC to drive a current of up to 40mA independent of the input voltage. The value of the external inductor defines the LED current. Instead of the photo resistor, the solar cell is directly connected to the IC for daylight level detection, and an optional resistor sets the light threshold. Depending on the voltage at this connection, the integrated step-up converter is switched on or off. During daytime the driver is shut-down and the solar cell charges the battery via the

external Schottky diode. With decreasing ambient light the voltage at the solar cell drops, the IC is activated and drives the LED current out of the battery cell.

Deep discharge of the battery cell is prevented as the PR4403 shuts off the driver when the supply voltage drops to less than 850 mV. Therefore PREMA's PR4403 saves cost for LED solar lamps as it reduces the number of components. Applications for the PR4403 are solar garden lamps as well as house number lights, decoration lights and road markers powered by solar cells.

Samples in SO8 package are available upon request.

www.prema.com/pdf/pr4403.pdf

(070996-V)

New MAX IIZ CPLDs for portable applications

Altera Corporation announced the new, zero-power MAX® IIZ CPLD designed specifically to address the power, package and price constraints of the portable applications market. Offering a resource advantage of up to six times the density and three times the I/Os compared to competing traditional macrocell-based CPLDs, MAX IIZ devices allow designers to meet changing functional requirements at the same or lower power while saving board space. Adding zero-power and ultra-small packages to the most popular CPLD series in the industry, the MAX

IIZ devices deliver the many benefits of CPLDs — including flexibility, faster time to market, and board-level integration — to handsets and other portable applications.

MAX IIZ devices are available in densities of 240 and 570 logic elements (LEs). The devices are available in ultra-small MBGA packages with up to 160 I/Os. This increased logic density and greater I/O count allow greater integration of existing functions from other devices, substantially reducing board space and power consumption while lowering overall system costs.



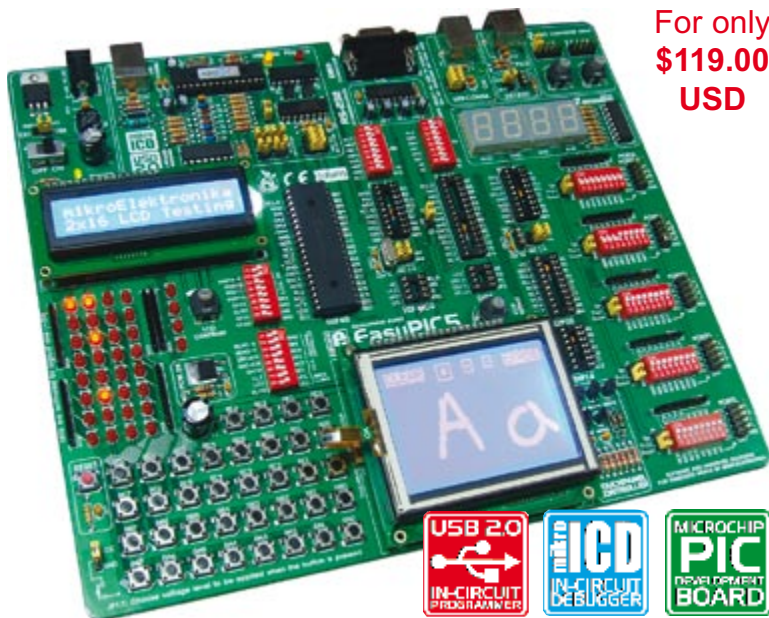
www.altera.com/b/maxiiz
www.altera.com/b/maxiiz-portable

(070996-VII)



EasyPIC5 with hardware In-Circuit Debugger

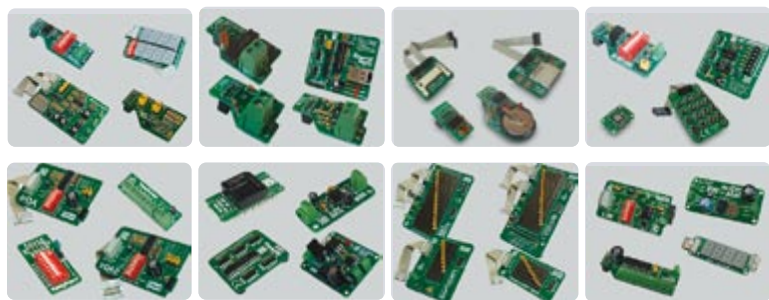
For only
\$119.00
USD



The system supports 8-, 14-, 18-, 20-, 28- and 40- pin PIC microcontrollers (it comes with the PIC16F877A). The **mikroICD** (In-circuit Debugger) enables very efficient debugging and fast prototype developing. Examples in **C**, **BASIC** and **Pascal** language are provided with the board. EasyPIC5 comes with printed documentation which includes: EasyPIC5 Manual, PICFlash with mikroICD Manual, mikroICD Manual.

EasyPIC5 Add-On Boards

Various range of additional daughter-boards for EasyPIC5 development board



Digital POT - MCP4010 SPI Interfaced digital potentiometer.

SmartMP3 Board - VS1001k MP3 decoder with SPI Interface.

Serial 7-seg Display 2 Board - MAX7219 SPI Interfaced, LED Display Drivers with 8 Common-Cathode LED Displays

LightToFreq Board - TSL230BR programmable light-to-frequency converter.

EasyConnect Board - Connects your peripherals easily and fast using connectors.

CAN-1 Board - Interfaces CAN via MCP2551.

CANSPI Board - Makes CAN network with SPI interface.

RS485 Board - Connects devices into RS-485 network.

Serial Ethernet - Make ethernet network with SPI Interface (ENC28J60).

IrDA2 Board - Irda2 serves as wireless RS232 communication between two MCU's.

Port Expander Board - MCP23S17 is the 16-bit port expander with SPI interface.

CF Board - Easy way to use Compact flash in your design.

MMC/SD Board - Easy way to use MMC and SD cards in your design.

EEPROM Board - Serial EEPROM board via I2C interface.

RTC Board - PCF8583 RTC with battery backup.

SmartADAPT MINI - Configures 8 output pins by moving jumpers on-board.

SmartADAPT 2 - Configures 16 output pins by moving jumpers on-board.

ADC Board - 12-bit analog-to-digital converter (ADC) with 4 inputs.

DAC Board - 12-bit digital-to-analog converter (DAC) with SPI.

Keypad 4x4 Board - Adds keypad to your application.

Accel. Board - Accel. is an electronic device that measures acceleration forces.

LIN Board - MCP201 LIN Transceiver up to 20K baud rate

AudioAMP Board - LM386 power amplifier designed for use in low voltage consumer applications.

World-Class Development Tool

A state-of-the-art very fast **USB 2.0** programmer including **mikroICD** (In-circuit Debugger) on-board with simplified driver installation.

The Best Just got Better

Following the tradition of its predecessor EasyPIC4 as one of the best PIC development systems on the market, the EasyPIC5 has more new features for the same price.

Train for the future

EasyPIC5 was designed to allow students or engineers to easily exercise and explore the capabilities of the PIC microcontrollers.

Designed to suit your needs

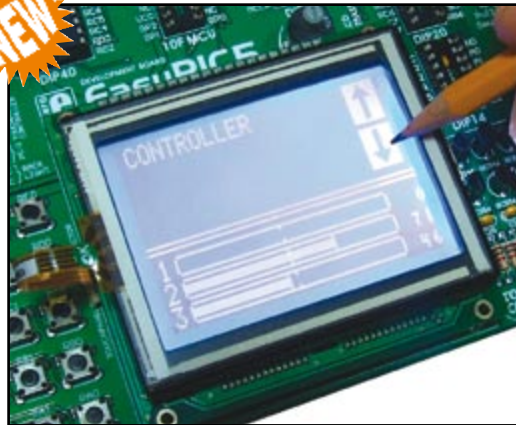
Your development time can be considerably reduced, resulting in an early prototype design and fast time-to-market for your end product.

mikroElektronika Compilers

Pascal, Basic and C Compilers for PIC microcontrollers



Supporting an impressive range of PIC microcontrollers, an easy-to-use IDE, several hundreds of ready-to-use functions and many integrated tools makes Mikro Elektronika compilers one of the best choices on the market today. Besides mikroICD, mikroElektronika compilers offer a statistical module, simulator, bitmap generator for graphic displays, 7-segment display conversion tool, ASCII table, HTML code export, communication tools for SD/MMC, UDP (Ethernet) and USB, EEPROM editor, programming mode management, etc.



Touch screen controller with connector is available on-board.

Please visit our web page for more info <http://www.mikroe.com>

Technology Highway at Nepcon UK

Nepcon UK invites exhibitors to step on board the 'Technology Highway' – where AOI and X-Ray Inspection will be firmly in the headlights for the 2008 event. From the entrance to the Nepcon event and running right through the hall, this hands-on feature will be visible to visitors from the moment they step onto the show floor. The Technology Highway will provide an exclusive opportunity to view a whole range of AOI and X-Ray equipment used across the production line. As visitors make their way along the Highway they will be able to see equipment in action

and quiz technical operators from participating companies – with stands adjacent to the Highway – on issues which affect their individual manufacturing process. Towards the end of the highway populated boards will be tested by both low and high volume systems, with real time data being collected from the inspection process. This invaluable information will be made available to visitors to assist them in their purchasing decisions according to their budget. The Technology Highway will be the central feature at the UK's national electronics manufacturing



event, providing participating exhibitors with a unique occasion to display equipment and to demonstrate capabilities to key industry buyers, alongside competitor products.

A 'Technology Highway Inspection Guide' featuring information on participants' products will be made available prior to the show, and handed out to visitors during

the 2008 exhibition. For more information on how to take part in the Technology Highway, call the Nepcon team on +44 (0)20 8910 7706.

Nepcon will take place 29th April – 1st May 2008 at the Birmingham NEC in Hall 20.

www.nepcon.co.uk

(070996-VI)

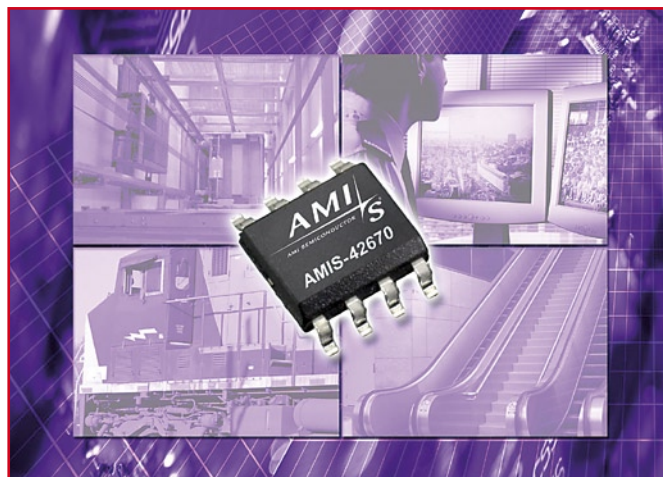
CAN for long-wire and low speed industrial apps

AMI Semiconductor (AMIS) has announced an ASSP family for long-wire and low baud rate Controller Area Network (CAN) applications. Designers now can use a qualified and proven CAN transceiver for very long wires and/or low baud rates, enabling the use of CAN-enabled equipment in industrial applications requiring line lengths in excess of 500 meters.

Available in 3.3 V and 5 V interface variants, the new ASSP family includes a device with a functionality that automatically adapts communication rates to the observed line speed. In addition, all of AMI Semiconductor's CAN

transceivers have exceptional over-voltage protection on the CAN bus of +/-45 V (common mode).

The CAN protocol requires an in-frame response which, for long



wires, is achieved by reducing transmission speed. However, at low speeds (below 60 kbaud), a timeout system limits CAN use and hence line length. To support

long-wire CAN communications in industrial applications, AMIS has extended its CAN product line by providing versions with adapted time-out function for all of its long-

wire CAN transceiver products.

The AMIS long-wire CAN transceiver ASSPs target end applications with wired communication in physically long or distributed systems. Examples of these systems include elevators, security monitoring systems, in-building communication, building control, process control, machine control, and HVAC systems.

There are five members of the long-wire high-speed CAN transceiver family: AMIS-42670 (5V), AMIS-42671 (3.3V, auto-baud rate), AMIS-42673 (3.3V), AMIS-42675 (low power) and AMIS-42770 (CAN repeater).

www.amis.com

(070996-VIII)

LEDs for railway applications

Historically LEDs have been perceived as difficult to use, requiring a range of power supplies, drivers, resistors, soldered connections, making them tricky to market in railway applications. CML-IT's new Connect&Glo® program is designed to make solid state lighting easy, and is changing this perception. The company is offering a system of linking LED lighting units that anyone can connect together, just as easily as ordinary light bulbs.

LED lighting modules from CML-IT allow the environmentally friendly

replacement of inefficient incandescent lighting and offer increased performance, increased life of approximately 50,000 h against 3,000 h for traditional incandescent lights, reduced maintenance and up to 80% reduction in energy consumption. When total life costs of lighting systems are considered, modern LED-based lights nowadays already come at a comparable cost to traditional incandescent lights.

Part of the Connect&Glo® program and specifically targeted at train interiors is the Acsentio series

of LED accent lights. Easy to fit and install, the lights feature an internal heat management system enabling them to run at relatively low temperatures. Acsentio offers subtle shades of light and are available in blue, red, green, yellow and white as part of a complete LED-based interior lighting system for commuter and underground trains.

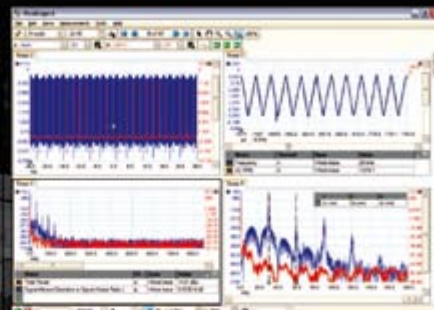
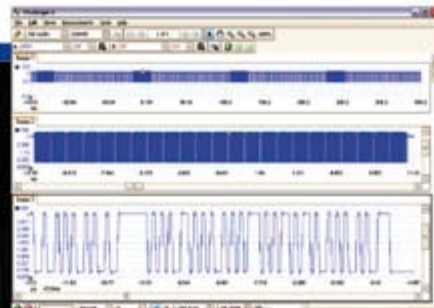
Also part of the Connect&Glo® program from CML-IT are LEDules, a behind-the-scenes system of LEDs mounted on PCBs in a whole variety of shapes and sizes and designed

to allow designers to mount lighting into whatever shape is available. LEDules feature 1, 3, 4, 8, 9 or 14 watt power and a consistent unit-to-unit colour temperature. Available colours are cool white, warm white, blue, cyan, green, amber and red. A new RGB version (featuring red, green and blue LEDs) enabling subtle colour changing for 'mood' lighting applications has also been added to the range.

www.cml-it.com

(070996-IX)

USB Connected High Speed PC Oscilloscopes



5000 SERIES

PicoScope 5000 Series The No Compromise PC Oscilloscopes

With class-leading bandwidth, sampling rate, memory depth and an array of advanced high-end features, the PicoScope 5000 PC Oscilloscopes give you the features and performance you need without any compromise.

250 MHz bandwidth
1 GS/s real-time sample rate
128 megasample record length

Advanced Triggers

In addition to the standard triggers the PicoScope 5000 series comes as standard with pulse width, window, dropout, delay, and logic level triggering.

250 MHz Spectrum Analyser
High-speed USB 2.0 Connection
Automatic Measurements

Arbitrary Waveform Generator

Define your own waveforms or select from 8 predefined signals with the 12 bit, 125 MS/s arbitrary waveform generator.

Waveform Playback Tool

PicoScope software now allows you to go back, review, and analyse up to 1000 captures within its waveform playback tool.

3000 SERIES

The PicoScope 3000 Series of oscilloscopes from Pico Technology includes general purpose and high resolution models: With 12 bit resolution and 1% accuracy, the 10MHz PicoScope 3424 is able to detect changes as small as 0.024% (244ppm) – making it the ideal 4-channel oscilloscope for analog design and analysis. The higher speed 8 bit models in the PicoScope 3000 series feature sampling rates up to 200MS/s and up to 1 MS/s record lengths for general purpose and portable applications.



2000 SERIES

The PicoScope 2000 series oscilloscopes offer single and dual channel units that offer highly portable/low cost solutions to general purpose testing. The award winning 25MHz handheld PicoScope 2105 fits comfortably into the palm of your hand yet still includes the powerful features found in larger oscilloscopes.



pico
Technology

VISIT

www.picotech.com/scope452

to check out our full line of PC-based instruments or call **01480 396 395** for information and a product catalogue

Ambience S.V.P! PC & TV Mood Lighting

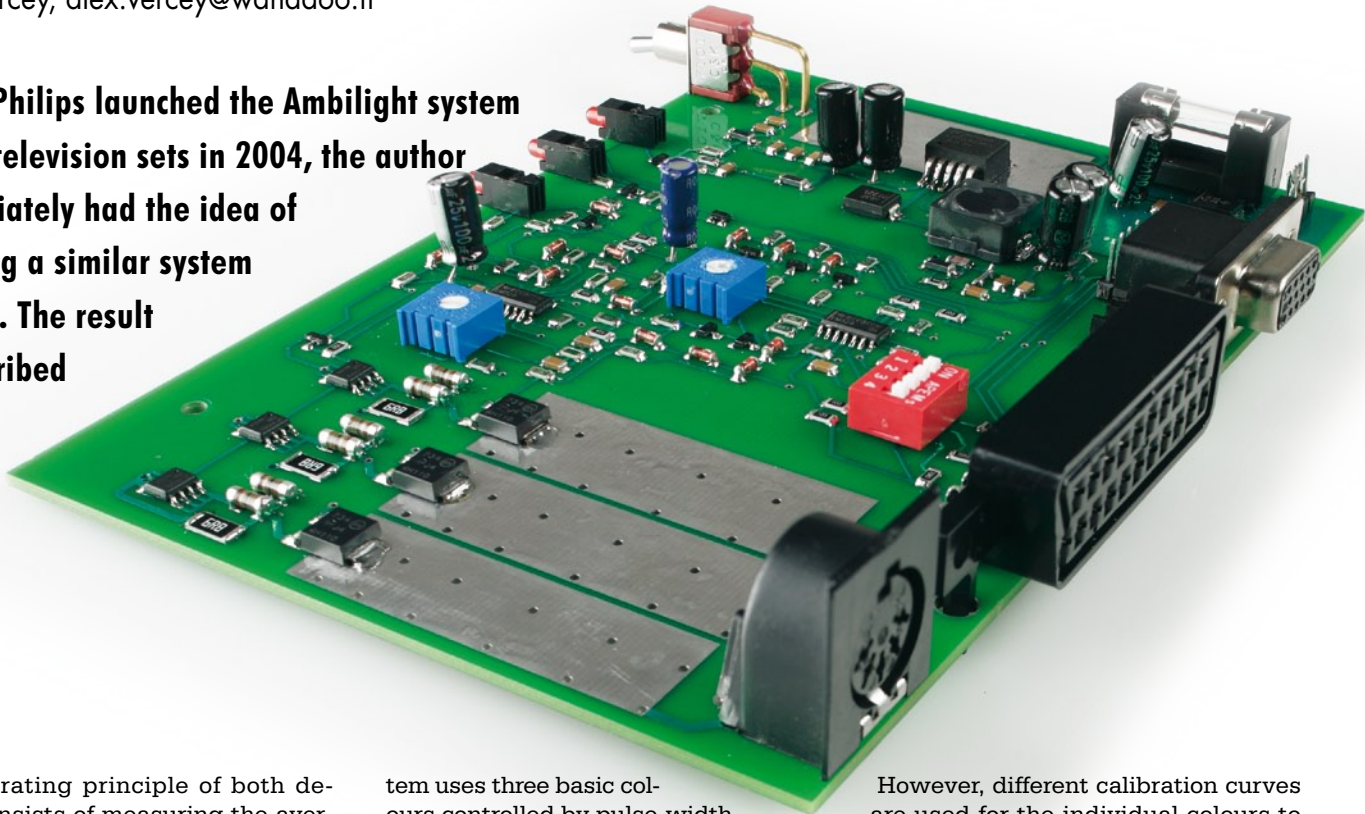


Due to the fact that we received two circuit designs for television mood lighting and they both fit with the theme of this issue, we initiated a unique Elektor project: in this issue we present two completely different designs that produce nearly the same effect. Our French contributor Alex Vercey took the analogue approach, while Steffen Schütte from Germany went the 'microcontroller way'.

The analogue approach Surround Light

Alex Vercey, alex.vercey@wanadoo.fr

When Philips launched the Ambilight system for its television sets in 2004, the author immediately had the idea of building a similar system for PCs. The result is described here.



The operating principle of both designs consists of measuring the average colour of an image and using colour LEDs to emit the same colour in order to 'paint' an impression of the image on the background behind the screen. This generates a more intense experience, creates a visual point of reference, and produces refined mood lighting.

The target audience for this product consists of dedicated film fans and voracious gamers.

Technical considerations

In its product, Philips uses a spectrum analyser integrated in the video matrix processor. This method is only used with LCD and plasma displays. The control logic of non-scanned displays of this sort allows digital analysis of the signal based on the individual regions of the internal display driver matrix. Philips originally used a system with small neon tubes and an acrylic reflector to diffuse the light. However, LEDs are used in the latest models. The sys-

tem uses three basic colours controlled by pulse-width modulated (PWM) signals with a resolution of only four bits.

The design described here operates on a different principle, with the objective of achieving better reproducibility. In addition, the system described here can also be used with a PC or a raster-scan monitor (an 'old-fashioned' CRT monitor).

The system described in this article is the PC version of the Surround Light design. The television version is more complex, primarily due to safety considerations rather than technical issues.

The Surround Light system consists of a three-colour LED lamp driven by analogue signals, which allows all possible colour combinations (14 billion) to be generated from the three basic colours. For comparison, the software-controlled version uses an ADC and PWM signal with 16-bit resolution, which yields 65,536 possible colours.

Three identical circuits are used for the LED drivers (one for each colour).

However, different calibration curves are used for the individual colours to adapt the visually perceived colours to the spectrum of the LEDs used in the system.

As specified by the CCIR VGA standard, the maximum amplitude of a PC video signal (700 mV) corresponds to a full white image. This was confirmed by measurements made using a GeForce FX7300 card. There is also an option for isolation of the input signal.

As a minor detail, this system (unlike the Philips system) does not support generation of different colours on the left and right sides of the monitor, since this would require a much more complicated colour analyser.

LEDs are active semiconductor devices with a non-linear response to an electrical signal, and they are **current driven** instead of **voltage driven**. This means that the brightness of a LED cannot be controlled by adjusting the supply voltage.

In theory, it would be possible to vary the intensity of a LED by very accurately adjusting the voltage across the

LED, but this approach has a very small tolerance and essentially requires individual calibration of each type of LED in order to obtain good results. For this reason, current control is used here, which allows any desired type of LED to be used with an assured output control range of 0 to 100%.

Protection

The LEDs used in the prototype became hot when stationary white are-

circuit is triggered at the end of a defined time. This is a distinctly analogue approach. This timeout is only necessary to avoid restrictions on the system when a stationary white image is displayed. The timeout is approximately 20 seconds, which is long enough to ignore 'white' sequences in films. The discharge time (after the screen is no longer white and the Surround Light can thus return to normal operation) is the same to keep things simple, and it

tor network to limit the rising edges of the signal with high-resolution video (1600 × 1200). An RC network integrates the signal to obtain the average voltage (the colour signal resulting from this process), which is fed to an adjustable voltage divider. The LEDs are driven by a voltage-to-current converter with a MOSFET power stage. Finally, the protection circuit responds to detection of a stationary image and the output level of the voltage regulator. If the supply drops too low or the regulator malfunctions, the LED drive current is reduced to prevent damage due to an unstable supply voltage or an inappropriate image. The overall transfer function of the system can be described with the following formula:

$$(V_{input} \div 2 \times 18.49 - 1.2 \text{ V}) \div 9.33$$

Schematic diagram

The schematic diagram in **Figure 2** shows the functional elements of the block diagram in more detail. Let's examine the technical aspects of some of them more closely.

Video input and clipping (A)

The input impedance is 10 kΩ to 22 kΩ, depending on the fitted resistors. This value provides a good match to the amplifier input, avoids overloading the output of the graphic card, and avoids distortion of the video signals due to excessively low parallel impedance. The input circuit attenuates the signal by 50% because the serial and parallel resistors have the same value. Jumpers are fitted at the input. They can be replaced by serial capacitors if clamping is necessary. Clamping is optional because it is not compatible with the video signal, but it may be necessary in some cases.

The gain (k1) is determined by the colour threshold value, which is set to 1210 mV by two 1N4148 diodes connected in series (this approach was chosen because it provides a stable threshold value). This value must correspond to **15% of the nominal signal voltage**. This is the key to the entire design, and maintaining a threshold level of 15% of the dynamic range of the signal is essential for good results. We can now calculate the gain as follows: 1210 mV across the series-connected diodes = 15% of (350 mV × k1) This yields a value of 18.49 for k1. This must be increased to compensate

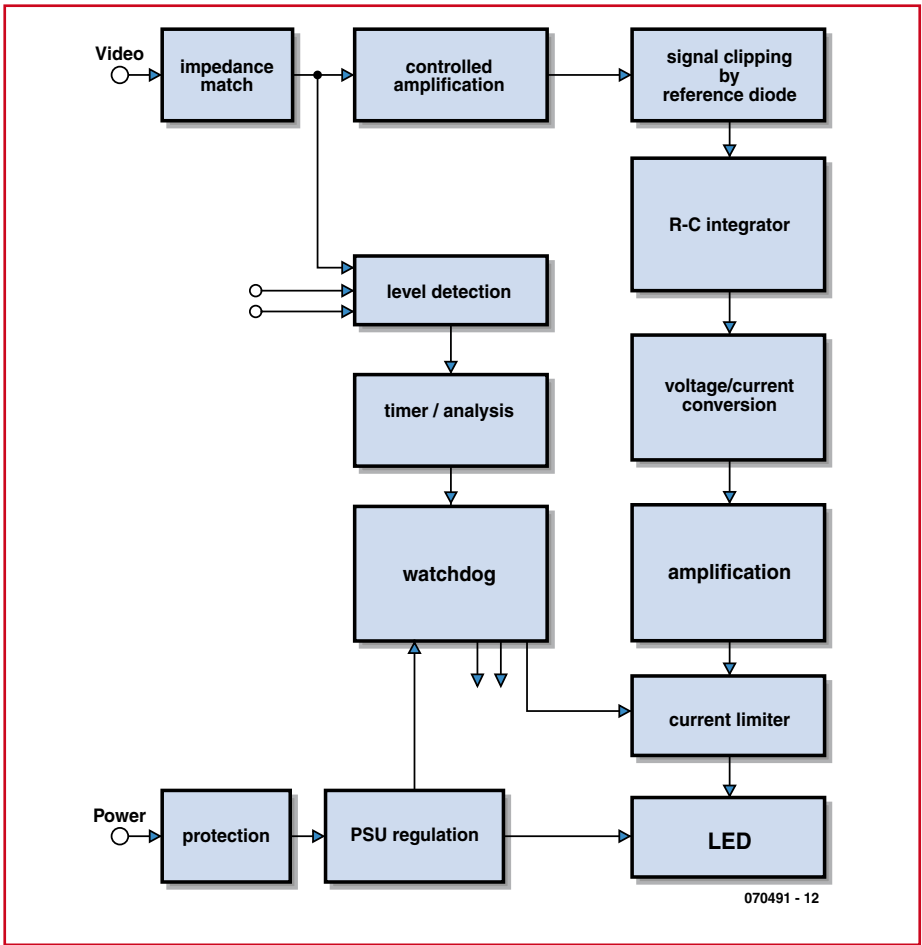


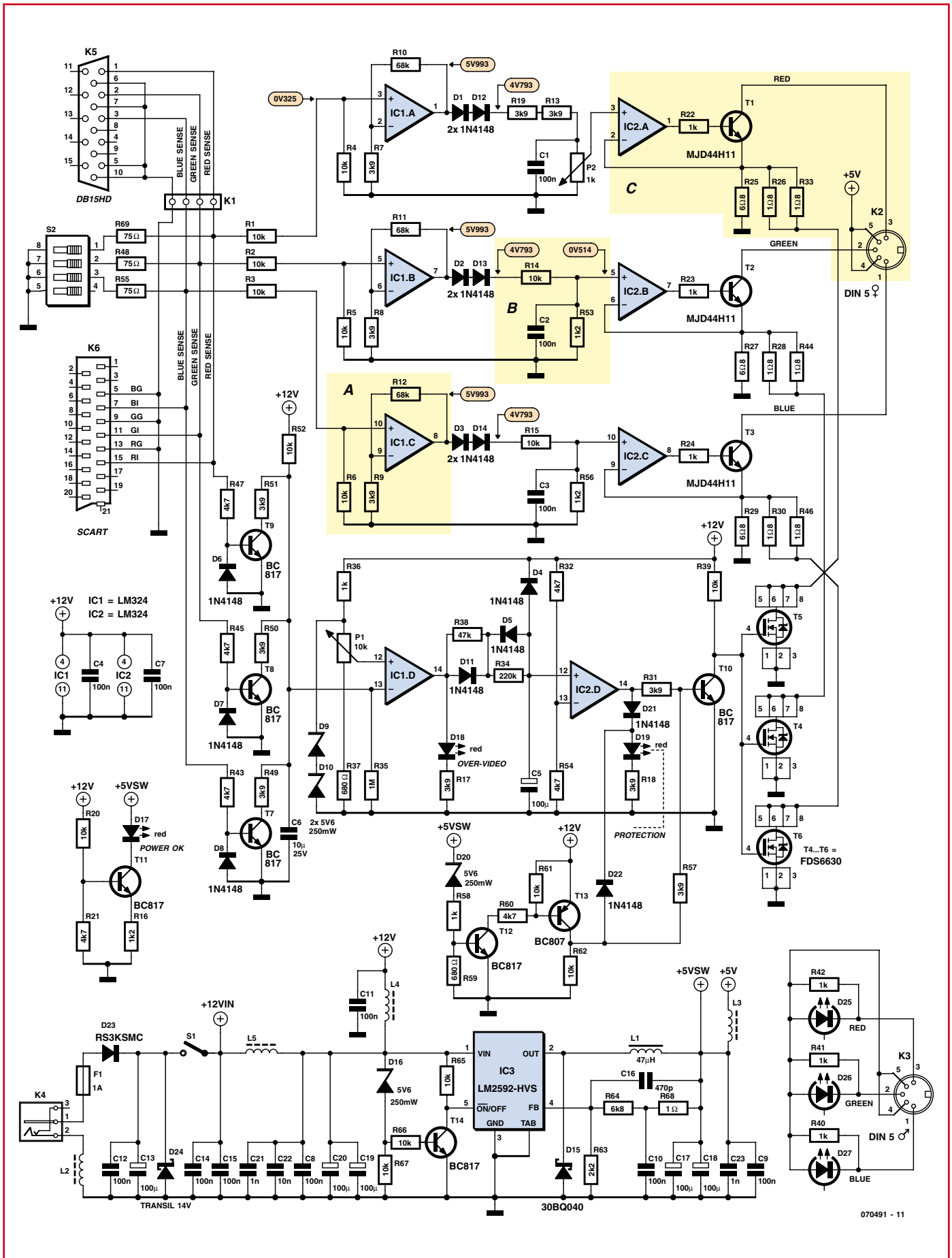
Figure 1. Block diagram of the Surround Light. Although the block diagram of the analogue version of this system looks much more complicated than its digital counterpart, the circuit is a lot smaller than you might expect.

as were present in the image (such as during word processing, working with text windows, or Web browsing), and in such situations mood lighting is anyhow not especially meaningful. For this reason, the whiteness of the image is measured and after a suitable delay the brightness of the LEDs is reduced by decreasing the drive current supplied by the MOSFET. Each colour is measured, and if white is detected a timeout is initiated using a capacitor charging circuit and a reference voltage, and a protection

avoids flickering when changing windows in an office application.

Block diagram

The block diagram in **Figure 1** is relatively complex. This arises from the processing of the video signal, which is received in VGA or X-XGA format. The signal first passes through a buffer. It is then amplified using a precisely defined gain. The resulting signal is clipped in a block that uses a diode. After this, the signal is fed to a resis-



070491 - 11

Figure 2. Schematic diagram of the Surround Light. You can easily see the various functions of the block diagram here.

Table 1. Power dissipation of the driver transistors at various LED voltages.

	Minimum		Average		Maximum	
	LED voltage	Power	LED voltage	Power	LED voltage	Power
Red LED	2.31 V	1.254 W	2.95 V	870 mW	3.51 V	534 mW
Green LED	2.79 V	966 mW	3.42 V	588 mW	4.23 V	102 mW
Blue LED	2.79 V	966 mW	3.42 V	588 mW	4.23 V	102 mW

for the loss over the diodes that provide the threshold value.

The SENSE lines are connected to the watchdog circuit, which monitors the average input voltage to see whether it rises above 600 mV. If it exceeds this value too long, the LEDs are placed in the protected mode.

Signal integration and converter adjustment (B)

The signal must be integrated before it is fed to the input of the voltage-to-current converter. The integration time constant is matched to the timing of the line pulses. The raster line pulses cause relatively weak modulation of the current, which is nevertheless sufficient to reduce the average power dissipation of the LEDs. (The LEDs used here are not suitable for pulse-mode operation.)

The time required to charge to 2/3 of the maximum level is 650 μs with component values of 10 kΩ and 100 nF, which is sufficient to eliminate the line sync pulses from the VGA signal.

The corresponding discharge time is 100 μs due to the presence of R53 in the voltage divider formed by R14 and R53. This value produces only a small delay in determining the colour (due to the total capacitance of the measuring chain), so the system has a sufficiently short response time.

Drive circuits for the LUXEON K2 LEDs (C)

As already mentioned, the LEDs are operated under current control. The LEDs are powered from the 5-V sup-

ply voltage with an average current of less than 700 mA (or 2.1 A peak if you ignore the breaks during the video signal flyback intervals).

The individual LEDs are driven by emitter followers (T1–T3) that form current sources in combination with the opamps in IC2.

The value of resistor R22 is small enough to supply sufficient current to T1 and large enough to limit the current from the opamp if no load (LED) is connected. The voltage rises to the maximum value when the output of the amplifier is open-circuited.

The LED current is sensed by resistors R25, R26 and R33 in the emitter circuit of the transistor, which also conduct the base current. The sensed value is $i_{LED} = i_C + i_B$, so i_B must be kept as small as possible to avoid adversely affecting current sensing: ($i_{Bmax} = i_{Cmax} \div i_{min}$) = 700 ÷ 60 = 11 mA max, or 1.57%).

The transistor type used here is designed for operation with a small V_{CE} , so it does not lose much of the 5 V even when in saturation. This ensures that there is sufficient voltage available for the LED.

The design value of the sense voltage is around 500 mV at the rated current, which yields a power dissipation of 350 mW in the resistors. A larger resistance would yield somewhat better accuracy, but it would also increase the power dissipation.

The transistors are thermally coupled to a copper plane on the PCB with an area of approximately 7 cm² to improve cooling.

The nominal dissipation depends on two parameters: the actual current through the LED and the voltage across the LED.

With regard to thermal dissipation at 25 °C, the manufacturer’s data sheet indicates that the power is approximately 500 mW per transistor at maximum brightness (with an average voltage of 3.75 V at 650 mA). The thermal coefficient of the transistor is 6.25 K/W, which would yield a temperature rise of 3.5 °C with an ideal heat sink.

The thermal resistance from the PCB to the air is not known, so the maximum temperature rise is not known precisely. An estimate based on the copper area on the PCB and the total volume of copper yields a value of 45 °C/W, which yields a maximum temperature rise of 24.5 °C (plus 3.5 °C due to the thermal resistance of the package), or $\Theta_{amb} + 24.5$ °C.

Transistor derating and possible effects from the power dissipation of adjacent devices have been ignored here.

Power dissipation

Each transistor dissipates a power P proportional to the current level:

$$P = (5\text{ V} - V_{LED} - V_{SEN}) \times i$$

The power dissipation of the driver transistors at various LED voltages is shown in **Table 1** for a LED current of 600 mA, a supply voltage of exactly 5 V, and $V_{SEN} = 500$ mV.

Protection circuit

The circuit is protected against stationary images on the monitor. There is not much point in mood lighting for office applications, so the current is reduced in such situations to minimise power dissipation and increase the useful life of the LEDs.

The protection circuit is triggered when a very bright image is present for longer than a defined time. When this occurs, the current through the

LED specifications					
	LUXEON K2				
Basic colour	Royal Blue	Green	Red	Blue	Red-Orange
Max. continuous current [mA]	1 500	1 500	700	1 500	700
Continuous voltage [V]	3.85	3.85	3.4	3.85	3.4
Effective continuous voltage [V]	3.2 V @350 mA	3.2 V @310 mA	2.56 V @230 mA	3.5 V @280 mA	2.7 V @190 mA
Wavelength [nm]	455	530	630	470	617
Luminous flux [lumen]	250 mW/rad.	130	75	46	100
Total included angle [°]	160	140	140	140	140

With the LUXEON configuration, Red-Orange is preferable to Red and Blue is preferable to Royal Blue.

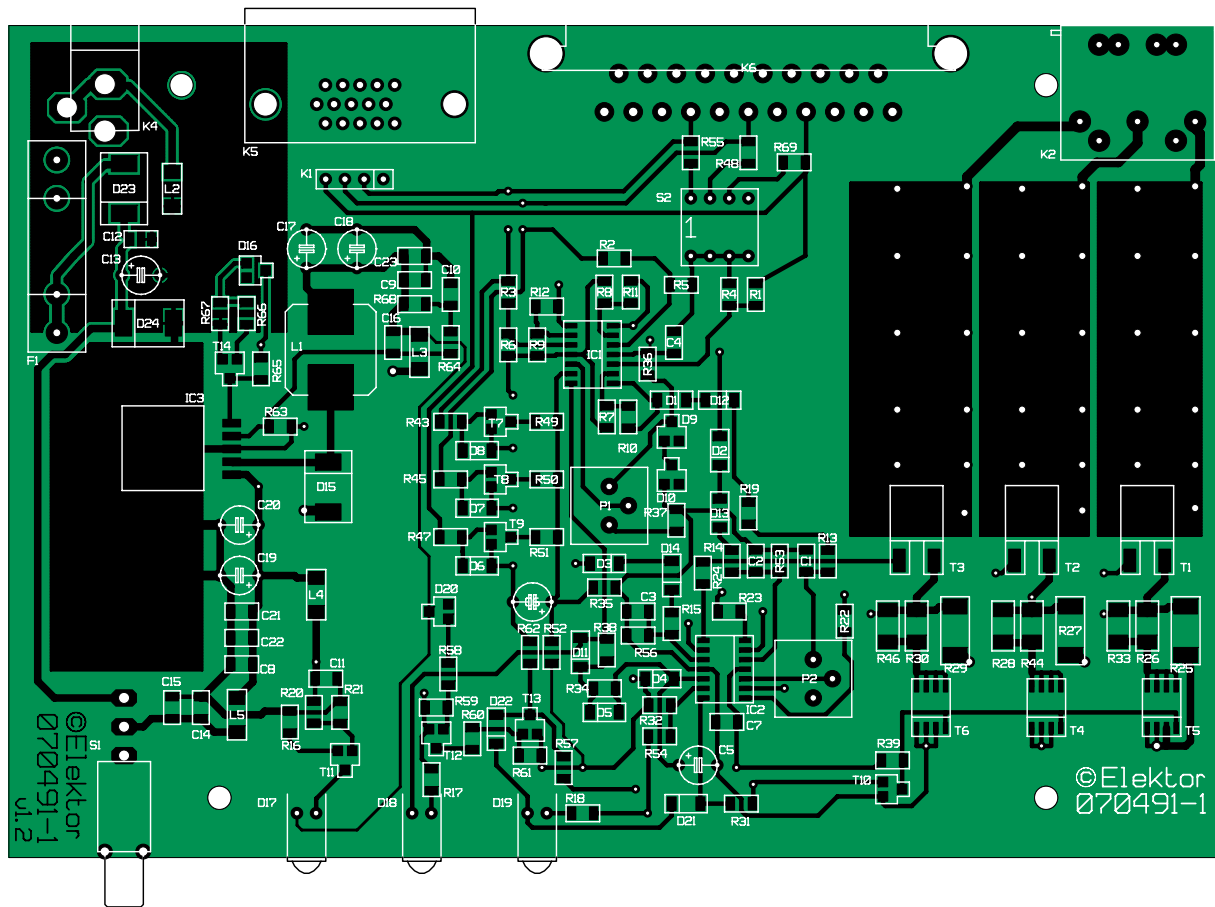


Figure 3. The component layout of the main circuit board...

LEDs is reduced by a factor of 10 and the power dissipation remains below 1 W (with a 5-V supply voltage).

Detection

The image is considered to be very bright if all three colours have high

levels at the same time. A circuit with three transistors measures these high levels approximately, since the detec-

COMPONENTS LIST

Resistors

R1-R6, R14, R15, R20, R39, R52, R61, R62, R65, R66, R67 = 10k Ω (SMD 1206)
 R7, R8, R9, R13, R17, R18, R19, R31, R49, R50, R51, R57 = 3k Ω 9 (SMD 1206)
 R10, R11, R12 = 68k Ω (SMD 1206)
 R16, R53, R56 = 1k Ω (SMD 1206)
 R21, R32, R43, R45, R47, R54, R60 = 4k Ω 7 (SMD 1206)
 R22, R23, R24, R36, R40, R41, R42, R58 = 1k Ω (SMD 1206)
 R25, R27, R29 = 6 Ω 8 (SMD 2512)
 R26, R28, R30, R33, R44, R46 = 1 Ω 8 (0207)
 R34 = 220k Ω (SMD 1206)
 R35 = 1M Ω (SMD 1206)
 R37, R59 = 680 Ω (SMD 1206)
 R38 = 47k Ω (SMD 1206)
 R63 = 2k Ω 2 (SMD 1206)
 R64 = 6k Ω 8 (SMD 1206)
 R68 = 1 Ω (SMD 1206)
 R48, R55, R69 = 75 Ω (SMD 1206)
 P1 = 10k Ω
 P2 = 1k Ω

Capacitors

C1-C4, C7-C12, C14, C15 = 100nF (SMD 1206)
 C22 = 10nF (SMD 1206)
 C21, C23 = 1nF (SMD 1206)
 C16 = 470pF (SMD 1206)
 C5, C13, C17-C20 = 100 μ F 25V
 C6 = 10 μ F 25 V

Inductors

L1 = 47 μ H (W \ddot{u} rth 12x12)
 L2-L5 = choke, 91 Ω @ 100 MHz (SMD 1808)

Semiconductors

D1-D8, D11-D14, D21, D22 = LL4148 (SMD SOD-80)
 D9, D10, D16, D20 = BZX84C5V6 (SMD SOT-23)
 D17, D18, D19 = LED, 3mm, red
 D23 = RS3K (SMD SMC)
 D15, D24 = 30BQ040 (SMD SMC)
 T1, T2, T3 = MJD44H11 (SMD DPAK-N)
 T4, T5, T6 = FDS6630 (SMD SO-8)
 T7-T12, T14 = BC817 SMD SOT-23)
 T13 = BC807 (SMD SOT-23)

IC1, IC2 = LM324 (SMD SO14)

IC3 = LM2592 (SMD SOT-263)

D25 = Luxeon LED, red (LXK2-PD12-R00)

D26 = Luxeon LED, green (LXK2-PM14-U00)

D27 = Luxeon LED, blue (LXK2-PB14-N00)

Miscellaneous

S1 = single-pole on/off switch (Farnell # 9575502)

S2 = 4-way DIP switch

K1 = 4-way SIL pinheader

K2, K3 = 5-way DIN socket

K4 = DC supply socket, PCB mount

K5 = VGA socket, PCB mount

K6 = SCART socket, PCB mount

F1 = fuse, 1A slow, with PCB mount holder

Enclosure, e.g. Vero # 16-3638089

PCBs # **070491-1** and **070491-2**, see Elektor Shop section or www.elektor.com

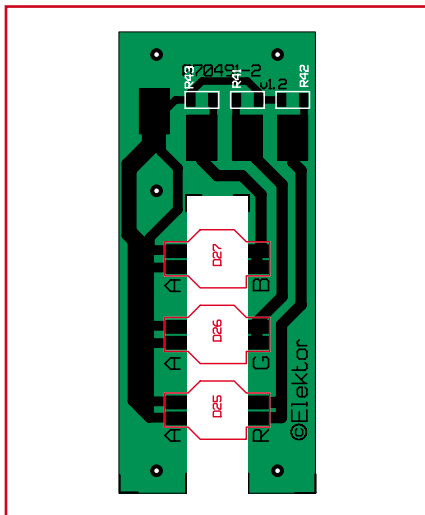


Figure 4. ...and the LED circuit board.

tion circuit is not thermally stabilised in order to keep the circuit simple. A digital signal indicates whether a bright image has been detected. A diode connected across the base-emitter junction of each detection transistor protects the transistor if there are problems with the video signal (such as a negative signal level due to poor clamping).

Timeout delay

The timeout delay is implemented very simply using an RC network with a binary comparator. The threshold level of

the delay circuit can be adjusted using trimpot RV1, but the actual time delay is not adjustable. The switch-on delay is much shorter than the switch-off delay. In other words, if moving imagery appears on the screen again, the LEDs will start operating again relatively quickly. This rapid return to normal operation is only necessary to prevent flickering when switching between windows on the PC.

Diode D4 prevents C5 from discharging via IC2d if the IC is not powered, in order to avoid damage to the IC.

Current limiting

The current flowing through the LEDs is limited by modifying the operation of the drive circuits. During normal operation the current limiter is not active, and it holds the MOSFETs in the fully conducting state with low source-drain resistance ($R_{DS(ON)}$). This increases the current level due to the relatively low resistances connected in parallel across the current-sense resistors.

When current limit protection is activated, the MOSFETs are switched off and the full LED current flows through a larger resistance (R29), so the nominal voltage across the sense resistor is obtained at a lower current level.

When current limiting is active, the current level is set by R29 alone, while in normal operation it is set by R29 and the parallel combination of R30 and R46 via the MOSFET (to use a simpli-

fied analysis).

If desired, the two parallel resistors can be replaced by a single resistor rated at $0.82 \Omega / 1 \text{ W}$. For the sake of convenience, the author used two $1.8\text{-}\Omega$ resistors in parallel to obtain an equivalent resistance of 0.9Ω , but a single resistor rated at $0.82 \Omega / 1 \text{ W}$ would work just as well. The current is 600 mA at 500 mV , which is not especially worrisome.

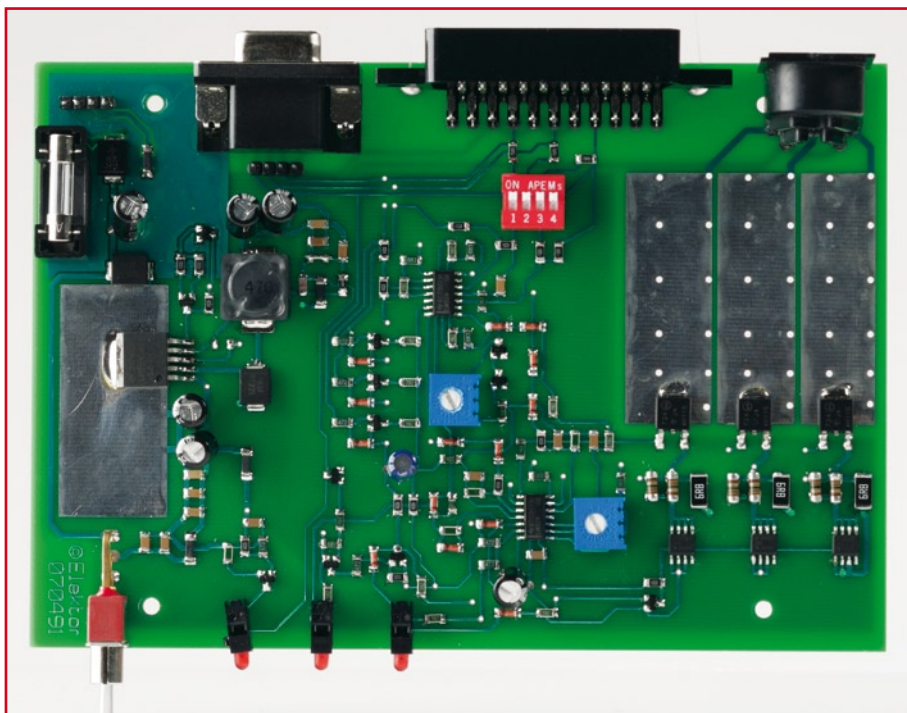
A Tyco RL733A R82 would be perfect for this application.

Supply voltage protection

If the supply voltage for the LEDs rises too high, protection is triggered by a circuit that detects an overvoltage condition on the 5-V supply line. This would cause excessive dissipation in the supply circuitry, which is not good for the circuit. The temperature must also be kept below 60°C everywhere in the circuit to avoid the risk of burns.

The detection threshold voltage is $V_{Dz20} + 1.2 \text{ V} = 6.8 \text{ V}$.

The supply voltage protection circuit (built around T12 and T13) generates a signal that causes the MOSFETs to be switched off using the same arrangement as for current limiting with a stationary image. Resistors R58 and R58 provide a path for the leakage current of the Zener diode next to the voltage sense transistor.



Our first prototype. All connections are at the rear.

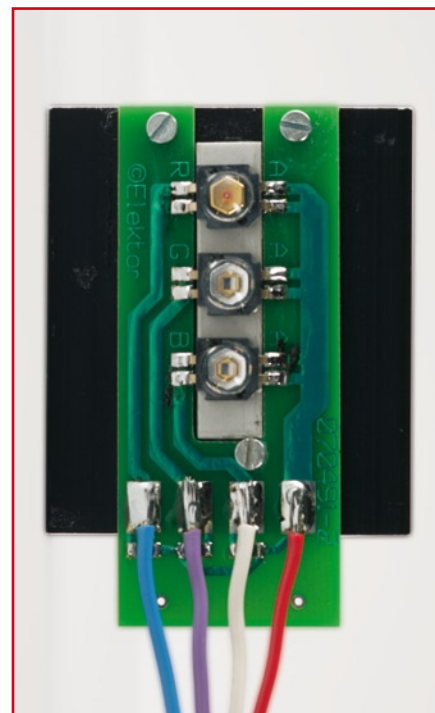


Photo of the printed circuit board with three LEDs. This requires a bit of mechanical assembly skill.

Supply voltages

The circuit has three types of on-board supply voltages, all derived from the main supply voltage obtained via power connector K4:

- Stabilised reference voltages
- A filtered supply voltage for the opamps
- A high-power supply voltage for the LEDs

The stabilised voltages are generated locally using Zener diodes. Most of them are reference voltages for the comparators. The main +12 V supply voltage comes from an AC mains adapter, or it can be taken directly from the PC. This voltage is stabilised externally, and the circuit includes a fuse (FU3) and a diode (D23) for reverse-polarity protection.

The LEDs are powered from a much lower voltage in order to minimise the power dissipation in the control transistors, which operate in their linear region in this design. A switch-mode regulator is used to provide this voltage in the circuit described here, and it generates an accurately stabilised voltage from the +12-V supply voltage. This reduces the amount of current that has to be transported by the supply cable and makes it easier to handle. If the circuit is built into the PC, a convenient alternative is to use the 5-V supply voltage from the PC power supply.

The switch-mode regulator is built around a National Semiconductor LM2592 using a standard design. According to the manufacturer's data, the efficiency is nearly 80%.

A standby mode is implemented by monitoring the voltage on T14 and D26. The regulator shuts down if the voltage on the +12 V line is less than 6 V. The 5-V supply voltage is thus not present if the 12-V supply voltage is absent or is too low to ensure correct operation.

Indicator LEDs

The circuit has three indicator LEDs:

- The 'Power OK' LED (D17) indicates that both supply voltages (12 V and 5 V) are present.
- The 'Over-Video' LED (D18) indicates that the video level is too high and the timeout has been actuated.
- The 'Protection' LED (D19) indicates that current limiting is in effect. It is lit when the MOSFETs are conducting. There are two possible causes for this: either temporary protection due to an excessive bright image or a power supply problem.

Use of the LUXEON K2 LED

The principal model employs a system with three discrete LEDs type LUXEON K2 Power.

The mounting of the LEDs on aluminium pads is identical to the previous model because the metal part on the board has been designed for compatibility with both systems.

Only the LED current is changed to fall within a range of 300 to 700 mA (per LED), with the Philips LUXEON chip capable of carrying this current and outputting very bright light at no less than 3 x 75 lumens.

Chromatic rebalancing may be viable by trial and error. The initial values are those resulting from tests with the triple LED (PROLIGHT).

Characteristics of PROLIGHT power LEDs

Total included angle:	140°		
Power:	red = 2.2 V	blue = 3.55 V	green = 3.55 V
Current :	350 mA max. for each colour		
Wavelength:	red = 625 nm	green = 530 nm	blue = 470 nm
Luminosity:	red = 30 lumen	green = 30 lumen	blue = 10 lumen

Mechanical assembly

After all this discussion of theory, it's time to turn our attention to something more interesting.

We designed two PCBs for this project: the main circuit board (**Figure 3**) and the LED circuit board (**Figure 4**). The figures show only the component layouts; the copper track layouts can be downloaded from the Elektor website. You can also order the two PCBs from the Elektor Shop (order numbers **070491-1** and **070491-2**).

Start by assembling the main circuit board. Solder the components in the following order: resistors, inductors, capacitors, diodes, transistors, ICs, and finally the MOSFETs.

Using a multimeter, check to ensure that the supply voltage lines are not shorted anywhere, and check for continuity between the supply sources and the positive supply voltage pins of IC1 and IC2.

After fitting all the components, check everything again for short circuits and incorrect or incorrectly fitted components. Ensure that the MOSFETs make good thermal contact with the associated copper surfaces. This also applies to the LM2592.

Now it's time to assemble the LED board as shown in the photo in **Figure 5**. To provide proper cooling of the LEDs, the LED board is secured to a heat sink using a DIY clamp fixture.

- Cut a piece of aluminium with the same thickness as the PCB (1.2 mm) to dimensions of 20 x 7 mm such that it fits in the slot in the LED circuit board (see photo).
- Prepare the heat sink by drilling and

tapping holes for securing the LED circuit board with the aluminium strip in between.

- Pre-assemble the board without applying any pressure to the heatsink surfaces of the LEDs and solder the LEDs to their solder pads.

- Loosely fit the assembly to the heat sink using screws of the right size. You can optionally place mica insulators under the LEDs. The mating surfaces of the components and the heat sink can be coated with thermal paste (this is recommended) to improve the thermal contact. Apply only a thin coating, as otherwise it will be ineffective.

After the LEDs with their mica insulators are properly fitted, carefully tighten the screws until they are moderately tight (to avoid damaging the LEDs). Take care to avoid applying any force to the LEDs during this operation. Also be careful with the diffuser lenses, which are very fragile.

– Solder four wires (three for the colours and one for +5 V) to the four solder pads, and then solder the other ends to a DIN 5 plug according to the schematic diagram shown in **Figure 2**.

Set-up and adjustment

- Fit the Surround Light board in an open plastic box to avoid electrical contact between the circuit board and any conductive surfaces.
- Set trimpots RV1 and RV2 to their midrange points.
- Connect the LED board via the connector.
- Place the LED board behind the PC monitor.

- Switch on the Surround Light supply voltage.
- Connect a cable from the monitor (VGA) to the Surround Light. You will need a VGA splitter for connection to the PC. Now you have to adjust trimpots RV1 and RV2.
- Configure the PC to display a bright white image on the screen, measure the currents through the sense resistors (maximum 700 mA), and ensure that the protection circuit is not activated (12 V on pin 14 of IC1 – if necessary, turn RV1 back until protection is

- no longer active).
- Again display a white image on the monitor (a picture or Word document) to adjust the protection circuit for office applications.
- Using a hair dryer, heat the Surround Light circuit board to around 35–40 °C and turn RV1 while measuring the voltage on pin 13 of IC1.
- Adjust until you reach the switching point of the comparator (from 0 V to 12 V, or until the 'Protection' LED lights up). Verify that the comparator output switches when the screen display

changes from a picture to the window of a word-processing program. Now you're all set to go. We wish you many pleasant hours with the Surround Light in your free time (or at work!).

(070491-1)

Web Links

LM2592 data sheet:
<http://cache.national.com/ds/LM/LM2592HV.pdf>

The digital approach TV Surround Light

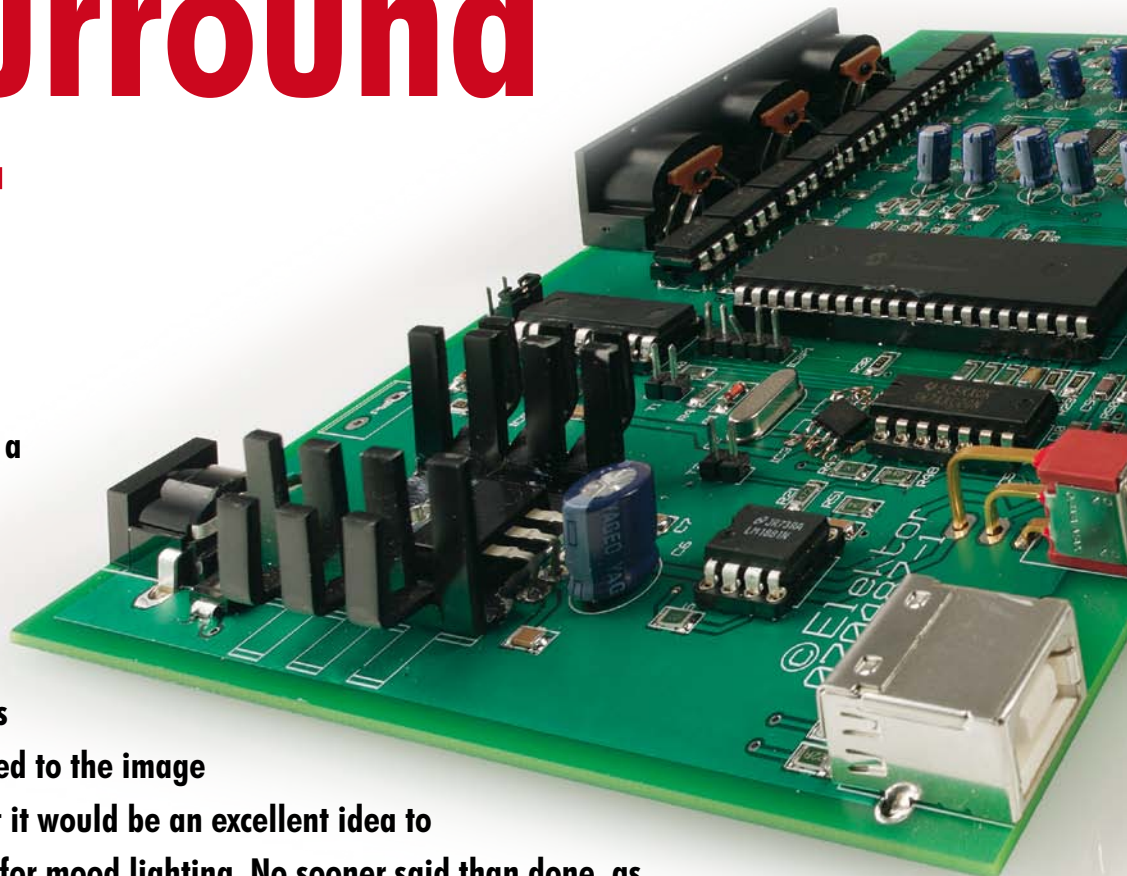
Steffen Schütte

A while ago the author saw a demonstration of a Philips television system equipped with the Ambilight system. This lights up the background with colours that are dynamically matched to the image content. The author thought it would be an excellent idea to create a similar DIY system for mood lighting. No sooner said than done, as can be seen from the TV Light project described here – a system that is very similar to the now legendary Ambilight system.

Before starting on this project, the author ploughed through a whole stack of specifications for different video signals. It shouldn't be all that difficult, he

thought – after all, there are only a few types of connections: the well-known Cinch (RCA) sockets and the SCART connector. All you have to do is to find

out which type of signal is being used in order to decide how to design a circuit for TV background lighting as quickly, simply and inexpensively as



possible.

He gradually realised that the SCART standard is only a point of reference for all sorts of signals that are necessary for connecting various kinds of video equipment to a television set. To avoid any misunderstanding, note that the circuit described here can only be used with equipment that supplies RGB signals, in combination with a fully wired SCART cable.

Due to the complexity of the composite video signal, it is not possible to use a direct connection to the yellow Cinch socket that provides this signal, which is also present on pin 19 of the SCART connector. For someone in the author's situation (i.e. not an expert in the complicated theory of signal processing), working with RGB signals is a lot easier – and it makes explaining the ins and outs of the circuit easier. See reference [1] for a summary description of video standards.

First considerations

Before delving in to the details of the design, we need to consider what types of LEDs to use for this project.

A bit of searching on the Internet turns up two usable types of LEDs:

1. SuperFlux LEDs [2] at approximately 70 p (euro 1.20) each;
2. LED arrays (light bars with nine SMD LEDs) at around £ 15 (euro 24) per bar.

The SuperFlux LEDs have a luminous intensity of 10,000 mcd and thus produce sufficient light (a maximum of six per section is needed), but they have the disadvantage that the colour mixing is not homogeneous.

A bit of browsing on the Internet to find a solution to this problem yielded a few tips and tricks, such as using baking paper and hot-melt glue, but they reduce the brightness too much. The LED light bars with SMD LEDs provide a better approach, but they are more expensive. They operate from a 12-V supply voltage (with a common anode) and provide a fully homogeneous colour palette, and they produce even more light than the SuperFlux LEDs.

Block diagram

The block diagram in **Figure 1** shows that the circuit uses four input signals taken from the SCART connector of a DVD player or the VGA connector of a graphics card in a PC. These four signals – red (R), green (G), blue (B), and composite video (C) – are fed to the circuit via two connectors. All of the signals received via these two connectors are processed the same way.

The first three signals contain the colour information for each scan line, while the fourth signal (C) is only used for horizontal and vertical synchronisation. This means we can use an IC that is very often used for this purpose: the LM1881 [3].

As the three colour signals are analogue signals, we have to start by converting them to the digital domain. This requires a set of A/D converters, and here we used the Analog Devices type ADC1175 [4]. This IC is designed specifically for digitising video signals

to drive the nine LED sections of the system, consisting of one section for each colour (R, G and B) for each of the three parts of the image. That's all there is to be said about the block diagram, so it's time to turn our attention to the next topic: the detailed design.

Schematic diagram

The schematic diagram in **Figure 2** is actually just a more detailed version of the block diagram in Figure 1. If you glance at the author's first prototype shown in the **photo**, you can recognise the main features of the block diagram in Figure 1. From left to right and top to bottom, you can see the three analogue to digital conversion modules using the ADC1175 (IC7–IC9). This A/D converter operates at 20 MHz and has a resolution of 8 bits.

After building the initial prototype using several circuit boards interconnected by a rat's nest of cables, we could

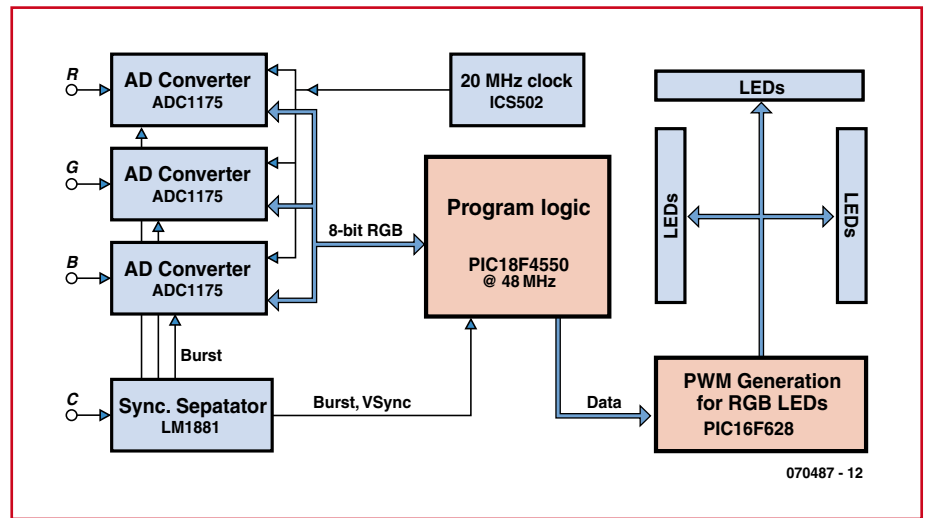


Figure 1. Block diagram of the TV Light. The digital approach to this ambient lighting system boasts two microcontrollers.

and can operate at clock rates up to 20 MHz. As the duration of a television scan line is 56 μ s, this would in theory make a resolution of more than 1000 pixels per line possible (or more precisely, 1120 pixels).

A Microchip PIC18F4550 microcontroller clocked by the sync signal from the LM1881 processes the digital data and uses integration to compute the average values of the colours in the left, upper, and right parts of the image on the screen. These values are passed directly to a second microcontroller, in this case a Microchip PIC16F628, which in turn generates the PWM signals used

test the circuit to determine whether it worked the way the author intended. When everything proved to work properly, we designed a 'clean' circuit board layout that held most of the circuitry. The A/D converters were placed on three separate modules, which were connected to the PIC18F4550 by lengths of 10-way flat cable.

To make the final version of the circuit more suitable for DIY construction, we put everything on a single printed circuit board for the Elektor version to eliminate the need for complicated interconnections. The input signals are received via a SCART connector (K2)

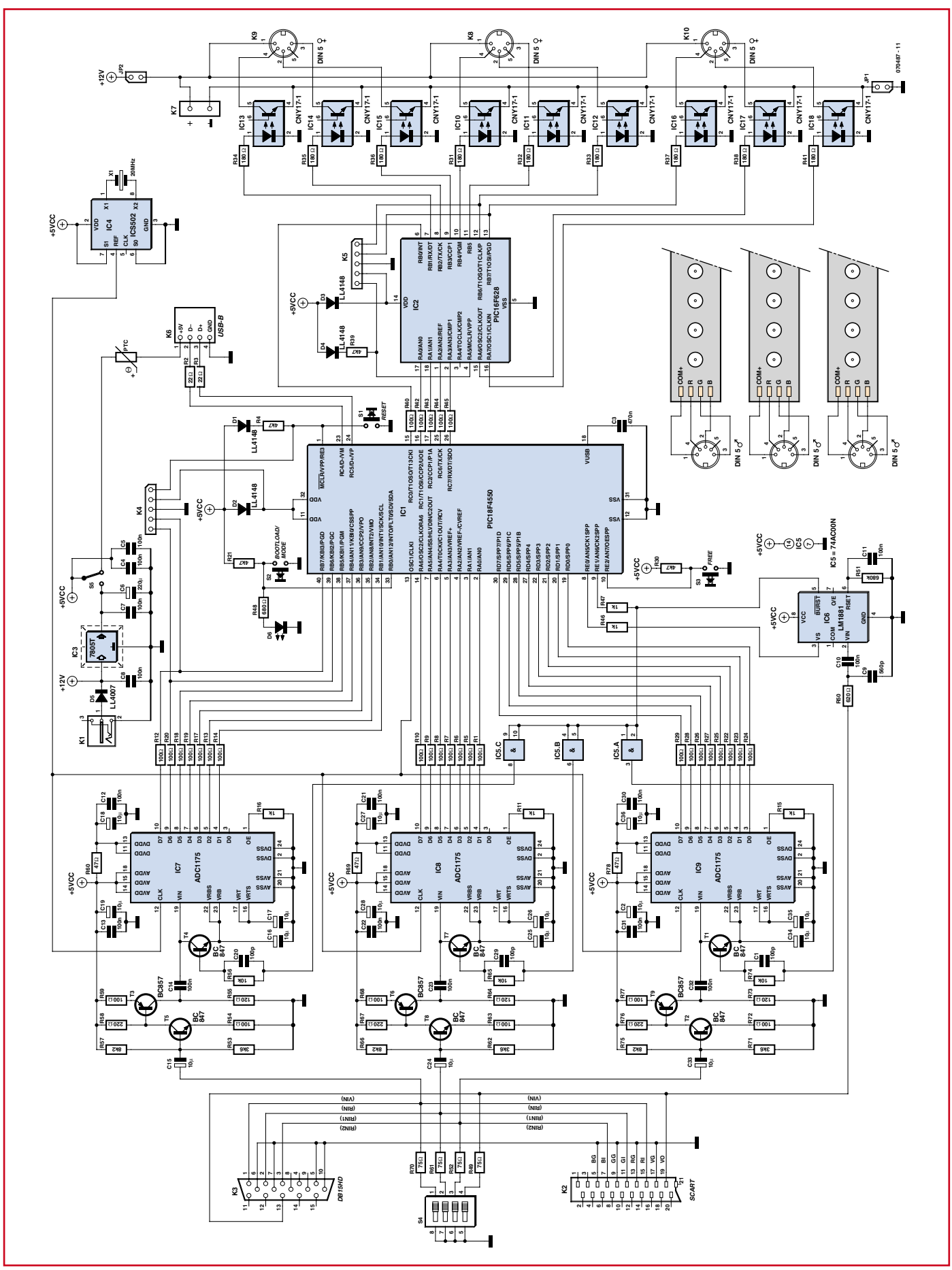


Figure 2. Schematic diagram of the TV Light. You can easily see the various functions of the block diagram here.

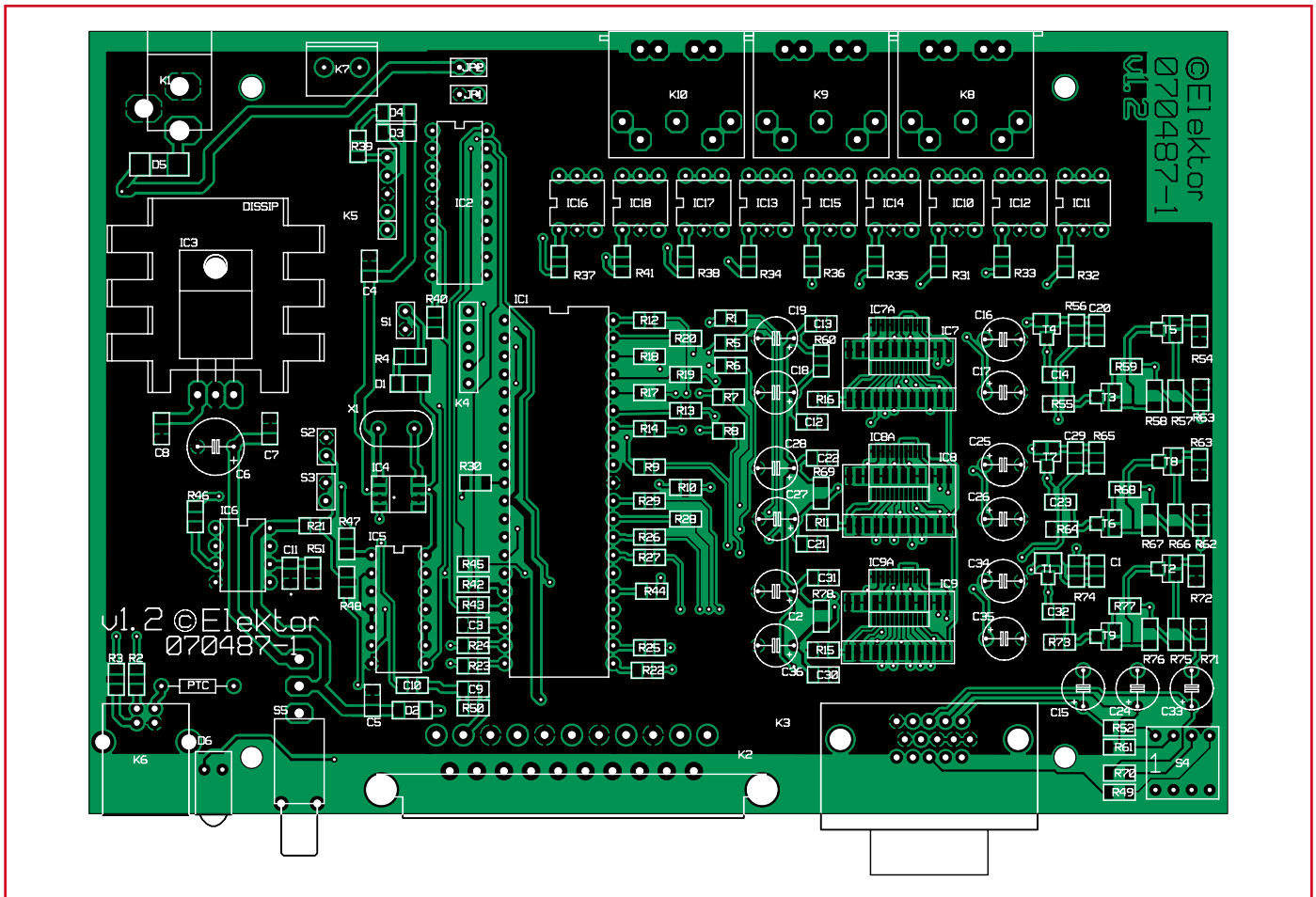


Figure 3. PCB layout for the TV Light circuit (reduced scale). Note that two positions are provided for components IC7 to IC9.

or VGA connector (K3). Now let's work through the schematic diagram from left to right and top to bottom. The system clock is provided by IC4, a type ICS502 [5]. This IC con-

tains a PLL circuit that oscillates at 20 MHz thanks to crystal X1. The 'inter-PIC' traffic is handled by five signal lines comprising a clock line and a line for each of the four data bits. There are

also 18 clock signals for the nine LEDs. The final clock pulse is held at a high level for a slightly longer interval to ensure proper synchronisation. The LM1881 (IC6) does exactly what

COMPONENTS LIST

Resistors

R1, R5-R20, R22-R29, R40, R42-R47, R54, R59, R63, R68, R72, R77 = 100Ω
 R2, R3 = 22Ω
 R4, R21, R30, R39, = 4kΩ
 R31-R38, R41 = 180Ω
 R48 = 680Ω
 R49, R52, R61, R70 = 75Ω
 R50 = 620Ω
 R51 = 680kΩ
 R53, R62, R71 = 3kΩ
 R55, R64, R73 = 120Ω
 R56, R65, R74 = 10kΩ
 R57, R66, R75 = 8kΩ
 R58, R67, R76 = 220Ω
 R60, R69, R78 = 47Ω

Capacitors

C3 = 470nF
 C4, C5, C7, C8, C10-C14, C21, C22, C23, C30, C31, C32 = 100nF

C9 = 560pF
 C1, C20, C29 = 100pF
 C2, C15-C19, C24-C28, C33-C36 = 10μF
 25V
 C6 = 220μF 25V

Semiconductors

D1-D4 = LL4148
 D5 = LL4007 (SOD-106)
 D6 = LED, 5mm, red
 T3, T6, T9 = BC857
 T1, T2, T4, T5, T7, T8 = BC847
 IC1 = PIC18F4550-1P, programmed, Elektor Shop # **070487-41**
 IC2 = PIC16F628-20I/P, programmed, Elektor Shop # **070487-42**
 IC3 = ICS502 (SO8)
 IC4 = 7805
 IC5 = 74AC00N (DIP14)
 IC6 = LM1881 (DIP8)
 IC7, IC8, IC9 = ADC1175
 IC10-IC18 = CNY17-1
 X1 = 20 MHz

Miscellaneous

S1, S2, S3 = 2-way SIL pinheader (pushbutton)
 S4 = 4-way DIP switch
 S5 = single-pole on/off switch (Farnell # 9575502)
 K1 = DC supply socket, PCB mount
 K2 = SCART socket
 K3 = VGA socket
 JP1, JP2 = 2-way SIL pinheader with jumper
 K4, K5 = 5-way SIL pinheader
 K6 = USB-B socket
 K7 = connector (optional)
 K8, K9, K10 = 5-way DIN socket
 PTC = Current protection (PTC660 or wire link)
 Enclosure, e.g. Vero # 16-3638089
 PCB # 070487-1, see Elektor Shop section or www.elektor.com
 Project software; PIC source and hex files in archive # 070487-11.zip, free download from www.elektor.com

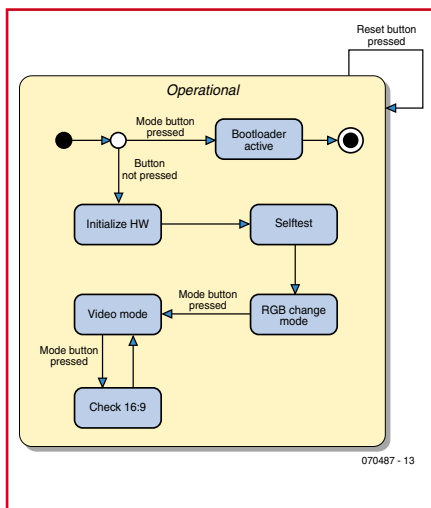


Figure 4. Summary of the functional modes of the TV Light.

it is designed to do: extract the sync signal from the composite video signal. The signal provided by this IC goes straight to the first PIC (IC1), which is the 'brain' of this complex design.

The four-way DIP switch (S4) can be used to connect termination resistors to the signal lines of the input connectors (SCART and VGA). They have the same effect here as in the Surround Light circuit described elsewhere in this issue. When the switches are open, the inputs have a relatively high impedance. When they are closed, the input impedance is 75 Ω.

The supply voltage for the circuit is provided by a 7805T (IC3) using a conventional circuit design that hardly needs any comment. LED D6 on the front side indicates that the supply voltage is present. Switch S5 can be used to select one of two supply voltage sources. This allows the supply voltage to be taken from a USB port if the TV Light is used in combination with a PC. The supply current is drawn via a thermistor that interrupts the supply voltage if the current becomes too large.

The red, green and blue LED light bars are connected to the system via 5-way DIN connectors (K8–K10). This method ensures reliable connections. Optocouplers IC10–IC18 provide galvanic isolation between the circuit and the LED light bars.

PCB

If you look at the PCB layout in **Figure 3** (designed using Layo 1 PCB), you can see right away that it uses quite a few SMD components. Due to

possible availability problems with the ADC1175, the board is designed to accommodate two different SMD versions: JM and TC. The locations on the PCB for the smaller version (TC) are marked with an 'A'.

As this circuit operates using high-frequency signals, a large ground plane extending over the entire board is provided on the component side. Ground plane areas are also placed beneath the connectors on the other side.

Assembly

Successful completion of this project requires a certain amount of experience in handling SMD devices. For readers with relatively little experience, we offer a PCB with all of these components pre-assembled (order number **070487-91**), so all you have to do is solder the connectors and operator control components. Preprogrammed PIC microcontrollers are also available from the Elektor Shop (**070487-41** and **-42**).

With the exception of a few ICs and connectors, all of the components are SMD types. It is thus important to always check everything that has to be done at each stage of assembly. Pay particular attention to correct orientation of the SMD ICs, since unsoldering incorrectly fitted IC can cause damage to the tracks on the PCB. Soldering the smaller version of the A/D converter requires special care to avoid producing shorts that will subsequently have to be eliminated.

A pair of pushbutton switches must be connected to the points marked 'S1' and 'S2'. They should be fitted to the rear panel of the enclosure between the 12-V power supply connector (J1) and the DIN connector for the red, green and blue LED light bars. These two buttons, which are labelled 'Reset' (S1) and 'Mode/Bootload' (S2), are used to select the operating mode of the unit. This is described in more detail below under the 'Operating modes' heading.

Note: jumpers JP1 and JP2 must be fitted (closed) if the LEDs are powered via supply voltage connector K1.

Operating modes

The PIC that generates the PWM signals (IC2) can be programmed using an ordinary programmer. The second PIC (the 18F4550) can be programmed using a USB cable, which is very practical if you want to develop your own software for the TV Light. The circuit can

remain switched on during programming, and you can program the PIC using a laptop computer next to the television set. Naturally, a boot loader has to be installed first. This is explained further on in this article.

The first button (S1, Reset) is used to restart the unit, while the second button (S2, Mode/Bootload) is used to select the operating mode after a restart. You can press the second button during a restart to activate the USB boot loader so you can reprogram the TV Light circuit, or press it in normal operating mode to switch between 4:3 and 16:9 image aspect ratios.

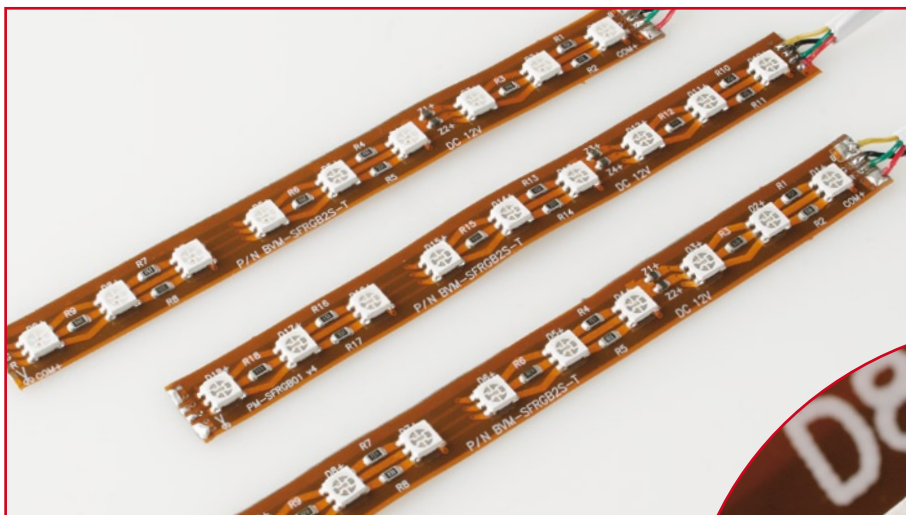
The various operating modes are summarised in **Figure 4** with associated comments.

To enter boot loader mode, hold the Mode button pressed while you switch on power or press the Reset button.

When you have finished programming the TV Light via the USB port, press the Reset button again (this time without pressing the Mode button). In response, the TV Light will initialise various parts of the circuit and then execute a test program that switches all the LEDs on and then switches off the nine outputs in sequence. This gives you an opportunity to check that the LEDs are positioned properly around the television set. This test is also very convenient for initial testing of the circuit after you have assembled the PCB, especially because it does not require any A/D conversion or input signals.

After the first test is completed, the TV Light switches to Light Show mode with RGB colours. In this mode it runs through a rainbow cycle with all nine LED light bars, which is repeated every 45 seconds. This low speed lets you get a good idea of the various colours. To exit this RGB mode, simply press the Mode button briefly. This causes the TV Light to switch immediately to the normal operating mode, in which the input signals are sampled and processed.

With films displayed in wide-screen format (16:9), it is not advisable to analyse the upper 10 percent of the image. To avoid this, simply press the Mode button once again. In response, the program will search for the first non-black line (note that here 'black' is not exactly zero, but instead a very low value from the A/D converter). The first non-black line is the uppermost line that is used for colour analysis (corresponding to the variable start-Line in the code segment detectTop of the source code).



An example of the LED light bars used in this project.

Development tips and tricks

We are often asked to shed a bit more light on the design and development processes of our authors. Some of the interesting aspects are described here.

RGB generator (PIC16F628A-I/P)

It is recommended to disable the brown-out reset while you are programming the PIC16F628.

After a bit of experimenting, it proved to be better to take the supply power for the LED light bars from a separate power supply.

It is advisable to use the I/P version of the PIC16F628A in this circuit because the PWM signals generated by a standard 16F628A produce flicker-

ing effects. The author does not know the exact reason for this, but the I/P version is intended for industrial applications and is probably less sensitive to electrical noise – and this circuit generates lots of noise.

TV Light control logic (PIC18F4550)

Almost all pins of the PIC are used here. As the Microchip loader routine normally uses RB4, the author recompiled the code to use RB0 instead. This means that one of the colours has a resolution of only 7 bits, but this is

not noticeable to the naked eye. If you want to recompile the loader routine, you need the full version of the C18 compiler (or an educational version for a trial period) due to the optimisation performed by the compiler.

The configuration bits [6] are used to program the loader.

We hope you have a lot of fun with your TV Light!

(070487-1)

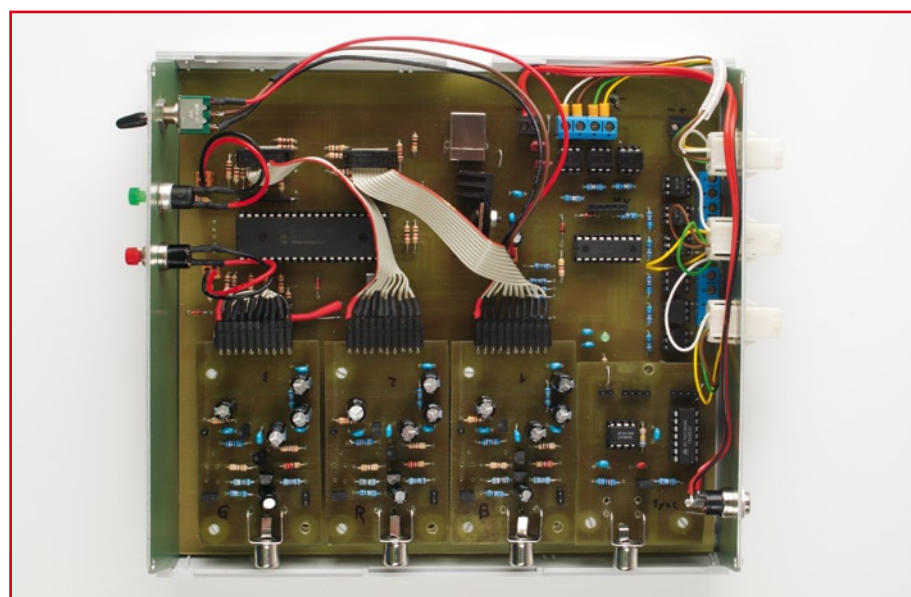
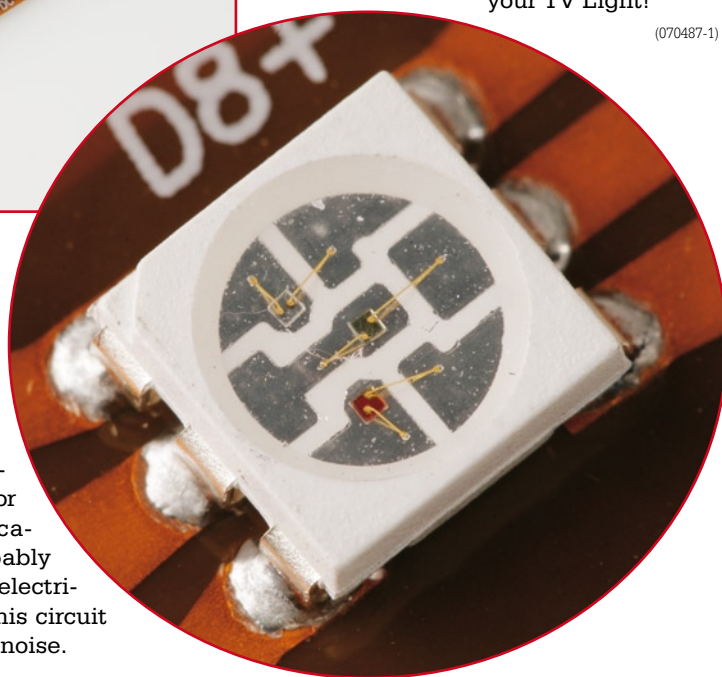


Photo of the author's initial prototype. It is somewhat larger than the final version described in this article.

Web Links

- [1] www.mediaprofis.net
- [2] SuperFlux LEDs datasheet: www.lumileds.com/pdfs/DS05.pdf
- [3] LM1881 datasheet: <http://cache.national.com/ds/LM/LM1881.pdf>
- [4] ADC1175 datasheet: <http://cache.national.com/ds/DC/DC1175.pdf>
- [5] ICS502 datasheet: www.idt.com/products/getDoc.cfm?docID=16325487
- [6] www.burger-web.com/Projects/PIC-18F4550USB/en_PIC18UsbBoard.htm.en

What University Electronics and Electrical Engineering courses in the UK

Steve Gold

So you were thinking of studying for an Electronics and Electrical Engineering degree or similar qualification at a UK university or other higher level educational establishment? BEng., MEng., perhaps a PhD.? Here at Elektor, we decided to take the pain out of asking the obvious not so obvious questions with our 3-step primer on the subject: (1) get oriented; (2) hear opinions and (√9) where to hang out.



1. www and what / where / who?

Studying at a university or higher educational establishment offering degree-level (or similar) courses in electronics and electrical engineering has never been easier in the United Kingdom.

The availability of low-cost loans (indexed to inflation and repayable only when obtaining employment with an annual income of more than £ 25,000, means that the age-related barriers to study are no longer there.

Students on these courses can now be (and are) of almost any age and from almost any country, although students from outside the European Union are generally charged higher fees.

We looked at six degree educational establishments in some depth and spoke to their Electronics and Electrical

Engineering course staff.

Whilst the establishments varied in funding and size, their main attribute — in common with all the colleges and universities we spoke to when researching this feature — was high levels of enthusiasm and, despite government cutbacks, healthy funding in the Electronics and Electrical Engineering departments.

It's also worth noting that the **main table**, which shows the UK establishments offering BEng (Bachelor of Engineering) and MEng (Master of Engineering) degree courses in Electronics and Electrical Engineering, and the places available. The data is based on 2006/2007 figures from HESA (www.hesa.ac.uk) and are the latest available at the time of writing.

**Universities in England, Scotland, Wales and Northern Ireland
offering courses in Electronics & Electrical Engineering**

England	website	places
Anglia Ruskin University	www.anglia.ac.uk	215
Aston University	www.aston.ac.uk	135
The University of Bath	www.bath.ac.uk	230
University of Bedfordshire	www.beds.ac.uk	5
The University of Birmingham	www.bham.ac.uk	400
The University of Bolton	www.bolton.ac.uk	255
Bournemouth University	www.bournemouth.co.uk	30
The University of Bradford	www.bradford.ac.uk	195
The University of Brighton	www.brighton.ac.uk	90
The University of Bristol	www.bristol.ac.uk	285
Brunel University	www.brunel.ac.uk	275
Buckinghamshire Chilterns University College	www.bcuc.ac.uk	5
University of Central England in Birmingham	www.bcu.ac.uk	820
The University of Central Lancashire	www.uclan.ac.uk	125
City University	www.city.ac.uk	465
Coventry University	www.coventry.ac.uk	190
Cranfield University	www.cranfield.ac.uk	5
De Montfort University (Leicester)	www.dmu.ac.uk	105
University of Derby	www.derby.ac.uk	275
The University of East Anglia	www.uea.ac.uk	5
The University of East London	www.uel.co.uk	190
The University of Essex	www.essex.ac.uk	135
The University of Exeter	www.exeter.ac.uk	45
The University of Greenwich	www.gre.ac.uk	270
University of Hertfordshire	www.herts.ac.uk	420
The University of Huddersfield	www.hud.ac.uk	370
The University of Hull	www.hull.ac.uk	95
Imperial College of Science, Technology & Medicine (London)	www.imperial.co.uk	505
The University of Kent	www.kent.ac.uk	170
King's College London	www.kcl.ac.uk	175
The University of Lancaster	www.lancs.ac.uk	40
Leeds Metropolitan University	www.leedsmet.ac.uk	25
The University of Leeds	www.leeds.ac.uk	260
The University of Leicester	www.leicester.ac.uk	110
Liverpool John Moores University	www.ljmu.ac.uk	260
The University of Liverpool	www.liv.ac.uk	255
London Metropolitan University	www.londonmet.ac.uk	240
London South Bank University	www.lsbu.ac.uk	225
Loughborough University	www.lboro.ac.uk	420
The Manchester Metropolitan University	www.mmu.ac.uk	250
The University of Manchester	www.manchester.ac.uk	465
The University of Newcastle-upon-Tyne	www.ncl.ac.uk	170
The University of Northumbria at Newcastle	www.northumbria.ac.uk	45
The Nottingham Trent University	www.ntu.ac.uk	65
The University of Nottingham	www.nottingham.ac.uk	380
Oxford Brookes University	www.brookes.ac.uk	180
The University of Plymouth	www.plymouth.ac.uk	155
The University of Portsmouth	www.port.ac.uk	515
Queen Mary and Westfield College of London	www.qmul.ac.uk	210
Ravensbourne College of Design and Communication	www.rave.ac.uk	85
The University of Reading	www.reading.ac.uk	280
The University of Salford	www.salford.ac.uk	30
Sheffield Hallam University	www.shu.ac.uk	265
The University of Sheffield	www.shf.ac.uk	365
Southampton Solent University	www.solent.ac.uk	60
The University of Southampton	www.so.es.soton.ac.uk	380
Staffordshire University	www.staff.ac.uk	80
The University of Sunderland	www.sunderland.ac.uk	60

(continued overleaf)

The University of Surrey	www.surrey.ac.uk	355
The University of Sussex	www.sussex.ac.uk	120
The University of Teesside	www.tees.ac.uk	240
Thames Valley University	www.tvu.ac.uk	5
University College London	www.ucl.ac.uk	170
The University of Warwick	www.warwick.ac.uk	215
University of the West of England, Bristol	www.uwe.ac.uk	170
The University of Westminster	www.wmin.ac.uk	235
The University of Wolverhampton	www.wlv.ac.uk	15
The University of York	www.york.ac.uk	335
Wales		
University of Wales, Aberystwyth	www.wales.ac.uk	65
University of Wales, Bangor	www.bangor.ac.uk	70
Cardiff University	www.cf.ac.uk	230
University of Wales Institute, Cardiff	www.uwic.ac.uk	75
University of Glamorgan	www.glam.ac.uk	200
The North-East Wales Institute of Higher Education	www.newi.ac.uk	55
Swansea Institute of Higher Education	www.sihe.ac.uk	20
University of Wales, Swansea	www.swan.ac.uk	145
Scotland		1740
The University of Aberdeen	www.abdn.ac.uk	110
University of Abertay Dundee	www.abertay.ac.uk	35
Bell College (Note 1)	www.paisley.ac.uk	5
The University of Dundee	www.dundee.ac.uk	60
The University of Edinburgh	www.ed.ac.uk	285
Glasgow Caledonian University	www.gcal.ac.uk	185
The University of Glasgow	www.gla.ac.uk	195
Heriot-Watt University	www.hw.ac.uk	185
Napier University	www.napier.ac.uk	70
The University of Paisley 1	www.paisley.ac.uk	25
The Robert Gordon University	www.rgu.ac.uk	275
The University of Strathclyde	www.strath.ac.uk	305
UHI Millennium Institute	www.uhi.ac.uk	5
Northern Ireland		335
The Queen's University of Belfast	www.qub.ac.uk	245
University of Ulster	www.ulster.ac.uk	90
¹ University of Paisley merged with Bell College in 2007.		

Considerable changes are taking place at many universities during the current academic year, with many campuses merging or changing their roles. Please check the relevant websites for more information. For less official stuff the portal website www.whatuni.com is also a good starting point.

Birmingham University

www.eece.bham.ac.uk
Electronic, Electrical & Computer Engineering
 The University of Birmingham, Birmingham B15 2TT. Tel. 0121 414-5630.

The EE & CE Department is research-led and has 28 academic staff and 15 support staff who look after over 500 undergraduate students, around 60 MSc Students and a similar number of students studying for their doctorate. Turnover on research is £ 2 million per year, and in the last government Research Assessment Exercise the Department attained a grade 5 listing, as well as 24/24 marks on Teaching Quality Assessment. The £ 2 million funding derives from a variety of sources

including government and industry as well as the European Union.

Brunel University

www.brunel.ac.uk
School of Engineering and Design
 Brunel University, Uxbridge, Middlesex UB8 3PH. Tel. 01895 274000

Brunel is a world-class university based in Uxbridge, West London and just over 40 years old. There are several electronics and Electrical Engineering courses available including the new Electronic and Computer Engineering MEng; Electronic and Electrical Engineering (Communications Systems) BEng; Electronic and Electrical Engineering (Control Systems) BEng; Electronic and Electrical Engineering (Power Electronics Systems) BEng; Electronic and Electrical Engineering BEng & MEng; and Electronic and Microelectronics Engineering BEng. The Electronics and Electrical Engineering (Communications Systems) BEng. course, for example, is a three year full-time

course, of four years 'thick' sandwich (block study) course that seeks to deliver well-rounded engineers with a high level of analytical and engineering design skills. Students are said to develop a sound knowledge of all aspects of Electronic and Electrical Engineering and related areas. The course is accredited by the Institution of Engineering and Technology (IET).

City University London

www.city.ac.uk
School of Engineering & Mathematical Sciences
City University, Northampton Square, London EC1V 0HB.
Tel. 020 7040-8130.

The School of Engineering has entered a new dynamic phase following the University's decision in 1999 to invest heavily in the School, its restructuring in 2001 into a department-less School headed by a new Dean and its merger with the Department of Mathematics to form the School of Engineering and Mathematical Sciences. Research in the School of Engineering and Mathematical Sciences has a basic and applied component and has a strong interdisciplinary character and it is characterised by close links with industry and awareness of its location in London.

London Electronics College

www.lec.org.uk
20 Penywern Road, London SW5 9SU. Tel. 020 7373-8721.

The London Electronics College is a centre of adult learning providing technical training dating back to 1892. This unique college attracts a wide range of students from all backgrounds, notable international and ethnic. The college says that small classes and a friendly environment help make learning enjoyable and rewarding. The college is very close to the exhibition centre in Earls Court and 20 minutes walk from Olympia. The area is well served by buses, tubes and rail.

University of Manchester

School of Electrical and Electronic Engineering
www.manchester.ac.uk
Oxford Road, Manchester M13 9PL. Tel. 0161 306-6000.

Established in 1924, the school has six research groups:

1. Microwave and Communication Systems (MACS) The MACS group considers a wide range of advanced topics applicable to communications and radar; from highly mobile wireless networks, propagation, microwave and millimetric components, through to digital signal processing, coding and signal analysis.
2. Control Systems (CS) — has an international reputation for its pioneering research in systems theory including the development of frequency domain design tools for multivariable systems, self-tuning and adaptive control and the use of symbolic algebra in the development of control algorithms.
3. Sensing, Imaging and Signal Processing (SISP) — pursues collaborative and cross-disciplinary research that exploits the complementary expertise in sensing, imaging and signal processing that is brought together in the group.
4. Electrical Energy and Power Systems (EEPS) — is at the

forefront of research and teaching in the field of electric power engineering in the United Kingdom and internationally with its 10 permanent academic members of staff and its 30+ researchers.

5. Power Conversion — The efficient conversion & control of electrical energy is a vital infrastructure technology that underpins much of what we take for granted in an industrialised country; electricity generation & distribution, land, sea & air transport, computer & communications systems, & countless industrial processes.
6. Microelectronics and Nanostructures (M&N) — Research activities cover a range of topics concerned with the fundamental materials and physics issues surrounding advanced semiconductor devices, novel high speed electronic and optoelectronic devices, and advanced sensors and systems.

Robert Gordon University

School of Engineering
www.rgu.ac.uk
Schoolhill, Aberdeen AB10 1FR. Tel. 01224 62000



Robert Gordon University's Garthdee library with its techno-futuristic architecture.

The University has developed an international reputation for providing high quality education from Undergraduate to PhD level.

In 2006 The Times newspaper named RGU as the top university for graduate employment. The uni says that all its electronics and electrical engineer courses are designed in close co-operation with industry, with collaborative work with professional bodies, industrial organisations, government departments and research institutes.

Many courses are designed with a part-time study option and a number of courses are available through the University's virtual campus, a remote university computer system.

Sheffield University

Department of Electronic & Electrical Engineering
www.shef.ac.uk/eee
Mappin Street, Sheffield S1 3JD. Tel. 0114-222-5355

Sheffield Uni's E&EE Department is respected internationally for its many important contributions in the field of Electronic and Electrical Engineering.

The Department currently has 35 academic staff (including 12 professors), 8 academic-related staff, 29 research staff, 81 PhD students, 54 MSc students and approximately 360 undergraduate students.

The Department's reputation in both teaching and research has been confirmed by the highest possible award in the Teaching Quality Assessment (24/24 points) and a five star award in the HEFCE Research Assessment Exercise.

2. Opinions: how far would you agree or disagree with the statement "electronics as a science, a study, a pastime and professional activity is migrating fast to India, China and the Far East?"



London Electronics College (LEC) classroom.

This is not so, says **Dr. Geoff Baines**, an admissions tutor with **Manchester University's School of Electrical and Electronic Engineering**, who says that, whilst a number of UK call centre jobs have been flowing steadily overseas to the Indian sub-continent in the last five years, students from around the world are now flowing into UK universities as never before.

"Around 40 per cent of our electronic and engineering students are from outside the European Union, despite the fact that their fees are around the £ 12,900 a year mark, compared to £ 3,145 a year for UK and European Union students," he told *Elektron*.

And, he added, overseas students' fees are paid from a wide range of sources, including parental contributions, bank loans, foreign government and similar scholarships and company sponsorships,

"In addition, once the international students have finished their courses, not all of them return to their country of origin. Many choose to stay in the UK and get a job or go on for post-graduate training," he said.

"This task has been made a lot easier by the fact that the UK government allows students to go on to get a relevant job for up to 12 months without having to get a work permit," he added.

Coupled with the fact that applying for a work permit on the employer's side, particularly in the electronics and electrical engineering industry, is now a lot easier than it used to be, Baines says that a sizeable minority of non-European Union students go on to settle in the UK.

"There's always been a shortage of graduates in the elec-

tronics and electrical engineering fields, so getting a work permit is easy enough, provided you fill in the required forms", he explained.

Over at the **London Electronics College, Malcolm Spalding**, the college's Principal, also dismisses any suggestion that electronics and engineering jobs are drifting overseas.

He should know, as the college has been providing technical training since 1892, when it was first established.

"We trained Harold Bridge, the radio operator of the Titanic, as well as his counterpart, Harold Cottam, on the Carpathian, the first boat to arrive as the Titanic was sinking after it hit an iceberg. Our students go on to a wide range of positions in the UK, as well as abroad," he told *Elektron*. According to Spalding, since the college is located close to the exhibition centre in London's Earls Court on the west side of London, it attracts a sizeable number of international students from all over the world.

"These students then go on to hold high-ranking positions in the electronics industry. Today the courses range from BTECs through to HNC/HNDs and we have around 160 students aged 19 years or older studying for a wide range of courses".

Unlike the traditional universities teaching electronics and electronic engineering courses, Spalding says that the average age of students at the London Electronics College is 36 years.

Course fees at the college are well below those of a traditional university at £ 600 per course per year and, says Spalding, anyone on benefits — any form of government benefits — can attend the college for their first course, free of all tuition fees.

International (non-European Union) fees come in at around £ 5,100 — again well below that of a traditional university, which is why, says Spalding, the college has around 70 of its students from ethnic minorities.

"Around 50 per cent of our students are from London, with the majority of the remainder coming from overseas," said Spalding, adding that his educational team stay in contact with their students after they have left the college.

"I'd say that around half of them go into further education with the remainder going into regular employment, both here and when they return to their home country."

Up in Scotland, at the **Robert Gordon University** in Aberdeen, which describes itself as a professional's university, having attained the distinction of being the top Scottish university for graduate employment, **Dr Christopher Macleod**, a Lecturer in Electronic Engineering, says there is some truth in the claim that electronics jobs are flowing abroad.

"Companies like Hewlett-Packard, Intel and Motorola are doing some of the production overseas, but the design and development is still largely here in the UK, as well as the US," he said.

Macleod, who is a course leader in Artificial Intelligence and Robotics with the university, as well as being leader of the university's artificial neural networks research group, says that, in some ways a move towards India may suit the UK.



Malcolm Spalding of LEC has reason to disagree with the proposed statement.

"This is because we have strong historical links in India — and arguably better than with the US, even if we do speak the same language — and there will be good opportunities for companies to expand on this," he said.

If anything, he told *Elektor*, the UK needs to view this as an opportunity and develop these links, rather than see them as a threat.

Interestingly, Macleod says that, as a pastime, electronics has been dead among the young for many years.

"When I started lecturing 20 years ago, if you asked a class of 50 how many of them were hobbyists, most students would have put up their hands, Now I ask the same question and only one or two do," he said.

According to Macleod, there are many reasons for this, especially — and somewhat paradoxically — when it comes to the field of new technology.

"Why spend hours building a crystal (radio) set when you can experience the wonders of the Internet," he said, add-

ing that at least some of the blame for this has to lay at the door of hobbies like amateur radio.

"If you pick up a copy of *RadCom* (the journal of the Radio Society of Great Britain) or *Practical Wireless* (now it is full of arguments about the use of morse code and the technical aspects of the hobby have been brushed aside," he explained.

"In many ways, the hobbies have no relevance for kids any more in what has become a mobile phone, Internet and iPod-enabled 21st Century. The hobbies have failed to keep up with modern times and integrate new technology as part of the pastime," he said.

Against this backdrop, Macleod predicts that these aspects of the hobby of electronics and radio amateurs, will be populated by an increasingly ageing membership ('old far-dom', as he calls it), so further alienating the younger elements of society.

3. Atmospheric soundings from ~~Ma~~nchester



Manchester – bridge at the Lowry.

With no less than three universities — the University of Salford, the University of Manchester and Manchester Metropolitan University — Manchester is truly a student city.

Electronics and Electrical Engineering courses are available at all three universities, who are also inextricably linked with each other historically.

According to **Abigail Ridgway**, a student studying Information Systems at Manchester Metropolitan University for two years, and who transferred to the university's Crewe campus for final year, Manchester is a great place to study and live.

"I lived in the student halls during my stay in Manchester, which was great for my social life, as the halls are so central" she said, adding that the only issue she had with her stay was the cost of living in Manchester from a student's perspective.

The cost of living in the halls of residence, she says, was not that cheap, even though the halls provided excellent self-catering facilities, but it was the cost of leisure pursuits that she found heavy on her pocket.

"Entertainment in Manchester, as in all large cities, is always going to be an expensive option. Going out in the evening, especially to one of the city's clubs, can be expensive," she explained.

When it came to choosing between stay in the halls of residence and renting private property, Abigail says she was only given minimal information by the university authorities to help her choose.

"I think we were given a leaflet on the accommodation choices and that was about it. I was, however, able to log into one of the many student forums on the Internet and read about other student's experiences with choosing where to live", she said.



Manchester University's Whitworth Hall.

The Internet forums for the various universities, she went on to say, has helped students immensely, since it allows students from different years share their information informally, even to the extent of allowing people to post their views between universities.

Manchester Metropolitan University is slightly unusual for a UK university in being split across five campuses in Manchester and a further two in nearby Alsager and Crewe. Abigail moved to the Crewe campus for her final year as it allowed her to move out of the halls of residence in order to save on her living expenses, which, she says, are the most troublesome part of university life. Her advice to prospective students wanting to study an Electronics and Engineering course at a UK university — or, for that matter any course at university — is to check whether they want to stay in the halls of residence or take up private accommodation.

"Renting privately can be cheaper than living in the halls, especially if you live in shared accommodation", she told

Elektor, adding that the cost of phoning home and to/from friends is another cost.

"In the halls we had phones of our own, but they all took phonecards, which proved to be expensive. In private rented accommodation, you can share the cost of a phone line with others and, if you have a mobile phone, that can help you reduce the cost of staying in touch with your friends and family", she said.

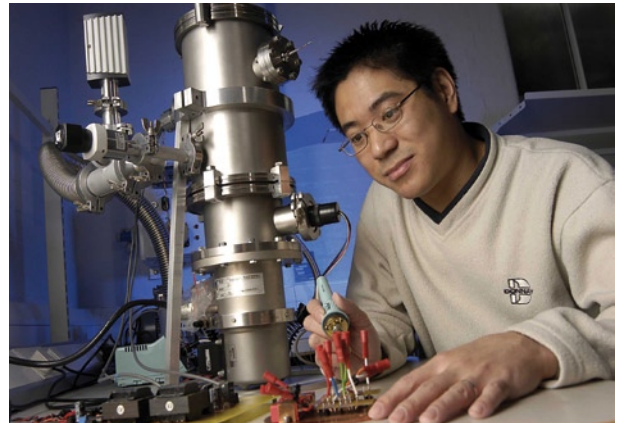
Manchester nightlife has changed immensely in the last few years, with the relaxation in UK licensing laws allowing bars and clubs to stay open much later than previously, and sometimes on a 24-hour basis.

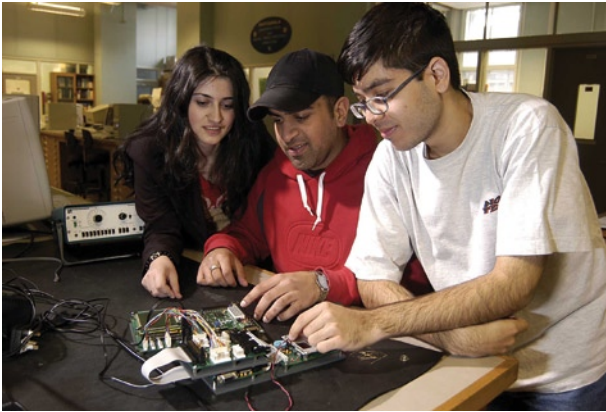
This hasn't triggered a drinking culture, however, as many students are now choosing to go out for a drink or club much later than they would have done just a few years ago.

Clubs in Manchester now numbers into several dozen, with the top four clubs — *Sankeys* in Radium Street, *Mint Lounge* in Oldham Street, *Twisted Elegance@Ampersand* in Long-



(left) Manchester's night life and general atmosphere are well geared to students. (right) Cryogenic research at EEPS Manchester.





(left) Programming microprocessors at EEPS Manchester....
(right) ... requires total memory clearing at certain times.

worth Street and *Funkademia* in Central Street — attracting regular visitors.

Although entrance fees at these clubs can easily run to £ 20 or £ 30, competition between the clubs for new customers is ferocious, meaning that discount schemes for students and/or regular visitors all help to cut the costs.

And, of course, the fact that the University halls of residence in Manchester are quite centrally located means that late night revellers can travel home by night bus or even walk, rather than taking a cab, which all helps to keep entertainment costs to sensible levels.

“The central location of the halls whilst I was there meant that, even if had to share a cab between us, the cost was relatively inexpensive”, said Abigail, adding that the sheer variety of culture in Manchester is a great plus point for living and studying there.

The culture scene in Manchester has also improved immensely in recent years, with a number of museums and other ‘cultural sites’ available during extended opening hours free of charge.

One key site that students should check out immediately on arrival in Manchester is the Urbis Centre in Cathedral Gardens in the heart of Manchester.

Urbis is an exhibition centre focusing on city life with entrance to exhibitions, which cover photography, design, architecture, music, contemporary art and other topics, free of charge.

The centre, which has become a cultural icon in its own right has free interactive exhibits, a range of family activities, a shop and a cafe bar.

The interactive exhibits allow visitors to take a ride through different cities around the world, create your own identity card or go global to discover a 3D satellite view of any city on the planet.

And, of course, because everything is centrally located in Manchester, as Abigail says, students can generally walk home to their halls of residence or private accommodation, if they miss their night bus.

(071019-1)



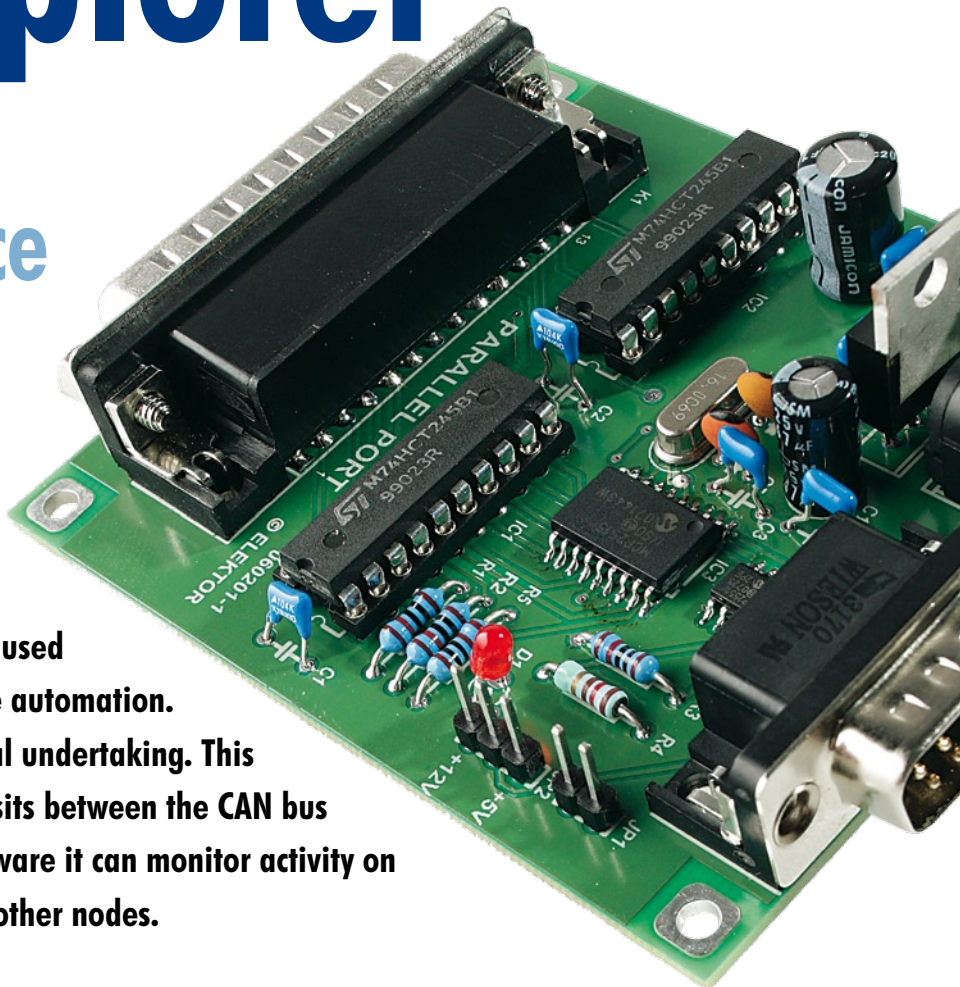
Urbis Centre – a must-visit for everyone arriving in Manchester.

CAN Explorer

Versatile PC-CAN Interface

Fredi Krüger

The CAN bus network is usually associated with vehicle systems or industrial automation but it can also be used in many other situations including home automation. Implementing the network is not a trivial undertaking. This low-cost solution is a CAN board which sits between the CAN bus and a PC. Using the versatile (free) software it can monitor activity on the network and test the functioning of other nodes.



Although originally conceived (by Bosch) to provide a network linking together electronic vehicle subsystems, the CAN bus was later adopted by companies specialising in industrial control systems. A quick trawl of the Internet indicates that the CAN bus has many devotees who have used it in a number of interesting applications [1]. Among the advantages of this network are its excellent error detection, good interference rejection and a wide range of low-cost components. Following links [2a] and [2b] will fill in some of the background information on this network standard. The available node hardware extends from so-called Stand-Alone-Controllers up to microcontrollers with integrated CAN controllers.

One of the difficulties in a network is to establish communication, so that information can be sent reliably between different system components. The level of difficulty is further multiplied if it is necessary to build the whole network from scratch and manage bidirectional data on the network. This article presents a CAN bus-to-PC

interface card which together with the use of free software can not only monitor traffic on an existing CAN network but also send and receive CAN-format messages and monitor the functioning of other nodes on the network. Use of these features gives the user a good insight into the workings and capabilities of the CAN bus.

Simple, low-cost and versatile

The CAN controller chip MCP2515 from Microchip is relatively low-priced while the PC software is available free-of-charge from Microchip [3]. The software allows direct access to the CAN controller's registers to configure the controller for specific applications. CAN bus messages can also be sent and received and a configurable filter/mask allows the user to set-up and test for message acceptance.

The board interfaces to the PC using the parallel printer port which nowadays (unless your printer is very old) is hardly ever used. This port offers good communication speed and low-

cost interface hardware (with regard to Windows Vista problems, see the *LabTalk* article elsewhere in this magazine). The parallel printer port must be configured in software for bidirectional data flow.

In order for the hardware to run the software from Microchip it is necessary that the circuit diagram (**Figure 1**) corresponds closely to the CAN bus board described by Microchip on their web site [3]. Two 74HCT245 bus transceivers (IC1, IC2) are used to buffer signals between the printer port and the MCP2515 CAN controller chip (IC3). Communication to the chip takes place using the serial SPI interface with the necessary signals produced/received by the PC software via parallel port pins. The additional signals are used to poll/control the status of other signals of the CAN controller. An MCP2551 (IC4) is used as the CAN bus driver/receiver but alternatives like the PCA82C521 are also suitable.

The PCB for this project, no. **060201-1** can be ordered through Elektor's business partner ThePCBShop. Jump-

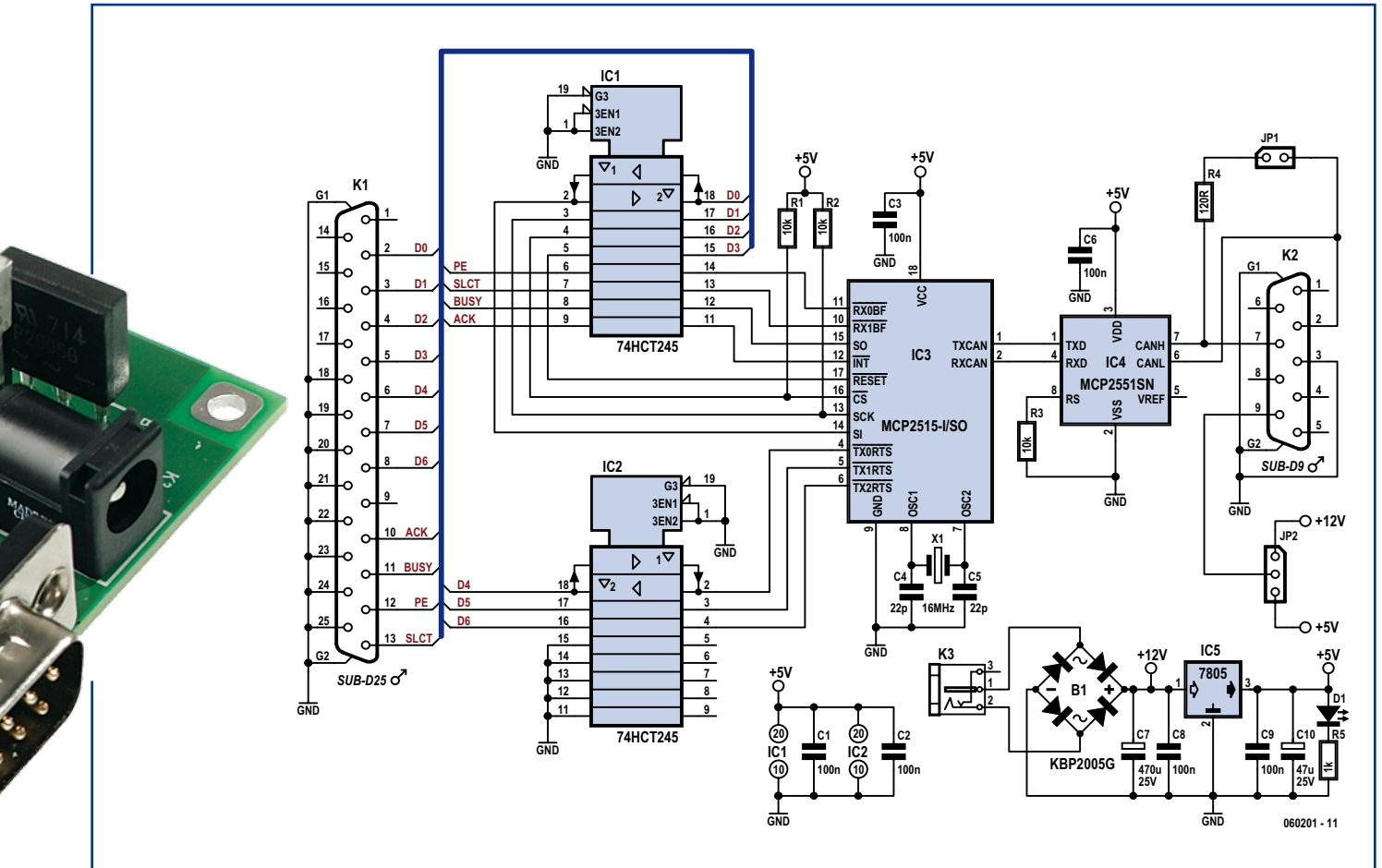


Figure 1. Bus transceivers IC1 and IC2 buffer signals between the printer port and the CAN controller chip (IC3). IC4 is a CAN bus driver.

er JP1 can be used to connect a 120 Ohm terminating resistor across the network cable if this board is the end node. This is recommended to reduce signal reflections in the cable. Physical connection to the CAN bus is made via a PCB mounted 9-way sub-D connector (K2). Pin assignments are given on the circuit diagram and spare pins are used to allow the board to be powered from the bus connector with either 12 V or 5 V (use JP2 to select). Alternatively a separate mains adapter input is provided (K3) to power the board. The bridge rectifier (B1) ensures that a mains adapter ('wall wart') producing a low-voltage AC or DC output (with a plug wiring of either polarity) can be used without problem.

Fitting it all together

The resistors and capacitors can be fitted first, followed by the other components according to their size. Make sure that the correct polarity is observed for the electrolytic capacitors (C7; C10), LED (D1), rectifier (B1), and

do pay attention to the correct orientation of the ICs on the board. Once you are happy that the layout is correct and you have not made any unintentional solder bridges between pads and tracks, it is time to connect the power supply (8 V to 12 V) to connector K3. LED D1 should now light. With the board connected to the par-

allel printer port of a PC and with the software (described below) running the hardware will automatically be recognised as an 'Eval-Board'.

Software

Software for the project can be downloaded free-of-charge from the Micro-

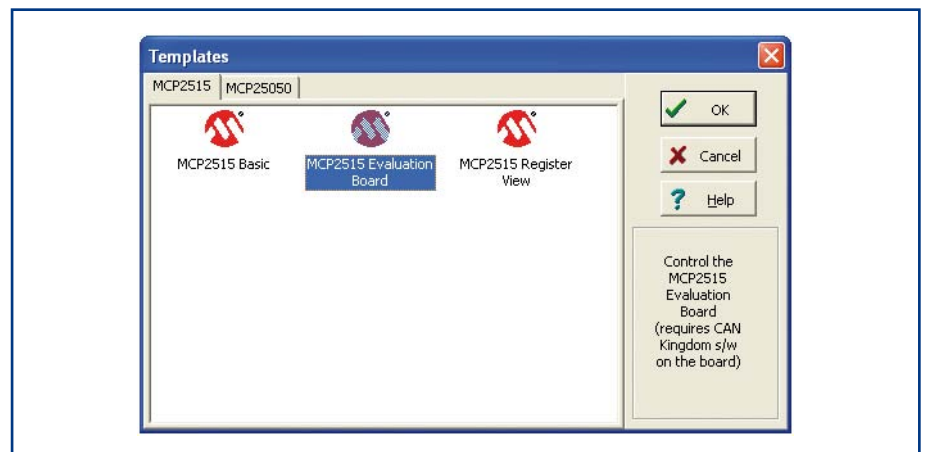
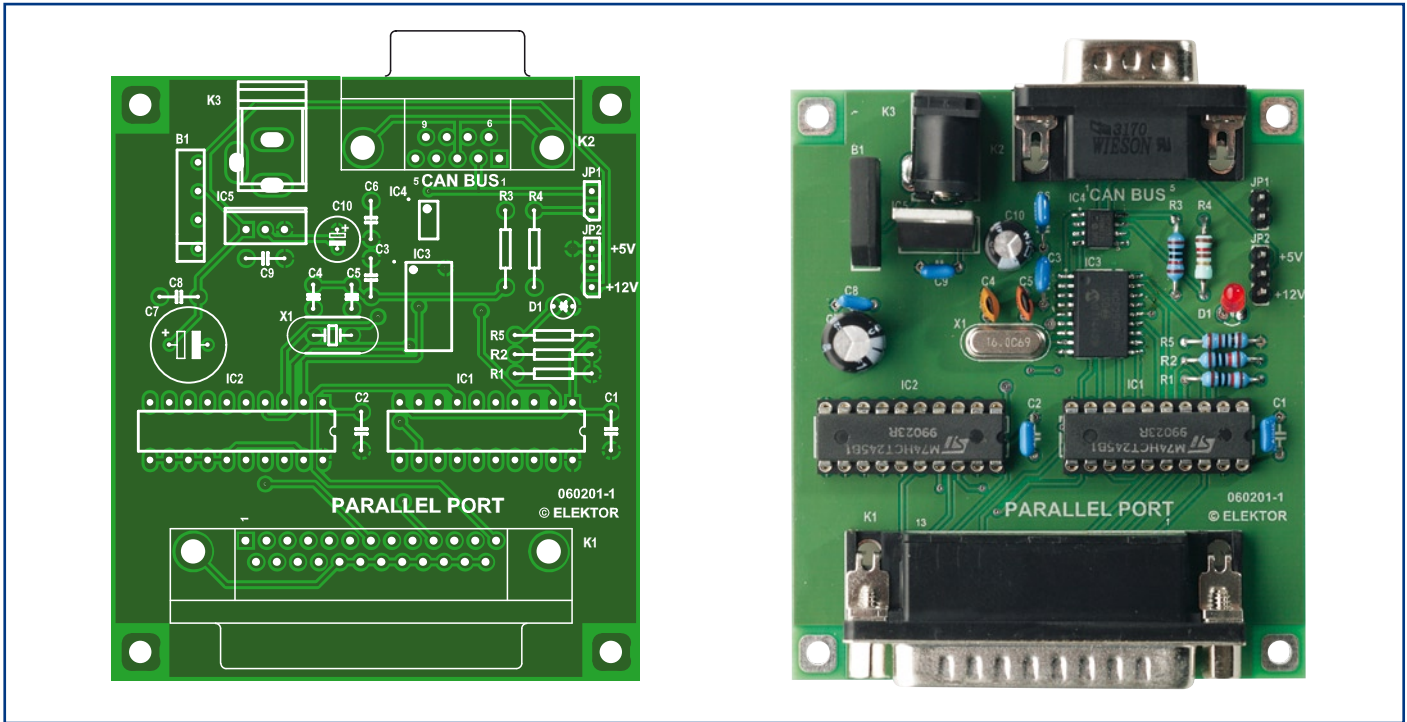


Figure 2. Following software installation and a few mouse clicks, these options are available.



COMPONENTS LIST

Resistors

R1,R2,R3 = 10kΩ
R4 = 120Ω
R5 = 1kΩ

Capacitors

C1,C2,C3,C6,C8,C9 = 100nF, 5mm lead

pitch
C4,C5 = 22pF
C7 = 470μF 25V (radial)
C10 = 47μF 25V (radial)

Semiconductors

B1 = KBP2005G (bridge rectifier)
D1 = LED, 3mm, 2mA
IC1,IC2 = 74HCT245
IC3 = MCP2515 (SOIC)
IC4 = MCP2551SN (SOIC)
IC5 = 7805 (TO220)

Miscellaneous

JP1 = 2-way pinheader with jumper
JP2 = 3-way pinheader with jumper
K1 = 25-way sub-D plug, right-angled pins, PCB mount
K2 = 9-way sub-D plug, right-angled pins, PCB mount
K3 = mains adaptor socket (HEBW25), right-angled pins
X1 = 16MHz quartz crystal (HC49U)
PCB, no. 060201-1 from www.thepcbshop.com

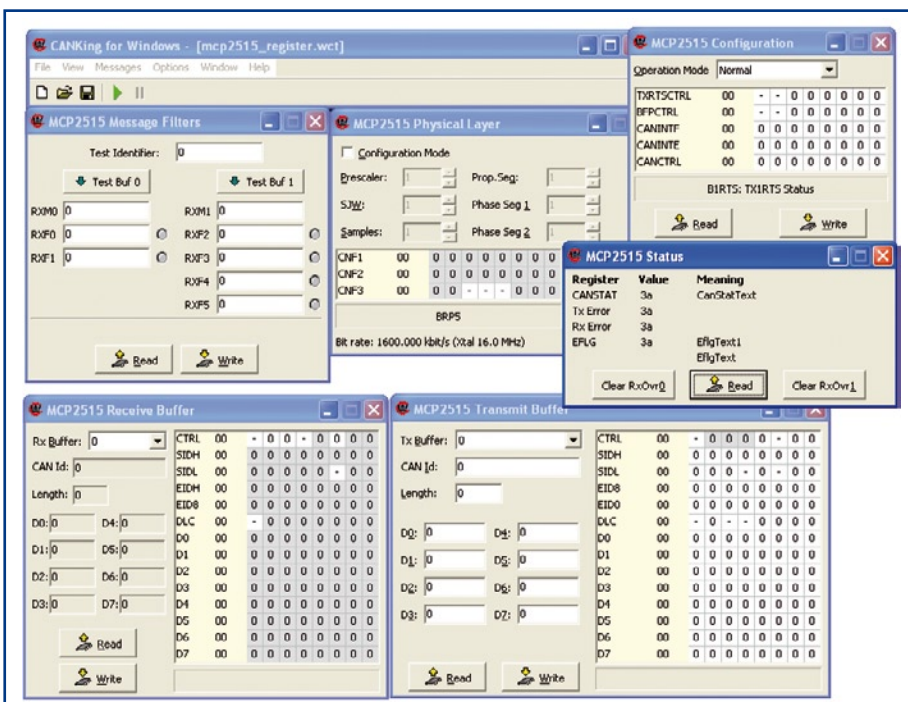


Figure 3. Using 'MCP2515 Register View' gives access to all of the MCP2515 registers.

chip web site [3]. It is based on the CANKing software produced by the company Kvaser [4] with a driver added specifically for the MCP2515. The software is compatible with all versions of Microsoft PC operating systems from Windows 95 upwards. To enable access to the port, a copy of dlportio.sys will also need to be saved to the C:\Windows\system32\drivers folder on the PC. It is free and can be downloaded from [5].

Once the Microchip software has been downloaded, installed and running the user is presented with the menu options shown in Figure 2. On some PCs the dlportio.sys driver does not run automatically and an error message appears on the screen. In this case the driver will need to be started manually. It is also necessary to select the correct address for the printer port; further information to help resolve these problems can be found in the accompanying file CANHelp.pdf which is avail-

able from the Elektor website [6]. Selecting 'MCP2515 Register View' gives you access to all the internal registers of the MCP2515. A new window pops up for each of the selected functions (Figure 3). Selecting 'MCP2515 Evaluation Board' / 'MCP2515 Basic' switches the software into bus-monitoring mode and bus activity is displayed (Figure 4). More detailed information of the software is available from the Microchip website [3].

(060201-1)

Web Links

- [1] <http://caraca.sourceforge.net>
- [2a] http://www.computer-solutions.co.uk/info/Embedded_tutorials/can_tutorial.htm
- [2b] http://en.wikipedia.org/wiki/Controller_Area_Network
- [3] http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=1406&dDocName=en531891
- [4] www.kvaser.com
- [5] www.driverlinx.com/download/dlportio.htm
- [6] www.elektor.com/canbusE

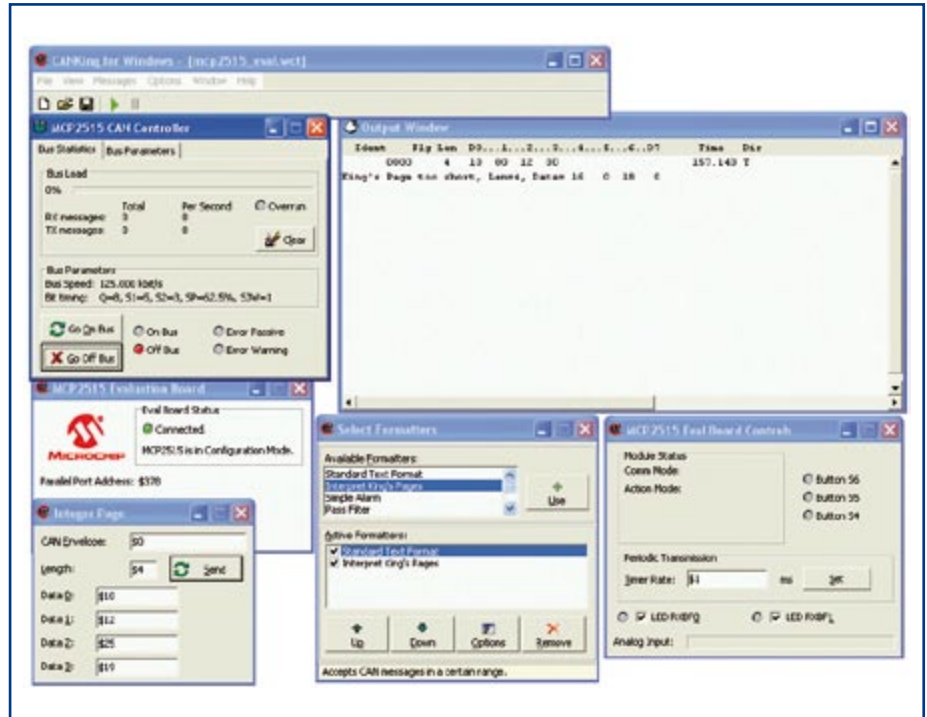




Figure 4. Choosing 'MCP2515 Evaluation Board' / 'MCP2515 Basic' (see Figure 2) switches the software into bus monitor mode showing all bus traffic.

Advertisement



Antex offer a wide choice of input voltages and bit profiles for our soldering iron range

visit: www.antex.co.uk



60+ years of experience

It may surprise you but buying an Antex soldering iron costs less than you think in the long run. British made to exacting standards, they last significantly longer than many imported brands. With a wide range of thermally balanced models, and temperature controlled irons too, you can always be sure to find an iron that meets your needs.

A large range of replacement tips are available for most irons, and technical help is on hand from our offices in Devon UK.

Buy Online

Our new website has all of our irons, and soldering spares and accessories available 24hrs a day. Most items are shipped next day, and we offer free carriage throughout Europe. Why not give antex.co.uk a try!

www.antex.co.uk
FREE shipping on all orders

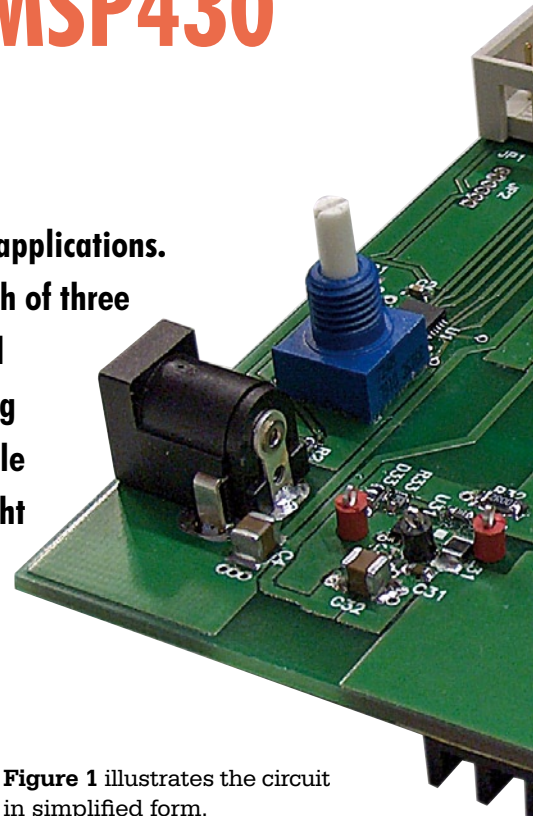
Antex Electronics Ltd
 2 Westbridge Industrial Estate
 Tavistock, Devon PL19 8DE, UK
 Tel: +44(0)1822 613565
 Fax: +44(0)1822 617598
 Email: sales@antex.co.uk
 Web: www.antex.co.uk

RGB LED Mood Light

Ambience courtesy of an MSP430

Dirk Gehrke and Christian Hernitschek

High-brightness LEDs are being used more and more widely in lighting applications. Here we present a simple 'mood light' using just a few components. Each of three LEDs is provided with a constant current using a switching regulator, and brightness control is performed by an MSP430 microcontroller generating three PWM signals. The printed circuit board could be fitted inside a table lamp with a frosted glass envelope or could be used with an LED spotlight for indirect lighting.



Whatever their power, LEDs are now normally driven using a constant current source. This is because their light output, measured in lumen (lm), is proportional to the current flow. All LED manufacturers therefore specify parameters such as light output (sometimes expressed as optical efficiency), viewing angle and wavelength as functions of forward current I_F rather than of forward voltage V_F as might be expected. We therefore use suitable constant current regulators in our circuit.

Constant current for high-brightness LEDs

The majority of switching regulators on the market are configured as constant voltage sources rather than as constant current sources. A small and easy-to-understand modification to the circuit is required to convert a constant voltage regulator to constant current operation. Instead of the voltage divider normally used to set the output voltage we use a current sense resistor, across which the voltage drop is regulated.

Figure 1 illustrates the circuit in simplified form.

Dimming LEDs

There are essentially two ways to dim LEDs. The first, and simplest, way is analogue control, where the current flowing through the LED is controlled directly: a lower current gives a lower brightness. Unfortunately there are two severe disadvantages to this method. First, the brightness of the LED is not exactly proportional to the current,

Caution! High-brightness LEDs!

Never look directly into the LEDs!

Very bright LEDs are not just uncomfortable to look at; they can actually be dangerous to the eyes as they can damage the retina. We therefore recommend operating the board with the LEDs pointing at a white wall to give indirect illumination.

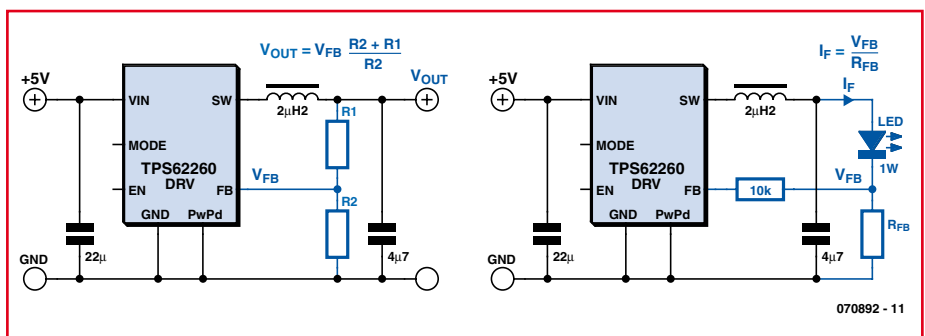
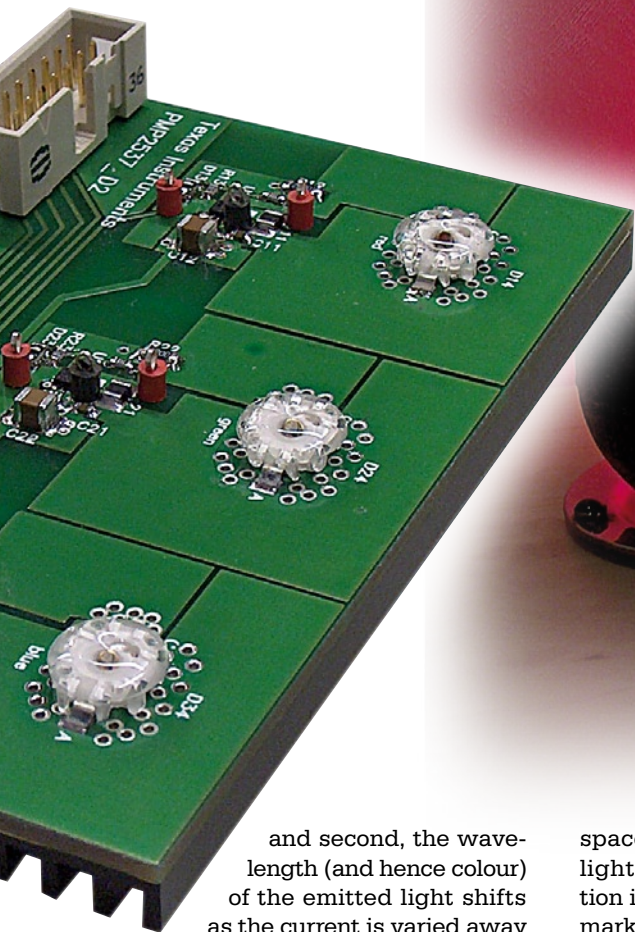


Figure 1. A switching regulator can be configured as a voltage source or as a current source.

ting



and second, the wavelength (and hence colour) of the emitted light shifts as the current is varied away from the nominal value for the LED in question. These two phenomena are seldom desirable.

The slightly more complicated control method uses a constant current source configured to deliver the nominal operating current for the LED. An additional circuit can then quickly switch the LED on and off with a given mark-

space ratio, on average emitting less light. This is perceived as a reduction in light intensity. By adjusting the mark-space ratio we can easily adjust the perceived brightness of the LED. This method is known as pulsewidth modulation (or PWM).

Dimming using PWM

We will look at ways of implementing PWM control using the TPS62260 as an example. The TPS62260 is a synchronous step-down converter with inte-

grated switching element, operating at a typical clock frequency of 2.25 MHz. In the circuit of **Figure 2** we show in black the possibility of connecting the PWM signal directly to the EN (enable) pin. The whole switching regulator circuit is started up and shut down in sympathy with the PWM signal. Experiments in our laboratory indicate that in this configuration we can use a PWM frequency of up to 100 Hz. The advantage of this arrangement is its simplicity: no additional components are required. It is also the most energy-efficient implementation, as the switching regulator draws very little quiescent current when disabled. Its disadvantage is that the reaction of the LED to a high level on the enable pin is delayed. This is because the switching regulator has a 'soft-start' function: when the device is enabled the output current is gradually ramped up until it reaches the nominal LED current. In some applications this ramp can be problematic as the wavelength of the light emitted by the LED varies as the current builds up from its minimum value to the normal operating level. For example, in a DLP projec-

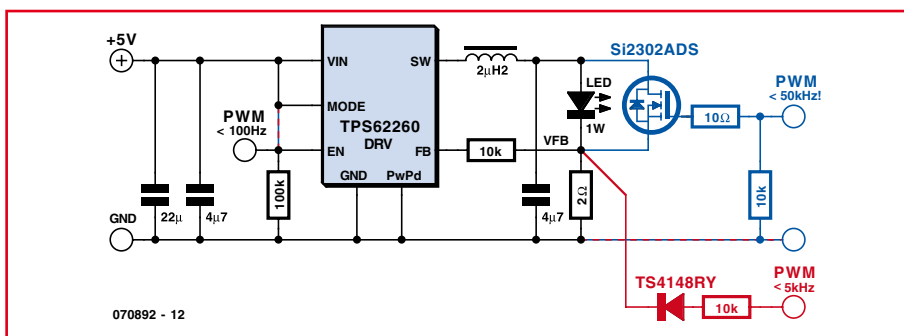


Figure 2. Three ways to implement the dimmer function.

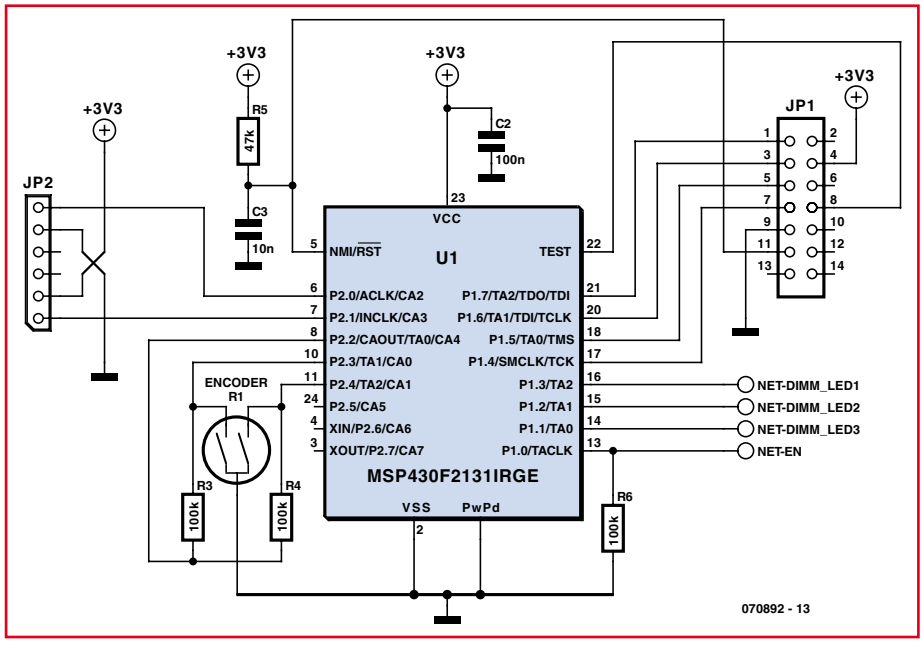


Figure 3. Control part of the circuit, based on an MSP430 microcontroller, with JTAG connection (JP1), eZ430 connector (JP2) and rotary encoder (R1).

tor or in the LED backlight for an LCD television panel, such variation might not be acceptable. For this demonstration project, however, the effect is not noticeable to the eye.

In the second variant (shown in red in Figure 2) the PWM signal is coupled into the error amplifier input of the TPS62260 via a small-signal diode. In this circuit a positive voltage in excess

of 600 mV applied to the control input will over-drive the error amplifier input and thus switch off the LED. Since this circuit does not use the enable input it does not suffer from the start-up delays associated with the soft-start function of the regulator, and the LED is switched on and off very rapidly. The shift in output wavelength due to the current ramp mentioned above is therefore negligibly small in this configuration. Furthermore, we found in the laboratory that the PWM frequency could be raised to 5 kHz.

The third possibility is shown in blue in Figure 2. Here the PWM signal is used to control a MOSFET wired across the LED. The MOSFET shorts out the LED and allows it to be switched on and off even more rapidly. The regulator is operating in constant current mode, and this current will flow either through the LED or through the MOSFET. Disadvantages of this approach include the additional cost of the MOSFET and poor energy efficiency: up to 180 mW of power can be dissipated continuously in the 2 Ω current sense resistor. Its advantage is the high switching frequency: in experiments we saw successful operation of the TPS62260 in this con-

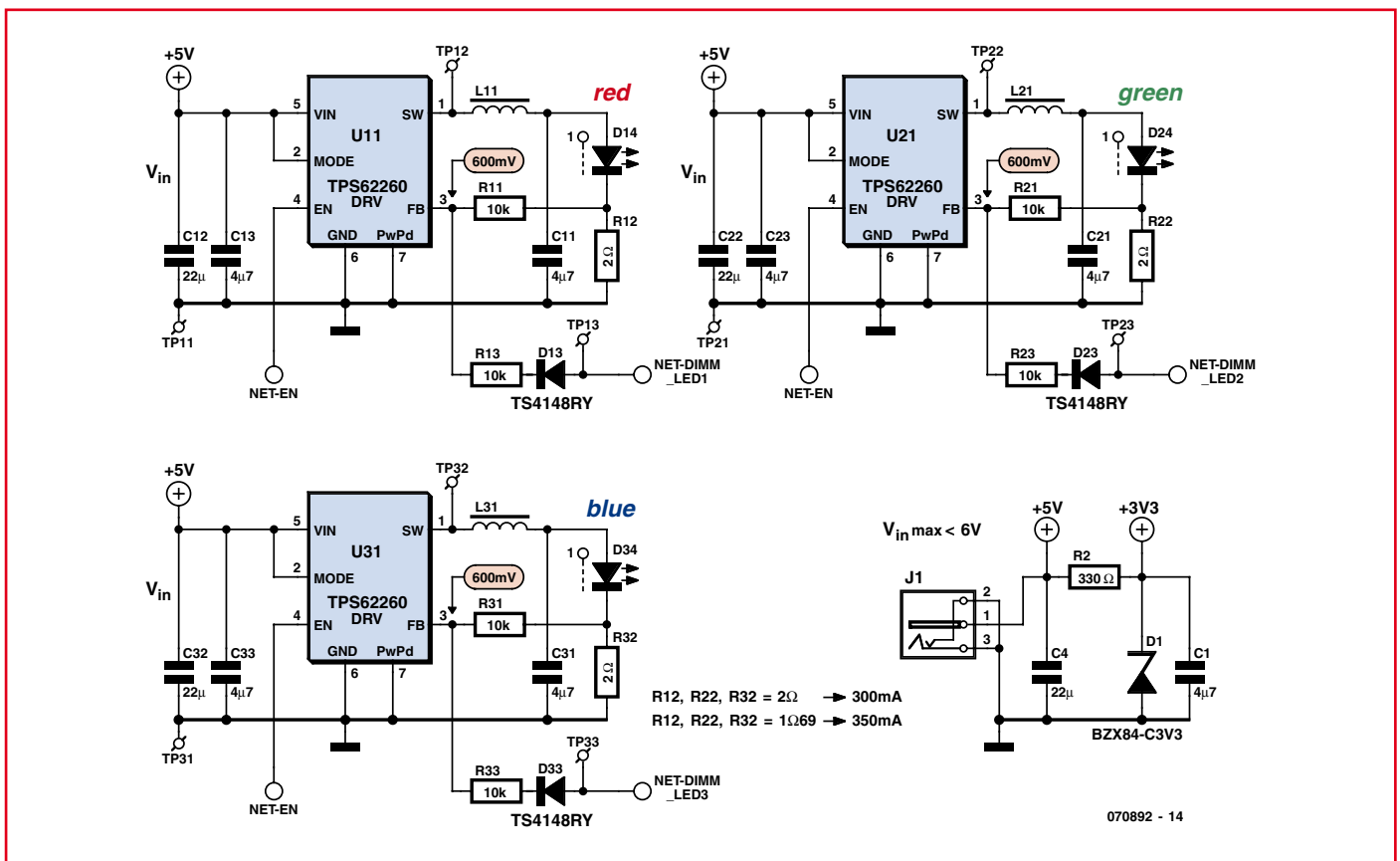


Figure 4. Circuit section consisting of three switching regulators configured as constant current sources and a 3.3 V stabilized supply built using discrete components.

A brief history of LEDs

The story of the light emitting diode (or LED), or 'luminescence diode', starts in earnest in 1962 when General Electric (GE) began to manufacture and sell red LEDs on the commercial market. Customers had to be satisfied with a rather poor light output: an LED of that time had an output of just 0.1 lm/W, corresponding to an efficiency of barely 0.1 %. The material used was a mixed crystal comprising gallium arsenide and gallium phosphide. Since then the market for LEDs has changed out of all recognition, with many other manufacturers making advances in LED technology, and light output available for a given current has increased steadily.

Efficiency, as well as electrical and thermal robustness, needed to increase still further before LEDs could be practically used as light sources in any significant quantity. At the same time, prices have fallen rapidly, opening up entirely new application areas. Such has been the result of forty years of research and development.

Today it is possible to buy very bright LEDs at moderate prices which run at respectable levels of efficiency: for example, the Golden Dragon range from OSRAM Opto (formerly Infineon), the Rebel LED range from Lumileds (Philips Semiconductors) and the X-Lamp range from Cree. There are of course many other manufacturers of high-brightness LEDs, although for reasons of time we were unable to evaluate them all for this article.

The light output of LEDs available today has risen to 20 lm/W, and some examples manage as much as 40 lm/W. These values correspond to efficiencies of 5 % and 10 % respectively, rather higher than the efficiency of a standard commercially-available incandescent bulb, which offers in the region of 10 lm/W, or an efficiency of around 2 %. High-brightness LEDs are already more efficient than halogen bulbs (around 25 lm/W) and will probably also soon be outperforming energy-efficient bulbs (around 60 lm/W).

figuration with PWM frequencies as high as 50 kHz.

The practical circuit

At the heart of the circuit (**Figure 3** and **Figure 4**) is an MSP430F2131 microcontroller. This is programmed to operate as a triple PWM generator and to read values from the rotary encoder (R1). The encoder value is used to index a look-up table containing mark-

space ratio values for each of the red, green and blue LEDs. The corresponding PWM signals are then made available on output pins TA0, TA1 and TA2 at a frequency of approximately 122 Hz. This is high enough to ensure that the LEDs do not appear to flicker, as the eye smoothes out the individual pulses of light to an average perceived intensity value.

For a practical implementation we chose the PWM control method shown

in red in Figure 2, which gives a good compromise between circuit complexity and performance. Each LED, red (D14), green (D24) and blue (D34) is supplied with a constant current from a separate TPS62260 DC/DC converter. The 2 Ω resistor sets the nominal current flowing through the LED at 300 mA. Higher currents (up to 1 A) can be obtained using a TPS62290, the TPS62260's 'big brother', which comes in the same package style.

Clock generation

MSP430 microcontrollers have a choice of integrated clock sources. In software, the MSP430 can switch between an external crystal-based oscillator and an internal RC-oscillator. To keep circuit costs down we have dispensed with external components and used the internal calibrated RC oscillator. 'Calibrated' means that the calibration parameters, stored in the MSP430's 'information memory', simply need to

be copied into the relevant control registers in the clock generator module. Using these calibration parameters gives an overall accuracy for the RC oscillator of $\pm 2.5\%$ over the temperature range from 0 °C to 85 °C. The RC oscillator frequency lies between 7.8 MHz and 8.2 MHz: this frequency is used as the CPU clock frequency and to drive the counter in the Timer_A module.

Implementation of triple PWM

The Timer_A module in the MSP430 consists of a counter block and a range of capture and compare blocks. The frequency of the generated PWM signals is determined by the rate at which the counter overflows. Since the Timer_A counter is 16 bits long, the PWM frequency is given by $f_{PWM} = f_{IN}/2^{16} = 8 \text{ MHz}/65536 = 122.07 \text{ Hz}$, where f_{IN} is the frequency of the clock input to Timer_A.

$$f_{PWM} = \frac{f_{input}}{2^{16}} = \frac{8 \text{ MHz}}{65536} = 122.07 \text{ Hz}$$

f_{PWM} : PWM signal frequency

f_{input} : Timer_A frequency – input clock

If we repeat this calculation using the minimum and maximum frequencies given above, we obtain the maximum deviation of the PWM signal frequency from its nominal value. We find that $119 \text{ Hz} < f_{PWM} < 125 \text{ Hz}$.

$$119 \text{ Hz} < f_{PWM} < 125 \text{ Hz}$$

Generation of the PWM signals themselves is carried out by the 'output units' which form a part of each capture and compare block. In the MSP430F2131 the Timer_A module has a total of three capture and compare blocks and therefore three output units. Each capture and compare block consists of a digital comparator which compares the current value in the counter with a value specified independently for each block (TACCR0, TACCR1, and TACCR2). If the values match then the comparator output triggers the output unit, setting the corresponding PWM output to a '1'. The PWM outputs are reset in software. The overflow of the 16-bit counter causes an interrupt; the interrupt service routine sets all the PWM outputs to zero in turn.

Using software to reset the PWM outputs puts a limit on the available range of mark-space ratios. Execution of the Timer_A interrupt service routine takes approximately 100 cycles, and so the three colour table arrays may only contain values in the range from 100 to 65535.

Rotary encoder

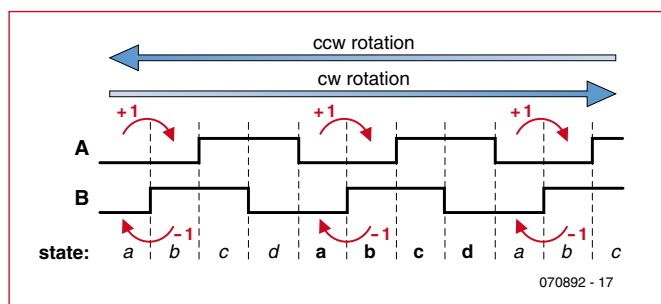
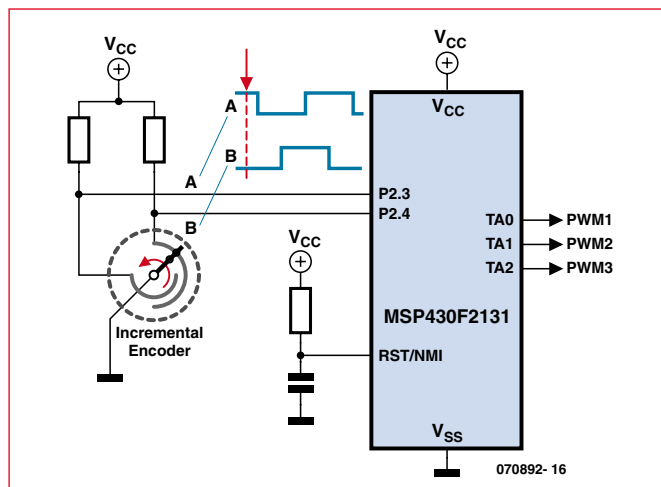
The PWM mark-space ratios can be set manually using a rotary encoder (or 'shaft encoder'), which is a device similar in appearance to a potentiometer. However, instead of containing a resistive track, it employs two contacts which open and close as the shaft is turned in a 2-bit Gray code pattern. The internal construction of the encoder is very simple. A wiper with two contacts sweeps over two conducting rings, insulated from one another. An insulating material covers the rings in a pattern such that as the wiper turns it operates as a switch, producing the two-bit Gray code on the output pins.

The upper figure shows in outline how the encoder is connected to the microcontroller, and the lower figure shows the output signals when the shaft is turned steadily in either direction.

Using the two signals A and B we can detect when the shaft is turned, as well as in which direction. In the timing diagram four states, a, b, c and d, are shown. These states repeat continuously as the shaft is turned. If the MSP430 software detects a change from state a to state b, it knows that the colour table pointer LEDptr needs to be incremented. Conversely, a change from state b to state a causes the pointer to be decremented.

If the encoder oscillates between states a and b the pointer will be alternately incremented and decremented. This can give rise to a flickering of the LEDs as the settings change to and fro. For this reason (as well as to reduce the effective resolution of the encoder to a more comfortable value for the user) the pointer LEDptr is divided by four before it is used to access the colour table arrays.

Finally, a note on the wiring of the rotary encoder. In the circuit diagram of Figure 3 the pull-up resistors for each contact are connected to pin 8 of the MSP430 (P2.2) rather than to VCC. This is not a mistake: P2.2 is taken high in software and is therefore at 3.3 V, the same vol-



ge as VCC. Of course, the pull-up resistors could be connected directly to VCC (3.3 V), freeing up P2.2 for other purposes.

COMPONENTS LIST

Resistors

(SMD 0603 unless otherwise stated)
 R2 = 330Ω
 R3,R4,R6 = 100kΩ
 R5 = 47kΩ
 R11,R13,R21,R23,R31,R33 = 10kΩ
 R12,R22,R32 = 2Ω (SMD 1206)

Capacitors

C1,C11,C13,C21,C23,C31,C33 = 4μF7
 6.3V; X5R, (SMD 0603)
 C2 = 100nF (SMD 0603)
 C3 = 10nF (SMD 0603)
 C4,C12,C22,C32 = 22μF (SMD1210)

Semiconductors

D1 = BZX84-C3V3 (SMD SOT23)

D13,D23,D33 = TS4148 RY (SMD 0805)
 D14 = 1W LED, Golden Dragon, red (Osram)*
 D23 = 1W LED, Golden Dragon, green (Osram)*
 D33 = 1W LED, Golden Dragon, blue (Osram)*
 U1 = MSP430F2131RGB (TI)
 U11,U21,U31 = TPS62260DRV SMD SON-6 (TI)

Inductors

L11,L21,L31 = 2μH2, 1.1 A, 110 mΩ, SMD 2x2.5 mm (MIPSA2520D2R2, FDK)

Miscellaneous

R1 = rotary encoder, Bourns 3315-001
 JP1 = 14-way boxheader
 JP2 = 6-way connector (Samtec)

TMS-106-XX-X-S-RA)
 TP11,TP12,TP13,TP21,TP22,TP23,TP31,TP32,TP33 = test pin, e.g. Keystone 5001
 Heatsink, Fischer SK 477 100
 Heat conducting self-adhesive tape, Fischer WLFT 404 R25
 PCB, order code 070892-2**

*LED alternatives:

Lumiled REBEL LED using PCB 070892-1**
 CREE XLAMP LED using PCB 070892-3**

** Artwork download and PCB ordering at www.elektor.com

Colour table

The colour look-up table takes the form of an array stored in the MSP430. The array is arranged so that it can at any time be extended with additional pulse width modulation values for the red, green and blue LEDs. Whenever the rotary encoder is turned new red, green and blue values are read from the array and used to generate the three

PWM output signals. Currently 252 values are stored, which can be changed if desired. A decimal value of 100 switches the LED off, and a value of 65535 produces a mark-space ratio of 100 %.

When the 5 V supply is applied the MSP430 goes into a demonstration mode where the values stored in the array are read and output in sequence in an infinite loop. As soon as the rotary encoder is turned the sequence stops and a particular fixed colour value can be selected.

The PWM signal is coupled in using a small-signal diode (D13, D23 and D33). When the PWM signal is high it overrides the normal error signal input of the corresponding switching regulator, which has a threshold voltage level of 600 mV. This means that a high level on the PWM signal forces the LED to extinguish. When the PWM signal subsequently goes low the regulator starts up again and the LED lights.

The whole circuit is powered from a regulated 5 V 1 A DC mains adaptor. A simple voltage stabiliser built using a resistor and a Zener diode reduces the 5 V level to 3.3 V for the MSP430 microcontroller.

The circuit can be built on the printed circuit board shown in **Figure 5**. There are three versions of the circuit board differing only in the footprint and connection arrangement of the LEDs. This allows various types of LED to be used. The LED options available are listed in the parts list.

Heat map

Operating temperature is an important parameter in the performance of a high-power LED. It strongly affects operating life, forward voltage, output wavelength and even the brightness of the device. The higher the operating temperature of the LED, the shorter will be its expected lifetime. For this reason the dimensions of our experimental printed circuit board have been chosen to allow a type SK477100 heatsink (made by Fischer Elektronik) to be fixed to the reverse of the board using double-sided adhesive thermal transfer material. Running at full power, this reduces the temperature of the LEDs from 61 °C (without heatsink) to 54 °C (with heatsink). The heatsink also helps to spread the dissipation of heat over the area of the printed circuit board.

To make an example thermal image we populated the board with LEDs from Cree. **Figure 6** shows the results vividly, illustrating the temperature of the LEDs without heatsink (on the left) and with heatsink (on the right).

Software

The source code for the MSP430 software for this application is available for download from the Elektor website. The code begins by including the

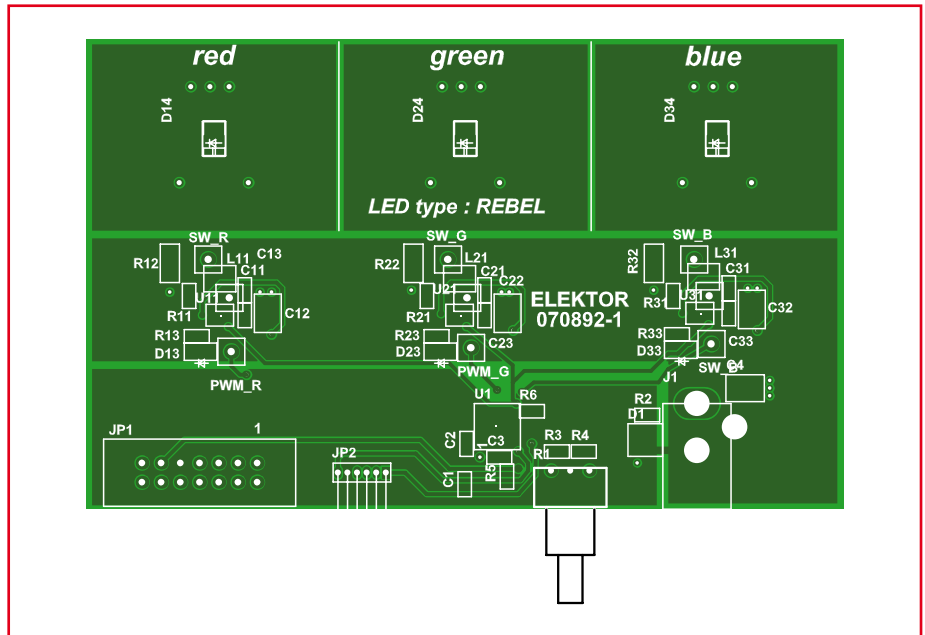
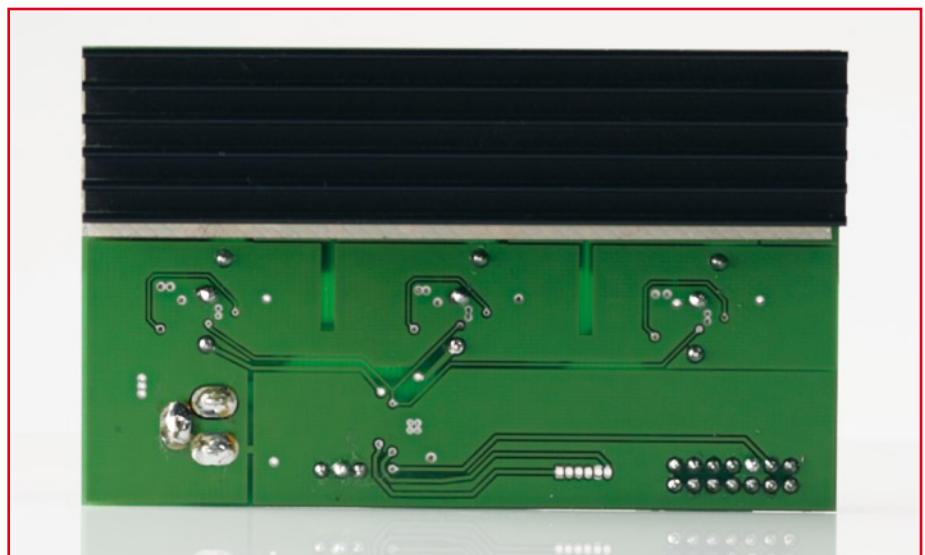
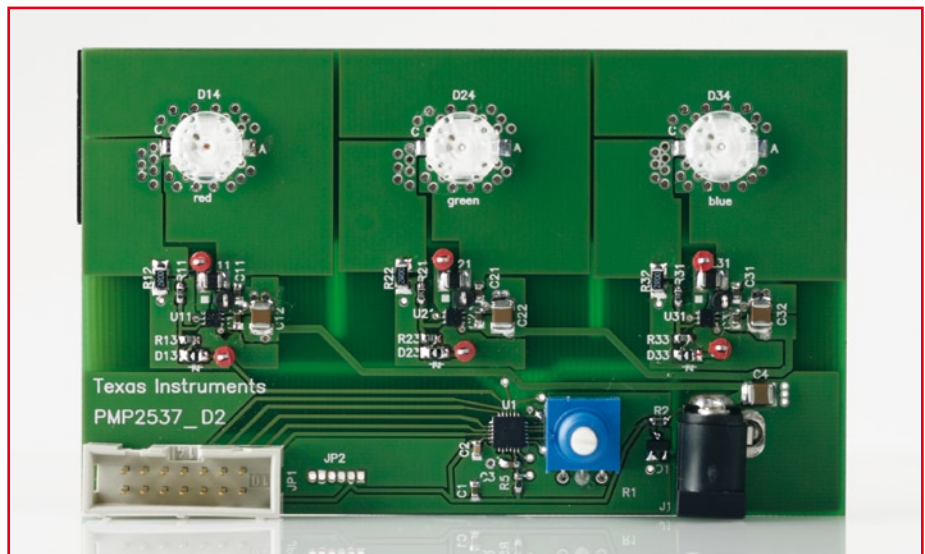


Figure 5. Printed circuit board for building the circuits of Figure 3 and Figure 4. Three variants are available for download, supporting different types of LED.



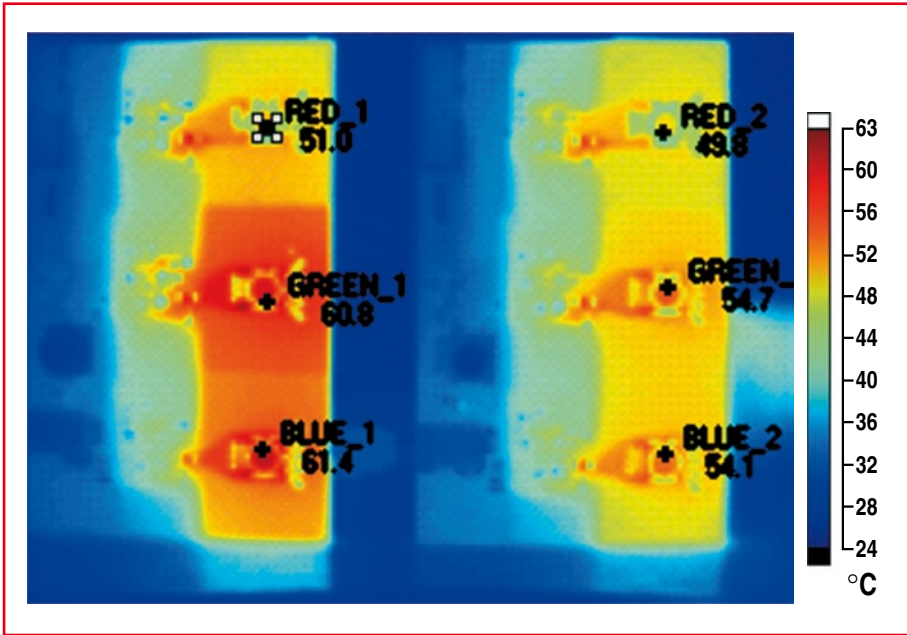


Figure 6. Thermal image of the circuit board, populated with LEDs from Cree. Left: without heatsink; right: with attached heatsink.

'MSP430F21x2.h' header file, which contains definitions of all the control register names and of the control bits available in the MSP430. Next the

length of the colour table is defined. Notice here that the value of 'LED_TableLength' is actually set to four times the length of the table. Then follows

the colour table itself, with a separate array for each individual LED. Pointer 'LEDptr' is used to read the relevant PWM mark-space ratio settings for each of the three outputs from the individual colour table arrays: see also the text box 'Colour table'.

The microcontroller is initialised at the beginning of the function 'main()'. The watchdog timer is disabled, the calibration values for the adjustable system clock are loaded, the Timer_A module is configured and the multiplexed inputs and outputs are suitably initialised. The main loop consists of two 'while' blocks. In the first 'while' block the colour table pointer LEDptr is incremented, which results in a continuous change in the PWM mark-space ratios and thus in the generated colour. The overall timing of these colour changes is governed using two nested 'for' loops. The first 'while' loop runs until the rotary encoder reports a change on one of its outputs. The second 'while' block, written as an infinite loop, then takes control: it increments or decrements the colour table pointer according to the direction in which the rotary encoder is turned.

A bright future

The printed circuit board allows additional functionality to be implemented. For example, there is a socket for a Texas Instruments eZ430-RF2500 radio module. The eZ430-RF2500 kit is supplied with two radio modules. One of these can be fitted with a rotary encoder (using the test pins on the microcontroller in the radio module), creating a radio link to the LED board.

The circuit board described here is primarily intended for experimentation and evaluation purposes. Since the MSP430 source code is made available, it is possible to modify it for a range of other projects. The switching regulators can also find use in other applications: have fun!

(070892-1)

About the authors

Dipl. Ing. (FH) Dirk Gehrke

Dirk Gehrke was born in Münster in Germany and studied communications technology at Dortmund University of Applied Sciences and Arts. He started working for Texas Instruments in 1998 as a Field Application Engineer (FAE) in Britain, France and the United States. From 2000 he worked in Freising, Germany, as an FAE for power management products, and in January 2006 he became Business Development Manager for analogue products in EMEA (Europe, the Middle East and Africa). Contact: <http://www.ti.com/europe/csc>.



Dipl. Ing. (FH) Christian Hernitscheck

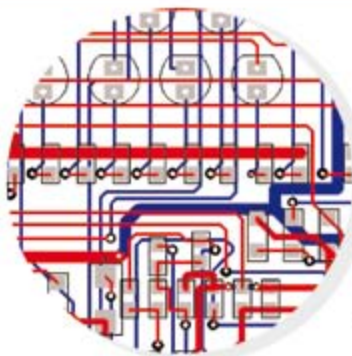
Christian Hernitscheck studied electronic engineering at the Landshut University of Applied Sciences in Germany, specialising in microelectronics. Since 1998 he has worked as an FAE for Texas Instruments covering the whole of Europe, focussing on the MSP430 microcontroller product line. Contact: <http://www.ti.com/europe/csc>.



Number One Systems

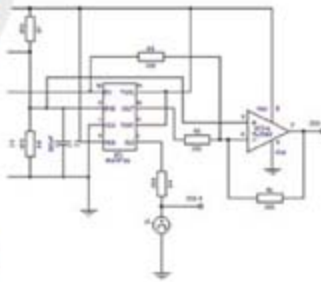
Easy-PC for Windows

The World Beating PCB design software



Version 11 features

- Design revision analysis
 - Star/Delta points
 - Apply layout pattern & groups
 - Design calculators
 - Electrical rules check (ERC)
 - Shape editing panel
 - Merge/subtract shape editing
 - Track analysis
- Plus many more exciting features...



The new Easy-PC reaches even higher!

The breathtaking new Easy-PC for Windows Version 11 is released. Winning accolades the world over, V11 of the market leading Easy-PC delivers even more remarkable value for money and sets the new benchmark for performance in PCB CAD.

Just try a demonstration copy of Easy-PC and prepare to be amazed...

Easy-PC delivers a simple to understand, fully integrated Schematics & PCB layout in a single application. 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...
Easy-PC is supported running under Windows Vista

STILL FROM ONLY
£247
PLUS VAT

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

Oak Lane, Bredon, Tewkesbury, Glos. GL20 7LR, United Kingdom



Microchip PIC Boards

Embedded webserver
USB, Ethernet
Dallas 1-wire
RS232/185, I2C
CAN-BUS
Serial LCD



Free project download
with source code

ARM Development Boards

High performance 32bit RISC
USB JTAG
Ethernet and USB
RS233, I2C, CAN-BUS
NXP LPC and Atmel SAM



Free C compiler and IDE
Free ARM7 tutorial download

Embedded Linux Boards

Low cost embedded Linux board
Two USB host interface
Two 40 pins sockets for
expansion
GSM / GPS Module add on
Create CGI using C language
Apache, PHP and SQLite
RSS Reader and LCD demo



Free SDK compiler download

Secure online ordering

www.skpang.co.uk
sales@skpang.co.uk



EzPCB
Professional PCB Supplier

**High Quality
Competitive Price**

URL: www.EzPCB.com

Email: sales@ezpcb.com Tel: +86 139 1002 1704
HDI Up To 50 Layers, 2.5mil T/C, 0.1mm Hole Size
Other Products: Stencils, Keypads, Frontpanels,
Flex PCB, Enclosures, Turnkey Services

LED Ringflash

Bernie de Fortcalquier

Proper lighting for macro-photography!



The availability of increasingly high-performance digital cameras and falling prices has encouraged a good many people to take an interest in photography, and macro-photography too. If lighting conditions are not ideal, it will be necessary to resort to the use of flash, with the attendant risk of shadows. The solution is a ringflash – and while we're about it, why not one using LEDs?

The author found himself confronted with the challenge of constructing a flash specially designed for macro-photography. That needed some thinking about, out of which came a list of...

Requirements

Not a mere wish-list, but a specification of what the operational device has to do:

- build a flash unit suitable for taking macro photos;
- produce a soft light (no risk of hard shadows);

- use sufficiently powerful white LEDs (20,000 mcd);
- arrange the LEDs in a circle (to avoid shadows);
- put as many LEDs on the ring as possible (32 if possible);
- have control over the duration of the flash, independently of the camera's shutter speed;
- be able to take, for example, photos of the splash of a water droplet.

It's all very well spelling out what you want on paper, but meeting these specifications means you have to solve certain...

Problems

The first hurdle we face is powering the LEDs. Although there aren't too many options to choose from – parallel or series – the implications of these are more restrictive (see **Table 1**).

Solutions in the form of a circuit diagram

Rarely have circuits published in *Elektor* been any simpler than our ringflash. To keep it both compact and simple, there's only one option: a micro-controller. It is used to:

- detect when the camera fires the



Photo : Huib Theunissen

flash;

- display the chosen flash duration via LEDs;
- switch the ringflash.

The author opted for series connection of the LEDs, and rather than re-invent the wheel, chose to use an electronic flash board cannibalised from a disposable camera – this was in fact the only readily-available electronics capable of supplying a voltage significantly in excess of the 64 V actually needed.

The circuit (Figure 1) of this electronics board from Kodak can be found on numerous websites, including the one listed at [1]. It's important to note that this is only a typical circuit — the various models of disposable camera may well have different electronics, but the principle remains the same.

Using this type of board has undoubted advantages: it comes ready-built, works very well, and is easy to get hold of. You can always ask your local photographer to let you have a disposable camera that's been opened for de-

veloping the film. If not, you could always go out and buy one.

Once the electronics from the disposable camera are available, all that remains is to separate off the part that's going to be useful for this project, i.e. everything upstream of capacitor C2. The high voltage will be taken from across the terminals of C2 (take care to discharge the electronics properly before you start – if capacitor C2 discharges to your fingers, you'll get a nasty jolt).

Let's move on to the electronics of the flash control board shown in Figure 2. The heart and brain of the ringflash takes the form of a PIC16F628 from the Microchip stable [2].

The PIC16F628's port B inputs have internal pull-ups.

Line RB0 is used to detect triggering. Line RB3 is used to trigger the MOSFET, an IRFBF20 [3] switched at 5 V and having a $V_{(BD)DSS}$ (drain-source breakdown voltage) of 900 V; this line is intended for setting the flash

Table 1. Parallel or series – that's the question

Configuration	Current	Voltage	Dropper resistor
Parallel	High 32 x 40 mA = 1.28 A	Low ~ 2 V	Either all LEDs in parallel 1 resistor Q: Will all the LEDs give good brightness? Or each LED has its own dropper means a large number of resistors
Series	Low ~ 40 mA	High > 32 x 2 ...>64 V	1 single resistor

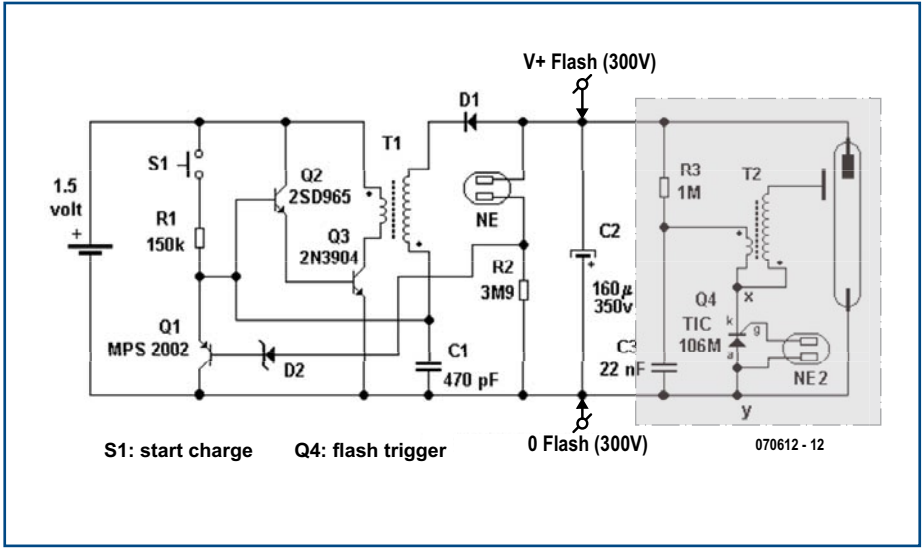


Figure 1. Typical circuit of disposable camera flash electronics (source: Kodak).

duration. Line RB4 is simply used to select a predefined switching time. By default, the first position corresponds to a duration equal to that of the camera itself (to within a few PIC instructions). Display of the selection is achieved by

way of a 4051 CMOS analogue multiplexer/demultiplexer IC, whose outputs drive a series of eight LEDs, all the cathodes of which are connected to ground. Provision is made for eight durations, encoded on lines RA0–RA2. The flash can be tested using minia-

ture pushbutton S1, while S2 is used to set the flash duration. Each time S2 is pressed, the duration increments, indicated by lighting of the next LED in the bargraph.

Connector K2 has been provided to allow the microcontroller to be programmed if necessary.

The block shown adjacent to the V+ Flash (300 V) and 0 Flash (300 V) points represents the recycled capacitor module mentioned throughout this article. This high voltage module connects between PC1 and PC2 (GND) points. Pay attention to the polarity of the capacitor module when connecting it to the control board.

The system uses a dual power system: one 9 V battery for the PIC-based control electronics, and a separate 1.5 V battery for the flash electronics – this cell can easily supply the over 2.5 A needed when capacitor C2 (160 μF/350 V) starts charging. The PSU is conventional: the 9 V supplied by the battery is smoothed and reduced to +5 V by the 78L05 regulator IC3. LED D10 is used to indicate the supply voltage is present.

And to end with, the most important module in this project, the ring fitted

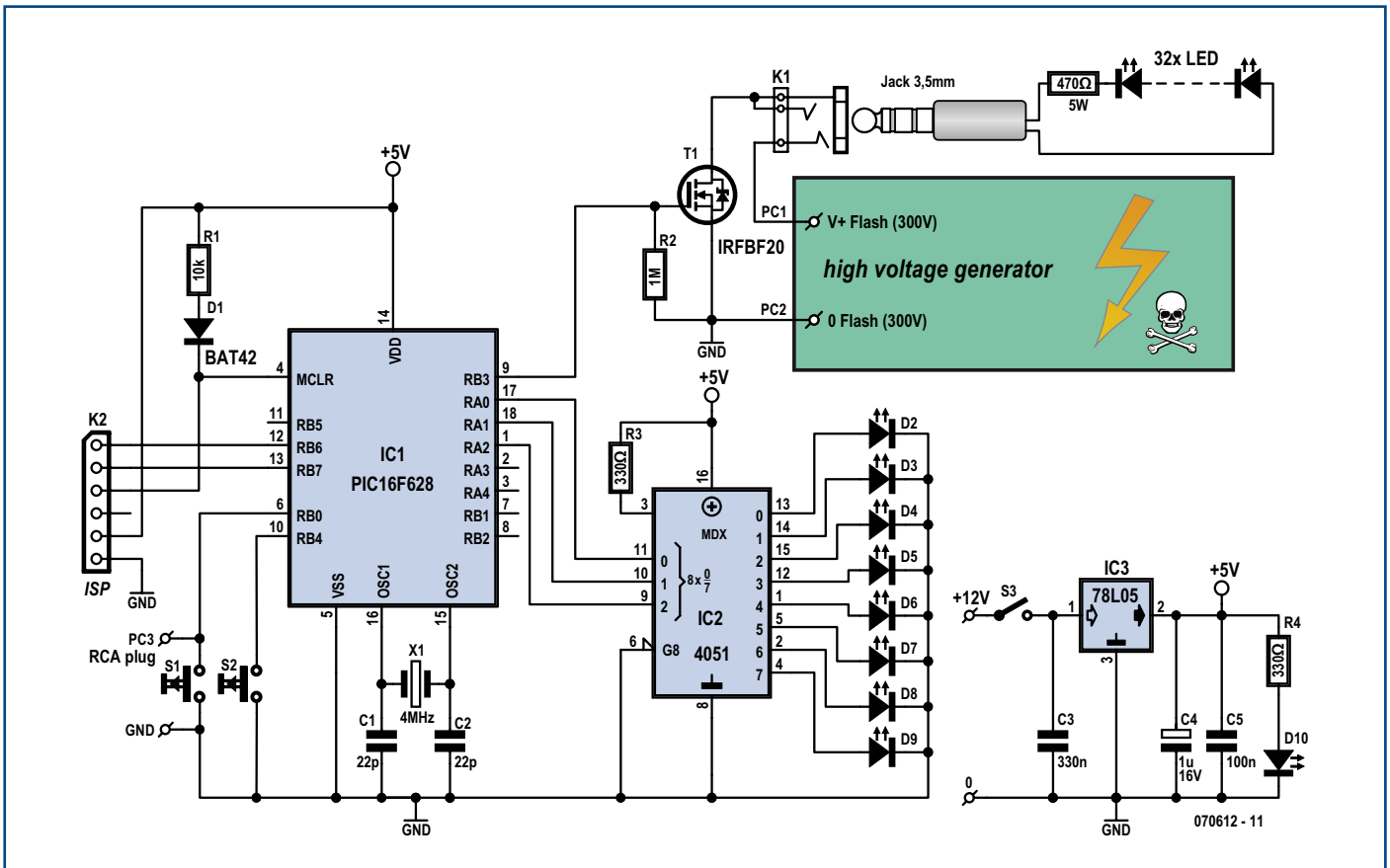


Figure 2. Circuit of the home-brew electronics: the ringflash control board.

with the 32 LEDs and their current limiting resistor connects to the main board via a 3.5 mm mono jack.

Construction

This involves two stages: constructing the electronics, and the ring.

The 'electronics' stage itself breaks down into two steps:

1) 'cannibalising' the flash board. As the photo in **Figure 3** shows, this sub-unit doesn't look particularly impressive. On certain models, the miniature neon is replaced by an LED. You will need, by some means or another, to prepare this module by replacing the pushbutton (which controls charging of the capacitor) by a switch. The alternative solution suggested by the author is to use a dual reed relay (in order to avoid pressing the switch inadvertently).

Once you have the flash charger, it's time to move on to constructing the control board, the component overlay for which is given in **Figure 4**.

The components should be fitted in the usual order, starting with the smaller components: jumpers, resistors, capacitors, diodes (watching out for their polarity), and then the larger components: pushbuttons, transistor, switches, crystal, ICs. The two DIL ICs should be fitted in sockets (good quality ones). The actual position of the LEDs and switches S1–S3 depends on how you plan on housing the circuit. We strongly recommended putting everything into one case, to which the ring of LEDs will be connected (the inset 'Constructing the ring' explains how to build it). That way there's no risk of getting a shock if you make a false move. If you opt for this solution, you'll need to mount the various indicator LEDs on the case, along with the on/off switch and push-buttons S1 and S2.

The free end of the link cable going to the flash socket on the camera connects to the PC3 and GND in the vicinity of S1. *Note that some cosmetic modifications have been made between the prototype shown in the photo (Figure 4) and the final version of the PCB.*

Operation in practice

The way the capacitor module works may vary from one disposable camera to another. On some, you have to keep the button pressed until the LED lights to show the capacitor is fully charged; on others (like the one we've used) you only have to press the button mo-

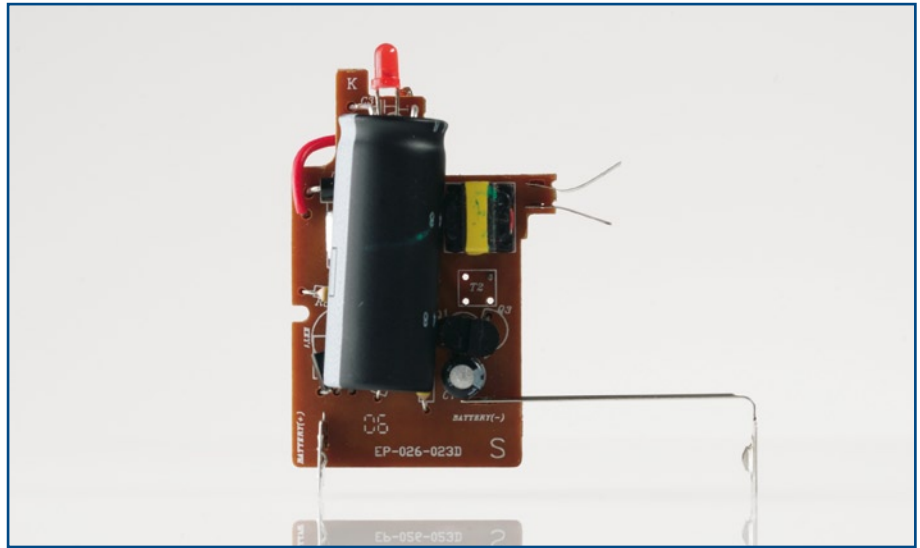


Figure 3. Photo of the active part of the flash recycled from a disposable camera.

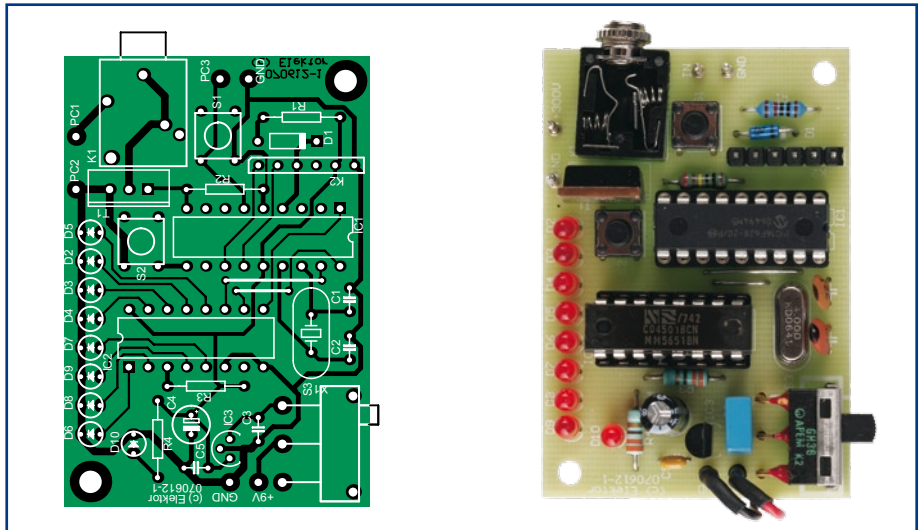


Figure 4. Photo of the prototype's control board.

COMPONENTS LIST

Resistors

R1 = 10k Ω
R2 = 1M Ω
R3,R4 = 330 Ω

Capacitors

C1,C2 = 22pF
C3 = 330nF
C4 = 1 μ F
C5 = 100nF

Semiconductors

D1 = BAT42
D2-D10 = LED, 3mm, red
T1 = IRFBF20
IC1 = PIC16F628, programmed, Elektor
Shop # **070612-41**
IC2 = 4051
IC3 = 78L05

Miscellaneous

X1 = 4MHz quartz crystal
S1,S2 = miniature switch, PCB mount
S3 = on/off switch
K2 = 6-way SIL pinheader
K1 = 3.5mm jack socket
6 solder pins
PCB, ref. 070612-1 from
www.thepcbshop.com
Project software, PIC source and hex. files,
free download # 070612-11-UK.zip from
www.elektor.com

LED ring parts

Semiconductors

32 LEDs, 5mm, white, HLMP-CW11-X1000
(Avago; from Farnell)

Miscellaneous

Ring support, home made (see inset "Constructing the ring")

Constructing the ring



There are several options for constructing the ring to hold the 32 LEDs. The author chose to turn up a special plastic ring in Ertalon® on a lathe. But not everyone has such a tool, so we set out to find another solution. A visit to a number of builders' merchants enabled us to get our hands on a 110 mm/80 mm soil pipe adaptor (seen in the background of the photo in Figure 5) which seems almost to have been designed especially for our purpose! We're



going to cut off the top part at a height of around 17 mm. Once the ring has been nicely trimmed and sanded, it's time to drill the holes for fitting the LEDs. We start by marking a circle mid-way between the inner and outer circumferences of the ring. To make this job easier, you can divide the ring into four 90° sectors, which will each hold 8 LEDs. The centres of the LEDs are spaced by 9.8 mm. Once the 32 points have been accurately marked around the circle, all that remains is to drill the 32 holes (5 mm dia.) for the LEDs. The LEDs can be fixed using a dab of hot-melt glue, and interconnected, anode of one to cathode of the next, as far as the last pair, whose respective anodes and cathodes will be left free to connect to the cable that plugs into jack K1.



mentarily and then wait for the LED to light showing the capacitor is charged ready.

In the light of experience

The author has been using this ring-flash for over six months, and it has become indispensable for macro work (see photos in **Figure 6**).

Practical experience has shown it to be very worthwhile for macro work at distances of less than 40 cm from the camera.

As our spec sheet stipulated, arranging the LEDs in a ring provides a nicely diffused light.

However, the 20,000 mcd (each) brightness of the LEDs is not enough to allow much stopping down (from $f/2.8$ to $f/8$, for example) to increase the depth of field.

Even white LEDs tend to be rather bluish in colour. So always remember to do a white balance before starting macro work. Or else reduce the blueness later using a photo retouching programme ('to photoshop' has become a very hip term of late in the world of mass-distribution magazine publishing...).

Since the LEDs are controlled independently, it's preferable to keep the camera in 'Manual' mode and try to find an acceptable compromise between f -stop and shutter speed.

As the LEDs brightness is not too powerful (and fortunately not the main object of the exercise), it has never in fact proven necessary to reduce the flash duration on the camera (works independently of the photo shutter).

The author uses a magnet to operate the reed relay to recharge the flash capacitor, and has noted that the LED system uses comparatively little power. You can fire off around ten or so 1/100th second flashes before thinking about recharging the capacitor.

This project offers lots of scope for development. In view of the high voltage generated by the disposable flash module, it might be interesting to try using other LEDs, like the Luxeon 1 watt or even 3 watt types – photographers are always after more light, to get as close as possible to natural daylight. Neither we nor the author have tried this approach – we'll leave that and other possibilities to our readers' imaginations. Happy macro photography! Don't hesitate to send us the best of your masterpieces.

(070612-1)

Web Links

[1] http://www.geocities.com/lemagicien_2000/elecpage/maxflash/maxflash.html

[2] PIC16F628 datasheet

http://www.datasheetcatalog.com/datasheets_pdf/P/I/C/1/PIC16F628.shtml

[3] IRFBF20 datasheet

http://www.datasheetcatalog.com/datasheets_pdf/I/R/F/B/IRFBF20.shtml

[4] 4051 datasheet

<http://www.fairchildsemi.com/ds/CD/CD-4051BC.pdf>



Figure 5. Our LED ring started life as a pipe connector found in many DIY stores.

Advertisement

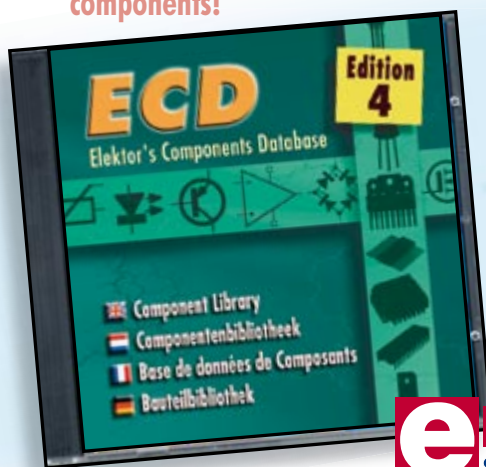
ECD 4

Elektor's Components Database

NEW!



**A must-have for all electronics enthusiasts.
Instant access to data on more than 68,000
components!**



elektor
SHOP

The program package consists of eight databanks covering ICs, germanium and silicon transistors, FETs, diodes, thyristors, triacs and optocouplers. A further eleven applications cover the calculation of, for example, LED series droppers, zener diode series resistors, voltage regulators and AMVs. A colour band decoder is included for determining resistor and inductor values. ECD 4 gives instant access to data on more than 68,000 components. All databank applications are fully interactive, allowing the user to add, edit and complete component data.

ISBN 978-90-5381-159-7 • £15.90 • US\$ 31.80

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

Elektor
Regus Brentford
1000 Great West Road
Brentford TW8 9HH
United Kingdom
Tel. +44 20 8261 4509

More information on www.elektor.com/shop

Thermometer / Thermostat

Let's take the temperature... and then maintain it

Jean-Paul Brodier

The previous applications we presented for E-blocks made use of fairly elementary data input/output modes: switches or photo-electric barriers as inputs, LEDs as outputs, always involving purely binary on/off information, often referred to as 'digital'. Now it's time to go analogue and hey presto Flowcode and E-blocks again turn out a perfect combination!

The thermometer described here measures the temperature as an analogue quantity and displays it in text form on the liquid crystal display (LCD). The thermostat operates in a binary manner on one output, to turn a heating device on or off.

Hardware

The liquid crystal screen used comes in the EB-005-00-2 E-blocks module, and plugs into the *Multi-programmer* board's port B socket. It's powered via a wire from the display board's +V terminals and the one on the *Multi-programmer* board. No negative wire is needed, as the module's ground is already connected to the *Multi-programmer* via the sub-D socket.

The microcontroller chosen is the PIC16F877. This application requires a type that includes an analogue-to-digital converter (ADC). This one has a resolution of 10 bits with eight inputs multiplexed onto the pins of port A. The screen can be included into the circuit by clicking on the 'LCD' symbol in the left-hand vertical bar. For all components added this way, you can click on the arrow on the top bar to display the *Properties* menu and modify, for

example, the connection location. By default, the display is connected to port B. The same thing has to be done for the thermometer on analogue input ADC0 and the control pot connected to analogue input ADC1. The display form chosen is the cursor, but you can also opt for a conventional button and choose the colours.

The output LED is connected to pin 3 of port A. The pins of port A can in fact be configured at will between analogue inputs and binary input/outputs – and if necessary, any mix of these.

Macro-commands associated with the hardware

The program handles the hardware by way of software libraries (available in Flowcode), loaded as and when they are called by the macro-commands. The Flowcode file 'thermo.fc' for the project discussed here is available free from the Elektor website.

Let's start with the LC display. Click on the square (hatched outline, in the symbol bar), announced by the help bubble as *Component Macro*, and keeping the mouse button pressed, drag it to its place in the flowchart. Right-clicking on *Properties* lets you choose the component (LCD), the macro to be executed to initialize it (*Init*), and to rename the box.

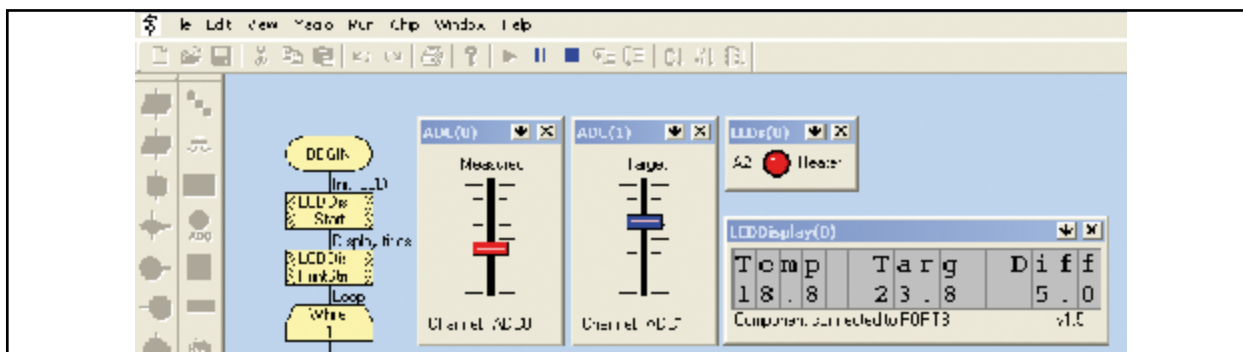


Figure 1. The PC screen shows all the system components in order to simulate operation.

The screen interface operates in 4- or 8-bit. To configure it, we need to send it a sequence of instructions in 4-bit format, separated by pauses of defined duration. This is the job of the *Init* macro-command, which takes account of the quartz crystal frequency in the microcontroller's configuration screen to set the speed. It automatically sets the format to 4 bits – handy for saving on input/output pins, and indispensable for the smaller types of controllers.

A call to the *PrintString* macro for the same component will display the text that has been set up in parameters. The string must be enclosed in double quotes, otherwise the compiler will take the characters as a variable name. The standard display's character table does not include accented characters. The compiler accepts them and the simulator displays them on the computer screen, but they do not appear on the display, or display wrongly. Using a series of commands to the display, it is possible to create up to eight special characters that will be stored in RAM alongside the ROM.

In our application, the first (top) line of the screen shows the labels for the numbers that are going to be displayed on the second line. Three quantities are displayed – two measured, one calculated. The LCD screen is useful in that it displays much more information than simple LED numeric displays. But there's nothing to stop you adapting the display to circumstances and to display the relevant data at a given moment – for example, an alarm and what's causing it.

Loop

After initializing the screen, the program enters the main loop. The same operations are repeated at intervals of one second, set by the box *Delay*.

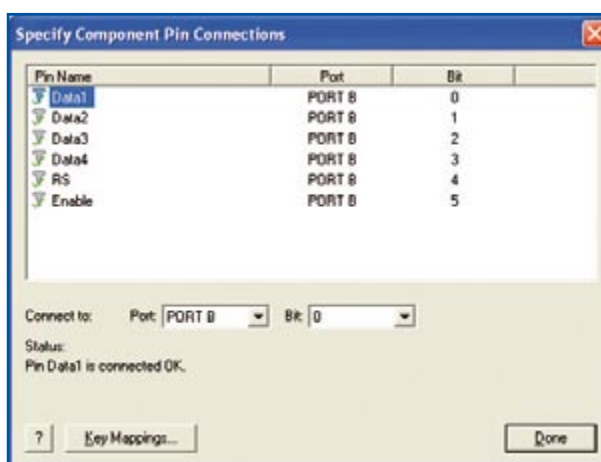


Figure 2. The LCD connection defaults to port B

We start by clearing the bottom line (line 1) by writing 16 spaces to it, starting from the first position (0). Then come the measurements, calculations, and displays.

Measurement and scaling

The two quantities measured are the result of the *Scaling* macro reading the analogue-to-digital converter – once for the temperature and once for the control pot. This measurement is followed by scaling. We want to make the 1,024 points (10 bits) of the measurement correspond to a range of 10 to 30°C, i.e. an amplitude of 20°C and an offset of 10°C. Whence the set of calculations in the *Scale* macro:

Advertisement

Your price conscious PCB supplier



Interested? Contact us: +44 2088 167 005
E-mail: euro@eurocircuits.com
www.eurocircuits.com

Online price calculation
Online ordering
Online order tracking
Online 24/24H and 7/7D

- Verified**
 - pooling for standard boards
 - up to 6 layers
 - from 1 to 1000 pieces
 - from 3 working days onwards
- A la carte**
 - pooling with more options
 - up to 8 layers
 - from 1 to 1000 pieces
 - from 3 working days onwards
- On demand**
 - your board, our challenge
 - up to 16 layers
 - from 1 piece onwards
 - from 3 working days onwards

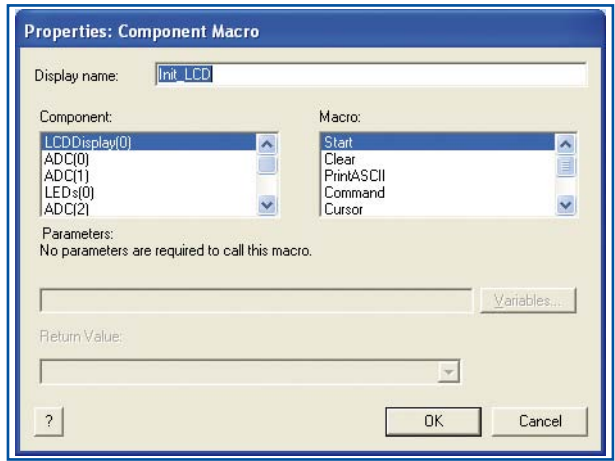


Figure 3.

Each component has a certain number of dedicated macro-commands. The LCD screen can display one character at a time, a string, or a number. It also accepts cursor movement commands etc.

```
MEASURED = MEASURED * 20
MEASURED = MEASURED / 102
MEASURED = MEASURED +100
```

The factors used in the calculation have been chosen in the ratio 200:1024, to avoid yielding an intermediate result over 32,767 (the maximum value for an integer in the FlowCode system). The error introduced by these approximation factors is just under 4 in 1,000, i.e. 0.4% – half the tolerance of precision components, so perfectly acceptable. The result is expressed by ten points per degree, so we'll have to cheat a bit so as to be able to display the tenths of degrees.

Display

The driver routines for the LCD only display whole numbers between -32,768 and +32,767. So it's up to us to organ-

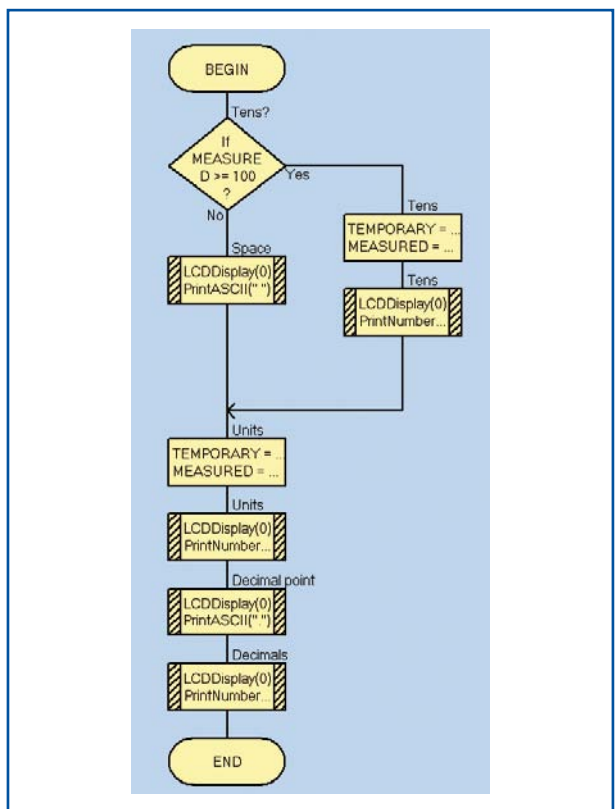


Figure 4.

The home-made display macro breaks down the number into digits and inserts the decimal point. As the format is fixed, this is much more economic than the FlowCode macro, which has to allow for all possible eventualities, with tens of thousands, thousands, the sign, and hexadecimal numbers.

ize the data in such a way as to make full use of the resolution of the converters.

The tens digit is displayed (except of course zero), the units, the decimal point, and then the tenths of degrees. We use the maths operations *division* and *modulo* (remainder after division). If the result of the measurement is less than 100 (tenths of a degree) the tens digit is replaced with a space. If it is 100 or more, the figure to be displayed is obtained by dividing the measured value by 100. The remaining digits to be displayed are the remainder after division by 100, obtained using the operation modulo. We do the same for the units (tens of tenths). The remainder after division by 10 is going to represent the tenths of degrees.

As these calculation and display routines are used three times over — for the measured temperature, the target temperature, and the difference — they form two macros, *Scale* and *Display*.

Between displays, we perform the measurements, and also reposition the cursor on the line. The LCD lines (y) and characters (x) are counted from zero. For example, the display of the Target temperature starts on (y=1; x=7) i.e. on line 1, character position 7.

Thermostat

The thermostat function consists of actuating a relay if the measured temperature is lower than the target temperature. Actuation of the relay is confirmed by the lighting of the LED connected to port A.

Calculation of the difference

The factor that determines the action of the thermostat is the difference between the target and measured values. The absolute value is the result of the subtraction

$$DIFFERENCE = TEMPERATURE - TARGET$$

or the opposite if the actual temperature is lower than the target. The method used is simpler than calculating the absolute value and determining the sign. If the difference between the measured temperature and the target is negative, the LED lights to indicate that the relay is activated. Because of the low frequency of the loop and the division performed for scaling, there is no risk of relay chatter as a result of noise from the converters.

The periodic blanking of the bottom line has the added advantage of showing that the system is working. But if you find this blinking annoying, it can be eliminated completely, or made more discreet — for example, by blanking only four of the characters. In any event, all the characters, including spaces, are updated each time round the loop.

The end-of-loop timer (*Delay*) is programmed with your choice of seconds or milliseconds. The compiler then looks after calculating the number of wait cycles or the value for reloading the counters, according to the clock frequency.

(070852-1)

Web Link

Update of FlowCode 3 to version v3.2.2.40 (needed for the thermometer/thermostat program to work properly)
<http://www.matrixmultimedia.com/Flowcode3a-X.php>

eweekly

elektor newsletter

Take out a free subscription to E-weekly now

Do you want to stay up to date with electronics and computer technology? Always looking for useful hints, tips and interesting offers? Subscribe now to E-weekly, the free Elektor Newsletter.

Your benefits:

- The latest news on electronics in your own mailbox each friday
- Free access to the News Archive on the Elektor website
- You're authorized to post replies and new topics in our forum



Register today on www.elektor.com/newsletter



tel. 01298 70012
fax. 01298 70046
www.peakelec.co.uk
sales@peakelec.co.uk

Handheld Test Gear - Cool, Smart.



Atlas DCA **£55**

Atlas DCA Model DCA55
Semiconductor Analyser
Identifies type and pinout!



Atlas ESR **£85**

New Low Price!
Atlas ESR Model ESR60
ESR and Capacitance Meter
Resolution of 0.01 ohms!



Atlas LCR **£79**

Atlas LCR Model LCR40
Inductor, Capacitor, Resistor Analyser
Automatic part identification.



Atlas SCR **£99**

New Low Price!

Atlas SCR Model SCR100
Triac and Thyristor Analyser
Auto gate test current up to 100mA

UK: Please add £1.00 p&p to your order. Prices include UK VAT.
Please see website for overseas pricing.

PCB-POOL®

SERVICING YOUR COMPLETE PROTOTYPE NEEDS

1 EUROCARD
(160 x 100 mm)
+ Tooling
+ Photoplots
+ VAT

€49

Price example
Any size and contour possible!

Optional:

- Soldermask
- Fast-turnaround
- Silkscreen
- 4-Layer Multilayer
- 6-Layer Multilayer

DOWNLOAD OUR FREE LAYOUT SOFTWARE!

Freephone **0800-3898560**

Tel.: +353 (0)61 701170
Fax: +353 (0)61 701165
pcb-pool@beta-layout.com

PCB-POOL.COM

ANDRE LAMOTHE'S XGAMESTATION

LEARN STEP-BY-STEP HOW TO BUILD AND DESIGN YOUR OWN VIDEO GAME CONSOLE!

Design inspired by the Atari 800/2600, Sinclair ZX Spectrum, Apple II & Commodore 64!

Parallax SX Key Compatible!

INCLUDES:

- Tools, Demos & Utilities!
- Great for Hobbyists AND Students!
- The Fun Way to Learn Embedded Systems!
- Fully Assembled XGS Micro Edition Unit!
- Complete Software Development KIT!
- eBook on Designing the XGS Console!
- Cables and Power Supply included!

WWW.XGAMESTATION.COM

PCBs in 24 hours from £30.00

PCBTrain.com

Tel: 01635 40347
Fax: 01635 36143
e-mail: circuit@newburytron.com

Newbury Electronics Ltd
Faraday Road, Newbury, Berks RG14 2AD
www.newburyelectronics.co.uk

The LEDBUS System

Programmable control for LED lighting

Jörg Prim

It is of course possible to drive LEDs using a simple series resistor. However, in a modern efficient lighting system we would not want to tolerate the wastage of power in these resistors. Also desirable is a remotely controlled dimming function.

The circuit described here, called 'LEDBUS', fits the bill perfectly. It also allows a practically unlimited number of LEDs to be controlled and up to ten lighting programs can be configured, which can be called up at the press of a button using a standard infrared remote control. Each lighting program specifies the desired brightness of each LED module individually. For example, one program could make the lights bright for reading while another could dim the lights and add a warm red tint for a more relaxing atmosphere.

In theory

The circuit consists of two printed circuit boards, the main unit and the power module (Figure 1). The main unit can control a number of power

modules over the 'LEDBUS', and one power module can drive from one to six 1 W LEDs, with the LED brightness adjustable in 256 steps. The LEDBUS operates like a shift register, and so there is no addressing in the protocol. Other parameters besides LED brightness can also be controlled from the main unit.

In the example configuration in Figure 1 the main unit is connected to a chain of three power modules. The main unit has an output shift register and an input shift register, while each power module has a shift register at its input and a pass-through output. A termination connector is therefore required at the end of the chain so that the signal can be shifted back to the main unit.

Normally a shift register would re-

quire a clock signal, a data signal and a strobe, but in the LEDBUS these three signals are replaced by a single wire, with the protocol being decoded in software.

The transmission of one byte is illustrated at the bottom of Figure 1. First comes the start bit which lasts for half a bit time. This is followed by a low level for the same period. Then comes the command bit and then the data bits from bit 7 to bit zero: each of these bits occupies a full bit time. The command bit indicates whether the accompanying byte is a command (1) or is data (0). A command is transferred immediately to the output of the power module so that all the power modules in a chain receive a command essentially simultaneously. If the byte is data then the contents of the internal data shift register are output. Rather than waiting for the entire byte to be received the module starts outputting data immediately after the start bit is seen, which means that each power module introduces a delay of one bit time. A more detailed description is given in the text box 'All about bits'.

Circuits

The circuit of the main unit is shown in Figure 2. An LCD panel with two lines of twenty characters displays status information and the selected program, all functions being accessible via menus. An I²C connector allows for easy expansion of the circuit: a mains relay board is already planned. The main unit is based on an ATmega32 microcontroller; other compo-

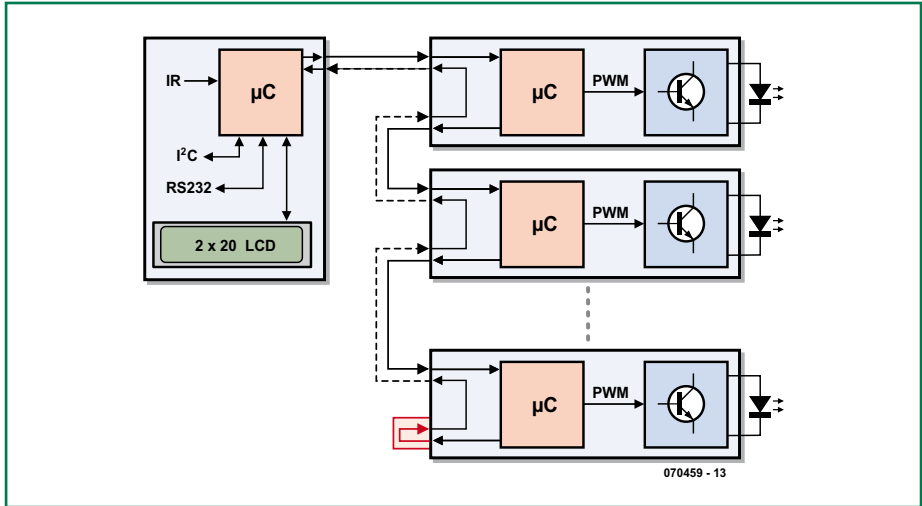


Figure 1. Block diagram of the complete system. In this example three power modules are connected to the main unit.

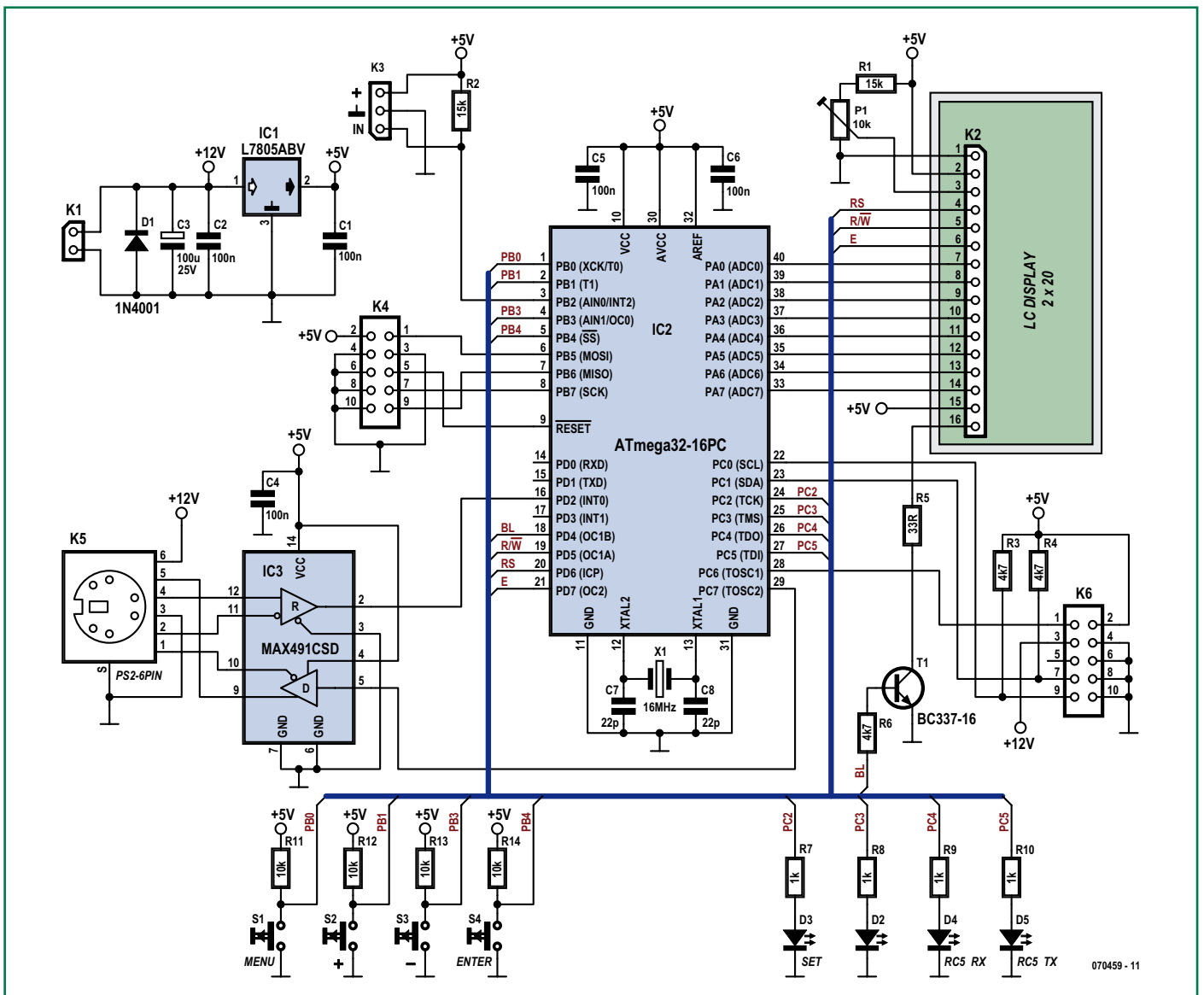
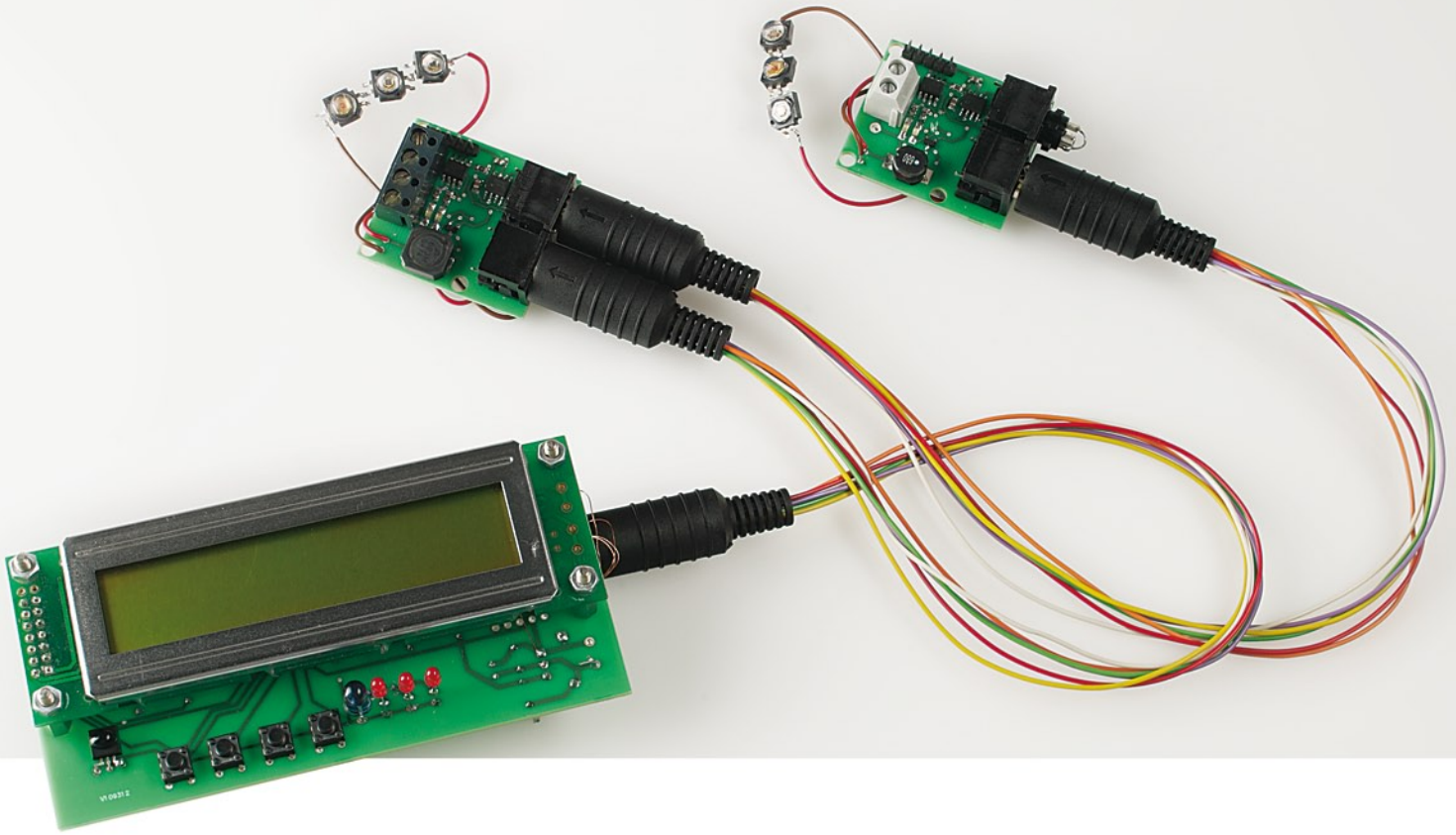


Figure 2. Circuit of the main unit, centred on an ATmega32.

All about bits

A command byte is divided into two four-bit nibbles. The high nibble specifies one of 16 possible command groups as follows:

- 0: Group 0: see below
- 1: Write register: lower nibble gives register address
- 2: Read register: lower nibble gives register address
- 3 to F: not used

Group 0 commands:

- 0: Clear data shift register
- 1: Device select: when the data register is zero the device is deselected; otherwise it is selected
- 2: Device activate
- 3: Query selection: data register is set to 1 if the device is selected
- 4 to E: not used
- F: Permanent save

A device (i.e., a power module) is either selected or not. When selected its green LED lights and it takes part in data transfers. If the device is not selected it does not take part in data transfers on the LEDBUS, and its output is equal to its input. In this state only commands in group 0 are executed.

Command 02 (device activate) always activates a device. Command 01 (device select), on the other hand, only activates a device if its data shift register holds a non-zero value. This allows the main unit to select individual devices and exchange data with them without having to clock the data through every device on the LEDBUS.

Up to 16 registers can be read and written using commands in groups 1 and 2.

0:	Current brightness: brightness changes immediately when this register is written
1:	Brightness change speed: 0 = fast; 1 = slow
2:	Current brightness: brightness changes gradually (at a speed determined by the contents of register 1) when this register is written
3...12	Not used
13:	Inversion flag: 0: 0 = off, FF = maximum brightness; 1: vice versa
14:	Minimum brightness
15:	PWM frequency: 0 = 8 kHz; 1 = 2 kHz; 2 = 500 Hz

In order to get a power module to operate at full brightness, first write FF into the data register. Then use command 10 to copy the value into register 0: the PIC will then switch the module to full brightness.

In order to make a gradual transition to half brightness, write the value 80 into the data register and then send command 12. The PWM signal will then gradually change (at a speed determined by the contents of register 1) until brightness 80 is reached.

The PIC can be configured to make it compatible with different LED driver ICs. If the value in register 13 is zero, FF will correspond to the LED being at full brightness and zero to the LED being off. Since in our circuit T1 inverts the PWM signal, we need to set register 13 to 1.

Register 14 sets the minimum brightness. The value varies from module to module, but the LED does not normally start to light until the brightness value reaches approximately 05. It would be preferable if the LED started to light at a value of 01, and this can be achieved using a suitable setting of register 14. Register 15 sets the PWM frequency to 500 Hz, 2 kHz or 8 kHz.

However, in practice there is no need for any mental binary arithmetic, as the main unit controls the power modules in response to simple commands. The settings for each power module can be stored in the PIC's internal EEPROM using command 0F so that the modules do not need to be reconfigured every time power is applied. On reset the PIC loads the values stored in its EEPROM into the 16 registers: observe that this also determines the brightness of the LED at power-on.

nents form the LCD interface, I²C bus and LEDBUS interfaces, and there are four status LEDs, four buttons, an IR receiver and a programming interface. The LCD data bus is connected to Port A of the microcontroller, and the R/W, RS and E signals are connected to port pins PD5, PD6 and PD7. The backlight can be switched on via tran-

sistor T1, connected to microcontroller port pin PD4. P1 sets the contrast of the display.

Pins PC0 (SCL), PC1 (SDA) and PC6 of the microcontroller are taken to the I²C connector K6. The connector also carries the 5 V supply and the unregulated 12 V supply, so that 12 V relays can easily be used on expansion

boards. PC6 acts as an spare enable signal. If I²C bus expansion is not required, components K6, R3 and R4 can be dispensed with. The current version of the software does not support the I²C bus.

PC2, PC3, PC4 and PC5 drive the status LEDs, with D5 being an infrared LED. The unit can generate RC5 format

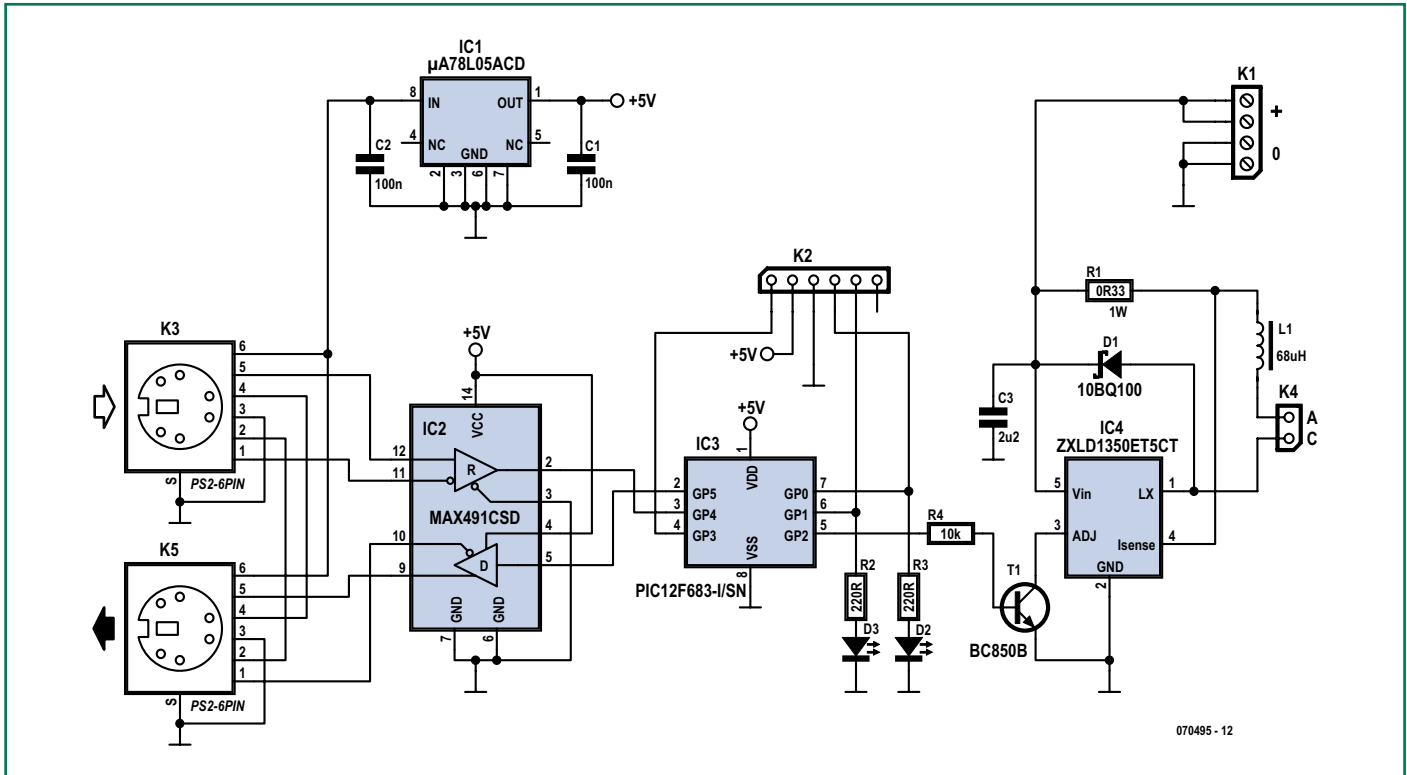


Figure 3. Circuit of a power module. Here again a microcontroller (a PIC12F683) provides the intelligence.

signals, making it easy to program a remote control that is capable of 'learning' commands. PB0, PB1, PB3 and PB4 are connected to buttons, which are not needed for normal operation: they are used for configuring the RC5 code parameters and setting the user interface language. All other functions are carried out using the remote control. The LEDBUS interface consists of a MAX491 (IC3) which conforms to the RS-422 differential signalling standard, which is relatively immune to interference. The LEDBUS also carries the un-

regulated 12 V supply, used to supply the PICs in the power modules. The remote control input uses a TSOP1736, which is connected to PB2 on the microcontroller. The device converts the 36 kHz-modulated infrared signals into a digital signal. It can be soldered directly to the printed circuit board or, if required in a particular application, it can be mounted off-board and connected using a cable. In our prototype we wired a stereo audio jack socket to the board, which we could then hide away in a cupboard with just

the infrared receiver externally visible. If a 2.5 mm jack socket is used, a Hauppauge TV card remote control sensor can be pressed into service: indeed, we found that we could connect the sensor to the TV card and to the main unit simultaneously (isolating the power supplies using a diode), and then use a single remote control to operate both. Alternatively, a TSOP1736 and some heat-shrink sleeving will do the job just as well. The 10-way ISP connector K4 is compatible with the standard Atmel con-

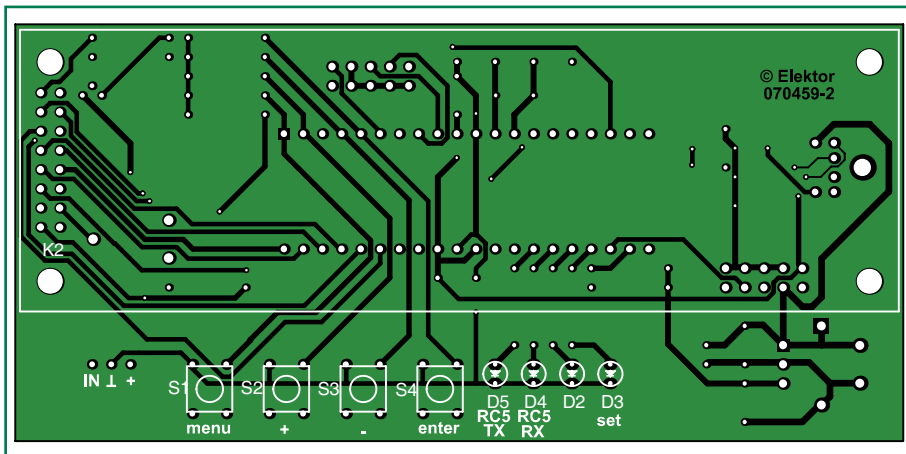


Figure 4. Printed circuit board for the main unit.

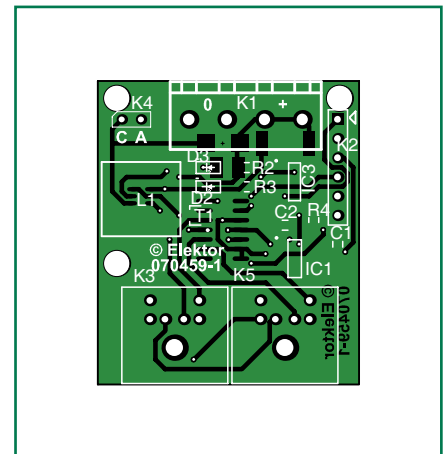


Figure 5. Printed circuit board for a power module.

COMPONENTS LIST

Power module 070459-1

Resistors

R1 = 0Ω233 1 W (SMD 2515)
 R2,R3 = 220Ω (SMD 0805)
 R4 = 10kΩ (SMD 0805)

Capacitors

C1,C2 = 100nF (SMD 0805)
 C3 = 2μF2 (SMD1210; dielectric X7R or X5R)

Semiconductors

D1 = 10BQ100 (Schottky)
 D2,D3 = SMD LED (SMD 1206)
 T1 = BC850
 IC1 = μA78L05ACD
 IC2 = MAX491CSD
 IC3 = PIC12F683-I/SN, programmed,
 Elektor Shop # **070459-41**
 IC4 = ZXLD1350ET5CT

Miscellaneous

L1 = 68μH SMD inductor, 10x10; e.g.
 Epcos B82464G4683M
 K1 = 4-way PCB terminal block, lead
 pitch 5mm
 K2 = 6-way SIL pinheader
 K3,K5 = 6-way mini-DIN socket, PCB
 mount
 Up to 6 power LEDs; e.g. Luxeon 1W
 types (see text)
 PCB, ref. 070459-1 from www.thepcb-
 shop.com
 Project software, free download from
 www.elektor.com

COMPONENTS LIST

Central unit 070459-2

Resistors

R1,R2 = 15kΩ
 R3,R4,R6 = 4kΩ7
 R5 = 33Ω
 R7-R10 = 1kΩ
 R11-R14 = 10kΩ
 P1 = 10kΩ preset

Capacitors

C1,C2,C4,C5,C6 = 100nF
 C3 = 100μF 25V radial
 C7,C8 = 22pF

Semiconductors

D1 = 1N4001
 D3, D4 = LED 3mm; low-current (D2
 omitted)
 D5 = LD271; IR-LED
 T1 = BC337
 IC1 = 7805
 IC2 = ATmega32-16PC (SMD), pro-
 grammed, Elektor Shop # **070459-42**
 IC3 = MAX491CSD

Miscellaneous

S1-S4 = pushbutton, 6x6 mm
 X1 = 16MHz quartz crystal
 K4,K6 = 10-way boxheader
 K5 = 6-way mini-DIN socket, PCB mount
 RC-5 receiver, e.g. SFH5110-36 (on K3)
 LCD Module with 2x20 characters; e.g.
 Displaytech 202A (on K2)
 PCB, ref. 070459-2 from www.thepcb-
 shop.com
 Project software and Guide to Operation,
 free download from www.elektor.com

necter and hence also with USBprog. The power module (**Figure 3**) uses a Zetex ZXLD1350 (IC4) to drive the LEDs. This device is a step-down converter with current regulation, with R1 setting the maximum current through the LEDs. A value of 0.33 Ω corresponds to a current of 300 mA. With a 24 V supply up to six 1 W LEDs can be driven in series. IC4 is very efficient and there is no noticeable heat dissipation. Control commands are processed by the PIC12F683.

The power module needs its own separate power supply: only the PIC is powered from the LEDBUS, via a 78L05 regulator. The microcontroller produces a PWM signal which is used to control the driver IC to dim the LED via T1. The PIC can generate a PWM signal with a choice of 256 different mark-space ratios, giving 256 different LED brightnesses.

The software for the main unit was

LED driver IC is particularly small. A fine-tipped soldering iron and a good measure of patience are required to solder this device successfully. When using PICKit2 to program the PIC via K2 pin 1 (marked by a triangle) should be nearest the corner of the board. If you are using a ready-programmed microcontroller, K2 may of course be dispensed with. Take care to allow enough space around K1 to connect the programmer if you need to. You will of course need to assemble as many copies of the power module as you need. The main unit employs only one SMD (IC3), which requires care in soldering. The buttons, LEDs, display connector, and IR receiver (if fitted) are soldered to the reverse of the board.

After the board has been populated the ATmega is programmed using USBprog or other suitable programmer. All software files for the project are available for free download from the *Elektor*

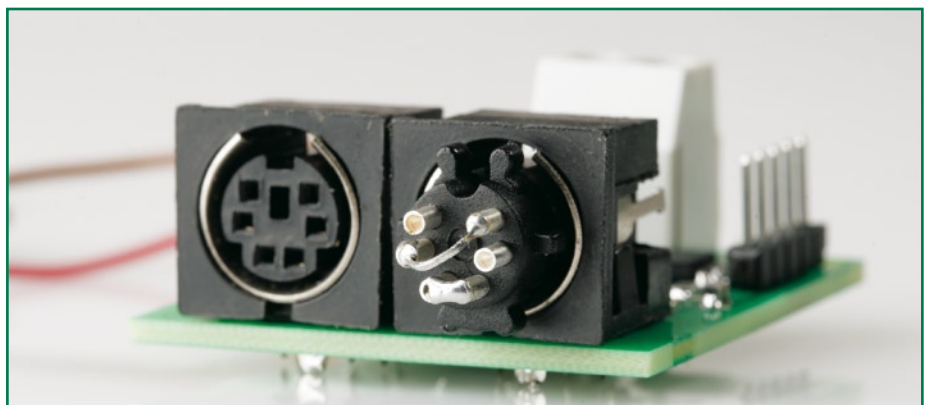


Figure 6. A couple of assembled boards in action.

written using AVR Studio 4 and the free WinAVR C/C++ compiler. Only the interrupt routine is written in assembler, the higher-level functions being written in C. The PIC software was written using the free MPLAB environment from Microchip (and is downloaded to the microcontroller using connector K5). The software uses interrupts to react to serial, infrared and LEDBUS signals: the interrupt routines simply set flags, leaving the actual processing to the main program loop.

Construction

Figure 4 and **Figure 5** show the printed circuit boards for the main unit and the power module. The latter is chiefly populated with SMD components: the

website (reference 070459-11). Ready-programmed microcontrollers are also available for purchase from the *Elektor* shop (see parts list).

The power modules are connected in a chain using 6-pin mini-DIN connectors. The first cable runs from the main unit to K3 on the first power module. The second runs from K5 on the first power module to K3 on the next, and so on. A terminator plug (see **Figure 7**) is fitted to K5 of the last module in the chain. The author has prepared a guide to programming and operation of the system, which for reasons of space we cannot print here. It is, however, available for free download from the *Elektor* website.

(070459-1)

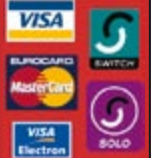


QUASAR
electronics

The Electronic Specialists Since 1993

Quasar Electronics Limited
PO Box 6935, Bishops Stortford
CM23 4WP, United Kingdom
Tel: 0870 246 1826
Fax: 0870 460 1045
E-mail: sales@quasarelectronics.com
Web: www.QuasarElectronics.com

Postage & Packing Options (Up to 0.5Kg gross weight): UK Standard 3-7 Day Delivery - £3.95; UK Mainland Next Day Delivery - £8.95; Europe (EU) - £6.95; Rest of World - £9.95 (up to 0.5Kg)
!Order online for reduced price UK Postage!
We accept all major credit/debit cards. Make cheques/PO's payable to Quasar Electronics. Prices include 17.5% VAT.
Call now for our FREE CATALOGUE with details of over 300 kits, projects, modules and publications. Discounts for bulk quantities.



08717

Credit Card Sales

177 168

Motor Drivers/Controllers

Here are just a few of our controller and driver modules for AC, DC, Unipolar/Bipolar stepper motors and servo motors. See website for full details.

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: 9Vdc. PCB: 80x50mm.
Kit Order Code: 3179KT - **£12.95**
Assembled Order Code: AS3179 - **£19.95**



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: 8-30Vdc. PCB: 75x85mm.
Kit Order Code: 3158KT - **£17.95**
Assembled Order Code: AS3158 - **£27.95**



Bi-Directional DC Motor Controller (v2)

Controls the speed of most common DC motors (rated up to 32Vdc, 10A) 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: 3166v2KT - **£17.95**
Assembled Order Code: AS3166v2 - **£27.95**



DC Motor Speed Controller (100V/7.5A)

Control the speed of almost any common DC motor rated up to 100V/7.5A. Pulse width modulation output for maximum motor torque at all speeds. Supply: 5-15Vdc. Box supplied. Dimensions (mm): 60Wx100Lx60H.
Kit Order Code: 3067KT - **£13.95**
Assembled Order Code: AS3067 - **£21.95**



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

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 £8.95

8-Ch Serial Isolated I/O Relay 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/500mA.
Kit Order Code: 3108KT - **£54.95**
Assembled Order Code: AS3108 - **£64.95**



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 45x45mm. Powered by PC. Includes one DS1820 sensor.
Kit Order Code: 3145KT - **£17.95**
Assembled Order Code: AS3145 - **£24.95**
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). 4 indicator LED's. Rx: PCB 77x85mm, 12Vdc/6mA (standby). Two and Ten channel versions also available.
Kit Order Code: 3180KT - **£44.95**
Assembled Order Code: AS3180 - **£54.95**



DTMF Telephone Relay Switcher

Call your phone number using a DTMF phone from anywhere in the world and remotely turn on/off any of the 4 relays as desired. User settable Security Password, Anti-Tamper, Rings to Answer, Auto Hang-up and Lockout. Includes plastic case. Not BT approved. 130x110x30mm. Power: 12Vdc.
Kit Order Code: 3140KT - **£54.95**
Assembled Order Code: AS3140 - **£69.95**



Infrared RC Relay Board

Individually control 12 on-board relays with included infrared remote control unit. Toggle or momentary. 15m+ range. 112x122mm. Supply: 12Vdc/0.5A
Kit Order Code: 3142KT - **£47.95**
Assembled Order Code: AS3142 - **£59.95**



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) **£14.95**
18Vdc Power supply (PSU010) **£18.95**
Leads: Parallel (LDC136) **£395** / Serial (LDC441) **£3.95** / USB (LDC644) **£2.95**

NEW! USB & Serial Port PIC Programmer

USB/Serial connection. Header cable for ICSP. Free Windows XP software. Wide range of supported PICs - see website for complete listing. ZIF Socket/USB lead not included. Supply: 16-18Vdc.
Kit Order Code: 3149EKT - **£39.95**
Assembled Order Code: AS3149E - **£49.95**



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 lead not included.
Assembled Order Code: AS3128 - **£44.95**



"PICALL" PIC Programmer

"PICALL" will program virtually all 8 to 40 pin serial-mode AND parallel-mode (PIC16C5x family) programmed PIC micro controllers. Free fully functional software. Blank chip auto detect for super fast bulk programming. Parallel port connection. Supply: 16-18Vdc.
Assembled Order Code: AS3117 - **£24.95**



ATMEL 89xxx Programmer

Uses serial port and any standard terminal comms program. Program/ Read/ Verify Code Data, Write Fuse/Lock Bits, Erase and Blank Check. 4 LED's display the status. ZIF sockets not included. Supply: 16-18Vdc.
Kit Order Code: 3123KT - **£24.95**
Assembled Order Code: AS3123 - **£34.95**



www.QuasarElectronics.com

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

Power to the LEDs

Luxeon Rebel – cool on a ceramic die

Rob Alferink, Philips Lumileds Lighting Systems R&D

LEDs are all the rage lately and the high-power blue and white ones in particular even appeal to unexpected audiences like youths of the msn & mp3 generation who use them to pimp their scooters and PCs. In two short picture stories we tell not only how LEDs are designed and produced (basically!), but also look at what Philips Lumileds Lighting Systems are pursuing technically in a bid at making a versatile high-power LED for mass production.

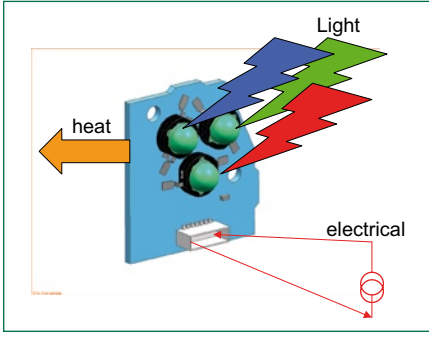
1 LED basics

What's an LED? Electrically, thermally, optically, mechanically?

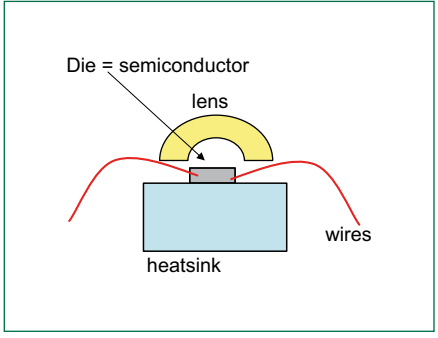
Basic principle

An LED (light emitting diode) converts electrical energy into light, with heat as an unwanted and highly problematic by-product.

The heart of an LED is called 'die' ("dai"). A die is composed of several materials specially selected for certain physical properties and exhibiting the so-called *semiconductor* effect. Its size is approx. 1x1 mm. To prevent overheating, the die for a high-power LED is secured on a heat-



sink that often doubles as the case. The die has wires attached to it for the

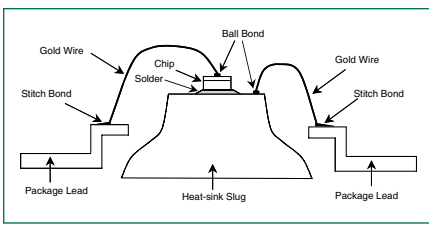


electrical connections.

What basic materials?

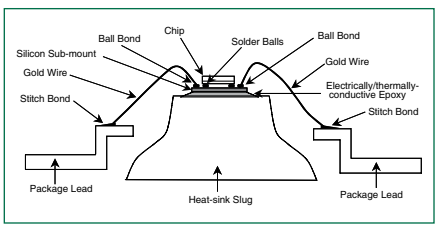
For red, orange/red and amber LEDs the basic semiconductor material is **AlInGaP**, where
 Al = aluminium
 In = indium
 Ga = gallium
 P = phosphor

Blue, cyan and green LED dies are produced using **InGaN**, where
 N = nitrogen



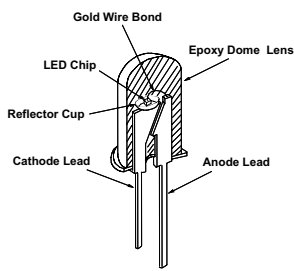
AlInGaP Luxeon LED internal construction

In a reactor, these materials are 'sputtered' at a certain mixing ratio onto a ruby (wafer-) carrier called the sub-



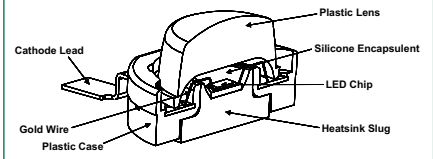
InGaN Luxeon LED internal construction

strate. The wafer has a diameter of 2 or 4 inch.



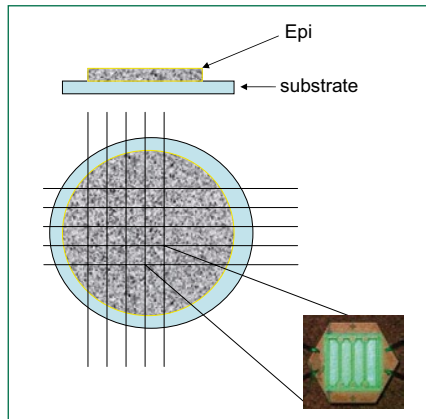
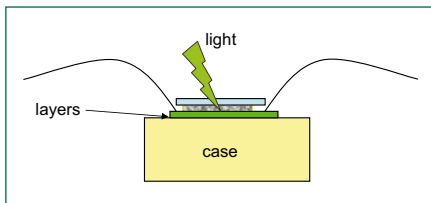
Low power LED with traditional leads. No problems with high temperatures, so no heatsink required. ←

High power LED; the case/heatsink and the lens/dome are the largest parts. →

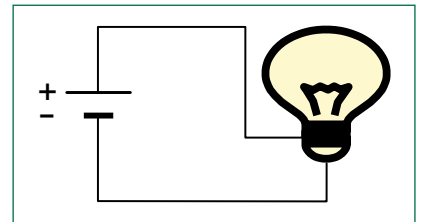


InGaN technology

Patterns may be created using lithography. The positive and negative electrodes are at one side.

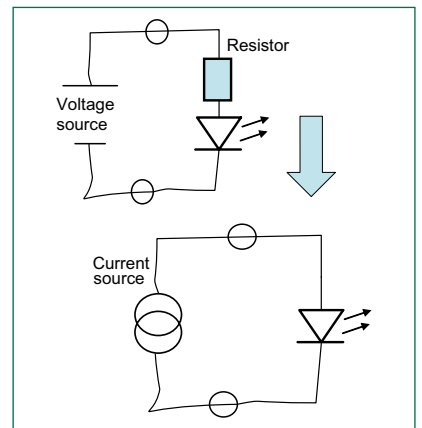


Making it light



An ordinary incandescent bulb can be powered by DC or AC voltage source.

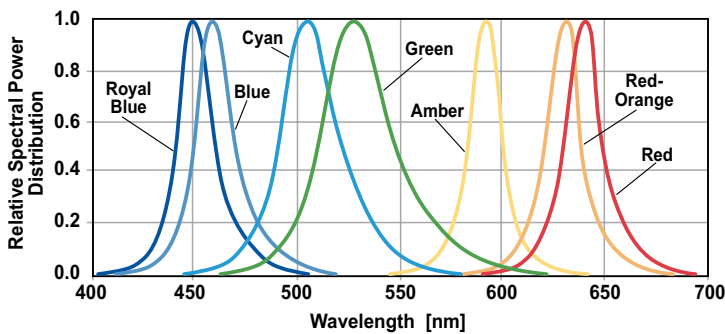
An LED can also be powered by a voltage source if a suitably dimensioned resistor is included. However, for more repeatable results and better control of the LED response, the preferred method is pure current sourcing.



The LED colour

can be chosen from a wide spectrum.

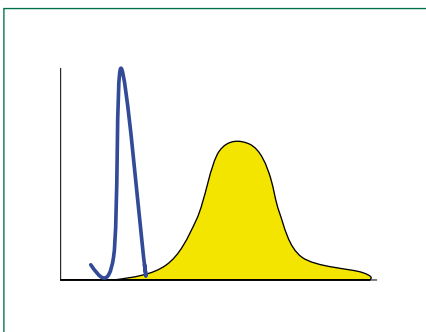
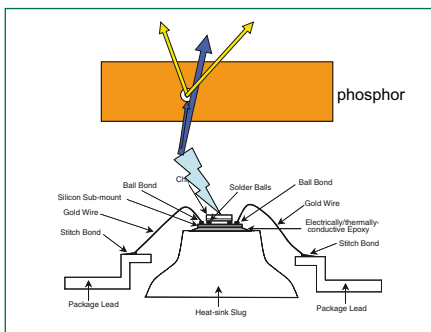
In practice, this is achieved by combining several semiconductor materials.



How to make white light

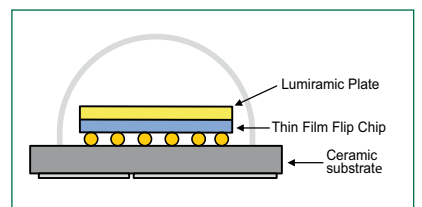
Blue light from an InGaN LED is converted into yellow using a phosphor layer. The result is a carefully control-

led shade of white.



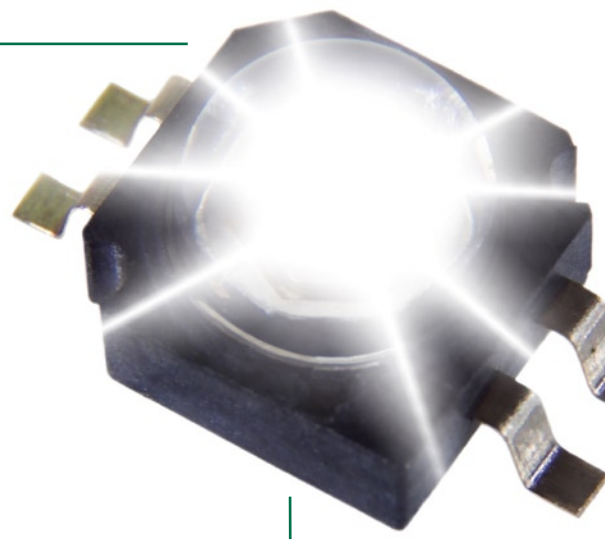
Lumiramics

New technologies allow a thin phosphor plate to be used instead of a damped-on powder.

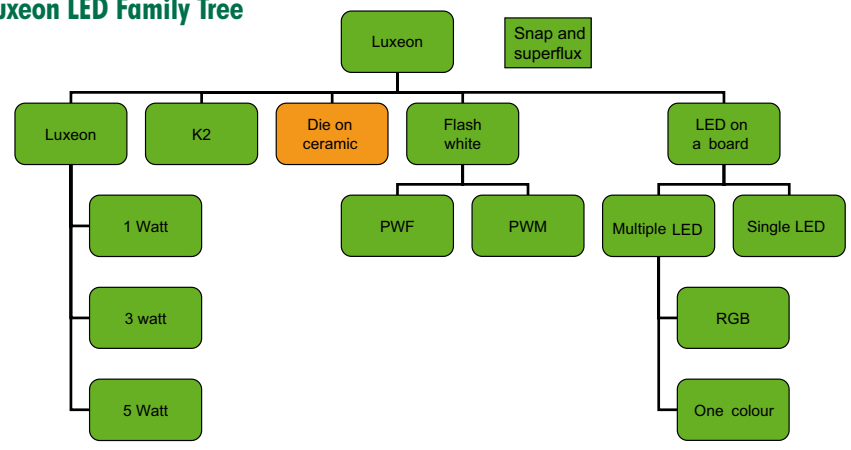


2 How the Luxeon Rebel came about

The Luxeon Rebel LED from Philips Lumileds has great potential for all sorts of lighting applications where energy wasting fluorescent lights and even incandescent lamps are long overdue for replacement by a smarter, more durable light source. The Rebel has its roots in earlier Luxeon technology.



Luxeon LED Family Tree



Standard Luxeon

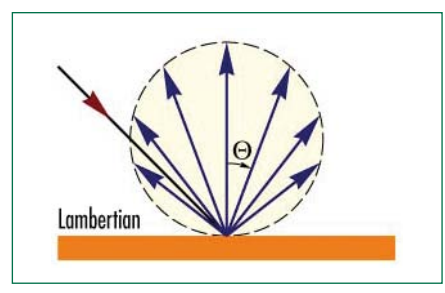
These devices can be classified by:

1. Power:

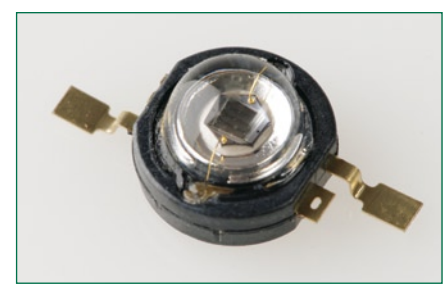
- 1 watts
- 3 watts
- (5 watts)

2. Colour:

- red
- orange/red
- amber
- green
- cyan



- blue
- royal blue



3. Radiation pattern:

- Lambertian
- batwing
- side emitter

'Binning': fine tuning the device selection

Within the constraints for colour, power and radiation pattern, LEDs are selected in a high-speed automated industrial process. The selection is on

- amount of light produced ('flux'), expressed in lumen (lm) or milliwatts (mW). Advanced radiometric measurement is applied.
- wavelength (actually, dominant wavelength)

- forward voltage

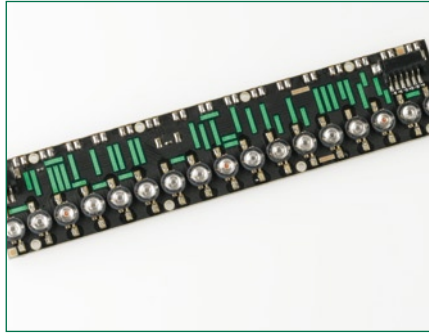
The selection employs 'bins' and the process is called 'binning' (nothing to do with rubbish, hopefully). A selection example for bin code **R2H**

Flux (green)	lower [lm]	upper [lm]	λ_{dom}^1 (green)	lower [nm]	upper [nm]	V_f (green)	[V]	[V]
Q	30.6	39.8	1	520	525	H	3.03	3.27
R	39.87	51.7	2	525	530	J	3.27	3.51
S	67.2	87.4	3	530	535	K	3.51	3.75
T	87.4	113.6	4	535	540	L	3.75	3.99
			5	540	545	M		
			6	545	550	N		

¹ Dominant wavelength (λ_{dom}) is determined for a colour using its coordinates in an x-y colour plane. The classification is meaningful for any primary colour except white.

LEDs on a board

Luxeon LEDs can be supplied pre-mounted on boards with several shapes. The individual LEDs are carefully selected for equal colour and brightness. Surprising applications include open top deepfreeze cabinets in supermarkets and beverage vending machines. In both cases the colour has to be controlled accurately for the best appearance of the foodstuffs and drinks on display. For sure, the colour produced by the LED lighting was adjusted from sales results based on



Luxeon DCC



Star

questionnaires and interviews with

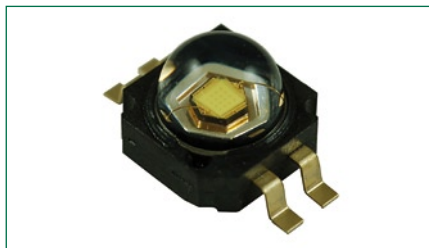
unsuspecting clients!

Luxeon K2 TFC and K2 Prime TFC

These two members of the Luxeon family are marked by

- availability as a Lambertian radiator only
- highly suitable for higher currents and temperatures
- suitability for reflow soldering (as opposed to standard Luxeon devices)

The basic K2 LED (Luxeon K2 TFC,



thin film flip chip) sustains a current

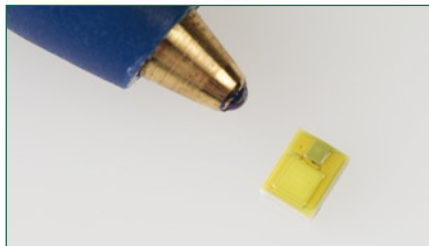


of 1.5 amps!

Luxeon Flash products

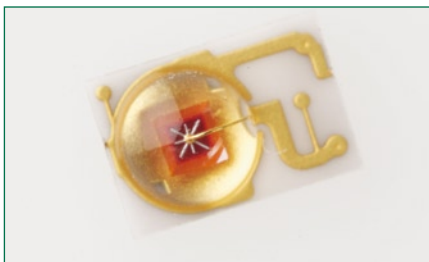
These are white LEDs invariably. They come in two main versions:

1. mounted on a carrier = PWF (F = flash)
2. integrated with a lens = PWM (M = module)



The next generation: LEDs on ceramics

The 'Luxeon Rebel' LED from Philips Lumileds is an unusual member of the Luxeon family in that it is produced on a **ceramic** die. Ceramics have a long history at Philips, and the relevant manufacturing technologies have been well documented as a result of extensive research over many years. Certain



ceramics have good heat conducting

properties, which helps to prevent the LED die from dying (pun intended) owing to overheating. Heat, by the way, is the main problem LED manufacturers are contending with. It's kind of obvious since thermal instability and runaway not only affect important device parameters like forward voltage and life expectancy, but also the colour produced by the LED (however slightly).

For further reading

Philips *Product Datasheet # DS25* on the Luxeon LED and the associated *Reliability Datasheet # RD25* delve deep in the technology of Luxeon LED production and application.

You can find the documents as free downloads on the web page for this

article at www.elektor.com, courtesy of Philips Lumileds Lighting Systems.

Further interesting documents may be found at these urls.

1. **General information on Lumileds:** www.lumileds.com/

2. **Luxeon K2:** www.lumileds.com/products/line.cfm?lineId=18

3. **Luxeon Rebel:** www.lumileds.com/products/line.cfm?lineId=19

(070906-1)



Philips LivingColo

Luc Lemmens

Strange people they are, the editors and technicians at Elektor. And I count myself among them. They generally show greater enthusiasm for disassembling things than for assembling them. It is therefore not surprising that I counted five colleagues around the table at my request to attack a Philips LivingColors unit with a screwdriver. It must be in our DNA.

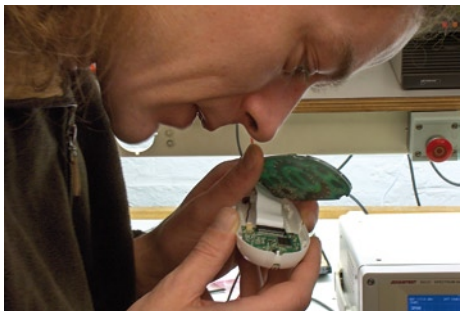
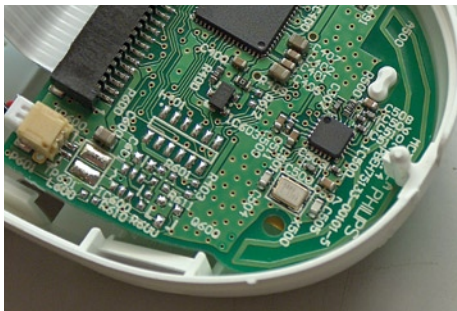
At first glance the LivingColors — a bit of an unusual name for a lamp — looks more like a set of speakers from Harman Kardon for a Mac. A handsome, transparent, spherical housing which contains a goblet shaped interior that looks more like a speaker than a heatsink. The lamp, on command, conjures up colours on a light wall and colours the room to your taste. A 'little bit' to your taste, because to fully appreciate the effect of this lamp all the other lights in the room have to be turned right down.

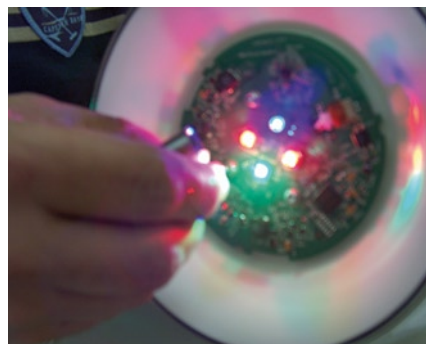
To conjure up all the colours of the rainbow, the lamp is provided with a number of coloured LEDs (2 x red, 1 x green and 1 x blue) which, when combined in various intensities generate the desired colour. It is a very effective demonstration of chromatics from physics class. Philips has been very fond of LEDs recently and has produced various household devices to add colour to your life. The 'singing LED candles' (because the LED is driven by a music chip) from Philips are a great success and this LED application is also certain to find its way to the consumer.

Unpacking and disassembling

In addition to the lamp the LivingColors box also produces a remote control, a few batteries and, of course, the manual. The goal of the assembled Elektor posse is to disassemble the thing in the shortest possible time. The RF boys rip into the remote control with military precision and the others realise quite quickly that brute, yet gradual force is best for removing the front panel of the lamp. In less than a minute we reach the PCB that also contains the four LEDs.

These LEDs generate quite a bit of heat so their bottom side is mounted on the goblet shaped fin in the lamp which acts as the heatsink. An amazing amount of electronics appears to be necessary to get the whole thing to go. There is obviously the RF section for the communication link with the remote control, there are four separate control circuits for driving the LEDs and then a further circuit that drives these four circuits. At the heart of this control circuits sits — surprisingly — an MSP430 processor from Texas Instruments.





rs Attacked with a screwdriver

Operation

The remote control uses a radio link and makes the lamp a very unusual toy. Completely in the style of 'everything-with-an-i-in-front' it has a kind of colour circle on the front. You would expect that this allows you to move continuously through all the colours, but that appears not to be so. It all works with capacitive sensors and you really have to place your fingers in a particular location to get the desired colour. The RF spectrum analyser should have given us an indication regarding the signal from the remote control, but no matter how hard we looked, there was only noise. Not that strange: after some detective work, i.e. looking very hard at what is written on the tiny IC, we learned that the remote control operates at 2.4 GHz. Quick googling of the part number CC2500 shows that it is a 2.4-GHz transceiver from (again!) Texas Instruments. The accompanying antenna is a closed $\frac{1}{2} \lambda$ folded dipole formed with a copper trace on the PCB — says Jan.

The remote control also has the ability to activate a few special functions. According to the manual we have to hold the remote control close to the logo on the lamp to make controlling several lamps possible and the same trick can be used to start the demo program. Because there are no sensors that allow the position of the remote control to be determined, we concluded that it works by signal strength detection in the receiver. By holding the remote control close the receiver an RSS-ish control circuit produces a signal that's used to activate the special functions.

Everything revolves of course around the LEDs. These are from the Luxeon K2 series from Lumileds. On the circuit board, under-

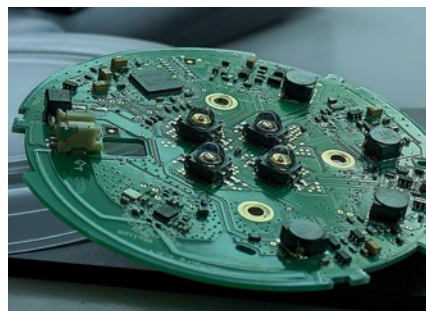
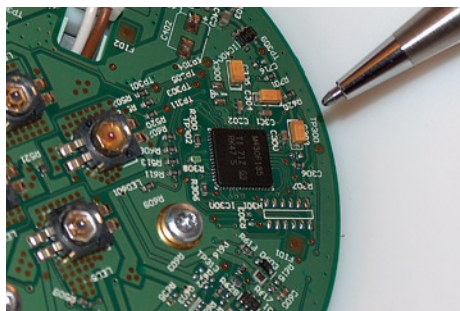
neath the LEDs, there are a large number of vias (plated through holes), which conduct the heat to the surface on the back of the PCB that in turn is in contact with the 'cooling tower'. Thermal conducting paste has been used very sparingly though...

Hacked & Cracked

Up to now this whole exercise has been more of a 'crack' instead of a 'hack'. Intriguing is the JTAG connection, the footprint for an SMD connector is on the board but the connector itself is not fitted. Through this we would have direct access to the contents of the processor and be able to do nice things ourselves, but in all likelihood Philips will have blown the JTAG fuse in this IC so that the interface is no longer usable (?). So off the cuff, could the LivingColors lamp be changed into a kind of Ambilight? Perhaps it is possible to drive the remote control separately and obtain other visual effects. Could we use the remote control for other things? Do you have any other ideas or suggestions?

The LivingColors lamp is currently heavily discounted. If you want more colour, you can use it to brighten up your home nicely and there are certainly other decorating applications to be found. In any case, we were quite surprised at the quality of the construction — real design, we could say. Now the only thing left is to collect all the loose parts and see if we can put the lamp back together again.

(070956-1)



Vista versus LPT

Deathblow for the printer port?

Paul Goossens

Last month in this column we described the problems in our lab concerning the use of Vista. The biggest stumbling block appeared to be the parallel printer port. This port is eminently suitable when designing cheap programmers, JTAG-interfaces and the like. With Vista, the new operating system from Microsoft, it appears to be very difficult for electronics enthusiasts to use this very useful interface.

That the parallel printer port has been slowly disappearing as a standard interface is clear. Many new computers are no longer fitted with a Centronics interface. This port was originally intended to control printers. A long time later, affordable scanners appeared for home use, which also used this parallel port.

These days it is common for such devices to be fitted with a USB connection. So it appears logical that the user will not miss the parallel port.

Internal debate

The debate during an editorial meeting became heated after I suggested this topic for this month's Labtalk.

Many of those present considered the parallel port a relic from another era. Comments such as "All peripherals have USB!" and "The parallel port is out of date!" were used as counterargument. But for an electronics designer this port is darn handy.

(Ab?)use

Electronics engineers have received the parallel port enthusiastically. The reason was that there now existed a standard interface, which could be used as a simple I/O-interface. With this interface you could use a number of status lines and 8 data lines as digital outputs. In addition there are a few lines available that can be used as digital inputs. Obviously, the parallel port was not originally invented for this purpose, but that does not mean that you cannot ab(?)use it for your own purposes.

During the nineties the parallel port was developed further, resulting in the EPP/ECP-port. The big step forward was that the data lines could now be switched between input or outputs as required. This was very interesting for a number of manufacturers of scanners and other external devices (such as ZIP-drives), because they were now able to send data at a much greater speed. Of course, this also increased the usefulness of this port to electronics engineers.

Applications

Many programmers and JTAG interfaces still make use of the parallel port. In many cases you can make a nice programmer with a few standard ICs that is directly connected to the parallel port. The development of a programmer or JTAG -interface with a USB interface requires considerably more time and especially knowledge.

Here at Elektor as well, we have often used the parallel port to drive

programmers and the like. It would be a shame if these could no longer be used with Vista.

Driver

As described in last month's article, we encountered some problems when installing a parallel port PCI expansion card.

Our usual programmer that uses this port to program an innumerable range of devices could not cope with this port. The Quartus FPGA software and Altium Designer refused to work as well. No parallel port found, was the message — despite the fact that the driver was installed correctly, according to Windows.

After some investigation on the Internet it appeared that the driver is solely intended to control printers, not to use the parallel port as digital I/O.

People who bought a PC with a parallel port on the motherboard do not appear to have these problems. Apparently, Microsoft Vista only supports the parallel port on this type of PC.

Strategy

Microsoft will (just like the motherboard manufacturers) in the foreseeable future cease to support the old interfaces such as the serial port, parallel port and similar. This is also apparent from two documents on their website, where they outline their strategy to banish this old technology to the museum. Microsoft have chosen for the intermediate solution of continuing to support the parallel port only if it is integrated on the motherboard.

Solution

It makes absolutely no difference to the processor whether the LPT-port is on an expansion card or whether it is integrated on the motherboard. So perhaps it is nevertheless possible to use our expansion board? The answer appears to be 'YES'.

The solution is to force Windows to use the file *parport.sys* (by default this can be found in the Windows folder) as the driver when installing the expansion board.

After this installation, the problems with Quartus and Altium Designer were gone. In all likelihood this trick will also work with all kinds of other software (for example for programming or debugging of controllers) when used with Windows Vista.

I do have to note that the base address of this LPT port is rather unusual, namely EF00-EF07. It is possible that some programs require that the LPT-port has a standard address. If that is not the case then you can just continue to use your parallel port with Vista!

(070854-1)

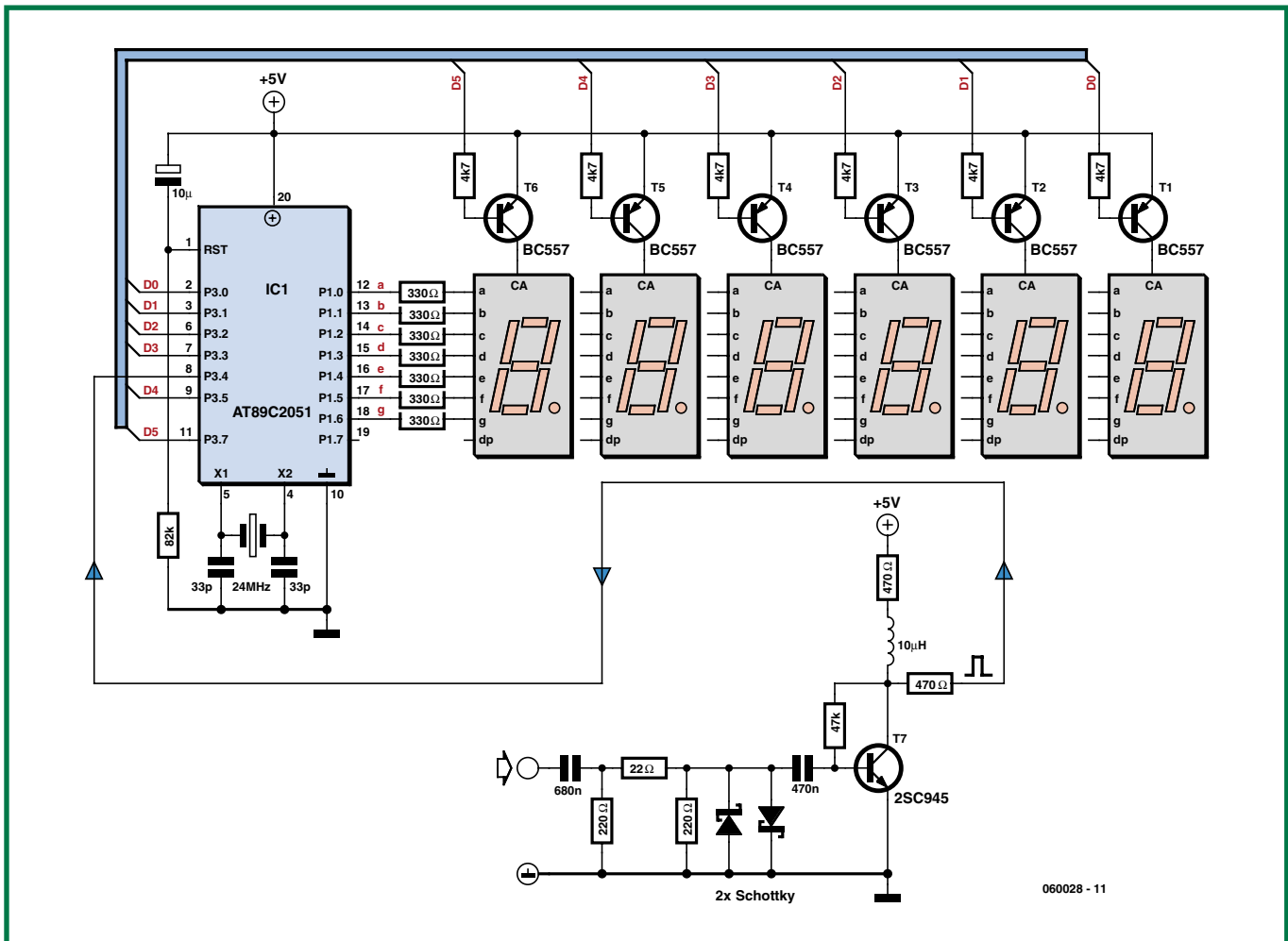
Web Links

<http://download.microsoft.com/download/1/6/1/161ba512-40e2-4cc9-843a-923143f3456c/>

ISAW2.doc

www.microsoft.com/whdc/archive/legacyIO.mspx

1 MHz frequency counter using AT89C2051



Sajjad Mosavi

Here's a very simple circuit capable of measuring frequency up to 1 MHz at 1 Hz accuracy without an additional divider or prescaler circuit. The circuit employs an Atmel microcontroller type AT89C2051-24XX as the main part.

The input signal should be a square wave with maximum and minimum level of +5 V and 0 V respectively. If you want to apply non-TTL waveforms you may use the level converter around T7 — it will convert your signal into to a TTL square wave as well as protect the counter from excessive signals swings. To be able to measure higher frequencies, divider (prescaler) ICs like the SAB6456 or SP8704 may be used. If so, the frequency appearing on display should be multiplied by the divi-

sion ratio to obtain the exact frequency in hertz. If you're not into gigahertz'ing then TTL dividers like those good old 74LS93 and 74LS90 with divide ratios like 2, 4, 5, 8 or 10 are a good choice. Such dividers can be cascaded to obtain higher ratios but the input frequency must not exceed the maximum stated for the part in its datasheets.

The Atmel AT89C2051 is a 20-pin 8-bit microcontroller with 2 k flash memory, 128 bytes RAM and two 16-bit timer/counter blocks. It is used here because of its price/performance tradeoff, compatibility with MCS-51 products, low pin count and last but not least... the author being familiar with its programming language!

The frequency is measured by counting the number of rising edges of the input clock pulse in

one second. The program uses timer/counter0 in 16-bit counter mode for counting the number of input pulses, and timer/counter1 in 16-bit timer mode to set up the one-second gate interval. The routine calculating the frequency stores its result in register bank 0 from R2 to R7. The display routine then shows the results on the 7-segment common-anode displays. To suppress trailing zeroes the program tests registers for 'zero' content before displaying. For the frequency display, each of the six digits (displays) in the readout is turned on individually and all others will be off while the desired number for that digit is output on the microcontroller's P1 port for a short time. The microcontroller then switches on the relevant digit, which shows the number. This action is so fast that you can't see any display flicker. The displays are bussed on the P3 port, with

4.7 kΩ resistors at the base of each pnp driver transistor to limit the current.

Note that you should use AT89C2051-24XX in this circuit because a 24 MHz crystal is used.

The AT89C2051 program that's available for free downloading with this article (ref. 060028-11.zip) may be assembled using any 8051 family assembler like ASM51 assembler and the OHS51 linker. The output will be a .hex file and can be programmed on the microcontroller using a suitable programmer. When building the counter, the display circuitry is best built on a separate board for convenient panel mounting.

The regulated +5 V supply voltage may be provided by a type 7805 regulator.

(060028-1)

Frost Detector

Above or below zero, that's the question

Ton Giesberts

In rooms without adequate heating but containing sensitive equipment it would be nice to obtain at least an indication as to whether the temperature has dropped below freezing. You then know that the heating is inadequate and that the equipment has to be moved somewhere else. This detector, thanks to its battery powered supply, can be used anywhere in the home.

To know whether it is freezing you only need to measure the temperature. This has to be done accurately, of course, and therefore we need to choose a temperature sensor that we have some confidence in.

The choice has again been made for a type that we have already used in many previous Elektor circuits, the LM35CZ (-40 to 110 °C). This sensor is not expensive and generates an output voltage that is proportional to the temperature in degrees Celsius (10 mV/°C).

Sensor

An LM35 is normally powered from a single-ended power supply and 0 °C corresponds to an output voltage of 0 V. It is therefore not possible to measure negative temperatures with an LM35 in the standard application circuit. It is however possible to measure negative temperatures if its output is connected to a negative supply voltage via a resistor. There needs to be a current of 50 μ A through this resistor (R2 in the schematic).

We only need to detect the freezing

point with this circuit. That is why there is a comparator after the temperature sensor, which turns an LED on if the temperature has dropped below 0 °C during the course of the night. To ensure that the comparator operates properly it is necessary that the measurement value can become slightly more negative with respect to the input. To solve this problem, a diode (D1) has been connected in series with the ground connection of the LM35. The voltage drop across D1 (because of the small current through the LM35 this is only 0.47 V) acts as 'negative' power supply. Since the non-inverting input of comparator IC2 is connected via R3 to the anode of D1 it functions as the 0°C-reference level for the comparator.

Comparator

The comparator is a standard opamp type TLC271, which we configured for minimal current consumption by connecting the bias-select input (pin 8) to the power supply voltage. There is no need for the detector to be fast and it will therefore work well with the opamp operating in its most economical mode.

LED D3 provides the frost indication. It is the intention that the LED stays on once the temperature in the room drops below freezing or when it has been below freezing. To realise this, an asymmetric hysteresis is created with the aid of R3, R4 and D2. The instant that the output goes high, the non-in-

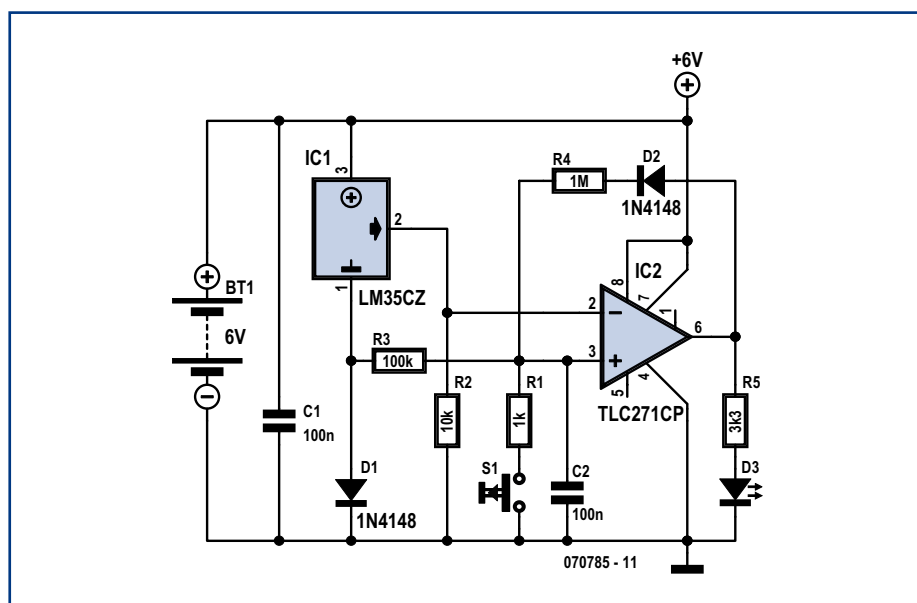


Figure 1. The frost detector circuit consists of a temperature sensor and comparator with LED indicator.



verting input goes more positive via D2 and R4, and the output therefore stays high. The temperature would now have to increase to more than about 30° before the LED will go out by itself. In practice this probably means that it is summer and that it is not likely to freeze anyway. If need be, the hysteresis can be increased by increasing the value of R3.

Capacitor C2 is added to make sure that the LED remains off (the circuit is reset) when the power supply is connected. The non-inverting input of the opamp is briefly connected to ground and the output is therefore low. R1 and S1 are only required if the circuit needs to be reset when the battery is connected. Instead of S1 you could also use a power supply switch or even just simply disconnect the battery for a moment.

Thrifty Power supply

Since the circuit is assumed to be powered from a battery there was a conscious effort to minimise the power consumption. The current consumption of the prototype, at a power supply voltage ranging from 6 to 9 V, was less than 120 μ A. When the LED is on, the current consumption rises to only 1 mA at 6V and 1.8 mA at 9V, because a low-current LED is used. In our prototype we used a green, low-current LED. If four AA penlight batteries (with a capacity of about 2 Ah) are used, then the

circuit will run for about two years in standby mode. When the LED is on this is considerably shorter, of course (about two months, this is easily long enough to run through a severe winter period). A standard 9-V battery will also last a single winter, provided you frequently check whether the LED is on.

Finally, a comment about the TLC-271CP used here. The version with the C-suffix is specified for an operating range from 0 to 70 °C, but will continue to work at lower temperatures, particularly considering that the IC is not

used in a linear application. If in doubt you can always try to get your hands on a version with the I-suffix (that is, TLC271IP: -40 to 125°C). But that is only necessary if you expect it to be real cold in the monitored room...

Quick assembly

The circuit contains very few parts and can therefore be easily built on a small piece of prototyping board. There is no need to calibrate anything, once built it is ready to go.

(070785-1)

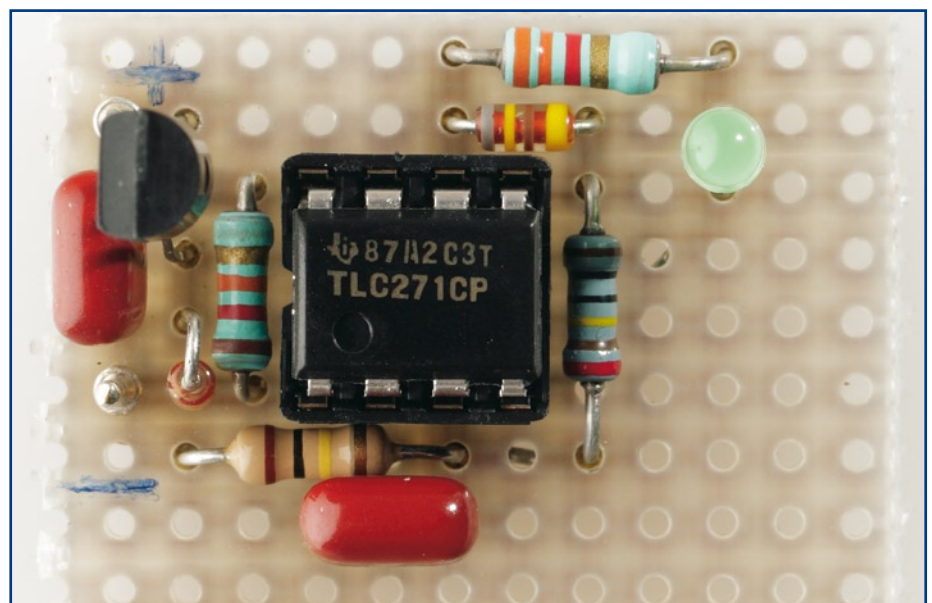


Figure 2. The prototype built on a piece of perforated prototype board.

Hexadoku

Puzzle with an electronics touch

Are you bothered by spring depressions? Then hopefully a few hours of puzzle solving will cheer you up. Elektor's Hexadoku is great medication, free but admittedly slightly addictive. Solving a Hexadoku is harder than a Sudoku and should take much longer. Correct answers again enter a prize draw for one of the prizes: an E-blocks Starter Kit Professional and three Elektor Shop vouchers.

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

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

SOLVE HEXADOKU AND WIN!

Correct solutions received enter a prize draw for an

E-blocks Starter Kit Professional

worth **£248.55**

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



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

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

PARTICIPATE!

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

editor@elektor.com - Subject: **hexadoku 2-2008** (please copy exactly).

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

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

PRIZE WINNERS

The solution of the December 2007 puzzle is: **97C65**. The **E-blocks Starter Kit Professional** goes to: Tim Eames (UK).

An **Elektor SHOP voucher worth £35.00** goes to: Kjell A. Løver (N); Terje Daleng (N) and Charles Metcalfe (SA).

Congratulations everybody!

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

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

Programmable disco lights array (1984)



Jan Buiting

Some time during the early 1980s, a trend grew to add light effects and someone called 'disc jockey' to parties originally about drinking, socializing and getting your ears slammed with loud music. 'Disco' was born and what a hype it was — not just pounding electronic drums and synthesizers but also glamorous matching attire for all & sundry under 20 or so.

The drinks and music were handed down by the 70's scene but the lights were relatively new. The best disco was one with several dark nooks and crannies, badly lit bars, a very loud PA, a disc jockey with a not too small ego and, most importantly, a brutally illuminated dance floor for everyone to show off nimbleness or, like Mr Bean, make a complete fool of himself.

Elektor in 1984 saw a niche for a disco lights controller that was unusual and novel in not being limited to dull, fixed light patterns. In other words, the keen

user of the ambitious project printed in the February 1984 issue of *Elektor* could really make the crowd go bezerk with light effects far more 'groovy' than those of a simple light organ, a couple of coloured floodlights and of course the corny globes on the ceiling.

The *Elektor* project offered no fewer than 32 programs in memory to control up to 30 lights individually. The associated triac driver unit was a separate unit described in, you guessed it, the March 1984 issue.

The disco lights controller used four 2 k × 8 static RAMs type 6116 or 5517 for its memory. The light patterns were 'programmed' using flip switches and LEDs on the front panel. A couple of 7-segment LED displays were provided to act as readouts for addresses, banks and programmes. Funny to think that all three terms have survived right into the microcontroller and FPGA era we're enjoying right now.

A clever speed control ('clock')

was added to the circuit, helping the DJ or MC to link the speed of the light effects to the bpm (beats per minute) of the music played. Patterns could be 'stepped' too, and there was even a repeat timer with a range of 1/8th to 1/6 minutes. How primitive it looks now compared with auto-bpm-locking sound and light equipment available today.

To make sure the many hours of meticulous programming of light patterns into all four banks were not a waste a time when the unit was switched off, a memory backup battery was provided on the CMOS RAM supply. It consisted of three AA Nicads or 1.5 V alkalines in a plastic holder mounted off the board (good! no risk of corroding the board). If dry cells were used, a resistor had to be cut to prevent charging.

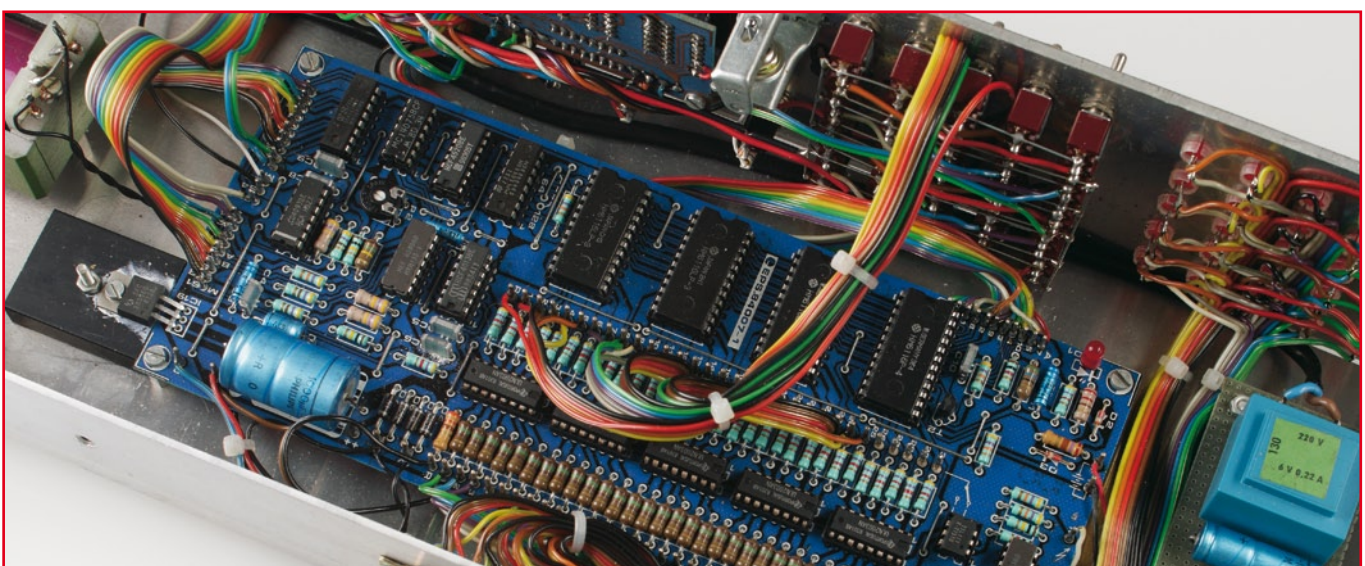
The prototype of the *Elektor* Discolights unit I rescued from our old offices in Beek, Holland, measures 48×17×8.5 cms in a clear attempt at making it 19-inch rack compatible. The unit

was impeccably built by Jan Visser who's still on our lab staff. At Jan's advice I removed 3 Nicads from the battery holder and found that they were certainly beyond rescue after a good 25 years.

A large sub-D connector is available at the rear side to hook up the triac power controller. The large blue circuit board is typically 'Elektor', single-sided (!) and stuffed with components like 0.25 watt carbon resistors, high IC sockets, blue electrolytics, wire links, solder pins and of course those horrible 'naked' grey&silver MKT capacitors. These parts now strike me as 'bulky' but then that's no more than a heavily SMD-affected perception.

With 3 kilowatts or so flashing under triac control the complete discolights kit must have been a regular EMC nightmare but then nobody cared about such EU regulations any more than being home in bed after the disco closed!

(070856-1)



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

ELEKTOR SHOWCASE

To book your showcase space contact Huson International Media

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

ATC SEMITEC LTD

www.atcsemitec.co.uk

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

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

Call today for free samples and pricing

Tel: 01606 871680 Fax: 01606 872938

AVIT RESEARCH

www.avitresearch.co.uk

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



See our webpage for more details. From £10.00.

BETA LAYOUT

www.pcb-pool.com

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



BOWOOD ELECTRONICS LTD

www.bowood-electronics.co.uk

Suppliers of Electronic Components

- Semiconductors
- Opto Electronics
- Passives
- Enclosures
- Switches
- Stripboard
- PCB Materials
- Popular Special Offer Packs

Online Store, all major cards

Same day despatch upto 3.00pm

Personal Service sales@bowood-electronics.co.uk

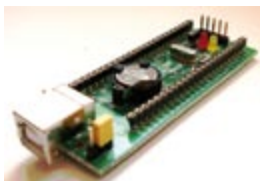
BYVAC ELECTRONICS

www.byvac.co.uk

32Bit ARM

Microcontroller, USB, built in RTC with it's own operating system, no complex tools, just a

terminal emulator, start writing programs in 20 minutes. Complete with CD-ROM, Software and 100 Page Foundation book



DECIBIT CO.LTD.

www.decibit.com

Smallest 2.4 GHz ISM band MCU embedded transceiver modules. Complete tiny solution, ready to transmit RF data by only attaching as example a CR2032 coin cell to it.



DESIGNER SYSTEMS

<http://www.designersystems.co.uk>

Professional product development services.

- Marine (Security, Tracking, Monitoring & control)
- Automotive (AV, Tracking, Gadget, Monitoring & control)
- Industrial (Safety systems, Monitoring over Ethernet)
- Telecoms (PSTN handsets, GSM/GPRS)
- AudioVisual ((HD)DVD accessories & controllers)



EasyDAQ

www.easydaq.biz

We design & supply low cost USB/RS232 based data acquisition, automation & control products:

- USB connected & powered, 8 opto isolated voltage inputs chans, 4DIO & 4 onboard relays capable of switching 240V@10A. With Labview, VC & VB examples - £60



EASYSYNC

<http://www.easysync.co.uk>

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



ELNEC

www.elnec.com

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



YOUR ELECTRONICS OPEN SOURCE

<http://dev.emcelettronica.com>

Website full of Projects and Resources for Electronics Engineers and DIY.

- Tutorial
- Hardware (Schematic & Gerber)
- Firmware (Asm & C)
- Reference Design

Everyone can submit a story as a useful source! 'Share for life'



FIRST TECHNOLOGY TRANSFER LTD.

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

Microchip Professional C and Assembly Programming Courses. The future is embedded.



Microchip Consultant / Training Partner developed courses:

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

FLEXIPANEL LTD

www.flexipanel.com

TEAclippers - the smallest PIC programmers in the world, from £20 each:

- Per-copy firmware sales
- Firmware programming & archiving
- In-the-field firmware updates
- Protection from design theft by subcontractors



FUTURE TECHNOLOGY DEVICES

<http://www.ftdichip.com>

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

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



FUTURLEC

<http://www.futurlec.com>

Save up to 60% on

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

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



ILP ELECTRONICS LTD

www.ilpelectronics.com

Tel +441233750481

Fax +441233750578

ILP have been manufacturing audio modules since 1971 and apart from our standard range we also offer a custom design service for the OEM market.



LONDON ELECTRONICS COLLEGE

<http://www.lec.org.uk>

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

products and services directory

MARCHAND ELECTRONICS INC.

www.marchandelec.com

- power amplifier modules
- electronic crossovers
solid state / valve / passive
- valve amplifiers
- phono preamps
- handheld sinewave generator
- kits or assembled
- software electronic instruments
- custom design services



MQP ELECTRONICS

www.mqp.com

- Low cost USB Bus Analysers
- High, Full or Low speed captures
- Graphical analysis and filtering
- Automatic speed detection
- Bus powered from high speed PC
- Capture buttons and feature connector
- Optional analysis classes



NEW WAVE CONCEPTS

www.new-wave-concepts.com

Software for Hobbyists:

- Livewire - circuit simulation software, only £34.99
 - PCB Wizard - PCB design software, only £34.99
 - Circuit Wizard - circuit, PCB and breadboard design software, only £59.99
- Available from all Maplin Electronics stores and www.maplin.co.uk



RADIOMETRIX

www.radiometrix.com

The leading global developer of ISM band, low power radio modules for wireless data transmission:

- Transmitters • Receivers • Transceivers
- RF modems • Evaluation Kits



ROBOT ELECTRONICS

<http://www.robot-electronics.co.uk>

Advanced Sensors and Electronics for Robotics

- Ultrasonic Range Finders
- Compass modules
- Infra-Red Thermal sensors
- Motor Controllers
- Vision Systems
- Wireless Telemetry Links
- Embedded Controllers



ROBOTIQ

<http://www.robotiq.co.uk>

Build your own Robot!
Fun for the whole family!

- Meccano™ Compatible
- Computer Control
- Radio Control
- Tank Treads
- Hydraulics



Internet Technical Bookshop,
1-3 Fairlands House, North Street, Carshalton,
Surrey SM5 2HW
email: sales@robotiq.co.uk Tel: 020 8669 0769

COMPONENTBIN.COM

www.componentbin.com

Kickstart your development with modules and parts from componentbin.com

- ARM7 modules
- Ethernet modules
- Superb Graphic LCD displays (all with example software)



and much much more...

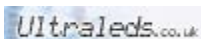
Online ordering and great prices!

ULTRALEDS

<http://www.ultraleds.co.uk>

tel: 0871 7110413 / 01625 576778

Large range of low cost Ultra bright leds and Led related lighting products. Major credit cards taken online with same day despatch.



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.



VIRTINS TECHNOLOGY

www.virtins.com

PC and Pocket PC based virtual instrument such as sound card real time oscilloscope, spectrum analyzer, signal generator, multimeter, sound meter, distortion analyzer, LCR meter. Free to download and try.



SHOWCASE YOUR COMPANY HERE

Elektor Electronics has a feature to help customers promote their business, Showcase - a permanent feature of the magazine where you will be able to showcase your products and services.

- For just £220 + VAT (£20 per issue for eleven issues) Elektor will publish your company name, website address and a 30-word description
- For £330 + VAT for the year (£30 per issue for eleven issues) we will publish the above plus run a 3cm deep full colour

image - e.g. a product shot, a screen shot from your site, a company logo - your choice

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

I wish to promote my company, please book my space:

- Text insertion only for £220 + VAT
- Text and photo for £330 + VAT

NAME: ORGANISATION:

JOB TITLE:

ADDRESS:

..... TEL:

PLEASE COMPLETE COUPON BELOW AND FAX BACK TO 00-44-(0)1932 564998

COMPANY NAME

WEB ADDRESS

30-WORD DESCRIPTION

.....

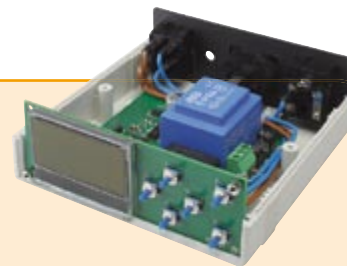
.....

.....

.....

Going Strong

A world of electronics
from a single shop!



Reflow Solder Controller

(December 2007)

The Elektor lab needs to solder SMDs more often these days, something that undoubtedly also applies to many of our readers. In the January 2006 issue we described in some detail how you could build your own reflow oven using an inexpensive electric oven. That article resulted in many comments from our readers, which confirmed to us that there was a lot of interest in such a project. We now present a completely new version of the control electronics for a DIY SMD oven.

Populated PCB with enclosure

Art. # 060234-91 • £171.80 • US\$ 343.60



USB Flash Board

(November 2007)

Flash microcontrollers are easy to program. In the past, program code was usually downloaded via a serial interface, but nowadays many PCs (especially laptops) only have USB ports. This versatile Flash Board provides a solution to this problem. It is built around an AT89C5131A, which is an extended 8051-family microcontroller with an 80C52 core and a Full Speed USB port. As a sort of bonus, the IC has a complete update interface for downloading new firmware. Atmel also provides suitable software in the form of its FLIP program, which is available free of charge.

Construction kit including the PCB and all parts

Art. # 070125-71 • £36.20 • US\$ 72.40

Detect stuffy air before you doze off

CO₂ Measurement

(January 2008)

Carbon dioxide (CO₂) is not just a threat to the environment, it is also an important and often ignored factor in determining air quality in the office and at home. Too high a concentration of CO₂ leads to feelings of tiredness, disturbs concentration, and causes headaches. The Elektor CO₂ meter makes it easy to determine the concentration of carbon dioxide in the air. A microcontroller monitors the measured value and can trigger an alarm or start up a ventilation system when a preset threshold is exceeded.

Kit of parts, PCB, Sensor PCB, ATtiny26 and display

Art. # 070802-71 • £107.50 • US\$ 215.00

NEW!



NEW!

All articles published in 2007

Elektor 2007

Year volume CD-ROMs are among the most popular items in Elektor's product range. This CD-ROM contains all editorial articles published in Elektor Volume 2007. Using the supplied Acrobat Reader program, articles are presented in the same layout as originally found in the magazine. An extensive search machine is available to locate keywords in any article.

978-90-5381-218-1 • £16.90 • US\$ 33.80



Bestseller!

More than 68,000 components

Elektor's Components Database 4

The program package consists of eight databanks covering ICs, germanium and silicon transistors, FETs, diodes, thyristors, triacs and optocouplers. A further eleven applications cover the calculation of, for example, LED series droppers, zener diode series resistors, voltage regulators and AMVs. A colour band decoder is included for determining resistor and inductor values. ECD 4 gives instant access to data on more than 68,000 components. All databank applications are fully interactive, allowing the user to add, edit and complete component data. This CD-ROM is a must-have for all electronics enthusiasts.

ISBN 978-90-5381-159-7 • £15.90 • US\$ 31.80

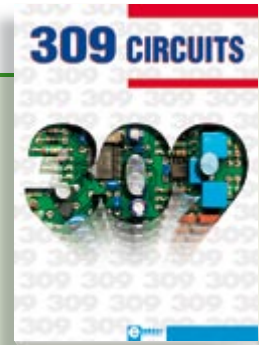


Bestseller!

Silent alarm, poetry box, night buzzer and more!

PIC Microcontrollers

This hands-on book covers a series of exciting and fun projects with PIC microcontrollers. You can build more than 50 projects for your own use. The clear explanations, schematics, and pictures of each project on a breadboard make this a fun activity. You can also use it as a study guide. The technical background information in each project explains why the project is set up the way it is, including the use of datasheets. This way you'll learn a lot about the project and the microcontroller being used. Even after you've built all the projects it will still be a valuable reference guide to keep next to your PC.

446 pages • ISBN 978-0-905705-70-5
£27.00 • US\$ 54.00

Fully elaborated electronics projects

309 Circuits

The present tenth edition of the popular '30x Circuits' series of books once again contains a comprehensive variety of circuits, sub-circuits, tips and tricks and design ideas for electronics. Among many other inspiring topics, the following categories are well presented in this book: test & measurement; RF (radio); computers and peripherals; audio & video; hobby and modelling; microcontrollers; home & garden; power supplies & battery chargers; etcetera.

432 pages • ISBN 978-0-905705-69-9
£19.95 • US\$ 39.95

5.0, 6.0, VBA, .NET, 2005

Visual Basic for Electronics Engineering Applications

This book is targeted towards those people that want to control existing or self-built hardware from their computer. After familiarizing yourself with Visual Basic, its development environment and the tool-set it offers are discussed in detail. Each topic is accompanied by clear, ready to run code, and where necessary, schematics are provided that will get your projects up to speed in no time.

476 pages • ISBN 978-0-905705-68-2
£29.00 • US\$ 58.00More information on the
Elektor Website:

www.elektor.com

Elektor
Regus Brentford
1000 Great West Road
Brentford
TW8 9HH
United Kingdom
Tel.: +44 20 8261 4509
Fax: +44 20 8261 4447
Email: sales@elektor.com

elektor SHOP

February 2008 (No. 374)

£ US\$

LEDBUS System

070459-1	PCB, power module	.....	see	www.elektor.com
070459-2	PCB, central	.....	see	www.elektor.com
070459-41	Programmed microcontroller, power module	.....	see	www.elektor.com
070459-42	Programmed microcontroller, central	.....	see	www.elektor.com

RGB LED Mood Lighting

070892-1	Printed circuit board	.....	see	www.elektor.com
070892-2	Printed circuit board	.....	see	www.elektor.com
070892-3	Printed circuit board	.....	see	www.elektor.com
070892-41	Programmed microcontroller	.....	see	www.elektor.com

Surround Light for PC Monitor

070491-1	Printed circuit board	.....	21.50	.....	43.00
070491-2	Printed circuit board	.....	5.00	.....	10.00
070491-91	PCB, partly populated with SMDs	.....	see	www.elektor.com	

LED Ringflash

070612-1	Printed circuit board	.....	www.thePCBshop.com		
070612-41	Programmed controller	.....	10.50	.....	21.00
070612-81	Software on CD-ROM	.....	5.20	.....	10.40

TV Surround Light

070487-1	Printed circuit board	.....	21.50	.....	43.00
070487-41	Programmed microcontroller	.....	12.70	.....	25.40
070487-42	Programmed microcontroller	.....	10.50	.....	21.00
070487-81	Software on CD-ROM	.....	5.20	.....	10.40

CAN Explorer

060201-1	Printed circuit board, MCP2515 and MCP2551SN	.....	see	www.elektor.com
060201-W	Testing & Error Sources Manual	.....	see	www.elektor.com

Thermometer / Thermostat

070852-11	Software	see	www.elektor.com
-----------	----------	-------	-----	-----------------

January 2008 (No. 373)

CO₂ Measurement

070802-1	PCB, bare	.....	14.40	.....	28.80
070802-41	Programmed controller ATtiny26	.....	7.20	.....	14.40
070802-71	Kit of parts, PCB, Sensor PCB, ATtiny26 and display	.....	107.50	.....	215.00
070802-81	Software on CD-ROM	.....	5.20	.....	10.40

Anti-Standby Switch

070797-1	PCB, bare	.....	14.40	.....	28.80
070797-41	ATtiny25, programmed	.....	5.20	.....	10.40

Control for Energy-saving Lamps

070638-71	PCB, FAN7710N and 2.5mH coil	14.40	28.80
-----------	------------------------------	-------	-------	-------	-------

Versatile DC Power Meter

070559-1	PCB, bare	.....	9.30	.....	18.60
070559-41	Programmed controller ATmega8-16P	.....	9.00	.....	18.00

December 2007 (No. 372)

Reflow Solder Controller

060234-91	Populated PCB with enclosure	171,80	343,60
-----------	------------------------------	-------	--------	-------	--------

AVR Web Server

060257-1	Printed circuit board	.....	9,60	.....	19,20
060257-41	ATmega644, programmed	.....	13,80	.....	27,60

Craft Drill Controller

060291-1	Printed circuit board	www.thePCBshop.com
----------	-----------------------	-------	--------------------

Christmas Flasher

010032-91	Kit of parts	3,60	7,20
-----------	--------------	-------	------	-------	------

LED's Dive!

070011-1	Printed circuit board	www.thePCBshop.com
----------	-----------------------	-------	--------------------

November 2007 (No. 371)

USB Data Acquisition Card

070148-1	PCB, bare	.....	9.50	.....	19.00
070148-41	PIC18F4550 DIP40, programmed	.....	15.50	.....	31.00
070148-81	Software on CD-ROM	.....	5.20	.....	10.40

Line Switcher

060288-1	PCB, bare	www.thePCBshop.com
----------	-----------	-------	--------------------

Headphone Amp with 3D Sound

070393-1	PCB, bare	www.thePCBshop.com
----------	-----------	-------	--------------------

Bestsellers

Books	1	↑	PIC Microcontrollers ISBN 978-0-905705-70-5 £27.00 US\$ 54.00
	2	↘	309 Circuits ISBN 978-0-905705-69-9 £19.95 US\$ 39.95
	3	↘	Visual Basic for Electronics Engineering Applications ISBN 978-0-905705-68-2 £29.00 US\$ 58.00
	4	→	Microcontroller Basics ISBN 978-0-905705-67-5 £19.50 US\$ 39.00
	5	↘	PC Interfaces under Windows ISBN 978-0-905705-65-1 £27.25 US\$ 54.50
CD-ROMs	1	→	ECD4 ISBN 978-90-5381-159-7 £15.90 US\$ 31.80
	2	↘	Ethernet Toolbox ISBN 978-90-5381-214-3 £18.90 US\$ 37.90
	3	↘	Home Automation ISBN 978-90-5381-195-5 £13.90 US\$ 27.80
	4	↘	USB Toolbox ISBN 978-90-5381-212-9 £19.90 US\$ 39.80
	5	↑	Robotics ISBN 978-90-5381-179-5 £12.90 US\$ 25.80
Kits & Modules	1	→	USB Flash Board Art. # 070125-71 £36.20 US\$ 72.40
	2	↘	Reflow Solder Controller Art. # 060234-91 £171.80 US\$ 343.60
	3	↑	CO₂ Measurement Art. # 070802-71 £107.50 US\$ 215.00
	4	↘	Stand Alone OBD-2 Analyser Art. # 070038-72 £55.20 US\$ 110.40
	5	→	USBprog Art. # 060224-71 £18.80 US\$ 37.60

Order quickly and safe through
www.elektor.com/shop
 or use the Order Form near the end
 of the magazine!



Elektor
 Regus Brentford
 1000 Great West Road
 Brentford TW8 9HH • United Kingdom
 Tel. +44 20 8261 4509
 Fax +44 20 8261 4447
 Email: sales@elektor.com

Prices and item descriptions subject to change. E. & O.E

MAY WE OFFER YOU SOME MORE?

You save:	Subscription PLUS
£39.00	10 magazines
+ £5.80	1 double issue (July/August)
+ £16.90	Annual-CD-ROM
+ £34.50	1 GB MP3 player

= £96.20	total value of individual items
- £49.00	Elektor year subscription PLUS

= £47.20	your saving

The Elektor PLUS subscription

Keep **£47.20** in your pocket!

11 x Elektor PLUS:

- Cheaper than 11 issues from the newsstand
- Subscribers get up to **40% discount** on special Elektor products
- As a welcome gift you get a **free** 1 GB MP3 player worth £34.50
- No queues, travelling, parking fees or "sold out" Elektor is supplied to your doorstep every month
- Always up to date – read your copy before everyone else



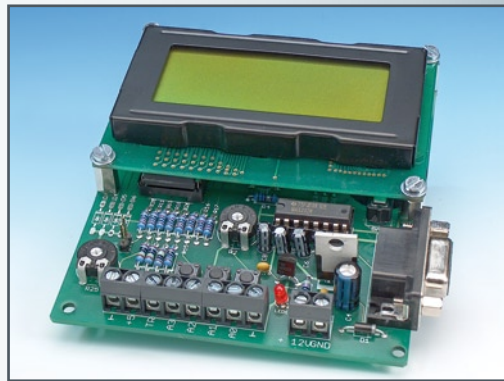
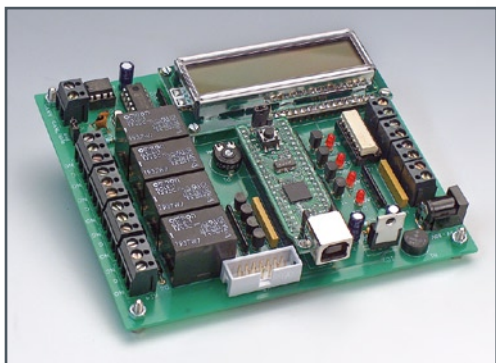
www.elektor.com/subs
Tel. +44 (0) 20 8261 4509

Or use the subscription order form near the end of the magazine.

elektor
electronics worldwide

Data logger with flash memory

Sure, data loggers have been published before in *Elektor*, but this one's special with an LCD and a serial connection. The logger has four analogue inputs and a measurement range of 0 to 5 V. Data is stored in flash memory using an SD memory card fitted on the board. Five different logging modes are available: manual triggering, external trigger-



ECIO PLC board

Here's the first real-life application of ECIO modules introduced in the October 2007 issue of *Elektor*. An ECIO module acts as the brains of a PLC board that has relays, opto-isolators, CAN connectivity and an LCD. All this I/O capacity together with Flowcode allow the board to act as versatile, powerful PLC for quite complex control and automation projects. The LCD module is used to display ASCII characters to the user as a means of troubleshooting during the software development stage or for monitoring the system.

I²C analyser

The I²C or 'Inter-IC' bus has seen applications for many years already as 'glue' between complex ICs in electronic equipment. The simplicity of the I²C bus really calls for DIY applications. Unfortunately, tracing error conditions on the I²C bus is not trivial and in fact requires special test equipment. Our I²C analyser is simple and easy to use. The compact circuit is hooked up to an I²C bus and displays received data on the PC via a USB connection. The PC does all the data dissecting using clever software.

RESERVE YOUR COPY NOW!

UK mainland subscribers will receive the magazine between 22 and 25 February 2008.

The March 2008 issue goes on sale on Thursday 28 February 2008 (UK distribution only).

Article titles and magazine contents subject to change, please check www.elektor.com.

NEWSAGENTS ORDER FORM

SHOP SAVE / HOME DELIVERY

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

Name:

Address:

Post code:

Telephone:

Date:

Signature:



Please cut out or photocopy this form, complete details and hand to your newsagent.

Elektor is published on the third Thursday of each month, except in July.

Distribution S.O.R. by Seymour (NS).

www.elektor.com www.elektor.com www.elektor.com www.elektor.com www.elektor.com

Elektor on the web

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

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

Also on the Elektor website:

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



ORDERING INSTRUCTIONS, P&P CHARGES

Except in the USA and Canada, all orders, except for subscriptions (for which see below), must be sent BY POST or FAX to our Brentford address using the Order Form overleaf. Online ordering: www.elektor.com/shop

Readers in the USA and Canada may (but are not obliged to) send orders, except for subscriptions (for which see below), to the USA address given on the order form. Please apply to Old Colony Sound for applicable P&P charges. Please allow 4-6 weeks for delivery.

Orders placed on our Brentford office must include P&P charges (Priority or Standard) as follows: Europe: £6.00 (Standard) or £7.00 (Priority) Outside Europe: £9.00 (Standard) or £11.00 (Priority)

HOW TO PAY

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

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

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

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

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

COMPONENTS

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

TERMS OF BUSINESS

Delivery Although every effort will be made to dispatch your order within 2-3 weeks from receipt of your instructions, we can not guarantee this time scale for all orders. **Returns** Faulty goods or goods sent in error may be returned for replacement or refund, but not before obtaining our consent. All goods returned should be packed securely in a padded bag or box, enclosing a covering letter stating the dispatch note number.

If the goods are returned because of a mistake on our part, we will refund the return postage. **Damaged goods** Claims for damaged goods must be received at our Brentford office within 10-days (UK); 14-days (Europe) or 21-days (all other countries). **Cancelled orders** All cancelled orders will be subject to a 10% handling charge with a minimum charge of £5.00. **Patents** Patent protection may exist in respect of circuits, devices, components, and so on, described in our books and magazines. Elektor 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 in writing. Such written permission must also be obtained before any part of these publications is stored in a retrieval system of any nature.

Notwithstanding the above, printed-circuit boards may be produced for private and personal use without prior permission. **Limitation of liability** Elektor shall not be liable in contract, tort, or otherwise, for any loss or damage suffered by the purchaser whatsoever or howsoever arising out of, or in connexion with, the supply of goods or services by Elektor other than to supply goods as described or, at the option of Elektor, 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 shall be determined in all respects by the laws of England.

September 2007

SUBSCRIPTION RATES FOR ANNUAL SUBSCRIPTION

	Standard	Plus
United Kingdom	£42.00	£49.00
Surface Mail		
Rest of the World	£56.00	£63.00
Airmail		
Rest of the World	£71.00	£78.00

USA & Canada For US\$-prices please check www.elektor.com

HOW TO PAY

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

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

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

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

SUBSCRIPTION CONDITIONS

The standard subscription order period is twelve months. If a permanent change of address during the subscription period means that copies have to be despatched by a more expensive service, no extra charge will be made. Conversely, no refund will be made, nor expiry date extended, if a change of address allows the use of a cheaper service.

Student applications, which qualify for a 20% (twenty per cent) reduction in current rates, must be supported by evidence of student-ship signed by the head of the college, school or university faculty. A standard Student Subscription costs £33.60, a Student Subscription-Plus costs £39.20 (UK only).

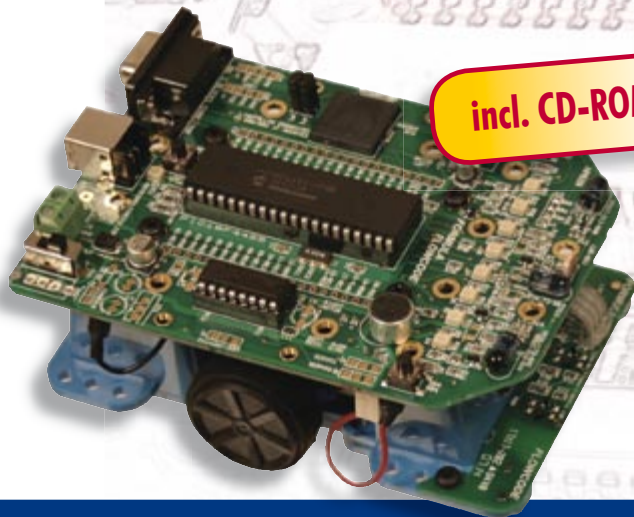
Please note that new subscriptions take about four weeks from receipt of order to become effective.

Cancelled subscriptions will be subject to a charge of 25% (twenty-five per cent) of the full subscription price or £7.50, whichever is the higher, plus the cost of any issues already dispatched. Subscriptions cannot be cancelled after they have run for six months or more.

January 2008

Formula Flowcode Buggy

USB-programmable robot vehicle



incl. CD-ROM

- A complete solution: robot + software + curriculum
- Line following and maze solving
- High-tech specifications
- Also programmable with C or ASM
- E-blocks compatible
- Motivating for education and hobby

Ready to use only £85.00 • US\$ 169.00

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

Elektor
Regus Brentford • 1000 Great West Road
Brentford TW8 9HH
United Kingdom
Tel. +44 20 8261 4509



Order quickly and safe through www.elektor.com/shop

INDEX OF ADVERTISERS

Allendale Electronics Ltd	www.pcb-soldering.co.uk	11	Mikro Elektronika	www.mikroe.com	13
Antex Electronics Ltd	www.antex.co.uk	41	MQP Electronics, Showcase	www.mqp.com	79
ATC Semitec Ltd, Showcase	www.atcsemitec.co.uk	78	New Wave Concepts, Showcase	www.new-wave-concepts.com	79
Avit Research, Showcase	www.avitresearch.co.uk	78	Newbury Electronics	www.newburyelectronics.co.uk	59
Beijing Draco	www.ezpcb.com	49	Number One Systems	www.numberone.com	49
Beta Layout, Showcase	www.pcb-pool.com	59, 78	Nurve Networks	www.xgamestation.com	59
Bitscope Designs	www.bitscope.com	3	SK Pang Electronics	www.skpang.co.uk	49
Bowood Electronics Ltd, Showcase	www.bowood-electronics.co.uk	78	Peak Electronic Design	www.peakelec.co.uk	59
Byvac Electronics, Showcase	www.byvac.co.uk	78	Pico	www.picotech.com	15
Decibit Co. Ltd, Showcase	www.decibit.com	78	Quasar Electronics	www.quasarelectronics.com	65
Designer Systems, Showcase	www.designersystems.co.uk	78	Radiometrix, Showcase	www.radiometrix.com	79
EasyDAQ, Showcase	www.easydaq.biz	78	Robot Electronics, Showcase	www.robot-electronics.co.uk	79
Easysync, Showcase	www.easysync.co.uk	78	Robotiq, Showcase	www.robotiq.co.uk	79
Eltec, Showcase	www.eltec.com	78	Showcase		78, 79
Eurocircuits	www.eurocircuits.com	57	Tsien (UK) Ltd, Showcase	www.componentbin.com	79
First Technology Transfer Ltd, Showcase	www.ftt.co.uk	78	Ultraleds, Showcase	www.ultraleds.co.uk	79
FlexiPanel Ltd, Showcase	www.flexipanel.com	78	USB Instruments, Showcase	www.usb-instruments.com	79
Future Technology Devices, Showcase	www.ftdichip.com	78	Virtins Technology, Showcase	www.virtins.com	79
Futurlec, Showcase	www.futurlec.com	78	Your Electronics Open Source, Showcase	http://dev.emcelettronica	78
ILP Electronics Ltd, Showcase	www.ilpelectronics.com	78			
Jaycar Electronics	www.jaycarelectronics.co.uk	2			
Labcenter	www.labcenter.com	88			
London Electronics College, Showcase	www.lec.org.uk	78			
Marchand Electronics Inc, Showcase	www.marchandelec.com	79			

**Advertising space for the issue of 25 March 2008
may be reserved not later than 26 February 2008**

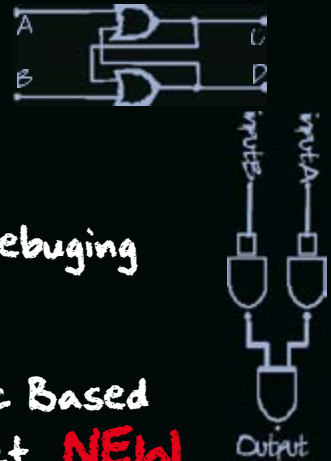
with Huson International Media – Cambridge House – Gogmore Lane – Chertsey, Surrey KT16 9AP – England – Telephone 01932 564 999 – Fax 01932 564998 – e-mail: gerryb@husonmedia.com to whom all correspondence, copy instructions and artwork should be addressed.

PROTEUS

DESIGN
SUITE

COMPUTER ~~AIDED~~ DESIGN ENHANCED

- Powerful, Easy to Use Schematic Capture
- Interactive Mixed Mode SPICE Simulation
- Unique Microcontroller Co-Simulation and Debugging
- Fully Featured PCB Design and 3D Viewer



+

Worlds First Schematic Based
USB Simulation Product **NEW**

=

- Complete Engineering Solution
- Rapid Development Environment
- Maximum Return on Investment
- Faster Time to Market



WINTER SPECIAL OFFER

20% off all new orders for the Proteus Design Suite when you spend £400 or more.

Electronic Design from Concept To Completion

LABCENTER ELECTRONICS LTD

A technology Pioneer in the EDA industry since 1988.
Technical support direct from the program authors.
Flexible packages and pricing tailored to customer requirements.

CONTACT US NOW

to discuss your requirements or
request a FREE evaluation copy.

labcenter  www.labcenter.com
Electronics

TEL: +44 (0)1756 753440
FAX: +44 (0)1756 752857
Email: info@labcenter.com

Labcenter Electronics Ltd., 53-55 Main Street, Grassington
North Yorks, BD23 5AA. Registered in England 4692454