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DOUBLE SUMMER ISSUE

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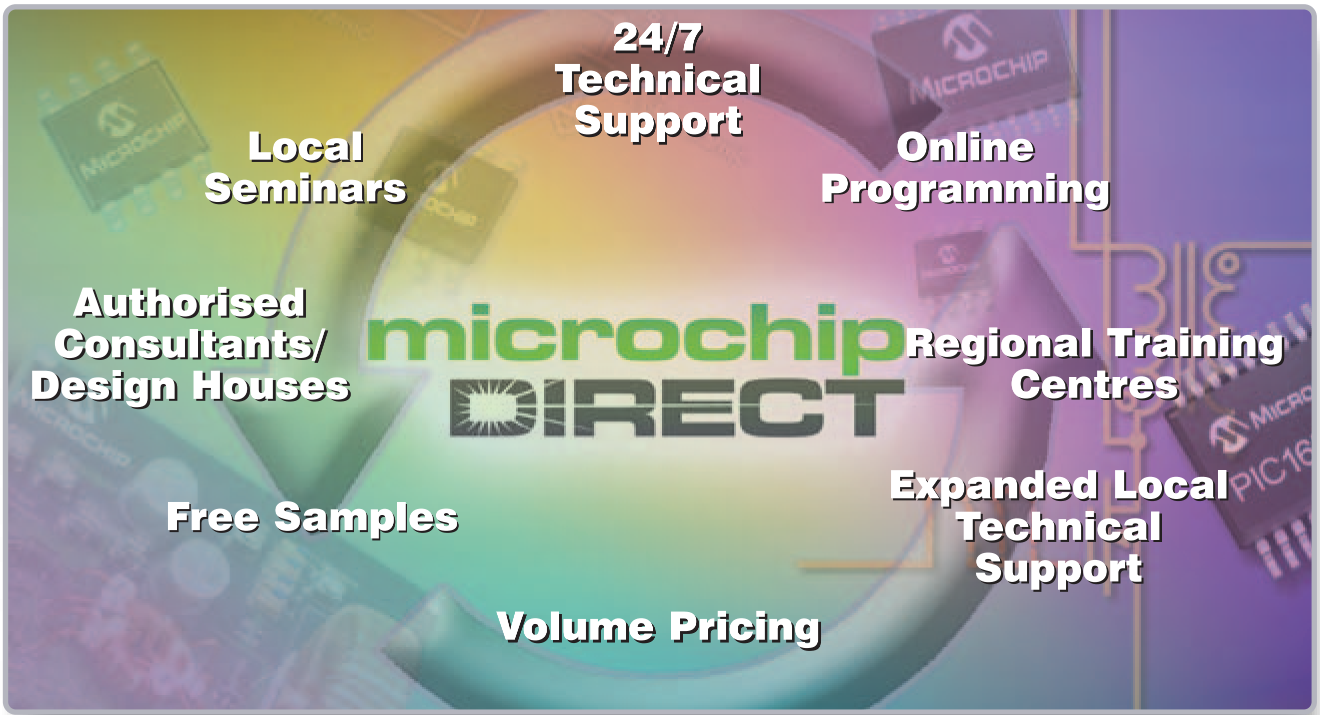

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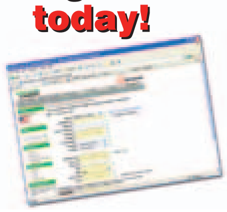

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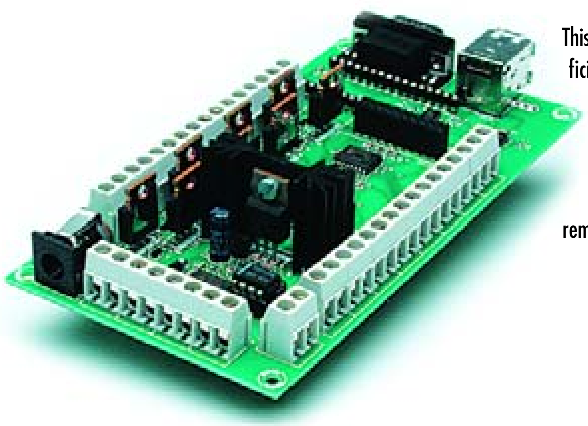
16 Gameboy PLC

Here we present GBPLC, a PLC based on the Nintendo GameBoy. Ready-assembled and tested boards are available through a reverse auction on our website!

24 I²C I/O Box



This add-on for the GBPLC offers sufficient I/O capacity to control roller shutters, outside lighting, curtains, an alarm system, the central heating system and even more, possibly even remotely via TXT (SMS) messages.

28 ElectroShack

Photoshoot showing how to totally clutter a bed-sitter with electronics

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Summer

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July/August 2006
no. 356

CIRCUITS 2006

Bold article title = PCB design included

102 Cracker Articles
no one has more
in a single issue
(or a year volume)

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Volume 32, Number 356, July/August 2006 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 Electronics (Publishing), Regus Brentford, 1000 Great West Road, Brentford TW8 9HH, England. Tel. (+44) (0) 208 261 4509, fax: (+44) (0) 208 261 4447 www.elektor-electronics.co.uk.

The magazine is available from newsagents, bookshops and electronics retail outlets, or on subscription. *Elektor Electronics* is published 11 times a year with a double issue for July & August.

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

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Internet: www.elektor-electronics.co.uk
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Rates and terms are given on the Subscription Order Form

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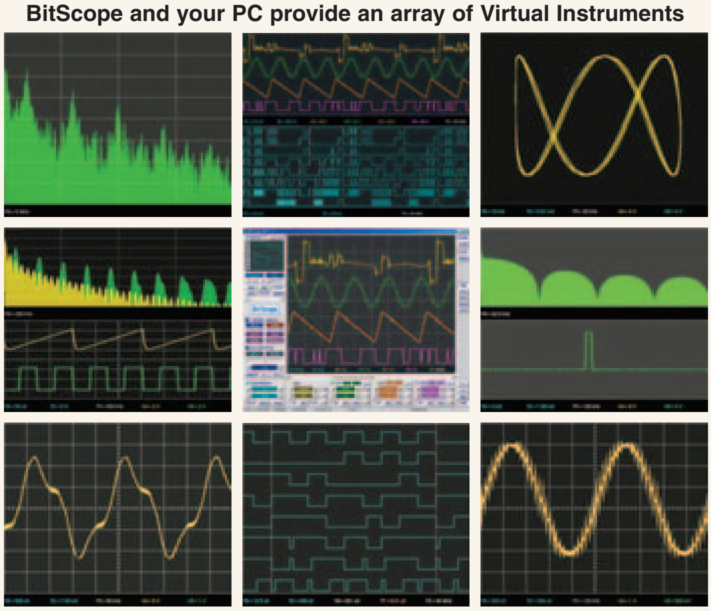

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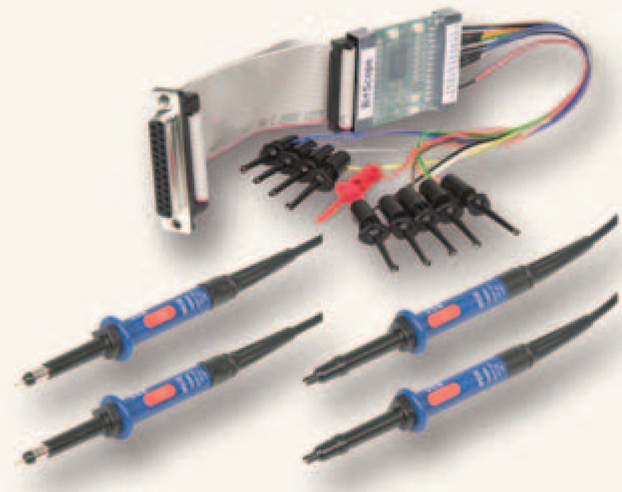

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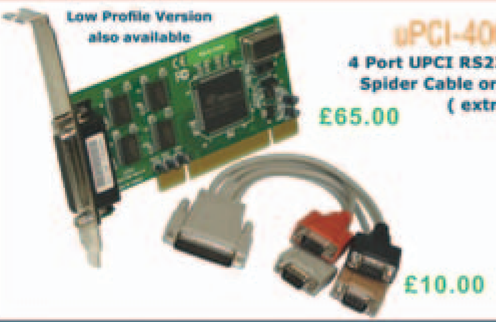

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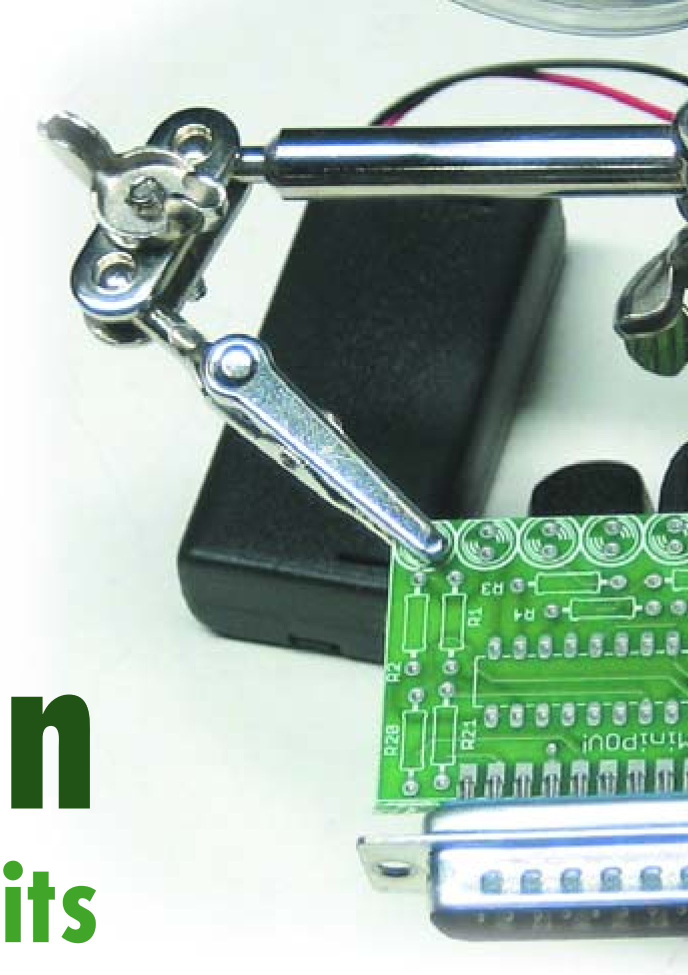

Hands-on
Assembling Circuits

The minimum requirement for putting together a circuit is a soldering iron. A stand to hold the hot soldering iron is also very convenient. If you do a lot of soldering, it's a good idea to buy a temperature-regulated soldering station that always provides the correct soldering temperature.

Soldering tips

A soldering iron with a narrow bent tip is highly practical for soldering small components located between other large components. In that case, the entire iron must be relatively thin, and not just the tip. Various types of soldering tips, as well as special miniature soldering irons, are available for soldering SMD components (see inset), A good pair of tweezers is nearly indispensable for working with SMDs. A magnifying glass or loupe can also come in handy for checking soldering points on circuit boards.

If you select a type of solder with a flux core, you won't need any additional flux for soldering. Desoldering braid is very handy for removing excess solder. The braided wick of thin copper wires 'sucks up' liquid solder. A solder sucker is more convenient for removing relatively large amounts of solder.

Always keep the tip of your soldering iron clean. You can use a damp sponge, special metal shavings, or a tip activator for that purpose. Adjust the iron to the proper temperature (approximately 370 °C) and ensure that your workplace has good lighting.

Most electronics enthusiasts will still use 'ordinary' lead/tin solder at home. However, make sure you also have lead-free solder on hand in case you need to make repairs on boards assembled using lead-free solder.

Assembling circuits

A piece of prototyping board is an excellent choice for assembling a small circuit. Several types of boards are available – with continuous copper strips, with independent islands, and with various other copper patterns. You can use thin, insulated copper wire to make connections between the various components.

A wide variety of adapter boards are available for experimenting with SMDs. Different types of SMD packages can be mounted on a small printed circuit board fitted with a standard 2.54-mm grid for headers and other components.

Making PCBs (or having them made)

Circuit board layouts are shown with some of the circuits in *Elektor Electronics*. Most of these circuit boards are available from *Elektor Electronics* or our business partner, The PCB Shop (Eurocircuits).

If you have designed a printed circuit board using a PCB layout program on your PC, you can make it yourself or have it made for you. There are several PCB firms these days (such as Eurocircuits and PCB-Pool) that make prototypes at acceptable prices, even for one-offs. Of course, you can also roll your own.

The first step is to use an inkjet or laser printer to make a good, opaque overlay film. Films specially designed for this purpose are commercially available. Use a hair dryer to dry the print after printing, and if necessary print the layout on top again to obtain good opacity.

After that you can use the film to expose the photosensitive circuit-board material (using a second-hand UV lamp, for instance).

You can use granulated iron chloride to etch the circuit board. It does not have to be heated, so it generates less vapour. That also means you can etch the board right away, because it works at room temperature. This chemical can be regenerated so it can be used several times, and it is less aggressive than other etchants.

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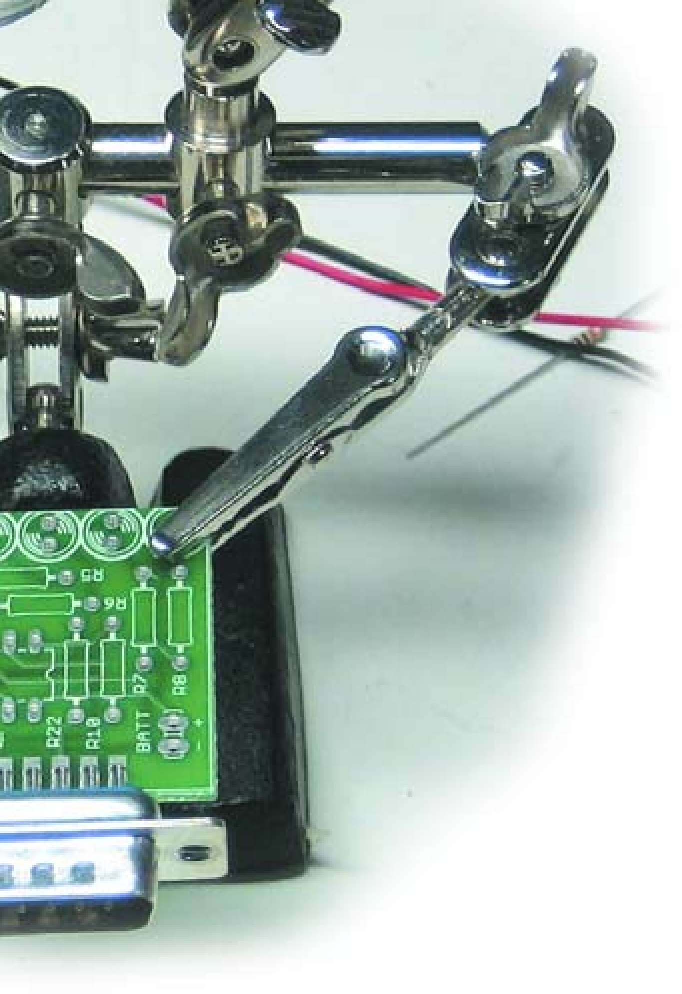
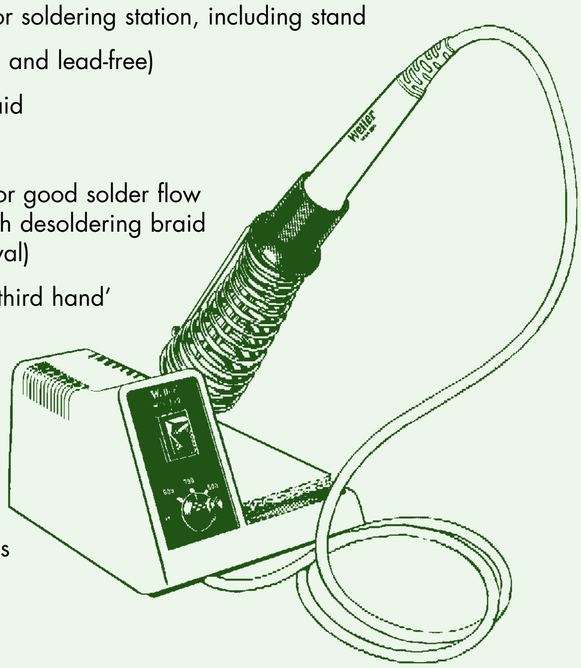
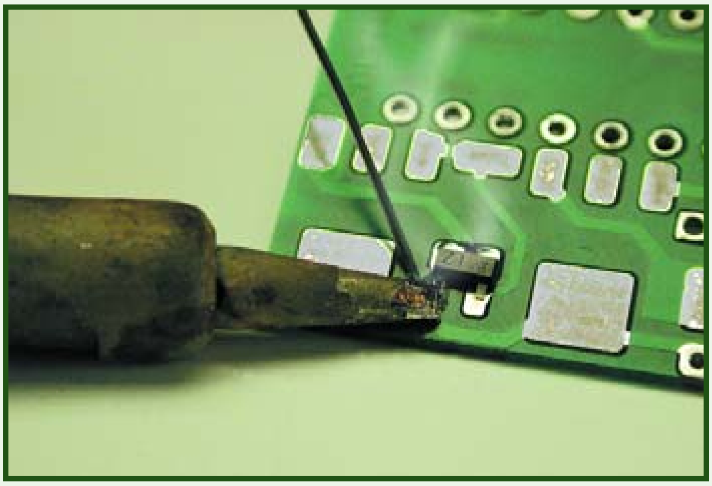
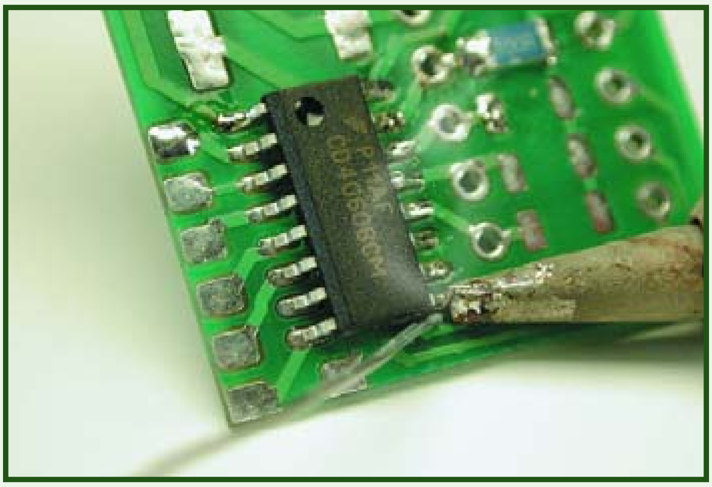


Standard tools

- Soldering iron or soldering station, including stand
- Solder (lead/tin and lead-free)
- Desoldering braid
- Solder sucker
- Soldering flux for good solder flow (also for use with desoldering braid for solder removal)
- PCB holder or 'third hand'
- Tweezers
- Cutters (side cutters) for cutting off protruding pins
- Loupe or magnifying glass







Soldering SMDs

It's perfectly possible to handle SMD components using the conventional method (a normal soldering iron with a fine point, solder, and extra flux for very small components).

First use tweezers to place the small components (such as resistors, capacitors and transistors) in the proper locations, and then secure one pin or solder pad using a drop of solder on the tip of the soldering iron.

Check whether the component is still properly positioned, and correct the position if necessary. After that, continue with the other solder pad(s) by heating the component and the solder pad. Feed solder under the rounded surface of the tip. The flux in the solder and the capillary action between the component and the solder pad will cause a tight solder joint to be formed. Finally, return to the first solder point, heat the solder already there, and add a bit more solder to create a sound solder joint here as well.

With a multi-pin IC, first align the IC properly and then solder one of the corner pins in place. Check the positioning again, and then solder a pin in place on the other side. If the IC is still properly positioned, you can now solder the other pins, taking care to allow enough time for IC to cool down in between. It's good practice to inspect your soldering afterward with a loupe. If there are shorts between the pins, you can use copper braid and liquid flux to remove the extra solder.

A different method can be used with ICs that have very narrow pins. After carefully aligning the IC and securing it at two corners, you can solder all the pins using a generous amount of solder. It doesn't matter if that causes shorts between the pins. Next, use desoldering braid to remove the excess solder, which will also eliminate the shorts between the pins.

Looking for a Nee

Searching for components can be difficult, particularly in case of newly announced types and types made by unknown manufacturers. A few tips and several good Internet addresses can make your search a lot easier.

Electronic component sales have increasingly shifted to the Internet during recent years, particularly in English-speaking countries. That's hardly surprising. It's nearly impossible for a local electronics shop to keep up with the enormous range of components and continuous stream of new components, so a larger-scale approach is necessary.

There's an especially good chance of encountering components in the Summer Circuits issue that are not so easy to obtain. If you at least know who the manufacturer is, you're already halfway there. Here we provide a few tips.

- Start with the manufacturer's website. Many manufacturers offer free samples. To obtain such parts, you usually have to look up the IC on the manufacturer's site, and then you can order samples. The conditions vary widely, but you often have to order using the name of a firm. However, it's certainly worthwhile to have a good look at this option.
- If you can't obtain free samples, there's another option. More and more manufacturers now have their own webshops where you can place small parts orders using a credit card. The advantage here is that the manufacturer knows exactly which of its own products it can supply. We have had good results with this method.
- Next, have a look at the adverts in our magazine. Start your search with a specialised mail-order company. Almost all such companies have websites where they sell special parts and construction kits. If you can't find what you're looking for there, try the large international mail-order firms such as Farnell and Digi-Key. The order charges are often relatively high with such firms, but you can keep them under control by waiting until you have accumulated a sufficiently large number of components or placing a large order with several colleagues or friends.
- Your search for a specific component may take you to a wholesaler or distributor. If you want to use the component for a personal project, you can take the address in question to your electronics dealer and ask whether he orders from there. For commercial use, you can simply place an order from your firm.
- There are also many firms on the

dle...

Buying components via the Internet

Internet that specialise in supplying spare parts for electronic equipment. They may also have special parts in their product lines. A common difficulty in such cases is that it's difficult to find a specific component because they use manufacturers' internal codes and part numbers. However, it can be worth the trouble.

• Finally, look beyond the border. For instance, there are a few specialised firms in Germany and the Netherlands where Elektor has a strong presence hence you can find components that are scarcely available anywhere else. Ordering is usually not a problem.

If your German or Dutch isn't that good, you can always try it in English!

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GBPLC – GameB

use a Nintendo GameBoy as a programmable logic controller for home automation

Sascha Koths & Stephan Ruloff,
in collaboration with Christian Müller

Home automation tasks – ranging from controlling roller shutters and awnings to alarm systems – can be handled nicely by small programmable logic controllers (PLCs). Here we present a very attractive approach that is convenient and inexpensive: the GBPLC, a PLC based on the Nintendo GameBoy. Ready-assembled and tested boards are available!

The key to this GameBoy transformation, like that of the legendary *Elektor Electronics* GameBoy oscilloscope (GBDSO), consists of a plug-in card with memory ICs for the application software and an I²C interface for communication with the outside world, but without its own processor. That allows the PLC to be programmed directly with the GameBoy (via a menu-driven interface) or indirectly using a program running under Windows on a PC connected to the module.

Here we describe the hardware of the GameBoy module and briefly sketch the structure and features of the software, which also includes ready-made sample applications. The associated I/O switching module ('I²C I/O box') is described in a separate article in this issue.

Overview

Among mass-produced game computers, the various models of the Nintendo GameBoy are not only the least expensive to acquire (via eBay, for example), but also the best documented. The standard model, with hardware built around a Z80-derivative microprocessor, can be programmed directly in C. A development environment tailored to this hardware is available free of charge on the Internet. With its microprocessor system, graphic LC display, serial interface and handy packaging, the GameBoy is a quite suitable for use as a platform for a programmable controller.

All GameBoy models based on the original ('classic') version (GameBoy, GameBoy Pocket, GameBoy Light, GameBoy Color, GameBoy Advance,

Boy PLC

Table 1.
GBPLC Module Features

- Available as a ready-assembled and tested PCB
- Load, delete and store up to 8 'logic programs'
- Disable under password control
- Program simulation
- Programming and simulation also possible in battery-powered mode
- Standard logic functions (AND, OR, NOT, XOR, SR)
- Two timers
- Two timing functions
- 64 flags
- Analogue comparator (less than, equal, greater than)
- Rising and falling ramps on analogue output
- PLC cycle time less than 500 ms
- Input and output names can be assigned freely in the software
- Names can be assigned to logic programs
- Run and Stop modes
- Log file can be viewed on the display
- Battery-backed real-time clock
- EEPROM for data storage
- Most recently loaded (active) logic program starts automatically after switch-on

Table 2.
GBPLC I2C I/O Box Features

- Available as a ready-assembled and tested PCB
- 8 digital inputs (for potential-free contacts)
- 8 digital outputs (relay or transistor)
- 4 analogue inputs (8-bit resolution)
- 1 analogue output (8-bit resolution)
- Inputs can be simulated by connecting pushbutton switches to the I/O box
- Socket for optional I2C SMS chip (with connector for Siemens S25 or C35i mobile phone)
- Port for linking to a Siemens S25 or C35i mobile phone
- All switch states can be indicated by connecting LEDs

Figure 1. Suitable GameBoy models. The unit in the centre is the GBPLC I²C I/O Box, which drives the GameBoy fitted with a GBPLC module.

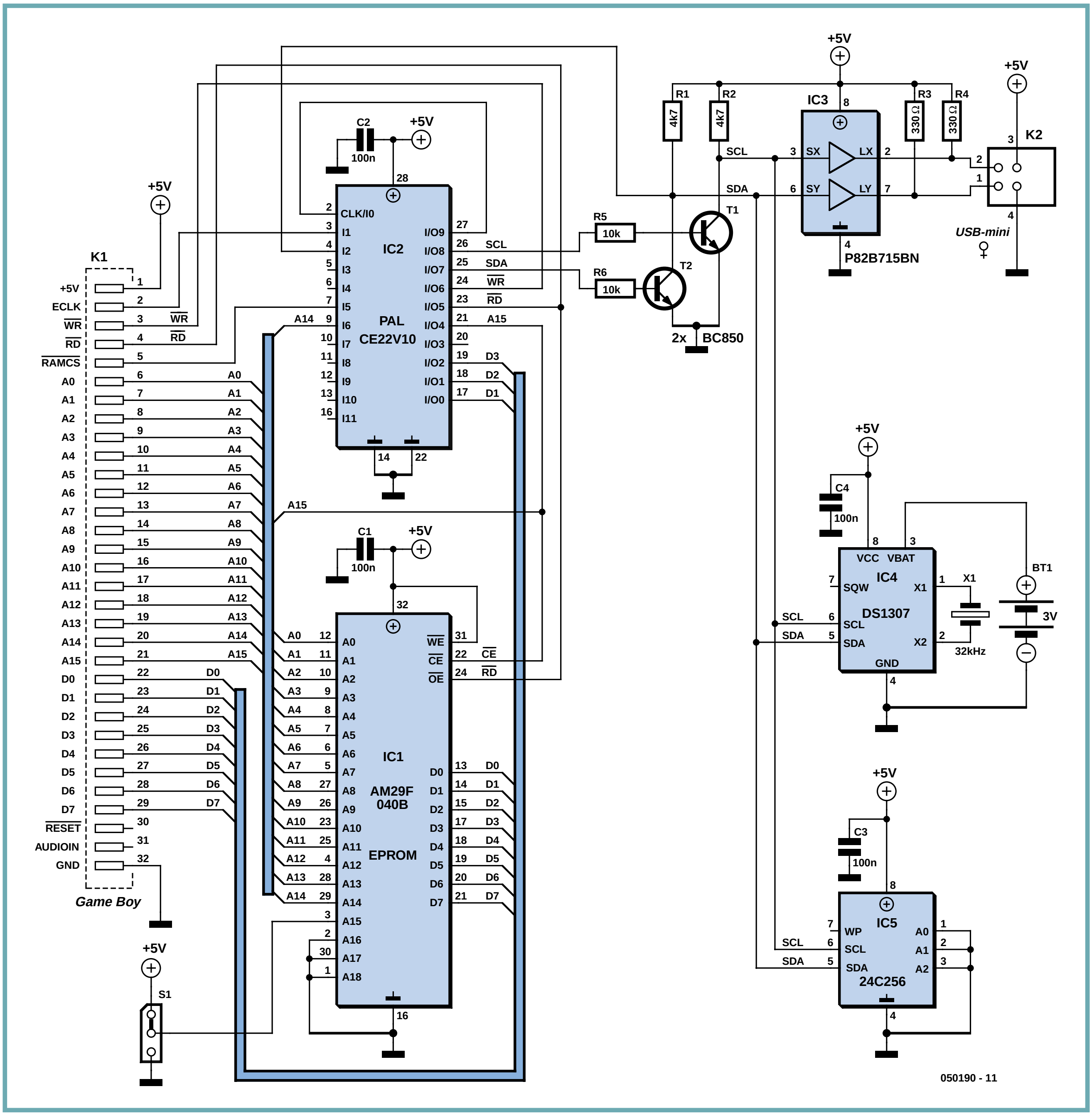


Figure 2. Schematic diagram of the GBPLC module, which transforms the Nintendo GameBoy into an easily programmed PLC.

and GameBoy Advance SP) are suitable for this project. **Figure 1** shows a few examples. The Nintendo DS and DS Lite (which actually do not belong to the GameBoy family) and the GameBoy Micro are **not suitable.**

The core of the system consists of the GBPLC module, which is inserted into the bay on the back of the GameBoy instead of the usual game cassette (ROM cartridge). This module consists primarily of memory: a flash EEPROM for the firmware and an I^2C EEPROM for the display messages and the PLC data, which constitutes the PLC application programs (also referred to as the 'logic programs' in the rest of this article). The I^2C EEPROM allows data to be exchanged between the GameBoy and a PC application running under Windows. The GBPLC module has an I^2C interface that can be connected to all types of commonly used PC ports (serial, parallel or USB) using suitable adapters.

Table 1 lists the key features of the GBPLC module. The PLC program can be generated on a PC using a convenient Windows-based program. The PC software can also run real-time simulations and exchange program code and data with the GameBoy. If necessary, PLC programs can also be generated, modified and simulated directly on the GameBoy. Up to eight PLC program sequences ('logic programs') can be stored in the GBPLC module, from which they can be individually retrieved and run. The data read in by the application can be shown on the GameBoy display as a log file and read out from the GBPLC module to the PC.

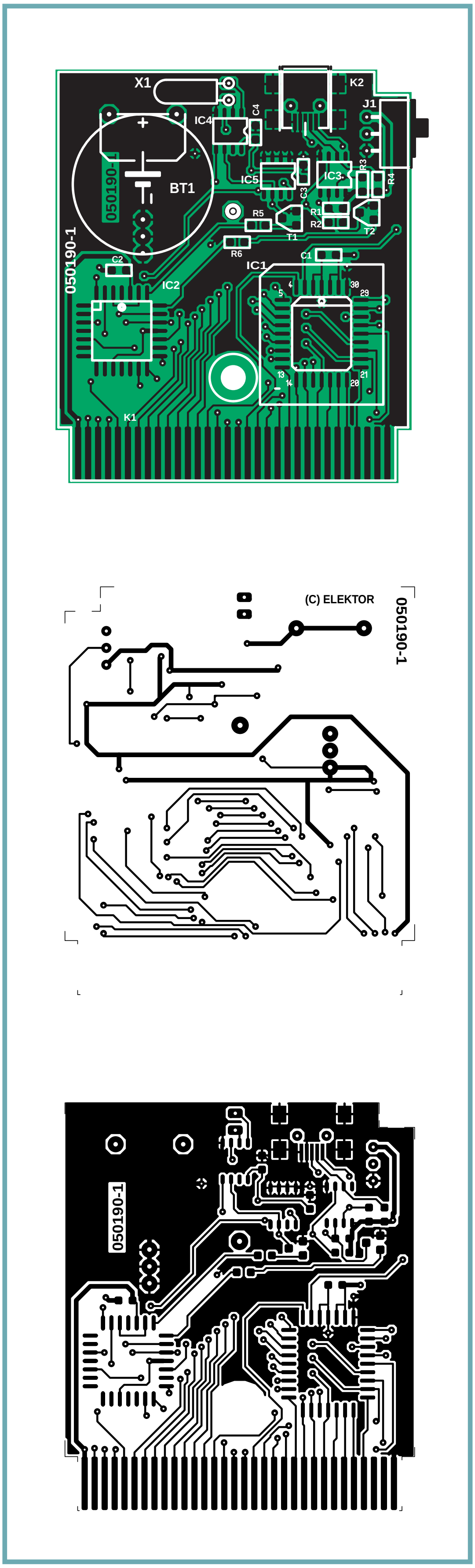


Figure 3. The double-sided, through-hole plated printed circuit board of the GBPLC module, which is assembled using SMDs. Board also available ready-assembled and tested.

For program execution, the GameBoy is connected to the circuit board of the I²C I/O Box, which is described in a separate article in this issue. The principal features of the I²C I/O Box are listed in **Table 2**. In addition to eight digital inputs and eight digital outputs, the I/O module has four analogue inputs and one analogue output. One of its special features is a socket for a small daughterboard fitted with an I²C SMS chip. This optional extension also has an I²C interface and allows the unit to be controlled and queried remotely by using SMS messages ('texting') and a mobile phone.

GBPLC module

As you can see in **Figure 2**, the circuit of the GBPLC plug-in module essentially consists of only five ICs. IC1 is a flash EEPROM that stores the application software (firmware), IC2 is a PAL that provides address decoding and generates the I²C signals, IC3 is an I²C bus extender, IC4 is an I²C real-time clock, and IC5 is an I²C EEPROM. From a functional perspective, the GBPLC module adds program and data memory, an I²C interface, and a battery-backed real-time clock to the basic GameBoy platform.

The GameBoy microprocessor, which resembles the Z80, has a direct address range of 64 K. However, the upper 32 K are used for the LCD, RAM, sound and so on, leaving the range 0000–7FFF available for external ROM and the range A000–BFFF available for external RAM. Consequently, the GameBoy uses only 15 of the 19 address lines of the flash EEPROM, which means that all programs in the flash memory are restricted to 32 KB. However, the 16th address line (A15 of IC1) can be addressed via switch S1, which can thus be used to select one of two programs stored in the flash memory. One of them is the actual application program (the PLC firmware), while the other is an editor that can be used to program or modify PLC application software directly on the GameBoy. As S1 should only be operated with power off, the circuit board layout (Figure 3) is arranged such that S1 is only accessible when the module is not fitted in the GameBoy. The assembled prototype board is shown in **Figure 4**.

IC2 (PALCE22V10) provides address decoding, and it generates the I²C bus signals SDA (data) and SCL (clock) with the assistance of transistors T1 and T2 and pull-up resistors R1 and R2. The programs held in the flash memory (IC1) are stored 'permanently' and can only be overwritten by a software update (which requires a flash programmer), but the content of the EEPROM (IC5), which is addressed via the I²C bus, is always accessible. It is used primarily to store the PLC application programs (eight maximum). The messages for the display are also stored in the I²C EEPROM. That means the firmware in the flash memory does not contain any messages, so it does not have to be re-assembled for every minor change to a message. That also has the advantage that it is easy to load different language ver-

COMPONENTS LIST

GBPLC Module

Resistors (SMD 0805)
R1,R2 = 4kΩ7
R3, R4 = 330Ω
R5,R6 = 10kΩ

Capacitors (SMD 0805)
C1-C4 = 100nF

Semiconductors
T1,T2 = BC850
IC1 = AM29F040B with socket, programmed *
IC2 = PALCE22V10, programmed *
IC3 = P82B715TD
IC4 = DS1307Z
IC5 = 24C256, programmed *

Miscellaneous
S1 = slide switch, sub miniature, angled pins, PCB mount (APEM type 236W)
Bt1 = 3V Lithium button cell, PCB mount, CR2032H
K2 = Miniature USB-B socket, PCB mount (Lumberg type 2486 01, Farnell # 4739826)
X1 = 32.768kHz quartz crystal
PCB, bare, order code **050190-1** (supplied together with 050190-2)
Set of ready-assembled and tested boards of 1 pc. GBPLC Module and 1 pc. GBPLC I²C I/O Box; order code **050190-91**

* set of programmed Flash (IC1), PAL (IC2) and EEPROM (IC5); order code **050190-51**.

For all items **050190-xx**: see SHOP pages and/or www.elektor-electronics.co.uk

About the authors

Sascha Koths and Stephan Ruloff developed this design as a graduation project at Bertolt-Brecht-Berufskolleg in Duisburg, Germany. During their studies for the Certified Electronics Technician diploma, the idea of using a GameBoy as a controller led to their graduation project. After receiving their technician diplomas in the field of data processing technology, they are now both enrolled in the Niederrhein University of Applied Sciences in Duisberg. Naturally, the only conceivable course of study for them was Engineering Informatics.

A word of thanks is also due to Christian Müller, who assisted in the project work.

sions. Display messages in German and English are included in the ready-made software.

The I^2C real-time clock (DS1037) provides the time of day in 12-hour and 24-hour format along with the date and day of the week, to allow switch-on and switch-off times to be programmed using the PLC and events to be logged. Thanks to the back-up battery, the clock is specified to operate for up to 10 years without losing track of the time. The internal 56-byte RAM of the DS1307 is not used in the GBPLC application.

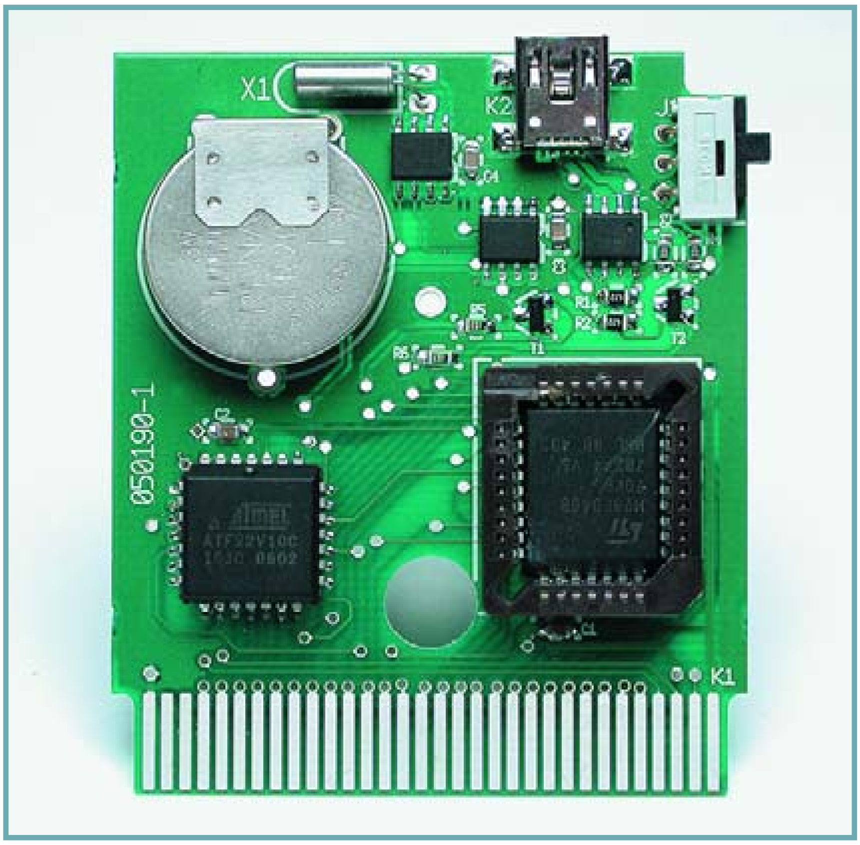


Figure 4. **Fully assembled prototype board of the GBPLC module.**

The 32-way card-edge connector of the module board (shown at the left in the schematic diagram) automatically connects the module to the GameBoy when the module is inserted. The only connection to the outside world is the I^2C port, which is located on the edge of the board that remains accessible when the module is inserted. The board is fitted with a miniature USB-B socket (K2) for the I^2C bus. In contrast to the GBDSO, the serial interface port of the GameBoy is not used in the GBPLC application.

GBPLC programming adapter

As the GBPLC module can only be accessed via the I^2C bus, an interface adapter that can be connected to a PC is necessary for linking the module to a PC. The circuit shown in **Figure 5** can be used for connection to a serial port or a USB port with a USB to serial interface adapter. However, using a 'virtual COM port' with a USB adapter is only a makeshift solution due to the very low data transmission rate.

A circuit board with a USB-A connector for the I^2C bus (**Figure 6**) has also been designed for the programming adapter corresponding to the circuit shown in Figure 3. If you use this adapter, you will need a cable with a USB mini plug at one end and a USB-A plug at the other end for the link to the GBPLC module. The same cable can be used to connect the GBPLC module to the I^2C I/O box. As the I^2C I/O Box has two I^2C connectors (a USB-A socket and a USB-B socket), the programming adapter and the GBPLC module can **both** be connected to the I²C I/O Box at the same time. That requires using the following cables, which are available as standard items:

Mini USB to USB-A for connecting the GBPLC module to the I²C I/O box.

USB-A to USB-B for connecting the programming adapter to the I²C I/O box.

The supply voltage (+5 V) for the programming adapter is tapped off from the I²C I/O box via the USB cable. An advantage of this arrangement (with the programming adapter connected to the I²C I/O box) is that the GBPLC module in the GameBoy remains permanently connected to the I²C I/O box. That eliminates unplugging and replugging cables to connect the GameBoy to the PC, since the 'spare' USB connector of the I²C I/O box can be used for that purpose as necessary.

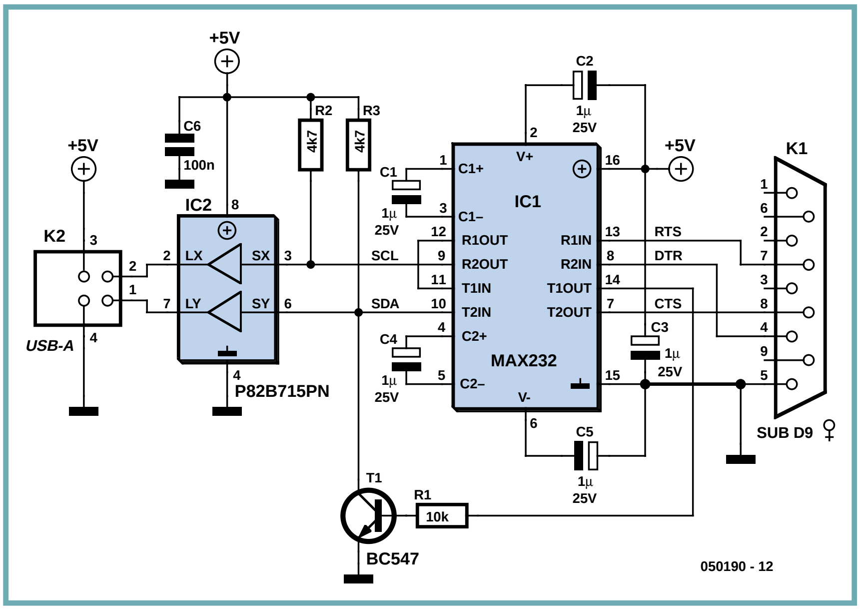


Figure 5. Schematic diagram of the programming adapter for connection to a serial PC port. The USB-A connecter is used here for the I²C bus signals.

Construction and assembly

Given the available space, the circuitry of the GBPLC module can only be assembled using a double-sided, through-hole plated PCB with SMD components. Due to the difficulties of assembling such a board, the GBPLC module is optionally available as a fully assembled and tested PCB, which only has to be fitted into an empty GameBoy cartridge housing. As such housings are not commercially available, you will have to remove the innards of a second-hand (cheap) GameBoy game cartridge and use its housing. As you can see from the photo of the GBPLC module (**Figure 7**), four openings must be made in the housing to accommodate the flash memory (IC1 with socket), the back-up battery, the external connector, and the slide switch on the edge of the board (S1).

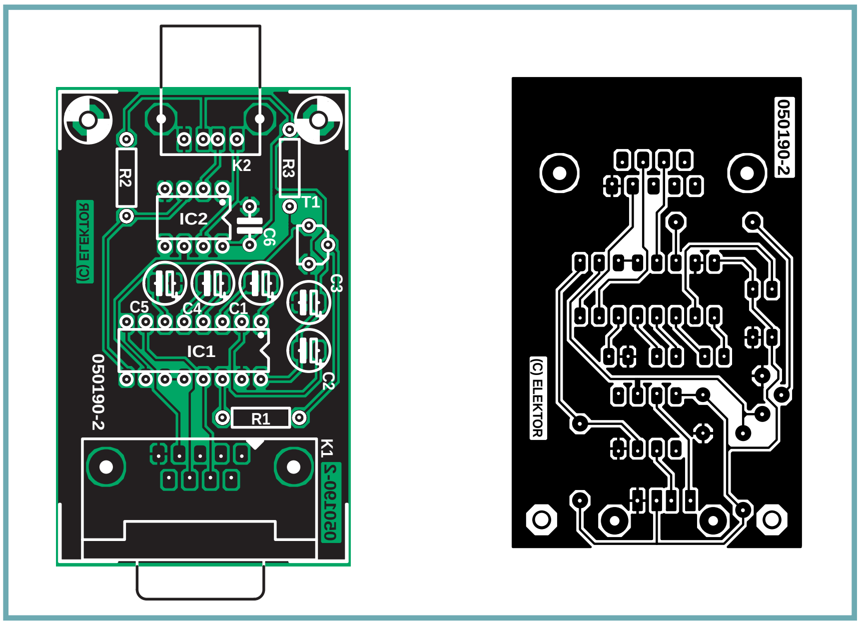


Figure 6. Circuit board track layout and component layout for the serial interface programming adapter. Board also available ready-assembled and tested.

GBPLC software

The firmware for the GameBoy (PLC application software and editor) has already been mentioned. These two programs, which can be selected using S1, are pre-installed in the flash memory of the assembled and tested GBPLC module. The I²C EEPROM is also already loaded with the display messages in one language (English). If you assemble the board yourself, you can order IC1, IC2 and IC5 pre-programmed (refer to the components list). All files necessary for programming these ICs are also available on the Internet for downloading (refer to the links at the end of this article). A

COMPONENTS LIST

GBPLC Programming Adapter

Resistors

R1 = 10kΩ
R2,R3 = 4kΩ7

Capacitors

C1-C5 = 1µF 25V radial
C6 = 100nF

Semiconductors

T1 = BC547
IC1 = MAX232
IC2 = P82B715PN

Miscellaneous

K1 = 9-way sub-D socket, angled pins, PCB mount
K2 = type-A USB socket, PCB mount
PCB, bare, order code **050190-2** (supplied together with 050190-1)
Set of ready-assembled and tested boards of 1 pc. GBPLC Module and 1 pc. GBPLC I²C I/O Box; order code **050190-91**

For all items **050190-xx**: see SHOP pages and/or www.elektor-electronics.co.uk

Table 3. GBPLC Windows Software

System requirements

- PC with Pentium-class processor
- Windows 95 with 32 MB RAM; Windows 98/ME with 64 MB RAM; Windows NT 4.x with Service Pack 4 or higher; Windows 2000 or Windows XP with 128 MB RAM (minimum requirement in each case)
- Administrator rights if Windows NT, Windows 2000 or Windows XP is used
- Microsoft Internet Explorer 5.0 or later
- Serial or parallel interface (USB can be used with a USB to RS232 converter but is very slow)

Ready-to-use PLC programs

- Aquarium/terrarium controller
- Alarm system
- Roller shutter controller

GBPLC Manager

- Generate and edit logic programs
- Print system logic and labels
- Buttons for running other program modules
- Configure interface

GBPLC Simulator

- Load logic programs
- Start and stop programs
- Real-time simulation of inputs
- Generate outputs

GBPLC Log Viewer

- Read log data from GBPLC module
- Display characteristic curves (plotted versus time)
- Freely selectable colours for characteristic curves
- Export to Excel or other programs

SMS Configuration (for optional I2C SMS chip)

- Configure short message service carrier (SMSC) number
- Configure recipient number
- Write SMS ('text') messages

Figure 7. The finished GBPLC module fitted in the housing of a salvaged GameBoy game cartridge. On the prototype pictured here, an IC socket was used for IC2, and a jack socket for K2. The ready-assembled module on sale through Readers Services has IC2 soldered on the board, and a mini USB socket for K2 (see Figure 4)

suitable programming device must be used to program IC1 and IC2. The I^2C EEPROM can be programmed using a simple programming circuit and software, such as PonyProg. You can also start up the GBPLC with IC5 empty (unprogrammed) and use the GBPLC PC software and GBPLC programming adapter to load display messages in the language of your choice into IC5. Even with a pre-programmed EEPROM, the selected language for the displayed messages can be changed at any time via the PC. The details of configuring the module for initial use are described in the 'Step by Step' guide (included in the download for the project).

After all the above-mentioned ICs have been programmed, you can also use the editor stored in the flash memory to generate an application program (PLC sequence program) directly on the GameBoy or modify a program that has already been loaded. However, it is more convenient to use the GBPLC PC software for that purpose and then use the programming adapter to download the program into the EEPROM of the GBPLC.

The documentation of the internal structure of the controller and the menus of the GBPLC is also contained in the download files for this article. However, you do not need to bother about the internal structure and byte

organisation if you use the Windows software.
The structure of a sequence program is the same, regardless of whether it is generated using the PC software or directly on the GameBoy. Up to eight PLC program sequences ('logic programs') can be developed in a single 'project'. The project programs (up to eight) can be stored in the 24C256 of the GBPLC module. They can be individually retrieved and run via the menu interface on the GameBoy LCD or from the PC. Each of these programs consists of a maximum of 64 blocks. Each block corresponds to a 4-byte line of program code that defines a function (also known as a 'logic gate'). The available functions are listed in **Table 1**. Each logic gate has a maximum of two inputs and a single output. The terminals of the I^2C I/O Box listed in Table 2 can be selected as the inputs or outputs. It is also possible to define 'block flags' ('flags' for short) for the inputs and outputs. These block flags interconnect the inputs and outputs of different blocks.

Windows software

A package consisting of three programs that run under Windows is provided to simplify using the controller. Like the firmware, it is available for downloading free of charge. Borland C++ Builder was used to develop the Windows software. Each of the three programs (GBPLC Manager, Simulator, and LogView) performs a specific task. A fourth program (SMS Configuration) can be used to configure the optional I^2C SMS chip. All the other programs can be run from GBPLC Manager, so all the Windows software can be used in the GBPLC Manager environment.

Table 3 summarises the major features of the Windows programs. Typical screen shots are shown in **Figures 8, 9 & 10**. The extensive help files for the Windows programs form an excellent tutorial with detailed explanations and examples. Three complete example projects that you can also use for your own applications are also available: a controller for aquariums and terrariums, a roller shutter controller, and an alarm system. For demonstration purposes, the authors installed these applications in a model display home that is also shown in the photos.

If you want to get an exact idea of the functions and capabilities of the GBPLC, you can download the Windows software free of charge and at no obligation and familiarise yourself with the display of the GameBoy PLC. After that, it's only a small step from a simulation to the real thing (see the 'Step by Step' guide included in the download file), with the added benefit that you know in advance that it will be worth the effort.

(050190-1)

Links for downloads

www.elektor-electronics.co.uk
(Elektor Electronics articles, software and documents)

www.rk-tech.org
(authors' website, software and documents)

http://gbdk.sourceforge.net
(GBDK – GameBoy Developers Kit)

www.work.de/nocash/gmb.htm
(NO$GMB – GameBoy emulator for Windows)

www.lancos.com/prog.html
(PonyProg)

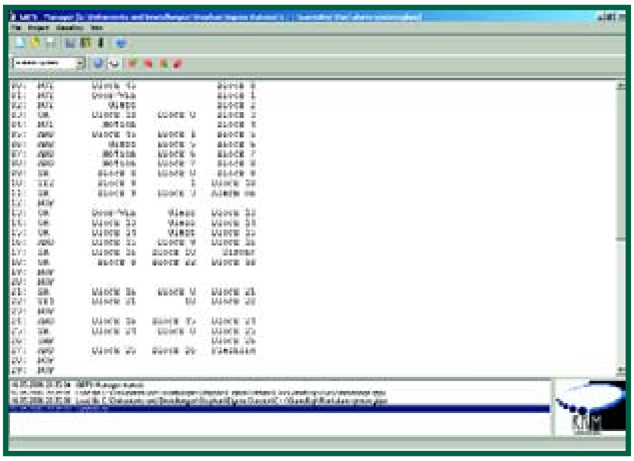


Figure 8. Screenshot of GBPLC Manager, the main program for operating and programming the GameBoy PLC under Windows.

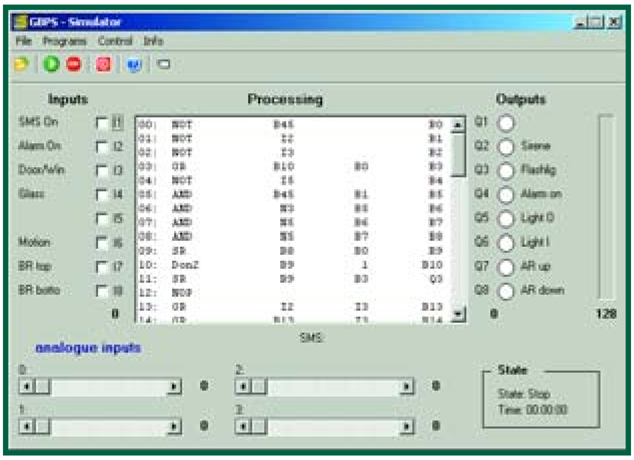


Figure 9. GBPLC Logic Simulator, which can be run from GBPLC Manager, can be used to test application programs without the GameBoy. The GameBoy functions are integrated into the simulator.

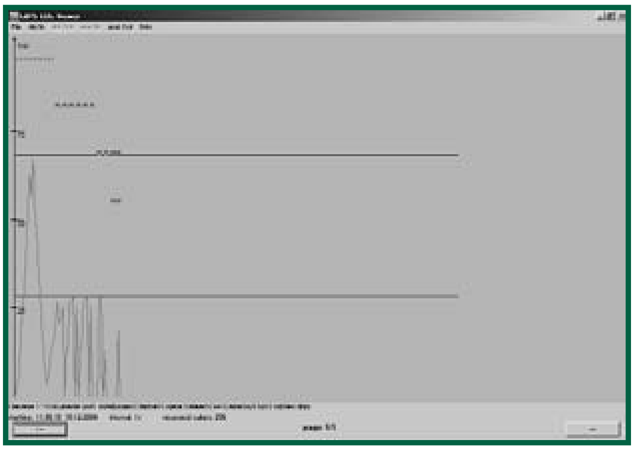


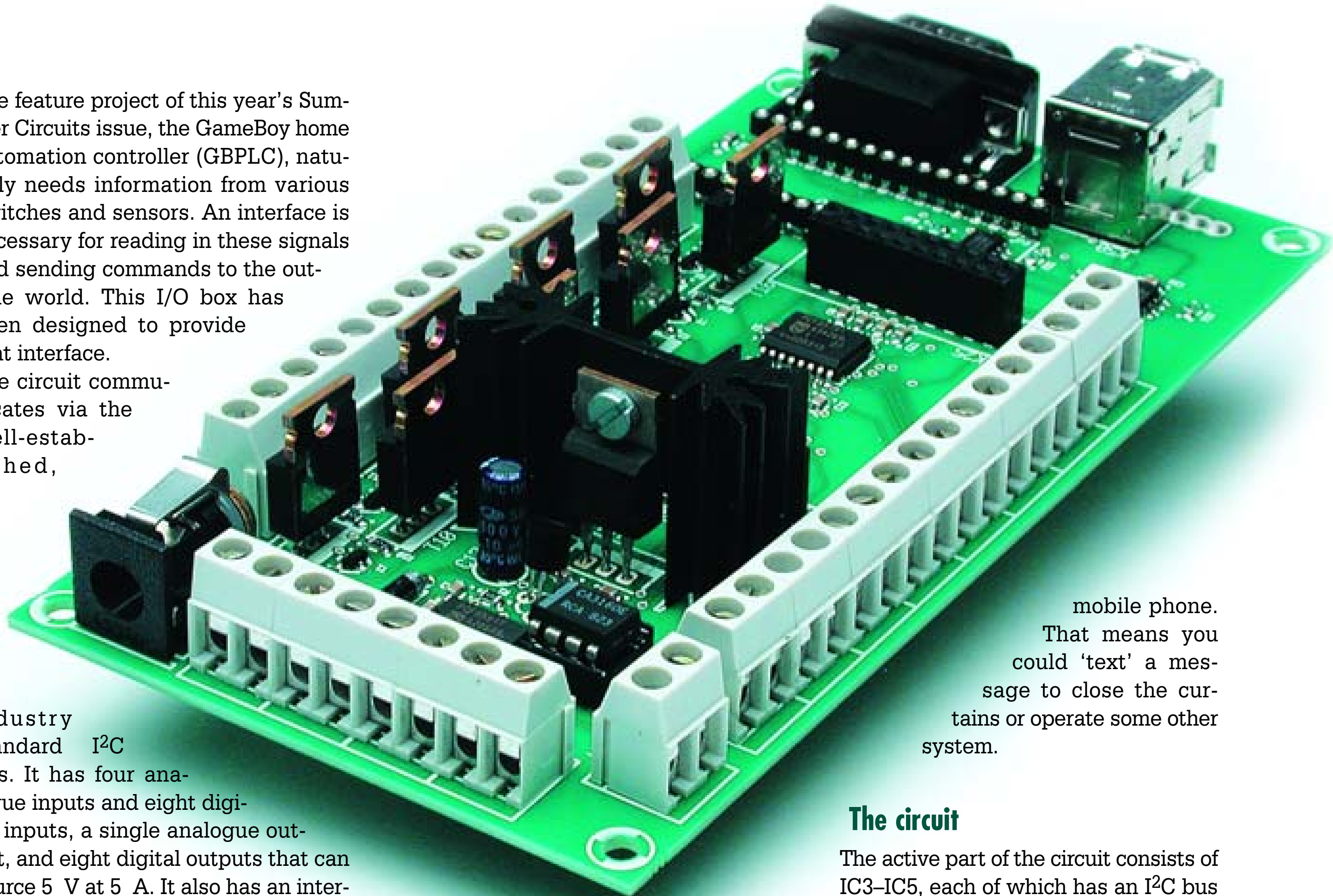
Figure 10. GBPLC LogView can be used to display and export control data collected by the PLC.

GBPLC I²C I/O Box

analogue, digital I/O plus TXT (SMS)!

Sascha Koths & Stephan Ruloff

To use the Nintendo GameBoy as a system control centre, you need an I²C interface in addition to the special plug-in card. The circuit presented here is cut out for the job. It has a total of 24 inputs and outputs, including 4 analogue inputs and 8 digital inputs. That's sufficient to control roller shutters, outside lighting, curtains, an alarm system, the central heating system and even more, possibly even remotely via TXT (SMS) messages.



The feature project of this year's Summer Circuits issue, the GameBoy home automation controller (GBPLC), naturally needs information from various switches and sensors. An interface is necessary for reading in these signals and sending commands to the outside world. This I/O box has been designed to provide that interface.

The circuit communicates via the well-established, industry standard I²C bus. It has four analogue inputs and eight digital inputs, a single analogue output, and eight digital outputs that can source 5 V at 5 A. It also has an interface for connecting a special SMS module to allow messages to be 'texted' to a mobile phone. In short, it has lots of capabilities. The SMS module also allows the circuit to be controlled by a mobile phone. That means you could 'text' a message to close the curtains or operate some other system.

The circuit

The active part of the circuit consists of IC3–IC5, each of which has an I²C bus interface. IC6 and IC7 are I²C bus extenders that act as boosters. They reduce the link's susceptibility to interference by increasing the current on the I²C bus and reducing its capacitance.

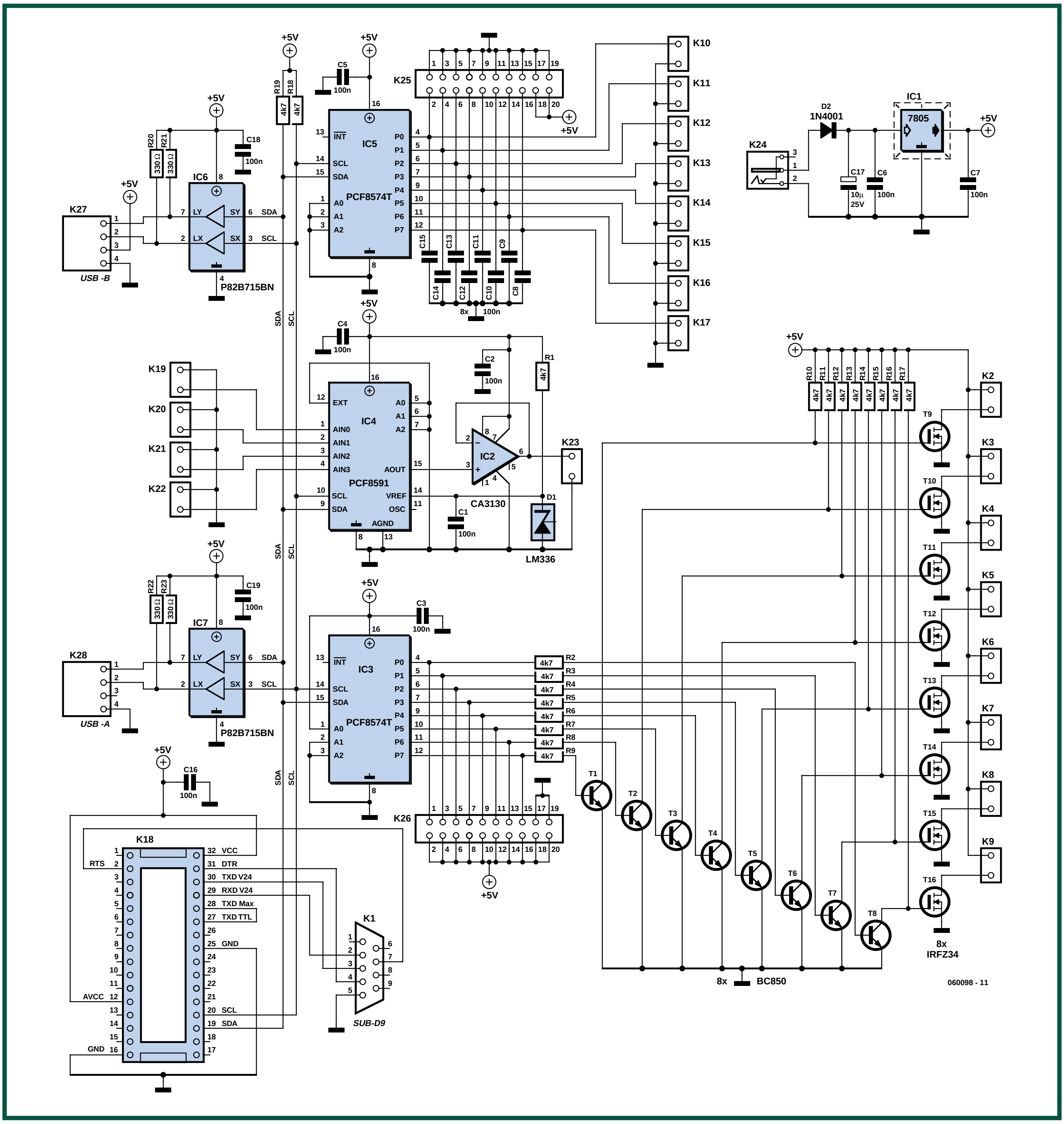


Figure 1. The main components of the circuit are the I²C drivers and the bus extender.

IC4 converts analogue signals into 8-bit digital data suitable for the I²C bus. The reference voltage on pin 14 is set to 2.5 V, which yields a resolution of approximately 10 mV. TTL signals can access the I²C bus via IC5. Capacitors C8–C15 decouple noise on the inputs. That's hardly an unnecessary luxury for signal lines that doubtless run over a considerable distance through your house.

Digital and analogue signals are output to the outside world via IC3 and IC4. The PCF8574 contains an 8-bit quasi-bidirectional port with internal latches. The latch retains the most recently configured output state. IC5 obviously does not use this data, since none of its outputs are used in the circuit.

The addresses of IC3, Ic4 and IC5 are hardwired in the circuit by tying address pins A0, A1 and A2 to fixed potentials. The PCF8591 has a different internal base address, which explains why IC4 and IC5 can apparently be assigned the same address. If you want to couple several of these modules to a single bus for a different application, you will have to modify address portion of the PCB track layout.

Standard USB connectors are used for the connection to the I²C bus. They are thus not real USB ports. K28 is a USB-A connector for connection to the

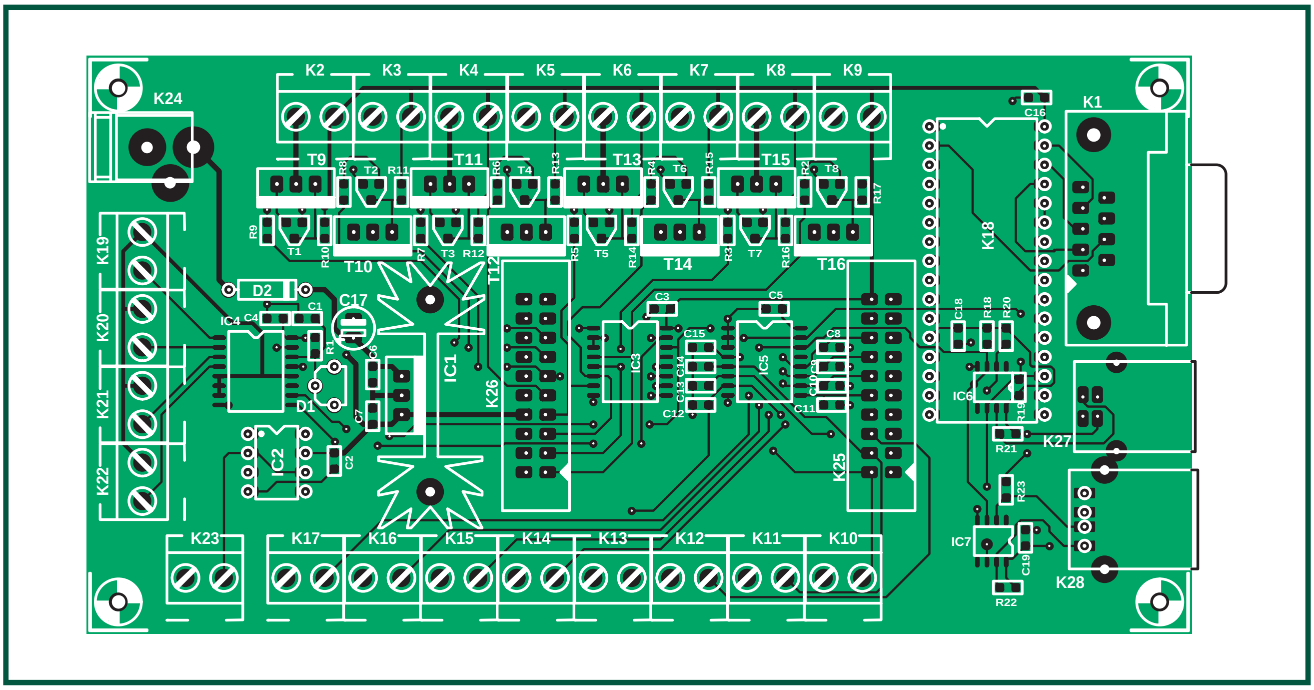


Figure 2. Practically the entire outer region of the board is occupied by a large number of connectors.

COMPONENTS LIST

Resistors
R1-R19 = 4kΩ7
R20-R23 = 330Ω

Capacitors
C1-C16,C18,C19 = 100nF (SMD 0805)
C17 = 10µF 25V radial

Semiconductors
D1 = LM336Z (TO92 case)
D2 = 1N4001
T1-T8 = BC850
T9-T16 = IRFZ34N
IC1 = 7805
IC2 = CA3130
IC3, IC5 = PCF8574T
IC4 = PCF8591T
IC6,IC7 = P82B715TD

Miscellaneous
K1 = 9-way sub-D plug (male), angled pins, PCB mount *
K2-K17,K19-K23 = PCB terminal block, lead pitch 5mm
K18 = 32-way DIL socket *
K24 = mains adaptor DC socket, PCB mount (CUI Inc. type PJ-002B, Digikey # CP-002B-ND)
K25, K26 = 20-pin (double row) socket, pitch 0.1"
K27 = USB connector type B
K28 = USB connector type A
PCB, order code **060098-1**
Ready assembled and tested board, order code **060098-91**

* only required in combination with SMS chip

For all items **060098-xx**: see SHOP pages and/or www.elektor-electronics.co.uk

GameBoy module. K27 is a USB-B connector intended to be used for connection to a PC. That makes it unnecessary to constantly disconnect and reconnect cables when you want to control the module from the GameBoy while linking it to a computer at the same time via an I²C to RS232 adapter.
All digital inputs and outputs are directly accessible on K25 and K26. That means you can check the outputs by connecting low-current LEDs directly to K26. Don't forget to use current-limiting resistors for the LEDs. The PCF8574T has open-drain outputs that can source adequate current for that purpose.
We use the SMD version of the well-known BC550 here for inverters (T1–T8, BC850) that drive MOSFETs T9–T16. Otherwise the outputs would go high immediately after the circuit was switched on, due to the initial state of the PC8574.
As already mentioned, the MOSFETs can handle currents up to around 5 A. Incidentally, you can also use the pin-compatible BUZ11 in place of the IRFZ34N. It is no longer being made, but you can doubtless still find it on the shelf here and there.
The power supply is a simple design using a 7805. That means you can simply use a standard AC adapter with a voltage of 9 V or more as a power source. D2 provides reverse-polarity protection in case you accidentally connect a different adapter with the wrong polarity.

Construction

Assembling the circuit board is not difficult. Start by soldering all the small SMDs. Next in line are the DIL and SMD ICs. IC2 can optionally be fitted in a socket. After that, you can fit the rest of the components.
You can connect a mobile phone directly to the circuit via a serial data cable connected to K1 if the optional SMS module is also fitted. You can order the SMS module at www.rk-tech.org.

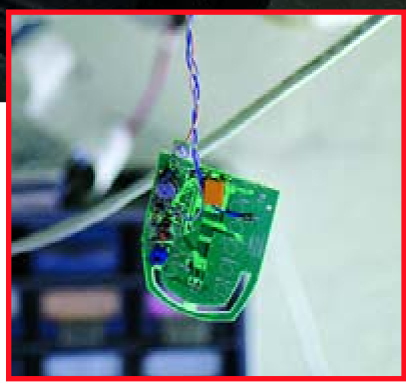
Of course, this circuit is also perfectly suitable for use as a general-purpose I²C bus interface — it doesn't have to be restricted to use in combination with the GameBoy module. An I²C-based system with all sorts of control and switching capabilities can be used for innumerable purposes aside from a home bus system. That makes this I²C I/O Box suitable for a wide variety of applications.

(060098-1)

ELECTROSHA

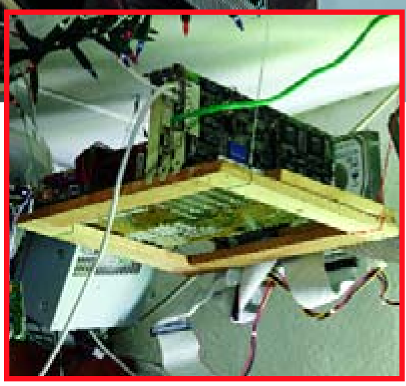
1. Workplace with various projects 'under development'.

2. Inexpensive (web)server (Feb. 2006) and Electronic Stamping (Sept. 2006).



3. Modding for Home Improvement (June 2006). Central control for all equipment.

CK free-lance Modding & Tweaking expert Jeroen Domburg in his student digs



4. Jeroen's personal server, secured 'suspending' to maximise space in the bed-sitter.

5. Modified display; supplies info on currently playing music selection.

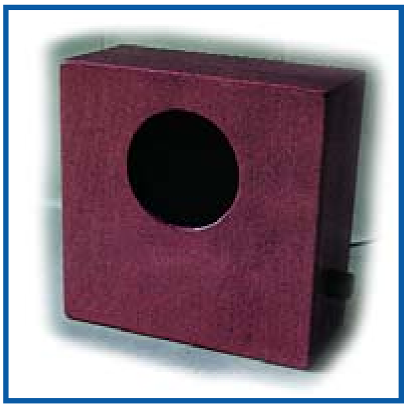
6. Christmas Light String (Dec. 2005) still in budget enclosure.

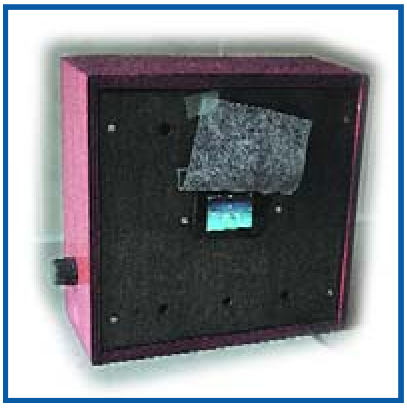
001

BBC Radio-MP3 for Seniors

Richard Salisbury

Just recently the author had cause to make an MP3 player for a 93-year old recently moved to a nursing home. There, radio reception turned out to be hopeless, mainly owing to interference from TL lamps. The elderly person involved can neither see well nor has good manipulative skills (arthritis), while learning new



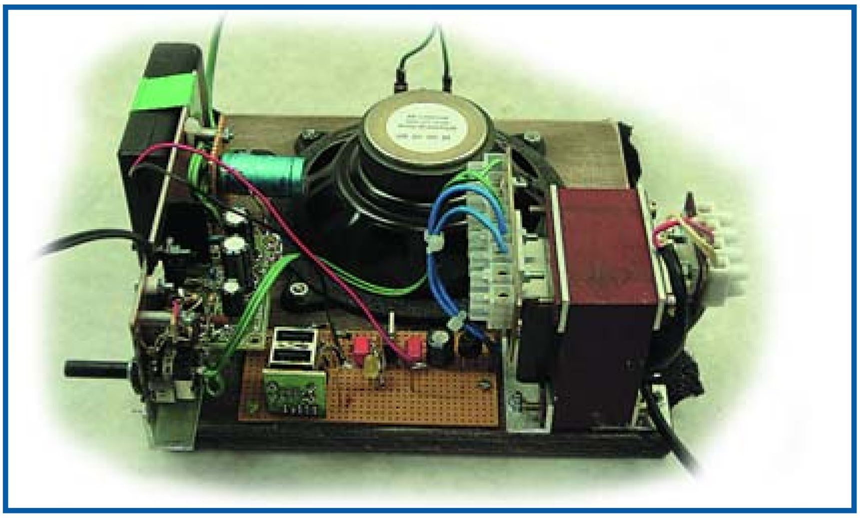


procedures is sure to present problems.

The solution to the radio reception problems was to build an iRiver U10 MP3 player into a speaker box which looks like an old fashioned radio and has only an ON/OFF button and volume control.

The unit is powered by the normal mains and can remain unplugged for about ten hours before it stops. Remarkably, that also happens on being replugged into the mains. Due to a firmware problem of the U10, on 5 volts appearing on the USB connector it assumes it is connected to a computer and stops playing.

The circuit diagram is all straightforward and speaks for itself. The U10 is fixed in a window on the back of the player with the keys locked. Hence, it plays continu-

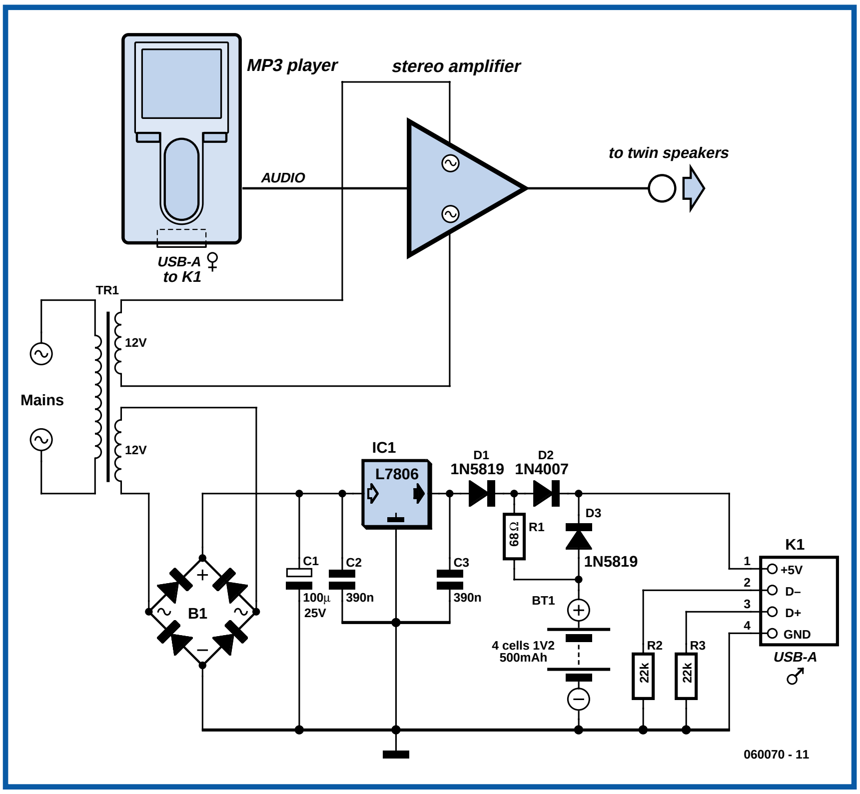


ously whether the amplifier is on or not (the author used a 15-pound speaker set / amplifier for a computer which switches the 12 volts AC). The transformer was replaced with a double secondary winding to avoid any earthing problems between the USB charging device and the amplifier ground.

The unit is working well and plays the client's favourite music for about 4-3/4 hours, more or less like a personal radio station. Of course, much more music could be loaded on the player since stereo makes no sense and it could be encoded at a slower rate.

An initial problem of the MP3 player's output level not being well matched to the amp input was solved by choosing another amplifier (Velleman K4001) which has a more suitable input sensitivity of 40mV.

(060070-1)



Laser Alarm

002

Dimitris Kouzis-Loukas

This circuit is a laser alarm system like the one we see in various movies. It uses a laser pointer beam to secure your valuables and property. Essentially, when the beam gets interrupted by a person, animal or object, the resistance of a photodiode will increase and an alarm will be activated.

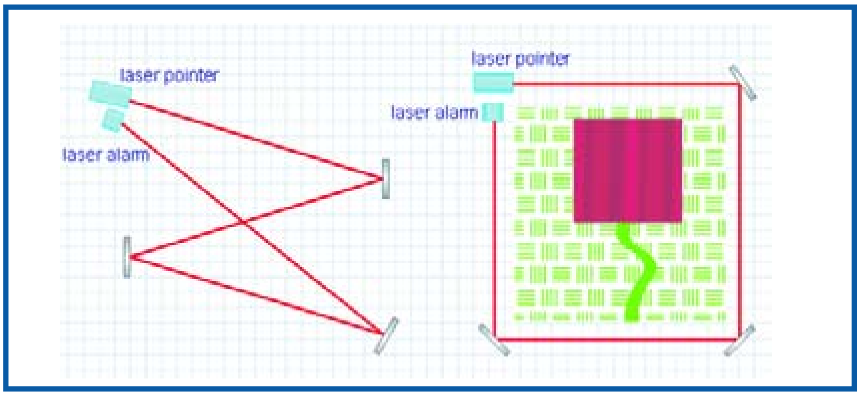
The laser and the receiver can be fitted in same box, sharing a common power supply. As the receiver draws less than 10 mA on average, you'll soon find that the laser is the most current hungry device! Mirrors are used to direct the beam in whatever setup you require. Examples of a passage and an area protected by the alarm are shown in the diagram.

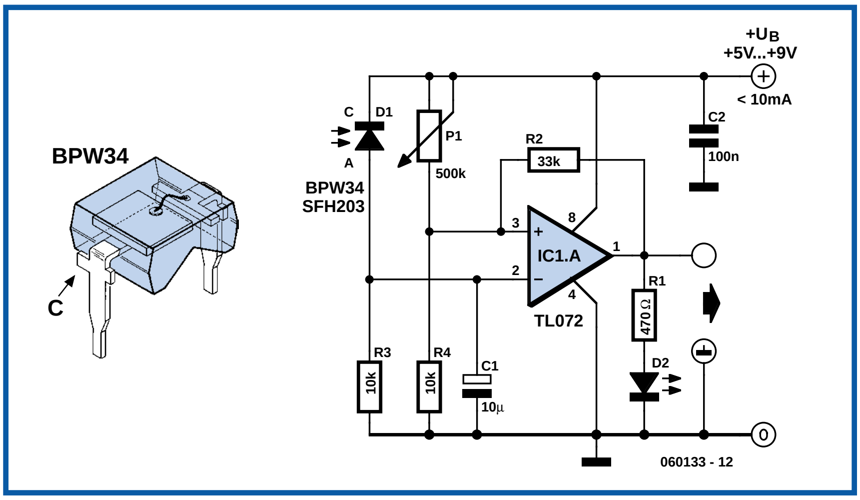
In the circuit diagram we find a TL072 op-amp (IC1.A) configured as voltage comparator between the voltage reference provided by the adjustable voltage divider P1/R4 and the light-dependent voltage provided by the voltage divider consisting of photodiode D1 and fixed resistor R3. When the laser beam is interrupted, the voltage on comparator pin 2 drops below that at pin 3, causing the output to swing to (almost) the positive supply voltage and indicating an alarm condition. This signal can drive a siren, a computer or a light that hopefully will deter the intruder. Alternatively it can be used to 'silently' trigger a more sophisticated alarm. Resistor R2 provides some hysteresis to prevent oscillation when the two comparator input voltages are almost equal. Capacitor C1 makes the circuit immune to short, accidental interruptions of the beam, e.g., by flying insects. If you want your circuit to have faster responses you can reduce its value to 1 µF.

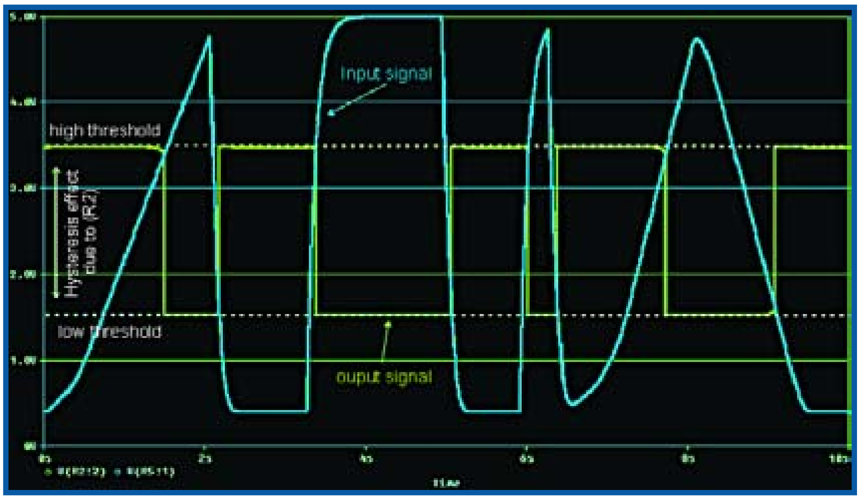
The operation of the circuit is illustrated by the waveform diagram, which also proves the hysteresis action that sets an upper and a lower threshold on the input voltage. You can also see the delay introduced by capacitor C1.

The circuit is simple and could be assembled on a piece of breadboard. After assembling the circuit and testing it, you should mount it in a black box that has just a small hole. You may decide to put the laser in the same box but only if you are sure there is no way the photodiode can 'see' the laser beam directly. The small hole should be filled with a black drinking straw so that only light from the direction of the laser beam can enter. With the appropriate setup of the box and the mirrors, the laser beam is so intense that even direct sunlight cannot affect the operation of the photodiode.

(060133-1)







Warning

All safety precautions supplied with the laser you are using must be observed. Laser power should be kept as low as possible.

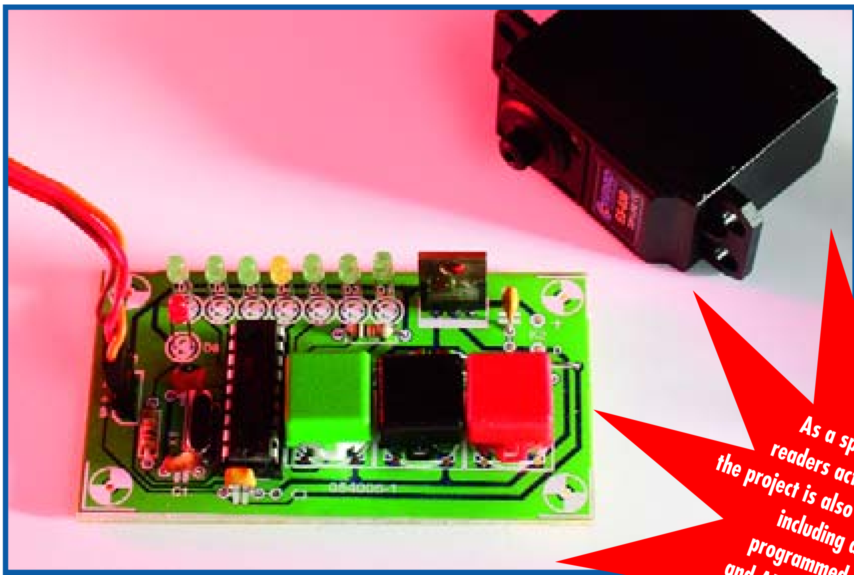
003

RC Servo Tester/Exerciser

Ray King

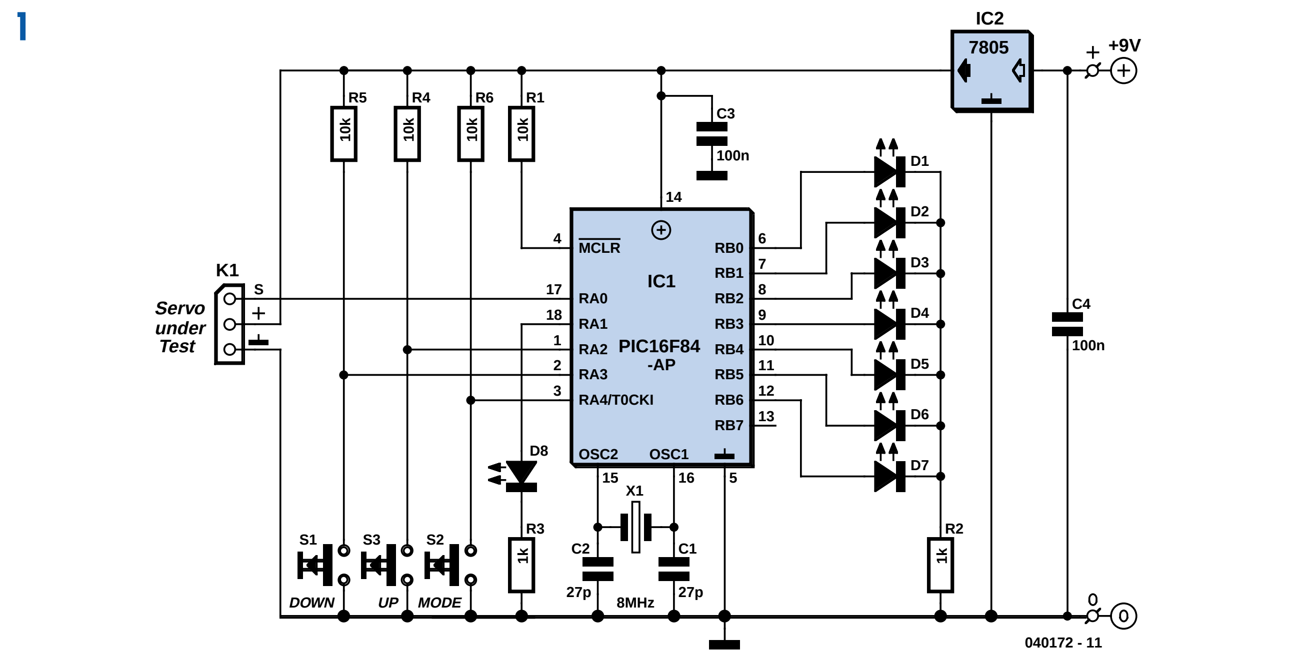
The design presented here is for a device for testing radio control (RC) servos. The present design has features that make it especially useful to people designing and building radio control equipment. By building a number of these devices in a single enclosure an entire radio controlled model can be set up and tested without having to actually use the RC transmitter.

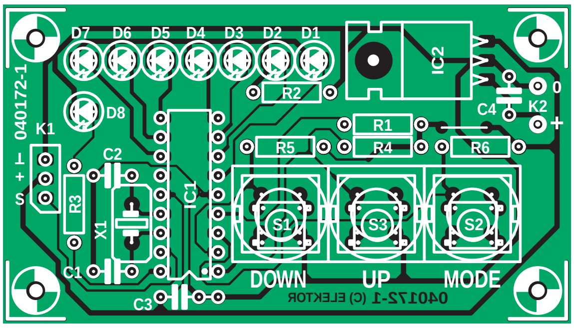
The most unusual feature of this design is that it doesn't use a joystick or similar analogue device to determine the servo position. Instead it gives an output of precisely 1.5 ms that can be changed up or down in steps of 0.166 ms and gives a display on a line of LEDs of the position selected. This is of particular use if you are designing and testing radio control devices that use the receiver output directly, enabling a known pulse width to be applied without resorting to using an oscilloscope. With this facility the devices can be calibrated simply and quickly.
Secondly the device has the ability to switch to an 'exercise' mode. Selecting this mode cycles the servo between the extremes of its travel and serves as a useful quick test of normal servos to verify correct working. A further LED indicates selection of this mode.
Finally the device uses very few components and is extremely cheap to build since the PIC processor carries out all of the timing functions.
The circuitry is a pretty straightforward implementation of the good old PIC 16F84 processor with eight LEDs D1-D8 and three switches S1, S2, S3 connected. The software generates a servo output signal every 20 ms then scans the switches for a button press. Depending on the button pressed the output pulse length will be adjusted accordingly.
When first switched on the circuit will output a servo pulse of 1.5 ms duration and the middle LED of the array will be lit. Pressing the 'up' or 'down' buttons will increase or decrease the pulse width by

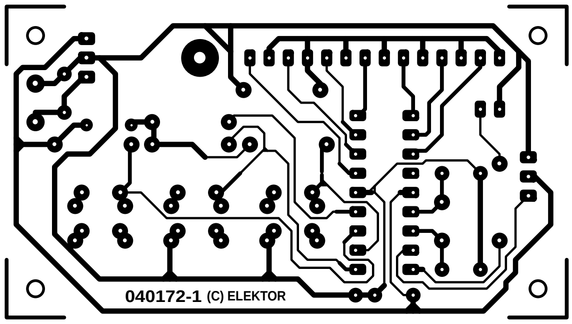


As a special service to our readers active in RC modelling, the project is also offered as a kit of parts including all parts, PCB, programmed microcontroller and ABS case. The order code is ***040172-71.***

1







COMPONENTS LIST

Resistors
(1/4W 10%)
R1,R4,R5,R6 = 10kΩ
R2, R3=1kΩ

Capacitors
(5mm lead pitch)
C1,C2 = 27pF
C3, C4 = 100nF

Semiconductors
D1,D2,D3,D5,D6,D7 = LED, 3mm, high efficiency, green
D4, D8 = LED, 3mm, high efficiency, yellow
IC1 = PIC16F84(A), DIL18 case, programmed, order code **040172-41**
IC2 = LM2940, TO220 case (or 5V 1A low drop equivalent)

Miscellaneous
X1 = 8MHz quartz crystal, 32pF parallel load capacitance, HC49 case or low-profile model
K1 = 3 way SIL pinheader
S1, S2, S3 = pushbutton, 1 make contact
Case: Hammond 1591ATBU
IC socket 18p
Mains adaptor DC socket
PCB, order code **040172-1**
Project software, free download **040172-11** from Elektor website

A kit of parts is available from Elektor Electronics; order code **040172-71**, see SHOP pages or website. Kit contents as components list.

0.166 ms and the LED display will move as appropriate to show the pulsewidth selected.

At any time the ‘mode’ button may be pressed which causes the device to switch to/from the ‘exercise’ mode. A servo connected to the output will cycle repeatedly from end to end of its travel — a useful indication of whether the servo is operational or not.

An Elektor-style PCB was designed for the project and the artwork is shown here. Only one wire is required on the board. The author’s own prototype incorporated two of these boards in a single enclosure so that two servos on a model can be tested at once. The board shown in the photograph is a prototype differing from the final version in minor detail.

The source code was written using Proton PIC Basic+ which then compiles into assembler and object code. For those with a PIC programmer, all project software including the hex and source code files is available as a free download, file ref. **040172-11.zip**, from the *Elektor Electronics* website. The PIC is also available ready programmed though Readers Services under number **040172-41**.

Several options are available for powering the circuit. A 9-V PP3 (6F22) battery may look okay at first blush but then it will be exhausted quickly even with small servos. A mains adaptor (‘battery eliminator’) is possible, but precludes field use. Undoubtedly the most elegant approach, then, is the use of a case with a battery compartment for penlight (AA size) batteries, and then use four alkaline cells or five NiMH rechargeables to obtain a raw supply voltage of 6 V. This will necessitate the use of a low-drop regulator for IC2, like the 4805 or the LM2940 you find suggested here because it will not drain an almost flat battery due to its own current. An on/off switch is also recommended. The standby current consumption of the circuit amounts to about 5 mA.

Finally, PIC burners among you using the hex file should set the config bits as follows: HS (10) (since xtal > 4 MHz); WDTE disable (0); PWRTE enable (0). The other config bits are for code protection and their use is at your discretion.

(040172-1)

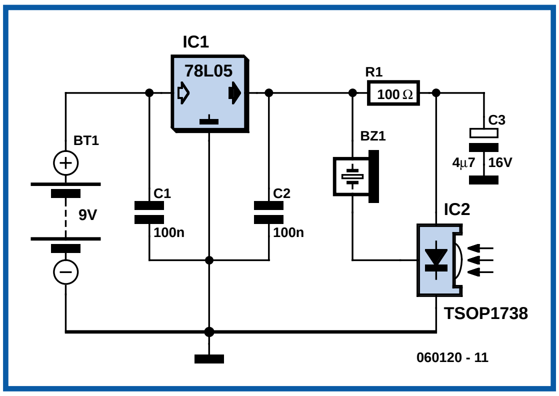
IR Remote Control Tester

Malte Fischer

This small circuit is ideal for checking the basic operation of an infrared remote control unit. The circuit is based on the brilliantly simple idea of connecting a piezo buzzer directly to an IR receiver IC. This method is almost as simple as connecting a photodiode directly to the input of an oscilloscope, but has the advantage that no oscilloscope is needed: the compact unit is always ready to use and much easier to carry around than bulky test equipment.

Operation of the remote control is indicated by the buzzer making a chattering noise. The circuit is very sensitive and has a range of several metres.

The TSOP1738 integrated IR receiver accepts, amplifies and demodulates the IR signal from the remote control, producing an output with a frequency of around 700 Hz. The piezo buzzer is connected to its output, rendering the signal audible.
All the other components are simply concerned with producing a stable 5 V power supply from the 9 V PP3-(6F22) type battery. Instead of the TSOP1738 similar devices from other manufacturers can be used, and of course carrier frequencies other than 38 kHz can be used. The circuit still works if there is a mismatch between the nominal carrier frequencies of the transmitter and receiver IC, but range is reduced. It is still, however, adequate for determining whether a remote control is producing an IR signal or not.



(060120-1)

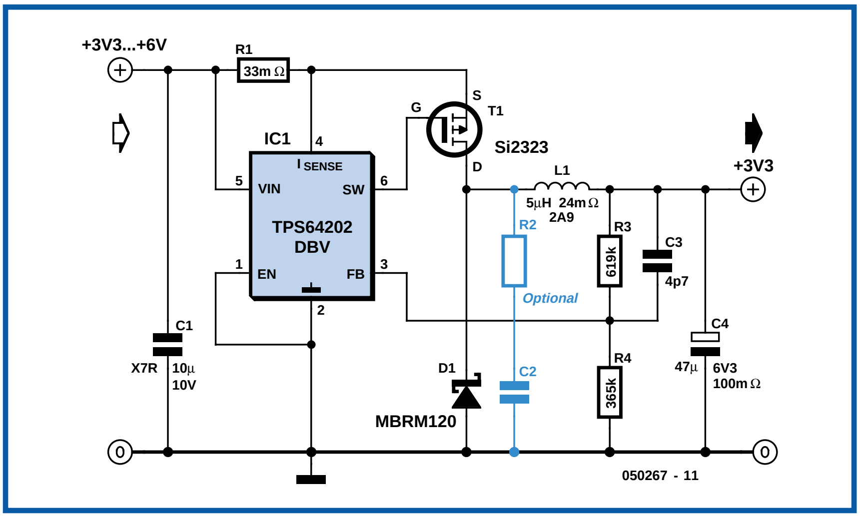
005

Step-Down Converter Controller

Dirk Gehrke, Texas Instruments

The TPS6420x controller is designed to operate from one to three series-connected cells or from a 3.3 V or 5 V supply obtained from a USB port. At its output it can produce 3.3 V at 2 A, suitable for powering a microcontroller-based system. With a suitable choice of external components (inductor, P-channel MOSFET and Schottky diode) the device can be operated over a wide range of possible output voltages and currents. A further advantage is its extremely low quiescent current consumption in power-down mode (100 nA typical) and in no-load operation (20 mA). Also, if the input voltage is less than or equal to the desired output voltage, the device can connect the output directly to the input.

Using just a few external components the TPS6420x can cover an output voltage range from 1.2 V up to the input voltage at up to 3 A, as long as a suitable P-channel MOSFET and Schottky diode are used. The device is an asynchronous step-down converter which, unlike the more widely-used PFM (pulse-frequency modulation) and PWM (pulse width modulation) types, involves a constant on-time and/or constant off-time. Conventional controllers operate in PWM mode at medium to high loads, switching to PFM at lower loads in order to minimise switching losses. The controller described here also adjusts its switching frequency in accordance with the load to achieve a similar effect to the PFM/PWM controllers.



TPS	On time	Off time	Applications
64200	1.6 µs	600 ns	Ideal for high efficiency over the entire range of output loads
64201	1.6/0.8/0.4/ 0.2 µs	600 ns	Reduced on-time for higher frequency operation than TPS64200, with switching frequency outside audio range
64202	0.6/0.8/0.4 µs	300 ns	Ideal for high switching frequency applications where the mark-space ratio approaches 1, such as converting 3.8 V to 3.3 V; the minimum off time determines the switching frequency
64203	0.6 µs	600 ns	Ideal for circuits with a low mark-space ratio where high switching frequency is required, such as converting 5 V to 1.5 V; the minimum on time determines the switching frequency

The circuit diagram shows a classical step-down converter with an input voltage range from 3.3 V to 6 V and an output voltage of 3.3 V at a current of up to 2 A. The optional 33 mΩ shunt resistor provides for current limiting. The TPS64202 offers a minimum on-time selectable between 1.6 ms, 0.8 ms, 0.4 ms and 0.2 ms and a fixed off-time of 300 ns. A MOSFET in the supply voltage path is switched on by the controller for as long as is necessary for the output voltage to reach its nominal value, or until the maximum permissible current, as determined by the shunt resistor, is reached. If the current does exceed this limit the MOSFET is switched off for 300 ns. If the nominal output voltage is reached, the MOSFET is switched off and remains in the off state until the output voltage once again falls below the nominal value. At very low output currents the controller therefore operates in 'discontinuous mode' (DCM). Each switching cycle begins with the current at zero. It rises to the threshold or maximum value, and then falls again back to zero. At the moment of switch-off the Schottky diode causes the residual energy in the inductor to appear as a quickly-decaying oscillation at the resonant frequency of the output filter. This low-energy oscillation in discontinuous mode is normal and has no adverse effect on the efficiency of the converter. It can be damped using the (optional) RC series network.
At higher output currents the switch-down converter operates in continuous conduction mode (CCM). In this mode the inductor current never falls to zero. The output voltage is directly proportional to the switching mark-space ratio in this mode.
If the Si2323 P-channel MOSFET from Vishay-Siliconix is not available, the IRLML6401 (12 V type) or IRLML6402 (20 V type) from IRF can be used instead. Both these types have a higher on resistance, but do offer a lower gate capacitance. An alternative for the Schottky diode suggested is the MBRM140 (available from Digi-Key and Farnell), although this is in an SMB package rather than the Powermite package of the MBRM120. The voltage drop at 1 A is somewhat higher: 0.6 V instead of 0.45 V. The devices are manufactured by IRF and ON Semiconductor.

(050267-1)

Literature at http://www.ti.com:

SOT23 Step-Down Controller, document reference number SLVS485

TPS6402 Evaluation Module (3.3 V, 2 A), document reference number SLVU093

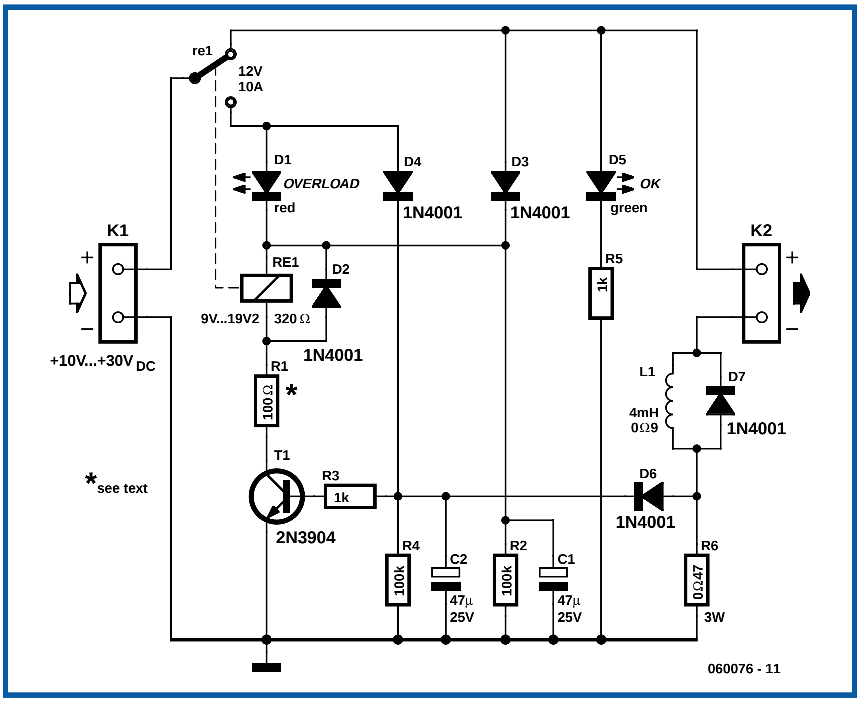
Fuse Saver

006

David Clark

This circuit will be particularly useful to those hobbyists who use a 'breadboard' to try out ideas and who also use a simple 'home-made' DC power supply consisting of a transformer, rectifier, smoothing capacitor and protective fuse, that is, one without overcurrent protection!

In this circuit, the detecting element is resistor R6. Under normal conditions, its voltage drop is not high enough to switch on transistor T1. The value of R6 can be altered to give a different cut-off current, as determined by Ohm's Law, if required. When a short circuit occurs in the load, the voltage rises rapidly and T1 starts to conduct. This draws in the relay, switching its contacts, which cuts off power to the external circuit, and instead powers the relay coil directly, latching it in this second state. The circuit remains in this state until the primary power supply is switched off.
Capacitors C1 and C2 hold enough charge (via D3, D4 and D6, which prevent the charge from being lost to the rest of the circuit, whichever state it is in) to keep T1 switched on and power the relay while it switches over, and R2 and R4 provide slow discharge paths. LEDs D1 (red) and D5 (green) indicate what state the circuit is in.
Inductor L1 slows the inrush of current when the circuit is switched on, which would otherwise cut off the circuit immediately. D2 and D7 provide the usual back-emf protection across the coils.
In use, the input of the circuit is connected to the main transformer-rectifier-capacitor-fuse power supply via K1, and the output is connected to the (experimental) load via K2. Note that the input voltage *must* be a floating supply if Vout– is grounded via the load, as Vin– and Vout– must not be connected together.
Some consideration needs to be given to



a number of components. First, the choice of relay Re1. For the prototype, this was obtained from Maplin, part number YX97F. This is has a coil resistance of 320 Ω, which with R1 forms the collector load for T1. Its allowed pull-in voltage range is nominally 9 V to 19 V, which limits the input power supply voltage to between around 10 V to 30 V (DC only). R1 could be replaced by a wire link for operation at input voltages below 10 V, or increased in value, as determined by either the application of Ohm's Law once more or trial and error, for an input voltage above 30 V.
Coil L1 was obtained from Farnell, part number 581-240. Finally, the protective fuse for the input power supply should be a 'slow-blow' type; 'fast' fuses will rupture before the relay has time to switch. Also note that this device is meant to save fuses, not replace them. A mains transformer must always be fused if it is not designed to run safely, i.e., without presenting a fire hazard, even if its output has a continuous short-circuit fault.

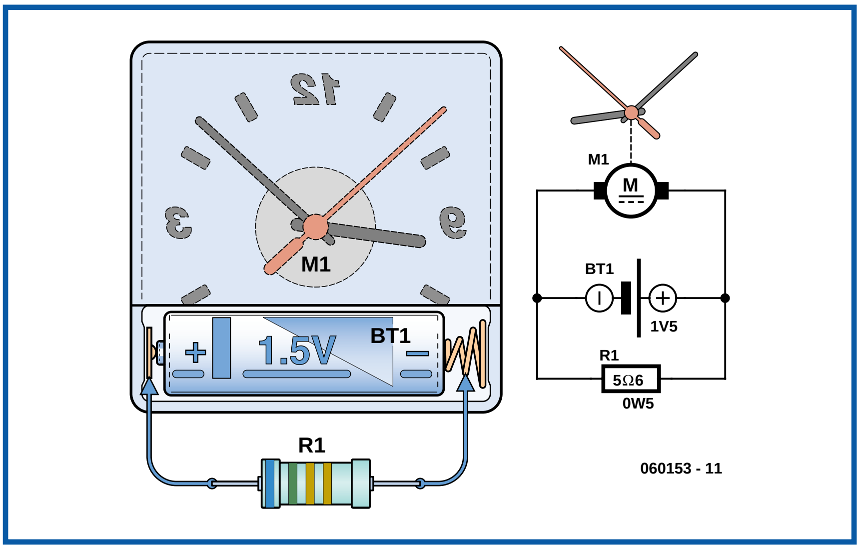
(060076-1)

007

Hyper-Simple Battery Capacity Tester

J. Van der Sterre

The circuit described here is eminently suitable to indicate the capacity of a battery. We use a cheap electric clock for this. By connecting a resistor across the battery terminals, the battery is discharged somewhat faster than with the clock alone. If we pick a resistor with a value of 5.6 Ω, the discharge current amounts to 1.2 V / 5.6 Ω = 214 mA. If we multiply this with the number of hours that the clock ran after the battery was connected up then we know (approximately) the capacity of the battery.



When discharging a NiCd battery we need to make sure we remove the battery the moment the clock stops running. NiCd batteries do not tolerate too deep a discharge very well. We therefore recommend keeping an eye on the voltage in one way or another, for example by connecting a multimeter in parallel with the resistor.

(060153-1)

008

Design for Märklin Light Signals

Nils Körber

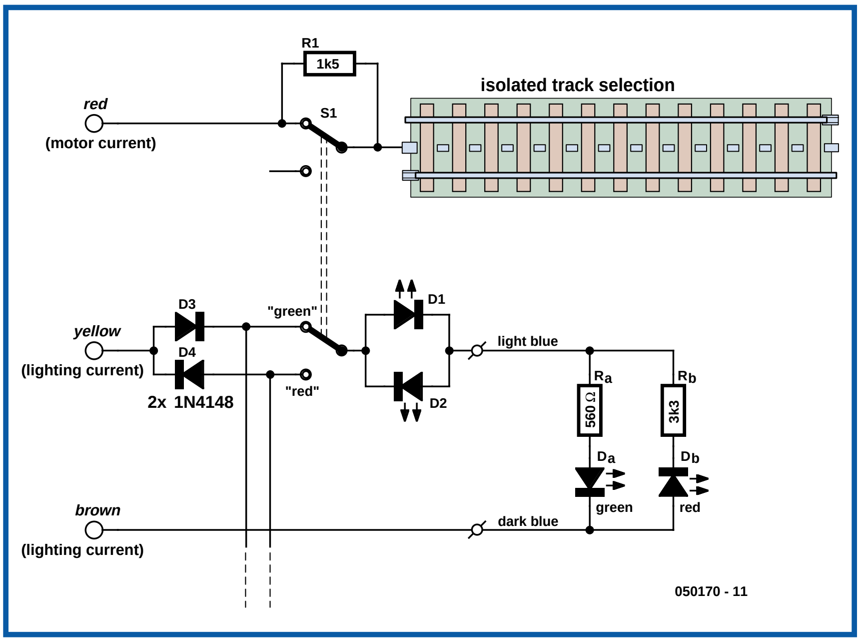
Märklin's light signal Type 74391 (blocking signal) for size HO model railway sets is fairly new and, at 10 euros (£7·00), reasonably affordable. There is, however, a little problem in that its operation requires the use of signal keyboard Type 72750, which makes the setup not only more expensive but also inflexible.
There is, fortunately, another solution, simpler and much more economical, which requires just a switch and two diodes. It is based on the fact that, seen from en electronics point of view, the light signal consists of two anti-parallel-connected LEDs with dropping resistors.

The lower section at the right of the diagram, Da, Db, Ra and Rb represents the typical inner circuit of such a light signal. When the output voltage of the light power source is applied to the circuit, both LEDs light. However, since only a red or green signal is wanted, the voltage is simply applied via diodes D3 and D4. Change-over switch S1 then determines which colour will be seen. Surely a very economical solution.
If in more complex setups it is required to have direct control over which colour the light signal on the track is to be, it suffices to add two further anti-parallel-connected LEDs, D1 and D2, in the connection between switch S1 and the light signal.
So far, so good. But now for a few spe-

cial aspects. Typically, a light signal contains a standard green LED, whereas the red LED is usually a low-current type. Therefore, the dropping resistors have different values. In the present circuit it is therefore necessary for D2 also to be a low-current type. Unfortunately, recent Märklin light signals are already fitted with two low-current LEDs. This can be ascertained by temporarily connecting the present circuit to the light signal and measuring the direct current for the two switch positions. Standard LEDs draw more than 10 mA, whereas low-current types draw not more than 5 mA.

If D3 and D4 are Type 1N4148, it is possible to use the circuit with about five light signals fitted with standard LEDs or with up to twenty fitted with low-current LEDs. If Types 1N4001 are used, up to 1 A can be drawn.

With railway tracks for analogue operation, which normally use 16 V AC power sources, Märklin light signals may be connected directly or via D1/D2. In case of digital tracks that use higher supply voltages, correspondingly higher-value



dropping resistors (or an additional one in series with D1 and D2) must be used. Finally, a tip that is as simple as it is practical. To retain the superb facility of analogue tracks whereby the train does not drive on when the signal is red, but stops automatically, isolate the power line to the last rail before the light signal and power this rail via the second contact of S1 — as already shown in the circuit diagram. Many other hints and advice for model railway enthusiasts may be found on the author's web site: www.koerber-home.de

(050170-1)

USB Switch for Printers

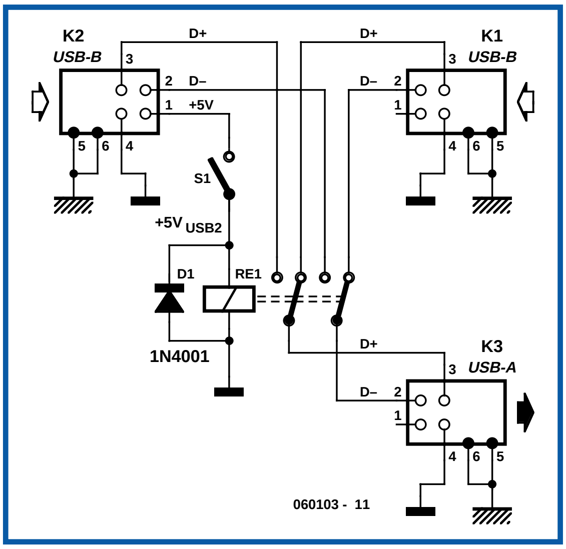
009

Liam Maskey

This circuit switches a printer's USB connection from a PC to a laptop. What was needed was a method of allowing a laptop to use the printer occasionally while at all other times the printer would be connected to the PC. Instead of unplugging the printer from the PC and then into the laptop, the circuit switches the USB connection automatically.

K1 and K2 are standard type-B USB sockets, while K3 is a USB type-A socket. The USB lead from the laptop plugs into K2 while the PC's USB lead plugs into K1. A USB cable from K3 connects the printer to this circuit. The cable from the PC is always plugged in while the cable from the laptop is only connected whenever this device needs to print.

In normal operation the laptop is not connected to K2, so the USB signal to the printer comes from the PC via K1, the normally closed contacts of relay Re1, through to K3 and from there to the printer. Whenever the laptop is connected up, the presence of the 5-volt power signal on its USB port causes Re1 to switch over to the printer's connection to K2 and the laptop. Unplugging the laptop returns control of the printer back to there PC.

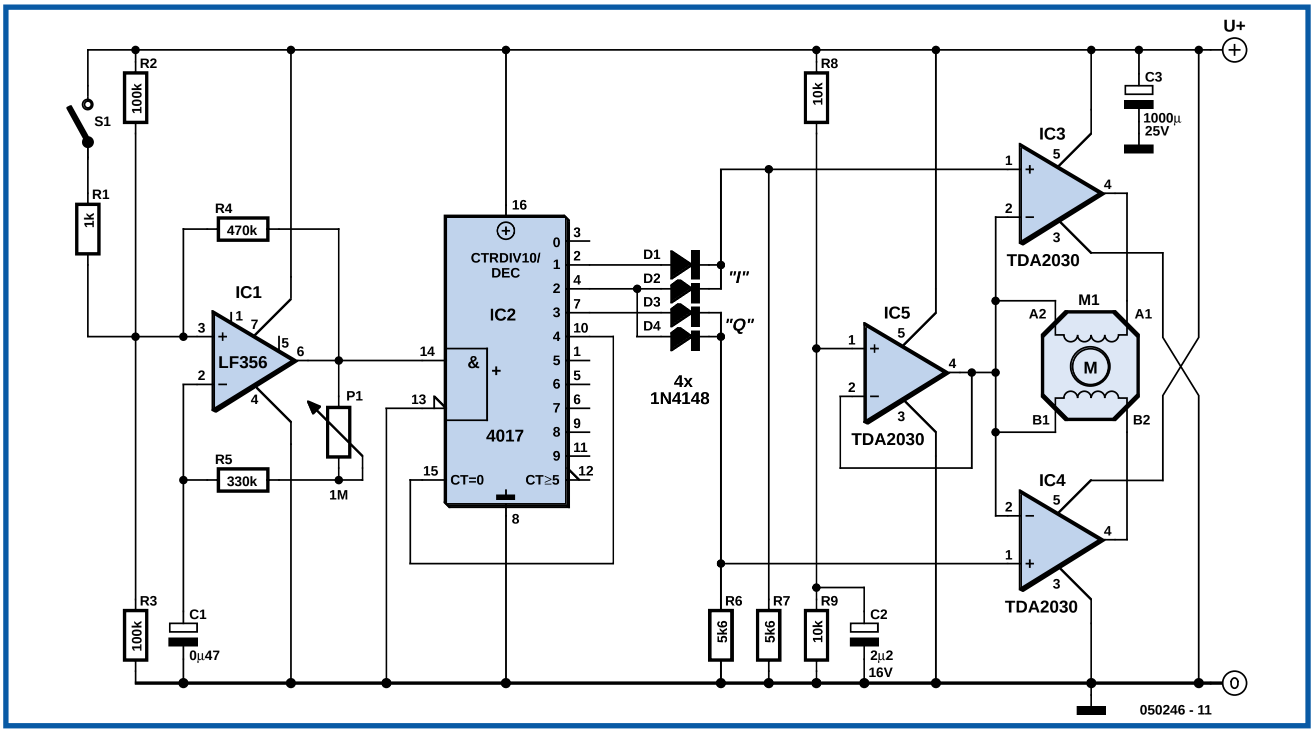


The circuit was tested on a USB-1.1 compliant printer and a PC and laptop that had USB-2.0 high-speed ports. The PCB traces for D+ and D– should be kept as short as possible and ideally should be the same length. The relay should be a low-power type (5 V at <100 mA coil current) with two changeover (c/o) contacts.

Switch S1 is only required in situations where the two computers you want to select between are permanently present and connected up to the circuit. The switch then selects the computer having access to the printer.

(060103-1)

010 Stepper Motor Controller



Gert Baars

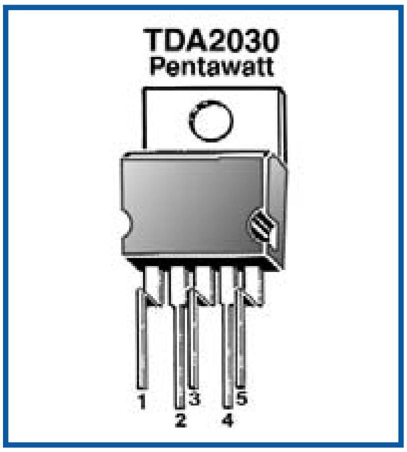
Stepper motors are available in several versions and sizes with a variety of operating voltages. The advantage of this general-purpose controller is that is can be used with a wide range of operating voltages, from approximately 5 V to 18 V. It can drive the motor with a peak voltage equal to half the supply voltage, so it can easily handle stepper motors designed for voltages between 2.5 V and 9 V. The circuit can also supply motor currents up to 3.5 A, which means it can be used to drive relatively large motors. The circuit is also short-circuit proof and has built-in overtemperature protection.

Two signals are required for driving a stepper motor. In logical terms, they constitute a Grey code, which means they are two square-wave signals with the same frequency but a constant phase difference of 90 degrees. IC1 generates a square-wave signal with a frequency that can be set using potentiometer P1. This frequency determines the rpm of the stepper motor. The Grey code is generated by a decimal counter in the form of a 4017. Outputs Q0–Q9 of the counter go high in succession in response to the rising edges of the clock signal. The Grey code can be generated from the outputs by using two OR gates, which are formed here using two diodes and a resistor for each gate, to produce the I and Q signals.

Here 'I' stands for 'in-phase' and 'Q' for 'quadrature', which means it has a 90-degree phase offset from the I signal.

It is common practice to drive the windings of a stepper motor using a pair of push-pull circuits for each winding, which is called an 'H bridge'. That makes it possible to reverse the direction of the current through each winding, which is necessary for proper operation of a bipolar motor (one whose windings do not have centre taps). Of course, it can also be used to properly drive a unipolar motor (with centre-tapped windings).

Instead of using a push-pull circuit of this sort, here we decided to use audio amplifier ICs (type TDA2030), even though that may sound a bit strange. In functional terms, the TDA2030 is actually a sort of power opamp. It has a difference amplifier at the input and a push-pull driver stage at the output. IC3, IC4 and IC5 are all of this type (which is economically priced). Here IC3 and IC4 are wired as comparators. Their non-inverting inputs are driven by the previously



mentioned I and Q signals, with the inverting inputs set to a potential equal to half the supply voltage. That potential is supplied by the third TDA2030. The outputs of IC3 and IC4 thus track their non-inverting inputs, and each of them drives one motor winding.

The other ends of the windings are in turn connected to half the supply voltage, provided by IC5. As one end of each winding is connected to a square-wave signal that alternates between 0 V and a potential close to the supply voltage, while the other end is at half the supply voltage, a voltage equal to half the supply voltage is always applied to each winding, but it

alternates in polarity according to the states of the I and Q signals. That's exactly what we want for driving a bipolar stepper motor.
The rpm can be varied using potentiometer P1, but the actual speed is different for each type of motor because it depends on the number of steps per revolution. The motor used in the prototype advanced by approximately 9° per step, and its speed could be adjusted over a range of approximately 2 to 10 seconds per revolution. In principle, any desired speed can be obtained by adjusting the value of C1, as long as the motor can handle it. The adjustment range of P1 can be increased by reducing the value of resistor R5. The adjustment range is 1:(1000 + R5)/R5, where R5 is given in kΩ.
If a stepper motor is switched off by removing the supply voltage from the circuit, it's possible for the motor to continue turning a certain amount due to its own inertia or the mechanical load on the motor (flywheel effect). It's also possible for the position of the motor to disagree with the states of the I and Q signals when power is first applied to the circuit. As a result, the motor can sometimes 'get confused' when starting up, with the result that it takes a step in the wrong direction before starting to move in direction defined by the drive signals.
These effects can be avoided by adding the optional switch S1 and a 1-kΩ resistor, which can then be used to start and stop the motor. When S1 is closed, the clock signal stops but IC2 retains its output levels at that moment, so the continuous currents through the motor windings magnetically 'lock' the rotor in position.
The TDA2030 has internal overtemperature protection, so the output current will be reduced automatically if the IC becomes too hot. For that reason, it is recommended to fit IC3, IC4 and IC5 to a heat sink (possibly a shared heat sink) when a relatively high-power motor is used. The tab of the TO220 case is electrically bonded to the negative supply voltage pin, so the ICs can be attached to a shared heat sink without using insulating washers.

(050246-1)

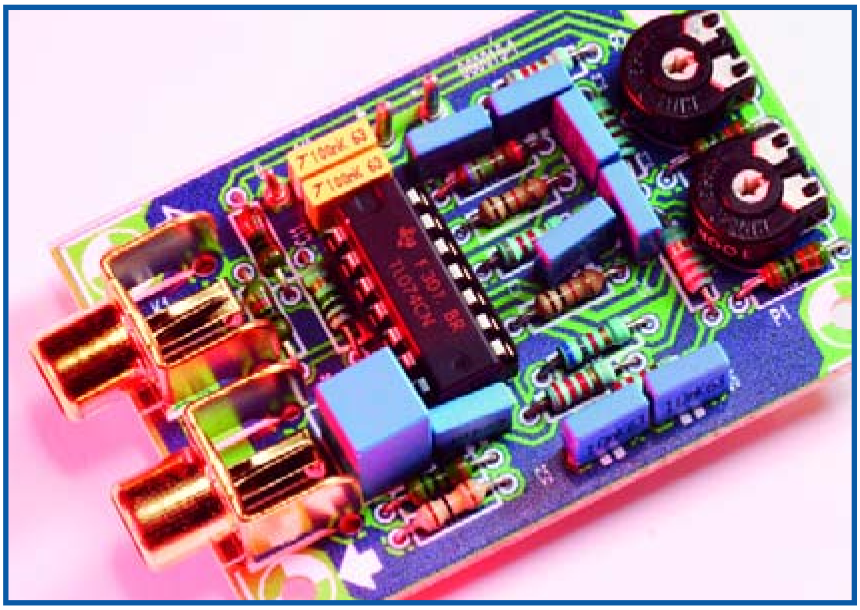
Paraphase Tone Control

011

Ton Giesberts

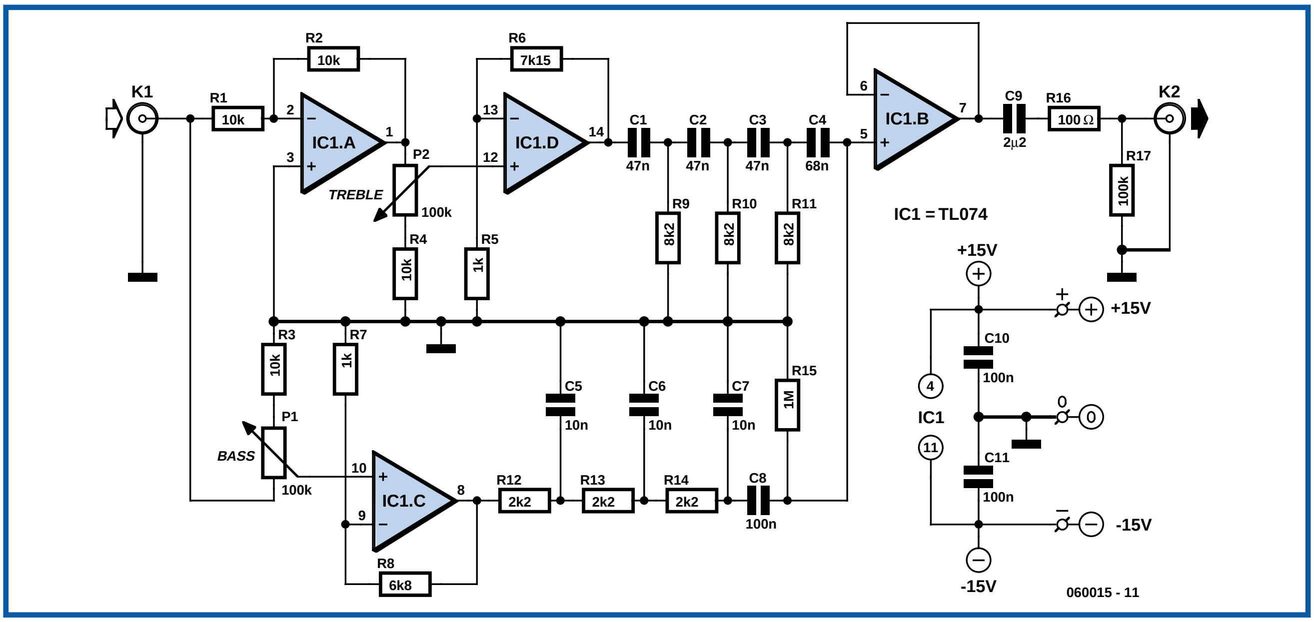
As opposed to the widespread Baxandall circuit (dating back to 1952!) a 'paraphrase' tone control supplies a straight frequency response as long as the bass and treble controls are in the same position. This unique property makes the 'paraphase' configuration of interest if *only* treble or bass needs to be adjusted — it is not possible to adjust both at the same time! Essentially, it's the difference in setting of the tone controls that determines the slope of the frequency response, and the degree of bass/treble correction.

The circuit in **Figure 1** is simplicity itself, based on two networks C1-C2-C3/R9-R10-R11 and C5-C6-C7/R12-R13-R14. The first is for the high frequencies (treble) response, the second, for the low frequencies (bass). The roll-off points have been selected, in combination with C4 and C8, for the sum of the two output signals to re-appear with a 'straight' frequency response again at the output. Roughly equal output levels from the networks are ensured by R6 = 7.15 kΩ and R8 = 6.80 kΩ. However, the operating principle requires the input signals to the two networks to be in anti-phase.
For best operation the networks are driven by two buffers providing some extra gain. The gain of IC1.D is slightly



Specification

Current consumption (no signal)		8 mA
Max. input signal		1 V_{eff} (at max. gain)
Gain	at 20 Hz	+13.1 dB max. –6.9 dB min.
	at 20 kHz	+12.2 dB max. –7.6 dB min
Gain (controls at mid position)		2.38 x
Distortion (1 V_{eff}, 1 kHz)		0.002% (B = 22kHz) 0.005% (B = 80 kHz)



higher than that of IC1.C to ensure the overall response curve remains as flat as possible at equal settings of the tone controls. Because each network introduces a loss of about 1.72 (times), IC1.D and IC1.C first amplify the signal. The gain is set at about 8 (times) allowing input signal levels up to 1 V to pass the circuit at maximum gain and distortion-free. The gain also compensates the attenuation if you prefer to keep the tone controls at the mid positions for a straight response.

To audio fans, the circuit is rewarding to experiment with, especially in respect of the crossover point of the two networks. R3 and R4 determine the control range, which may be increased (within limits) by using lower resistor values here. The values shown ensure a tone control range of about 20 dB.

IC1.B buffers the summed signal across

COMPONENTS LIST

Resistors

R1-R4 = 10kΩ
R5,R7 = 1kΩ
R6 = 7kΩ15
R8 = 6kΩ80
R9,R10,R11 = 8kΩ2
R12,R13,R14 = 2kΩ2
R15 = 1MΩ
R16 = 100Ω
R17 = 100kΩ
P1,P2 = 100kΩ preset or chassis-mount control potentiometer, linear law

Capacitors

C1,C2,C3 = 47nF MKT, lead pitch 5mm
C4 = 68nF MKT, lead pitch 5mm
C5,C6,C7 = 10nF MKT, lead pitch 5mm
C8,C10,C11 = 100nF MKT, lead pitch 5mm
C9 = 2µF2 MKT, lead pitch 5mm or 7.5mm

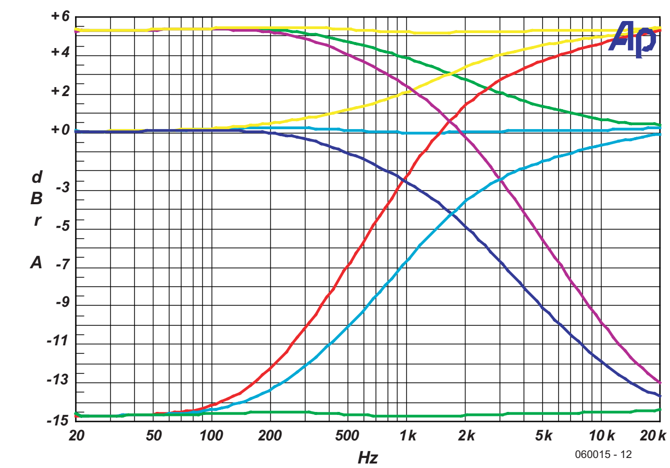
Semiconductors

IC1 = TL074

Miscellaneous

K1,K2 = line socket, PCB mount, e.g. T-709G (Monacor/Monarch)
PCB, ref. 060015-1 from The PCBShop

2



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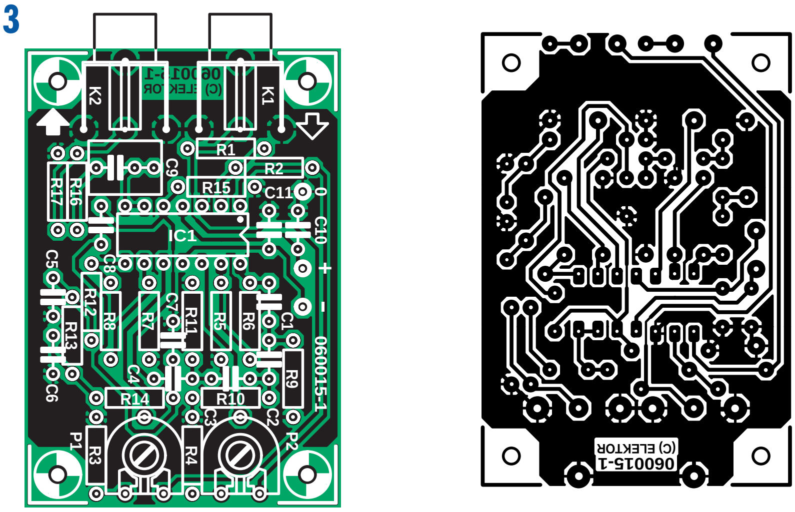


R15. C9 removes any DC-offset voltage and R16 protects the output buffer from the effects of too high capacitive loads. R17, finally, keeps the output at 0 V.
The choice of the quad opamp is relatively uncritical. Here the unassuming TL074 is used but you may even apply rail to rail opamps as long as they are stable at unity gain. Also, watch the supply voltage range.
The graph in **Figure 2** (produced by our Audio Precision analyser) shows nine response curves obtained by setting the two tone controls to minimum, mid position and maximum. Note that 0 dB is relative to the mid position of the pots!
A simple circuit board was designed for the project (**Figure 3**). Linear-law potentiometers may be fitted directly onto the board. Two boards are required for a stereo application. The relevant connections on the boards are then wired to a stereo control potentiometer.

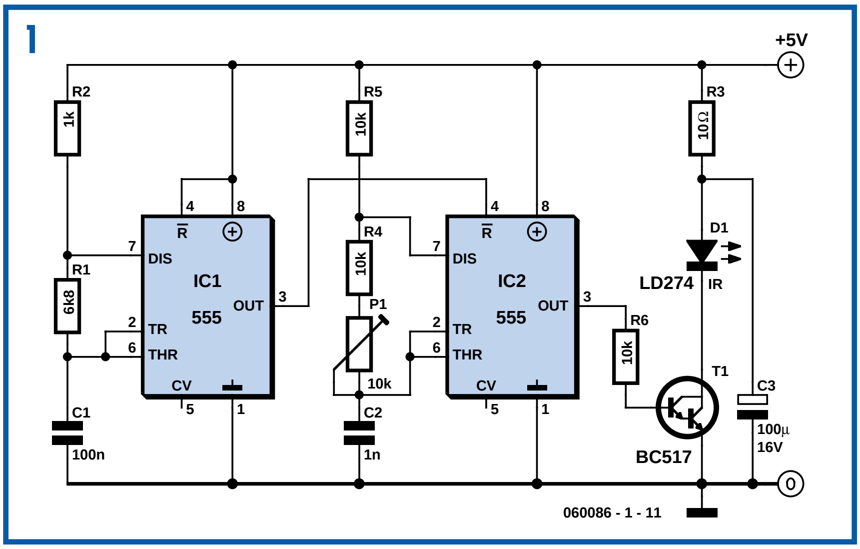
(060015-1)

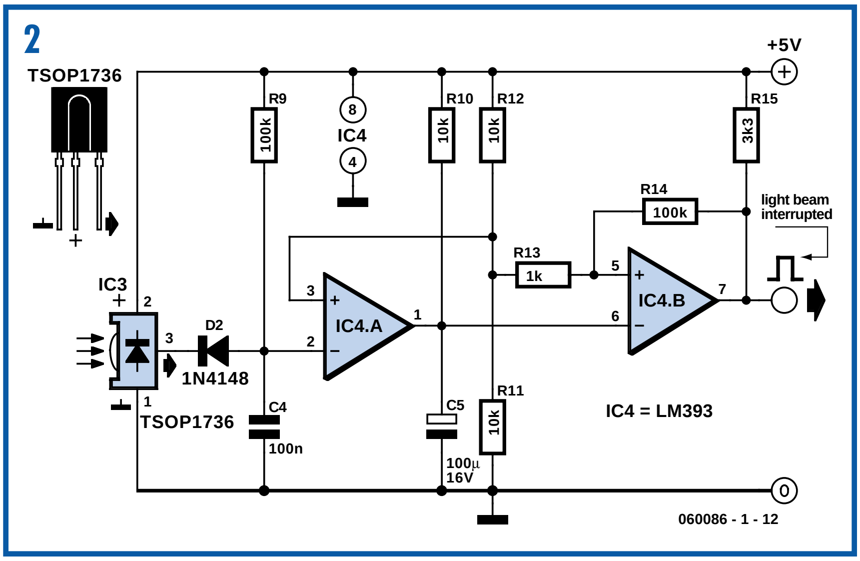
Modulated Light Barrier

012

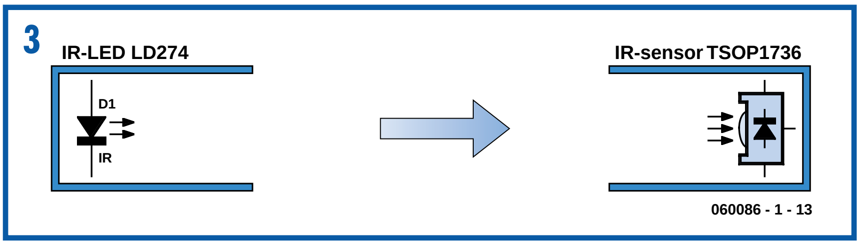
Heino Peters

It's good fun to keep an eye on all sorts of things in your environment and on the basis of events in this environment to switch, for example, lamps or buzzers. To help with this, the light barrier described here can be used to guard an entrance. You can use it to signal of someone is walking through the corridor, or to check if the car has been parked far enough in the garage to be able to close the door. The circuit consists of a transmitter, which sends modulated infrared light and a receiver, which recognises this. The circuit used here is almost insensitive to daylight or fluorescent light and therefore can be used outside.
The transmitter (**Figure 1**) generates about 1000 times per second, for a period of 540 ms, a burst of 36 kHz. IC1 has been set with C1, R1 and R2 to a frequency of about 1000 Hz. The output of IC1 ensures that IC2 will oscillate about 1000 times per second for a period of about 540 ms. IC2 is set to a frequency of 36 kHz with C2, P1, R4 and R5. The output of IC2 drives the IR LED D1 via transistor T1. C3 and R3 prevent the reasonably high current through D1 from generating too much interference on the power supply rail.
The receiver (**Figure 2**) is quite a simple design, because IC3 already does a lot of the work for us. When the IC 'sees' an IR-signal with a frequency of 36 kHz, the output of IC3 will become '0'. The transmitter circuit alternates between sending an IR-signal of 36 kHz for 540 ms and is quiet for 470 ms. When this signal arrives at IC3, C4 will discharge via D2. Because the non-inverting input of IC4a is set to 2.5 V, with the aid of R10 and R11, the output of IC4a will be a '1'. In the intervening quiet periods of 470 ms, C4 will partially charge via R8, but this is not of sufficient duration to exceed the voltage of 2.5 V. Only when the light barrier is interrupted will C4 charge far enough that the output of IC4a will toggle and become a '0'. Because IC4a has an open-collector output, C5 will be immediately discharged and the output of IC4b will become a '1'. With R9 and C5 this signal is stretched to about one second. If you increase the value of R9 to 100 kΩ, then this will become about 10 seconds. R12 and R13





are included to prevent chatter of the output around the trigger point, although there is not really a risk of that happening in this circuit. Together with R14, the output of IC4b delivers a clean logic signal that we can use for further processing.
The quickest way of calibrating the frequency of IC2 to 36 kHz, using P1, is with the aid of an oscilloscope. If you do not have one of those, then point the IR-LED D1 at the receiver IC3 and turn P1 so that the voltage on the inverting input of IC4a is as low as possible. Make sure that IC3 during the calibration does not receive too high a signal by placing the IR-LED a considerable distance away or by not pointing directly at the receiver. If this procedure is not that successful then just set P1 to the centre position, this works just fine usually.



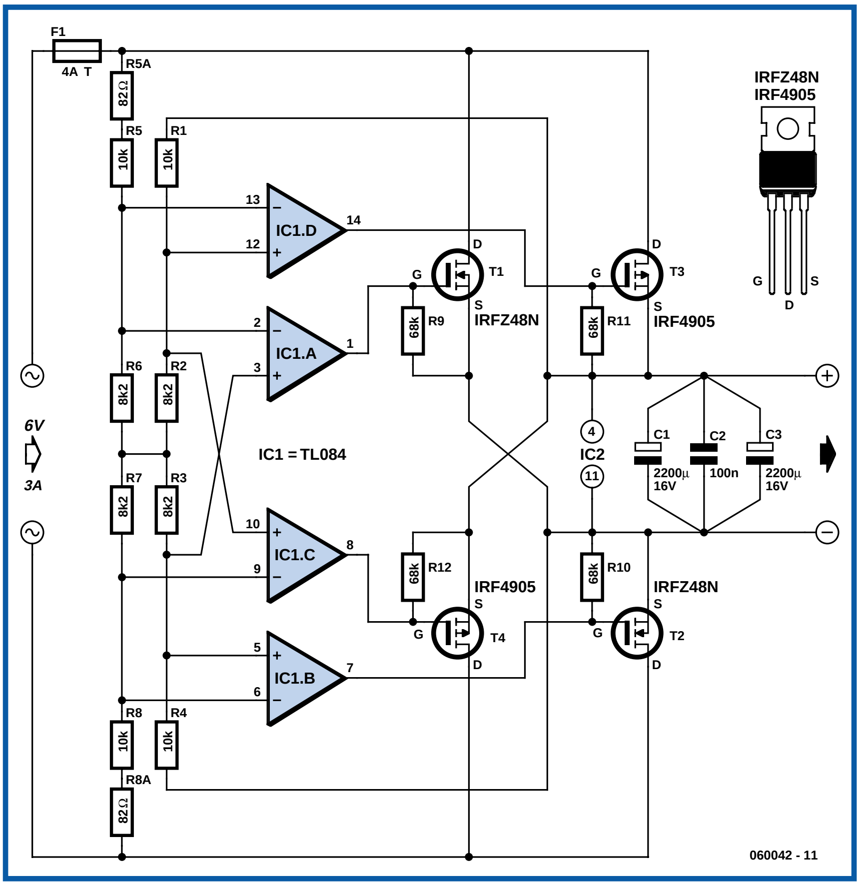
You should not have a problem with ambient light with this circuit. If you do have a problem because, for example, there is direct sunlight on IC3, then you will need to place it inside a small tube and point it at the IR LED. In this way no direct sunlight can reach the receiver. If the IR LED and the receiver are placed too close together it is possible that the receiver will sense light reflected off the walls, even when someone is standing between the transmitter and receiver. In this case the solution is also a short piece of tube for both the transmit LED as well as the receiver (**Figure 3**). Make sure that the tubes are opaque (paint black or use water pipe, for example). The wires to the IR LED can be several meters long without any problems. Do not place the receiver IC too far from the circuit.

(060086-1)

013

Power MOSFET Bridge Rectifier

Wolfgang Schubert



The losses in a bridge rectifier can easily become significant when low voltages are being rectified. The voltage drop across the bridge is a good 1.5 V, which is a hefty 25% with an input voltage of 6 V. The loss can be reduced by around 50% by using Schottky diodes, but it would naturally be even nicer to reduce it to practically zero. That's possible with a synchronous rectifier. What that means is using an active switching system instead of a 'passive' bridge rectifier.

The principle is simple: whenever the instantaneous value of the input AC voltage is greater than the rectified output voltage, a MOSFET is switched on to allow current to flow from the input to the output. As we want to have a full-wave rectifier, we need four FETs instead of four diodes, just as in a bridge rectifier. R1–R4 form a voltage divider for the rectified voltage, and R5–R8 do the same for the AC input voltage. As soon as the input voltage is a bit higher than the rectified voltage, IC1d switches on MOSFET T3. Just as in a normal bridge rectifier, the MOSFET diagonally opposite T3 must also be switched on at the same time. That's taken care of by IC1b. The polarity of the AC voltage is reversed during the next half-wave, so IC1c and IC1a switch on T4 and T1, respectively.
As you can see, the voltage dividers are not fully symmetrical. The input voltage is reduced slightly to cause a slight delay in switching on the FETs. That is better

than switching them on too soon, which would increase the losses. Be sure to use 1% resistors for the dividers, or (if you can get them) even 0.1% resistors.
The control circuit around the TL084 is powered from the rectified voltage, so an auxiliary supply is not necessary. Naturally, that raises the question of how that can work. At the beginning, there won't be any voltage, so the rectifier won't work and there never will be any voltage...
Fortunately, we have a bit of luck here. Due to their internal structures, all FETs have internal diodes, which are shown in dashed outline here for clarity. They allow the circuit to start up (with losses).
There's not much that has to be said about the choice of FETs – it's not critical. You can use whatever you can put your hands on, but bear in mind that the loss depends on the internal resistance. Nowadays, a value of 20 to 50 mW is quite common. Such FETs can handle currents on the order of 50 A. That sounds like a lot, but an *average* current of 5 A can easily result in peak currents of 50 A in the FETs. The IRFZ48N (55 V @ 64 A, 16 mW) specified by the author is no longer made, but you might still be able to buy it, or you can use a different type. For instance, the IRF4905 can handle 55 V @ 74 A and has an internal resistance of 20 mΩ.

At voltages above 6 V, it is recommended to increase the value of the 8.2-kΩ resistors, for example to 15 kΩ for 9 V or 22 kΩ for 12 V.

(060042-1)

Multimeter as Lightning Detector

014

Karel Walraven

Most digital multimeters have a sensitivity of 200 mV and in input impedance of 10 MΩ. With this information you can calculate that at full scale there will be a current of 20 nA (nano-ampères). In reality you have a very sensitive ammeter in your hand.
Now that we know this, it becomes a mission to do something with that knowledge. In other words, here is a solution that requires a problem...

For example, try the following:

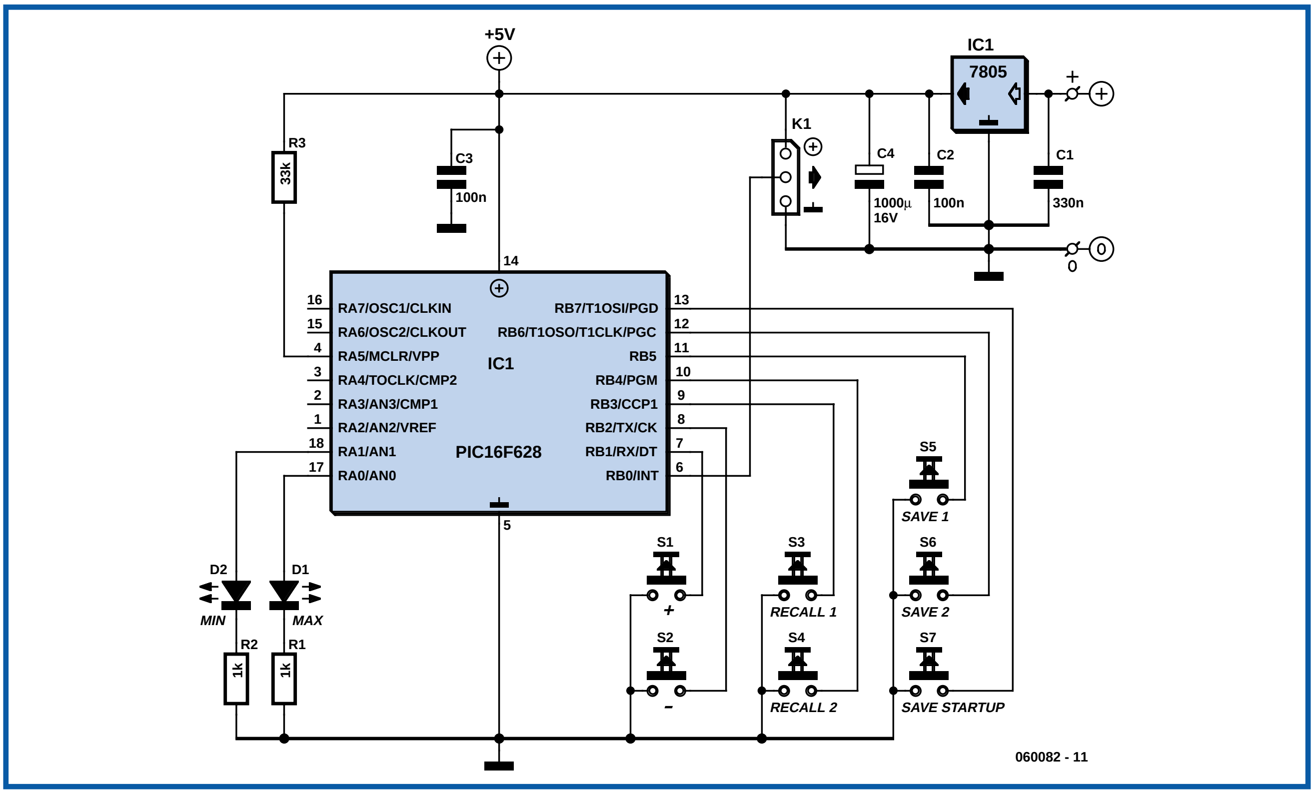
Connect the 'COM' of the voltmeter to ground (safety earth from a power point, central heating, plumbing, etc.). Connect an old bicycle wheel spoke or a length of thin copper wire to the 'V' socket so that you get a kind of antenna. When you place this impressive looking apparatus on a windowsill during a thunderstorm and set the meter to the 200 mV range, you will, with a bit of luck, see nice deflections during lightning strikes. A nice thing is that you will see a build-up of static charge long before the flash, and immediately after the lightning flash the charge is gone. Be aware of your own safety and those of others: Don't walk outside with the thing or surreptitiously lead the 'antenna' to the outside. This is really dangerous. In these modern times people still die from lightning strikes!
According to theory it is possible to improve the lightning detector somewhat. A sharp point or edge collects more than a rounded one. You probably have a razor blade somewhere. Attach this razor blade at the top of the antenna. And again, be careful: keep children and pets away.

In the picture you can see an assembly were the top of the antenna has one turn. The razor blade is clamped in this and in addition it is a lot harder to injure yourself this way.
The 'reception' can be improved a lot more by ionising the air in the region of the antenna with the aid of radioactivity. Most of the mantles used in gas and petroleum lamps contain a small amount of radioactive material and also smoke detectors that work with an ionisation chamber are (lightly) radioactive. It is better to leave the smoke detectors alone, because they often contain very poisonous substances, but a piece of lamp mantle could be secured to the razor blade with some two-component epoxy glue.

(064015-1)

015

Preset Circuit for Servos



Elmar Jongerius

This circuit was called into life to operate servomotors from the model world. The emphasis here is remembering certain preset values. For this, the internal memory of a PIC16F628A is used.
The module can be used to automate various mechanical functions. In addition to the usual model building applications, the circuit can also be used for the operation of small cranes, mirrors, etc. The preset-circuit can also be useful when doing demonstrations.
The hardware is very simple by design. When the circuit is powered up, it automatically drives the servo to the initial position. The circuit is operated using seven pushbuttons. The table details the functions of the pushbuttons. The pull-up resistors for the pushbuttons are already built into the PIC and the de-bouncing is handled by the software. Two LEDs are used to indicate the limit values and the power supply is provided by a standard circuit around a 7805. Additionally, it is convenient to use a connector so that a servomotor can be connected easily.
The operation of the servo is done with pulses of different lengths. These pulses need to be repeated about every 20 ms. A pulse duration of 1.5 ms corresponds approximately to the neutral position of the servo. The limit positions of the servo are at pulse durations of about 0.8 and 2.2 ms (this depends on the type of servo).
The program running in the microcontroller consists of a loop, which is repeated every 20 ms and comprises the following steps:

- check for pushbutton presses;
- check for valid values and turn on one of the LEDs if the limit value has been reached;
- send the pulse;
- wait 20 ms.

When checking for pushbutton presses, the IC will immediately carry out the corresponding action, for example storing a value in EEPROM. Because the buttons are checked once every 20 ms, additional de-bouncing is not necessary.
We have a few things that need to be noted regarding the construction of the circuit. Provide sufficient cooling for IC1, particularly if it is used with a high power servo or if the servo is exerting force continuously, for example against a spring. Also make sure that the servo is connected correctly. Different manufacturers use different colour codes. Fit C3 as close as possible to the PIC. This is because C3 serves to suppress interference from the servo.
The software for the project has been written in PICbasic and includes comments.

No.	Name	Function
S1	Up	Move the servo in the positive direction
S2	Down	Move the servo in the negative direction
S3	Recall 1	Recall the value of Set 1
S4	Recall 2	Recall the value of Set 2
S5	Set 1	Store the current position in Set 1
S6	Set 2	Store the current position in Set 2
S7	Set Initial	Store current position as initial position

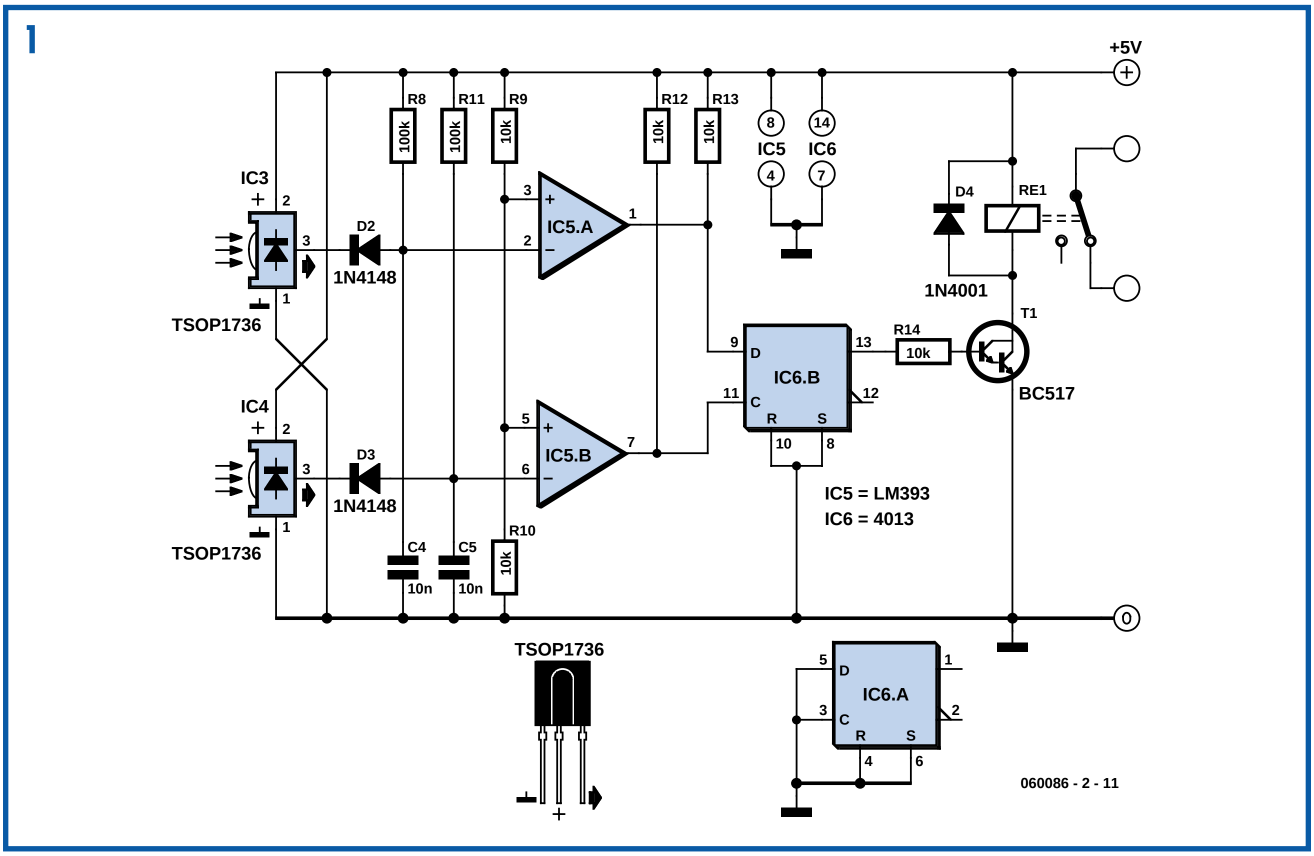
The program is easily compiled and optionally changed with the free Lite version of the Proton PICbasic compiler. It is however necessary to remove the comments.

The program code can be downloaded from www.elektor-electronics.co.uk, you'll find it filed as number **060082-11.zip**. A pre-programmed PIC is available as order code **060082-41**. A version of PICbasic can be obtained from www.picbasic.org.

(060082-1)

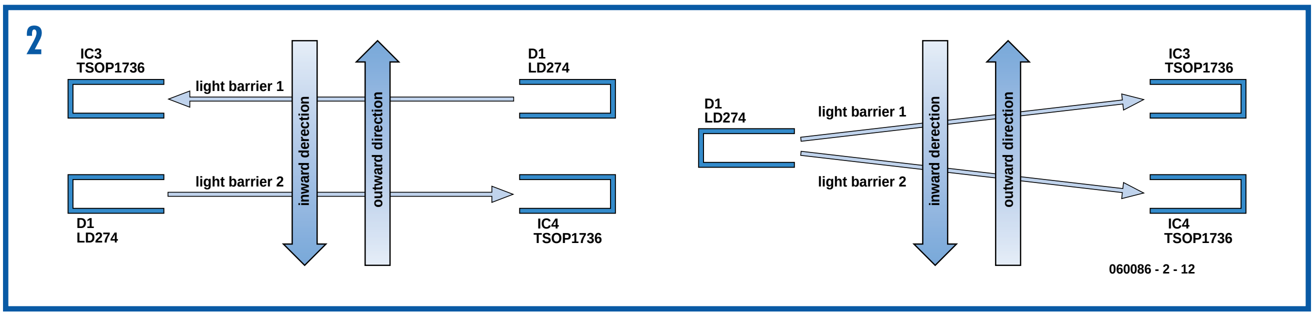
Direction Sensitive Light Barrier

016



Heino Peters

With two light barriers closely positioned one after the other it is possible to establish in which direction they have been crossed. If, for example, you place it at the entrance of the toilet then you can use it to control the lights: on when entering and off when leaving the room. The circuit for this has many similarities with the modulated light barrier appearing elsewhere in this Summer Circuits issue. There are two ways to position the light barriers, namely a completely duplicated installation in opposing directions (this to prevent mutual interference) and a version with one IR transmitter and two receivers. Both types of installation are shown here, which one is most suitable depends on the actual application. When used in a doorway, one transmitter is sufficient if the receivers are placed about 5 cm apart. With a wider passage, an installation with two separate



IR-transmitters is a better solution. This circuit has a range of several meters, even if the sun shines directly on the receiver!

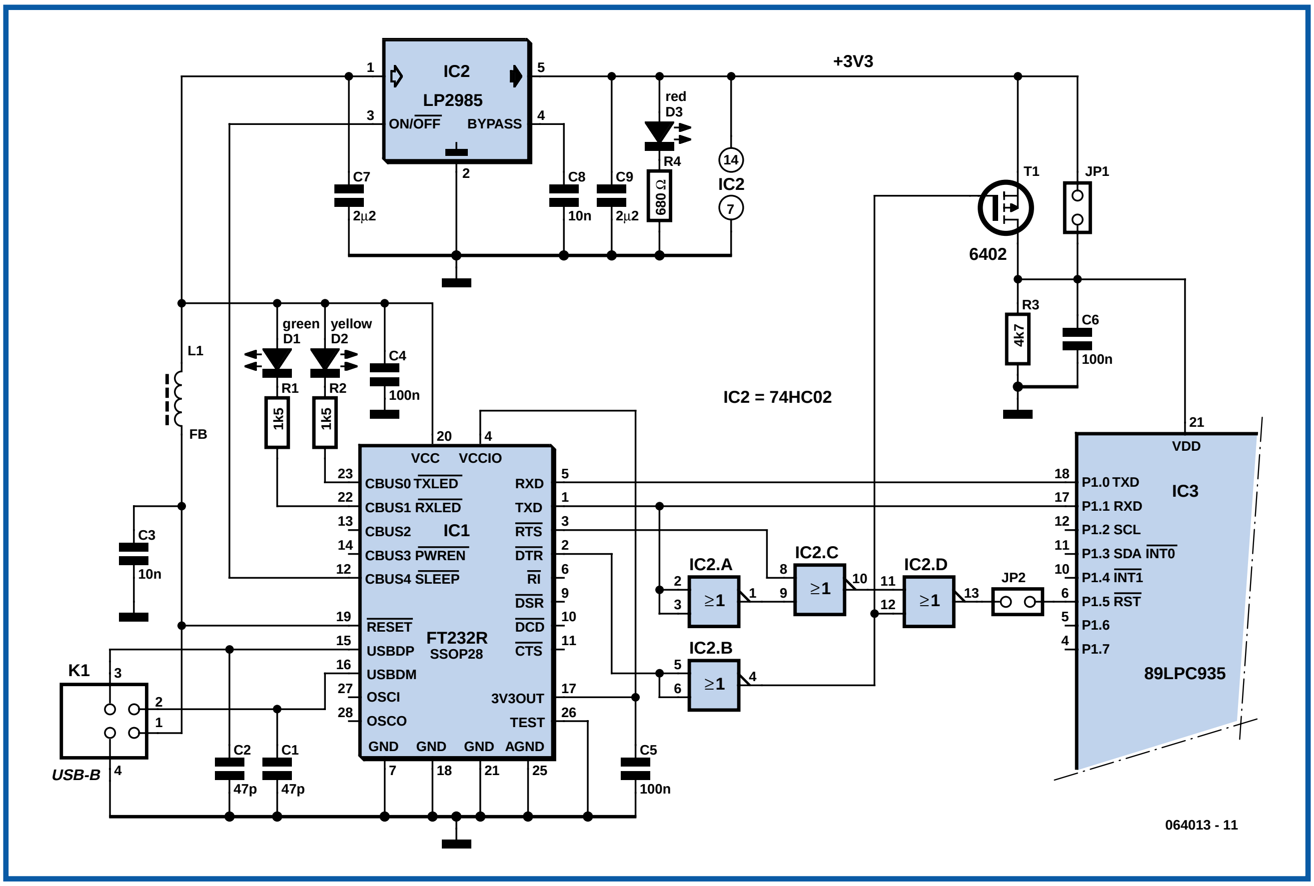
We use the exact same IR-transmitter(s) as for the modulated light barrier. For the installation with two separate IR-transmitters it is sufficient to duplicate R6, T1, D1, C3 and R7 from the circuit of the modulated light barrier. Output OUT (pin 3) of IC2 can drive two of these IR-drivers without any difficulty. The receivers are slightly different than those of the modulated light barrier and the circuit is the same for both types of installation.

We again use the TSOP1736, which is sensitive to IR-light that is modulated at a frequency of 36 kHz. D2, R8 and C4 ensure that the received pulses from IC3 at the output of IC5a result in a '1' when the beam is not interrupted. When the beam is interrupted this output will become a '0' within about 1 ms. In the same way IC5b generates a '0' when IC4 stops receiving IR-light. The 4013 CMOS-IC used here contains two D-flipflops, of which we use only one. The instant that light barrier 2 (IC4) is unblocked again, is used to clock the state of light barrier 1 (IC3) through to output Q1. This signal drives the relay via T2, which operates the light in the room. The circuit therefore turns the light on or off the moment that light barrier 1 is uninterrupted.

(060086-2)

017

89LPC9xx USB Programming



Back in November 2003 you could already read about a small development system for the (then) new series of controllers from the 8051-compatible 89LPC9xx-family. A nice feature of the current 89LPC9xx-series is that these chips can remain in the circuit while (re-)programming. All that's required for this programming is an RS232 port. But because many modern computers do not have an RS232 connection any more, we propose here a USB version. For this we use a well-known USB/RS232-converter chip, the FT232R.

The 89LPC9xx series can be placed in programming mode in two different ways: by transmitting a 'break' over the serial port or by providing three defined reset pulses immediately after power-on. We use the latter method, because this is a hardware solution. This is because the 'break' has to be sensed by software. In plain language: this method only works with a well-behaved program. And this is obviously not always the case in a development environment!

When you also look at the schematic from 2003, you will see that very little has changed. Really the only difference is that the RS232 interface chip has been replaced with the FT232R. As you will know, the USB-interface is terribly slow when the handshake lines such as DTR and RTS are used. Fortunately that is not the case here, since DTR and RTS are used just once at the beginning and end of the programming cycle. The actual programming is done by transmitting commands and data across the serial port.

A few remarks:

To be able to program you will have to change a jumper each time. On the one hand this is a little tedious, but on the other hand it gives a little bit of security. During software development a double pole change-over switch does wonders!
Note that the processor is placed in programming mode by three reset pulses after power-on. If the power supply voltage does not drop sufficiently beforehand (<2.7 V), then the processor will not be placed in power-up mode by the brownout circuit and therefore cannot be placed in programming mode either. That is why a resistor of 4k7 has been added to drop the power supply voltage faster and lower. Check the inputs in your application. If these are powered from another voltage then the processor will be powered from its inputs via the protection diodes and programming will not work then!
It is possible (but not necessary) to power the circuit through a low-drop regulator from the USB-connection.
You can also omit L1, but it is better to put a few turns of wire through a ferrite bead.
The pin numbering shown is for the SSOP-28 package.

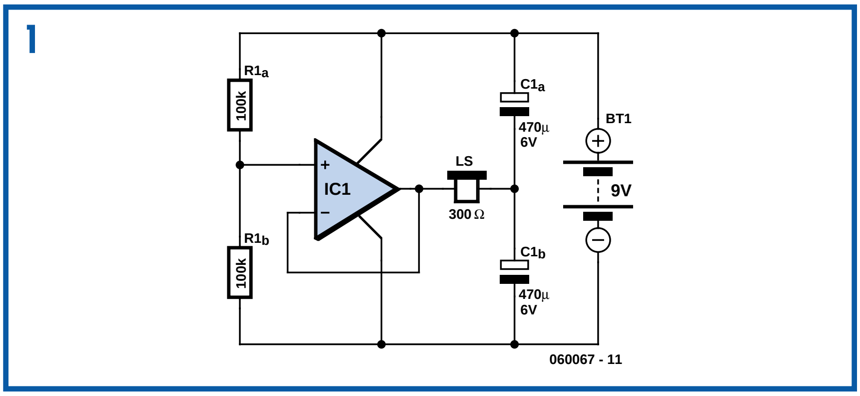
(064013-1)

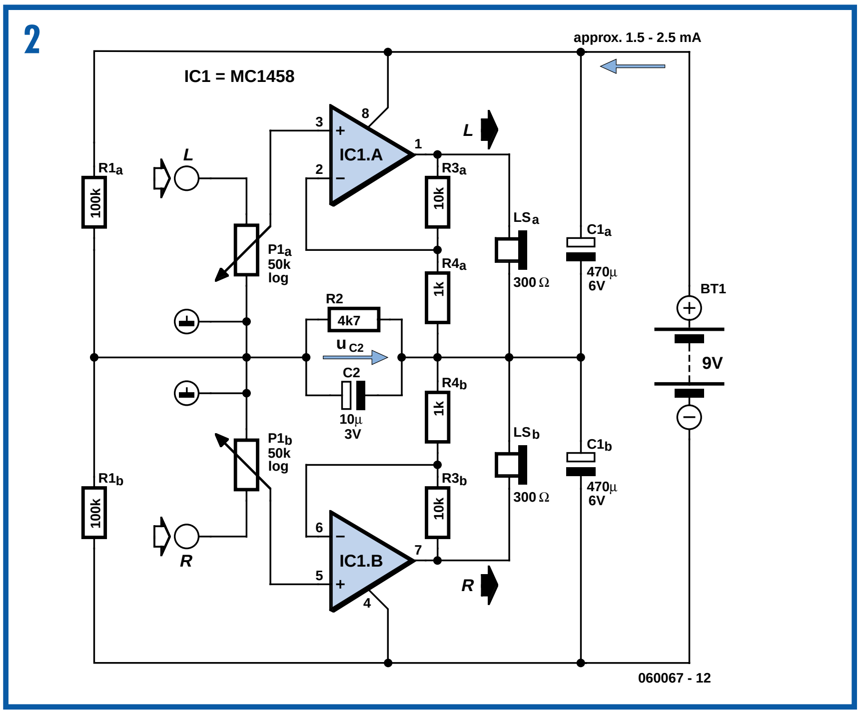
DC-coupled Audio Amplifier

018

Peter Bitzer

Designs for audio amplifiers with DC coupling to the load are not often encountered these days, even though they offer definite advantages. One advantage is that there is no need for the complication of a second (symmetric) power supply; another is good frequency and phase response. Also, no special electrolytic capacitors are needed for voltage stabilisation, and switch-on 'thump' is much reduced.
To try to rescue this class of circuit from obscurity the author has designed a headphone amplifier working along the lines illustrated in **Figure 1**. It consists of a voltage divider, a voltage follower and the loudspeaker in the headphones, whose other side is connected to the junction of two electrolytic capacitors, providing the virtual earth. The potential at this point is, of course, half the supply voltage. All we need to do now is suitably couple in the audio signal to be amplified.
Figure 2 shows a practical realisation of this idea in the form of a stereo headphone amplifier. The amplifier itself consists of IC1 and P1, R3 and R4 (giving a gain of 11). This part of the circuit demands no further explanation, and the same goes for the voltage divider mentioned above, formed by R1a and R1b. The signal is coupled in via the potentiometers. C2 and R2 have a special purpose: C2 connects the bottom end of the potentiometers (ground for the input signal) to the virtual earth. However, this capacitor creates a feedback path which can lead to oscillation of the amplifier under some circumstances. R2 damps this

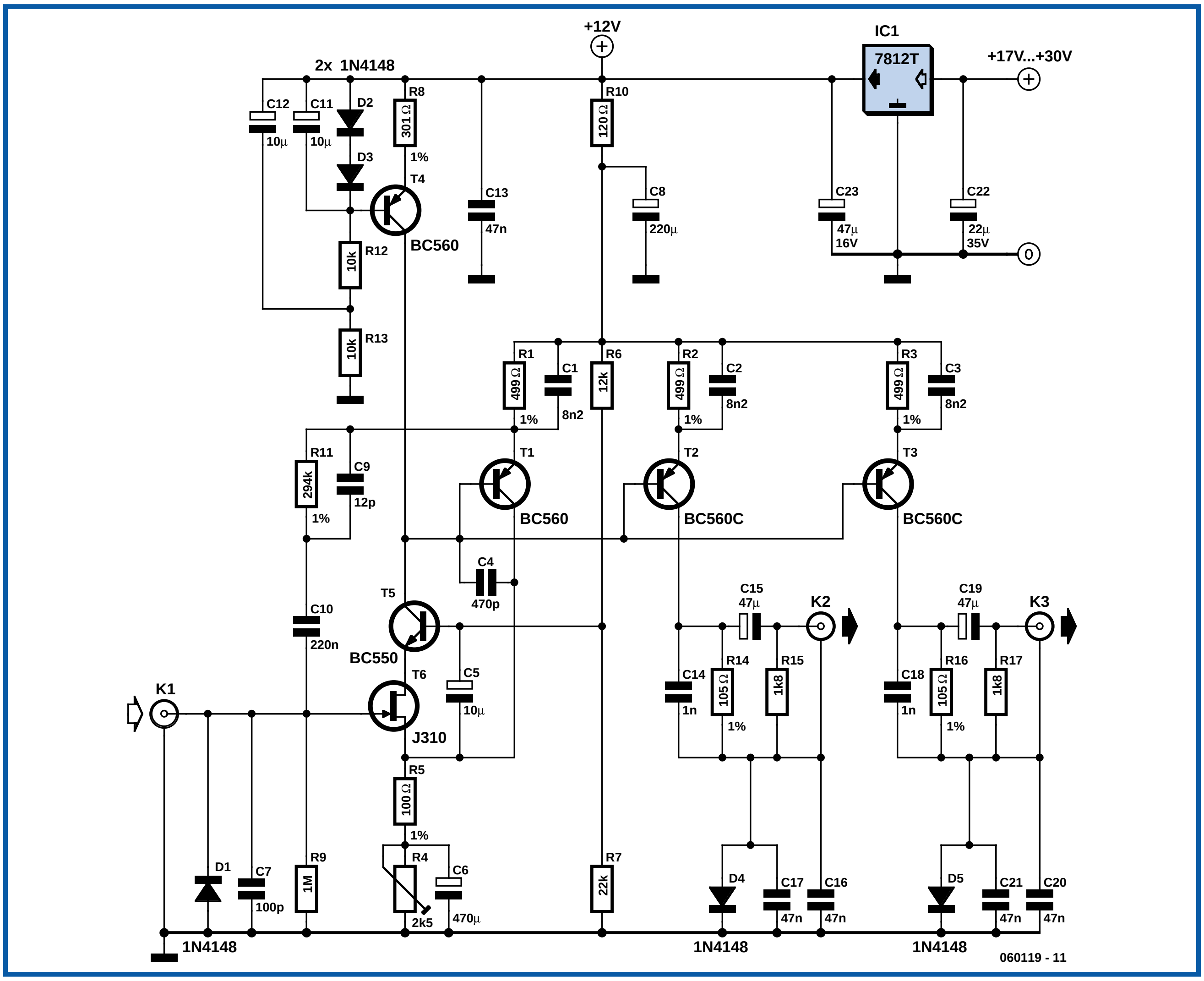




tendency to oscillate. It is possible to calculate suitable values for these components, but it is better to determine them by experiment. C2 must be sufficiently large that stray electric fields do not cause unacceptable hum at the output. R2 must be sufficiently large that the voltage at the amplifier's virtual earth stabilises quickly enough after switch-on. The polarity of the electrolytic is unimportant as no significant voltage appears across the network. It is possible to try the circuit out with the C2/R2 network shorted and observe the behaviour of the circuit at switch-on using an oscilloscope. Depending on the degree of asymmetry in the circuit, the voltage at the virtual earth point can take a considerable time to stabilise.

(060067-1)

019 Phono Splitter



Marcel van de Gevel

This circuit is intended to send the signal from a record player with a magnetodynamic (MD) element to two different RIAA-amplifiers without creating any problems with ground loops. A kind of distribution amplifier for phono signals, in other words.

The circuit was originally designed by a local VHF FM broadcast station called 'Haarlem 105'. For the golden-oldies programme, the signals from two record players had to be sent to a large radio mixing panel (which is also the entry point for jingles and presenter microphones). For a programme with modern dance music the signals had to be routed to a small club mixing panel that was positioned between the two record players.

Connecting in parallel was not an option, because it will create a ground loop and the load for the element will be wrong. An RIAA amplifier for each player was not possible either because all the line inputs of the small club mixing panel were already in use. Switching between them was also not desirable; another switch that can be in the wrong position…

The circuit works as follows. The feedback ensures that the signal voltage of the element will be across R5. The signal current that results from this, runs through T1 and, because the bases are tied together, also through T2 and T3. This causes a signal voltage across R14 and

R16. By connecting one side of R14 or R16 to the local ground of the mixing panel, the signal voltage will be between the input and the local ground of the mixing panel. This connection to the local ground of the mixing panel is done via the screens of the phono plugs. The part of the chassis at the output must definitely be isolated.

D4 and D5 operate like a kind of automatic ground lift switch. It is the intention that the ground from the distribution amplifier is connected in one way or another to the ground of the mixing panels, obviously without creating a ground loop. The DC from T2 and T3 flows via the screens of the phono cables and the ground connection back to the distribution amplifier. There is hardly any DC voltage across D4 and D5, so that they do not conduct. As a result the outputs for the signal voltages are well isolated from each other, which reduces the risk of a ground loop.

If there is no connection between the ground of the distribution amplifier and the grounds of the mixing panels then D4 and D5 will conduct. Everything continues to function, but there is a relatively low-impedance connection between the screen of X2 and the screen of X3 via the diode, which can cause a weak ground loop if the grounds of the mixing panels are also connected together via another path.

An input impedance of 47 k is absolutely essential to properly terminate an MD-element. This is realised in this amplifier with feedback via R11. This results in lower input noise compared to simply soldering a 47-kΩ resistor in parallel with the input. Trimpot R4 is required because of the wide tolerance of field effect transistor T6. Adjust R4 so that there is about 1 V across R1. If R4 is a carbon trimpot, then the wiper has to be connected to the positive side (as indicated in the schematic) to prevent anodisation of the wiper.

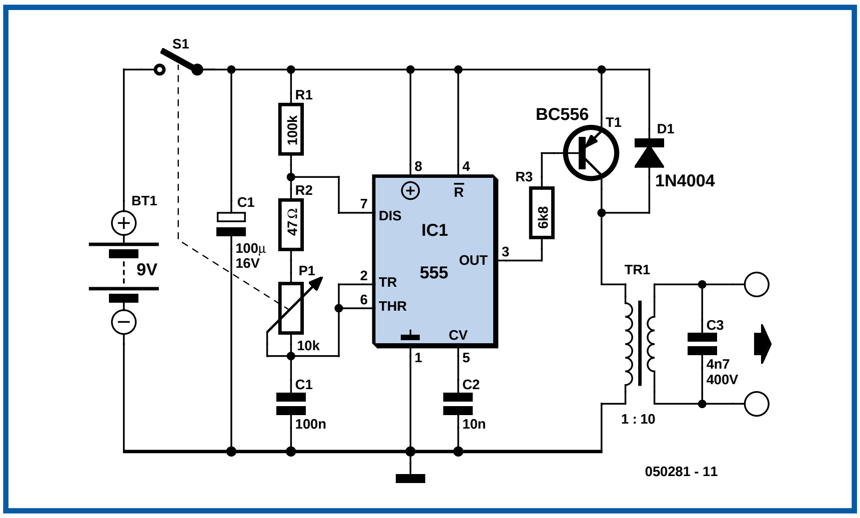
The distribution amplifier has four identical channels, enough for two stereo record players and is powered from one 7812, which does not need a heatsink.

(060119-1)

Transcutaneous Electrical Nerve Stimulator (TENS)

020

Klaus Rohwer



A Transcutaneous Electrical Nerve Stimulation (TENS) device is, put bluntly, a machine for giving electric shocks. The author was prescribed such a device on loan by his orthopaedic specialist. The unit has a large number of programmes, of which he used only one. Measuring the signals at the output of the device in this mode revealed damped oscillations at a frequency of approximately 2.5 kHz, with a repetition rate of approximately 100 Hz. How hard can it be to make such a device ourselves?

The simple circuit uses a CMOS 555 timer to produce a brief pulse which feeds a 1:10 miniature transformer. Together with a 4.7 nF capacitor the transformer makes a parallel resonant circuit: the resonance leads to a considerable increase in the output voltage.

The pulse width can be adjusted using a potentiometer, here shown combined with the on-off switch. Wider pulses produce higher output voltages. Since a peak voltage of up to 200 V can be produced, the transformer must have adequate insulation: Conrad Electronics type 516260-62 is suitable. A low-cost phono socket at the output gives reliable connection to the electrode cable. The adhesive electrodes shown in the photograph (disposable and permanent types are available) can be obtained from pharmacies and medical suppliers. They generally have connectors compatible with 2 mm banana plugs, and so it is possible to make up the necessary cable yourself.

To treat responsive parts of the body, such as the arm, the potentiometer need not be turned up far to obtain the necessary sensation. Less sensitive parts, such as the knee or foot, need a rather higher voltage and hence a correspondingly higher potentiometer setting.

Anyone considering building a TENS unit with multiple (microprocessor-controlled) programmes might wish to read the article 'Low Impact Muscle Stimulator' in the April 2000 issue of *Elektor Electronics*. The article is also available for purchase as a pdf file at http://www.elektor-electronics.co.uk.

(050281)

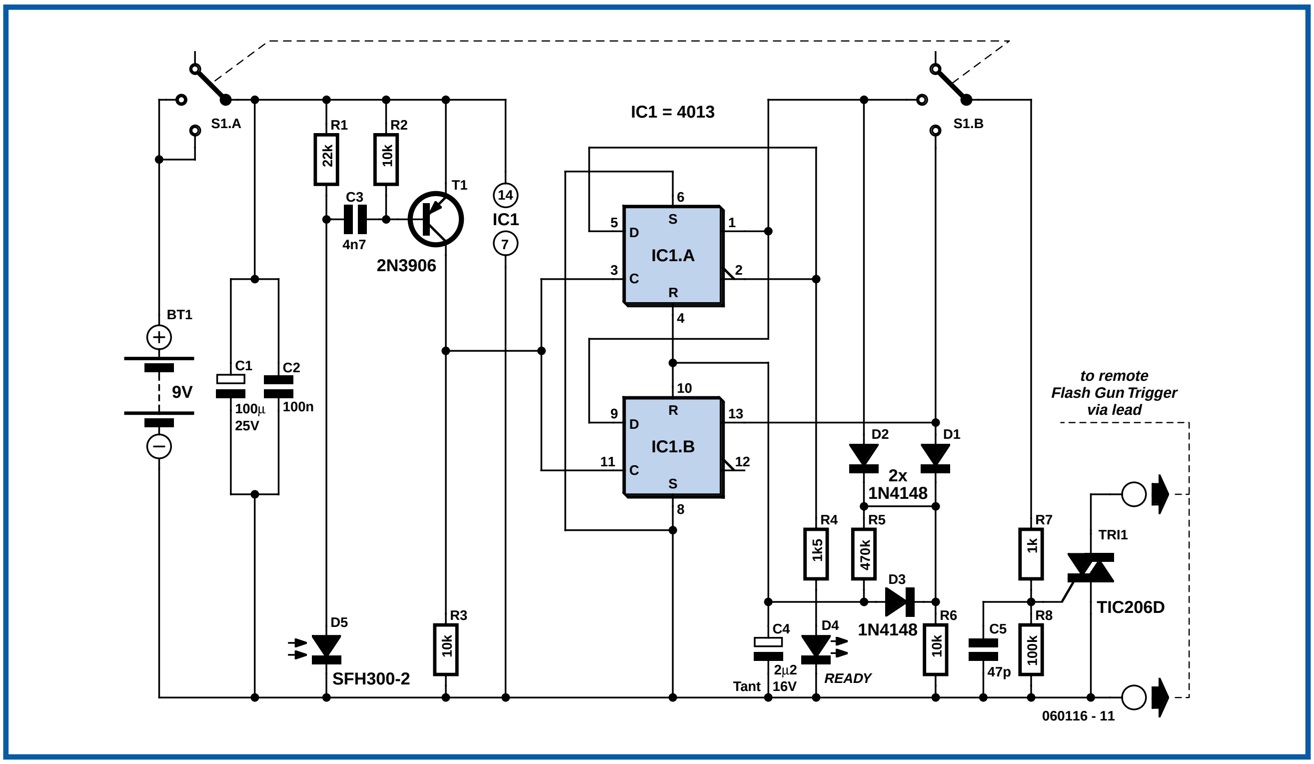
Warning

No part of this circuit may be connected to the mains voltage, accidentally or intentionally, by means of any equipment or component including a transformer.

Disclaimer

This circuit is not approved for medical use and must not be used on young children or persons suffering from epilepsy. Medical advice should be sought from your GP before all use.

021 Slave Flash Trigger

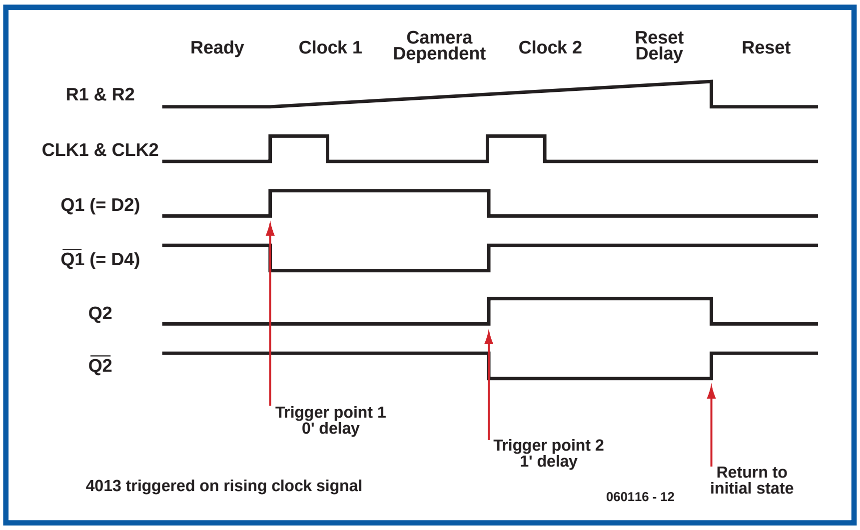


Peter Metcalfe

Using any camera in a dull or dark environment generally requires the use of supplementary light. This is a standard technique, and even where adequate natural lighting exists, to take conventional film pictures with enhanced contrast using a 'fill-in' flash for foreground subjects in shade. A flash is often built into the camera body, but the internal flash is not usually powerful enough to illuminate subjects much more that 3 m or so from the camera. On SLR cameras a hot-shoe is provided for triggering an auxiliary, more powerful flash, but the small pocket cameras are not so equipped. However, it is possible to trigger a slave flash from the camera flash by optical means. Even so, things are not so simple, for some cameras, e.g. Olympus, Nikon, Canon actually fire twice, although it appears to be once to the naked eye. The first flash sets the exposure and the second takes the picture. Help on synchronisation requirements may be found at various websites maintained by professional photographers. See also www.caves.org.uk/flash/docs.html for a series of articles with kits by a caving enthusiast.

The presented trigger circuit optically receive the camera flashes and either fires at the same time as the first flash or has one flash delay before triggering the slave flash. Additional counting circuitry is required for more than one delay (covered by modified circuit not presented here).

Here's how it works. The response of phototransistor D5 to the external camera flash is pulsed by a transistorised amplifier T1 into the dual flip-flop clock IC1. One output of a flip-flop illuminates an LED as a 'ready' signal. A double pole 3-position slide switch, S1, selects none (e.g. for Kodak camera) or one (e.g. for Olympus camera) flash delay before triggering. Both flip-flops are used in the 4013, the clock signal derived from the flash is used (triggered on the rising clock signal) to 'divide by two' and trigger the TIC206 triac on the first or second flash. A simple RC timed reset



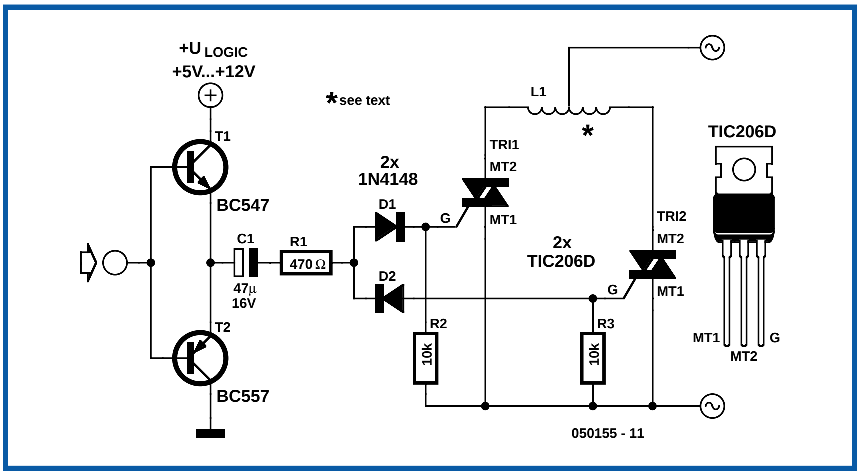
mechanism around R6-C4 is used with a relatively long delay (about half a second) before resetting the entire circuit. The advantage of the triac is that a trigger voltage of either polarity can be handled.
The 2N3906 may be replaced by its near equivalent the BC212L. The SFH300-2 photodiode is supplied by Maplin as part number MES NP64U. The triac may also be a TIC126D.

(060116-1)

Model Railway Turnout Control

022

Hans Zijp



This small circuit can be used to control model railway turnouts operated by AC voltages. A logic level in the range of 5–12 V can be used as the control signal. The coils of the turnout are switched using triacs.
Changes in the logic level of the input signal are passed on by the buffer stage built around T1 and T2. The buffer stage is included to boost the current available at the gates of the triacs. If the input goes high, this positive change is passed through via C1. That causes a positive current to flow through D2 (D2 is reverse biased) to the gate of T3. That triac switches on, and power is applied to the turnout coil. This situation persists until C1 is fully charged. No more current flows after that, so the triac does not receive any gate current and switches off.
If the input is set low, a negative current flows briefly via C1. It can flow through D2, but not through D1. T4 is switched on now, and the other turnout coil is energised. This circuit takes advantage of the fact that triacs can be triggered by negative as well as positive gate currents.
If the turnout coils are energised for too long, you should reduce the value of C1. If they are not energised long enough, increase the value of C1.
The TIC206D can handle several ampères, so it can easily drive just about any type of turnout coil.
You can also use a different type of triac if you wish. However, bear in mind that the TIC206 requires only 5 mA of gate current, while most triacs want 50 mA. That will cause the switching times to become quite short, so it may be necessary to reduce the value of R1.

(050155-1)

Pipe Descaler

023

Christian Tavernier

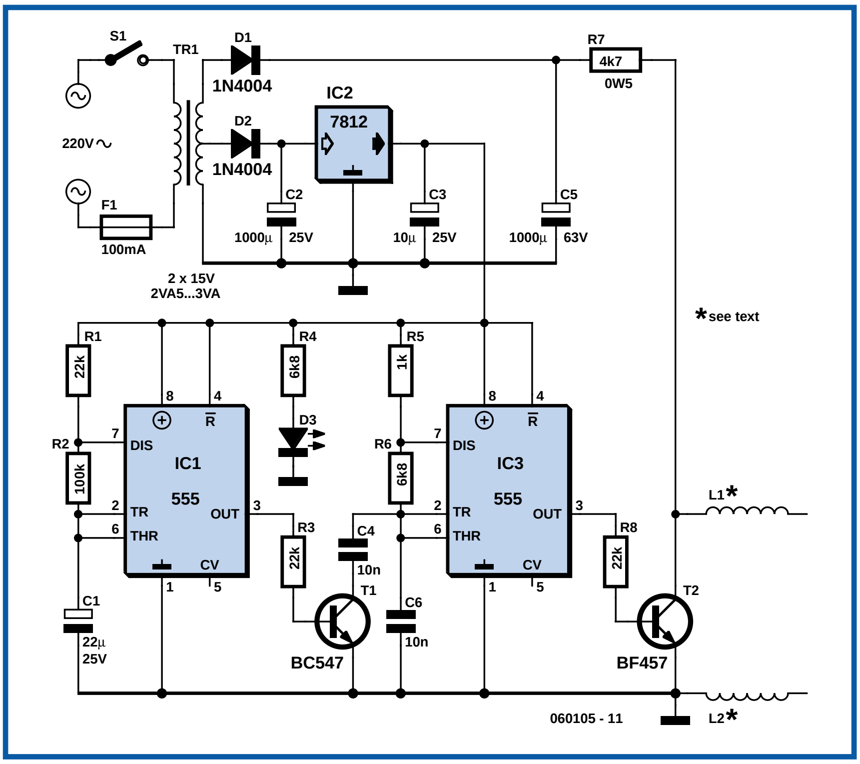
For many years now, magnetic (or electromagnetic) water descaler devices have been showing up on the shelves of Home Improvement and other DIY stores all over Europe. Despite the numerous studies completed on that subject, by manufacturers as well as by various consumer associations, none have been able to conclude on the efficiency of commercial pipe descalers in a decisive manner. Since electronic devices of this type are relatively expensive (especially when we discover what they are made of!), we decided to offer this project to our readers. For the price of a few tens of pounds, you will be able to evaluate the state of your own faucets, pots, and other pipes.
The device we're offering as a project is identical to top-of-the-line items found on sale; in other words, it includes the bi-frequency option because it seemed that would be the best way to fight lime scale deposits. An initial astable oscillator, based on a traditional 555, labeled IC3, functions at around 10 kHz when the only capacitor C6 is operating; in other words, when T1 is blocked. The latter is controlled by another astable oscillator, based on IC1 this time, but which functions at about 1 Hz. When T1 is turned on by IC1, capacitor C4 is effectively in parallel with C6 which divides the frequency produced by IC3 by two, i.e. to about 5 kHz.
In order to have high amplitude signals, the power supply operates with a mid-point transformer utilized in an unconventional way, with simple half-wave rectifica-

tion. The first half of the secondary delivers 15 VAC which, after being rectified, filtered and regulated by IC2, supply stable current of 12 VDC to supply power to the oscillators.

The entire secondary makes it possible to have available, after rectification, approximately 40 VDC which is used to supply power to coils L1 and L2, wound around the pipe systems on which the assembly will work. To do that, IC3 is followed by high-voltage transistor T2 (a BF457 or equivalent) which chops this high voltage to 5 or 10 kHz frequency depending on the state of IC1.

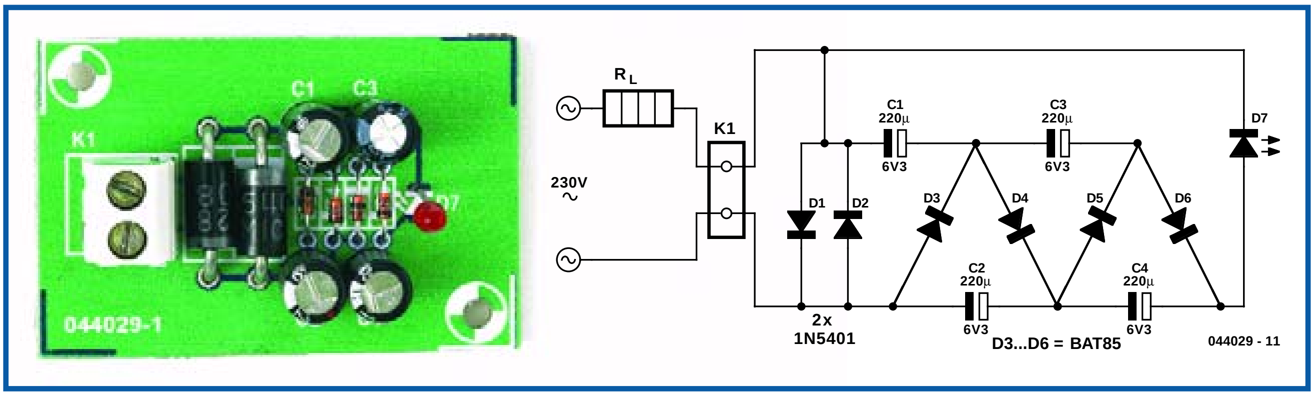
LED D3 lights up to signal that the power supply is present.

Coils L1 and L2 are simple inductors made from insulated flexible wire, with about ten windings each. They have to be wound around the pipes carrying the water to be 'treated' and are spaced about ten centimeters from each other. Neither the material of the pipe system, nor its diameter, should have any influence on the efficiency of the device. Paradoxically, these coils have one end in the air, which may surprise you as much as us but we indicated at the beginning of this article, that our goal with this project is not to explain the principle but rather to allow you to make the same device as those sold in stores, so that you can perform your own tests.



www.tavernier-c.com (060105-1)

024 Mains Indicator



Karel Walraven

It is not always immediately obvious whether a power-consuming appliance is switched on or not. Examples are the lamp in the attic or the shed, or electric heating in an awkward place. A nice solution would be to connect an LED directly in series with the appliance, unfortunately you'd better duck for cover if you tried…

The obvious solution would be to place a (power-) resistor in series with the load and connect an LED with series resistor across it. However, this solution has significant disadvantages, for instance, the power loss is relatively large (easily a few watts). In addition, the value of the resistor should be adjusted depending on the magnitude of the current.

It would be better to insert two anti-parallel diodes in the power lead. Unfortunately, the voltage drop is too low to power an LED. It does work with 6 diodes, for that matter, but the power loss is then also 3 times greater.

We therefore chose a solution with two

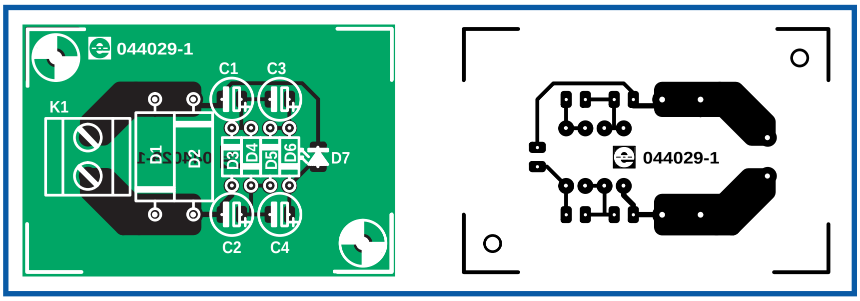
diodes, followed by a 4 times voltage multiplier in the form of a cascade rectifier. That is an energy friendly solution. The current through the LED is automatically limited by the internal impedance of the cascade rectifier. The impedance isn't that small, despite the large electrolytic capacitors. Use a low-current LED, otherwise the LED will probably not be bright enough. The 1N5404 used here can handle up to 3 A

(3 A × 230 V = 690 W).

If the power is less than 200 W, you could use two 1N4004s instead.

The voltage across the diodes is a square wave with an amplitude of about 1.3 V_{pp}. The voltage multipliers are used to turn this into the LED voltage. This will only work if the voltage drop across the diodes in the multipliers isn't too large. That is why these diodes are Schottky diodes. These only have about a 0.35 V voltage drop. Exactly which type of Schottky diode that you use is not too important.

You are free to experiment with the value of the electrolytic capacitors. The larger their value, the greater is the amount of current that can be delivered.



COMPONENTS LIST

Capacitors:
C1-C4 = 220µF 6.3V

Semiconductors:
D1,D2 = 1N5401
D3-D6 = BAT85 (or any other Schottky diode)
D7 = LED, low current

Miscellaneous:
K1 = 2-way PCB terminal block, lead pitch 5mm
PCB, order code 044029 from The PCBShop

Keep in mind that working with mains voltage can be fatal. Build the circuit in such away that there is no risk that live parts can be touched and maintain isolation distances of 6 mm (also in air). For the same reason, use a 5 mm LED (not a 3 mm one!) and fit it as far into the enclosure as possible. Mount the PCB in the enclosure with nylon bolts.

(044029-1)

Simple Slave Flash

025

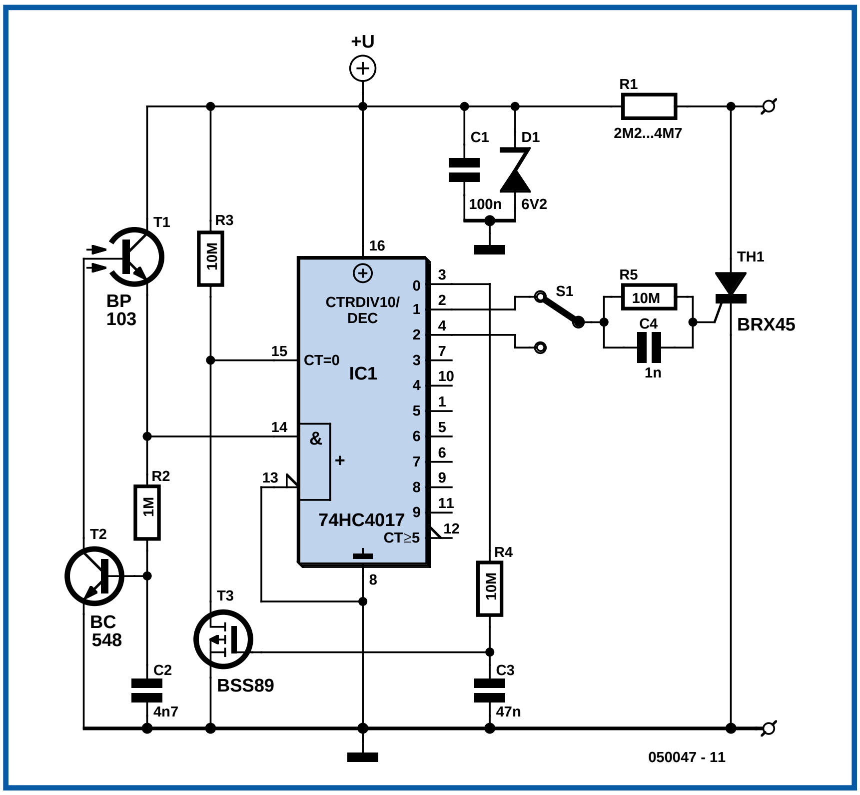
F Roesky

Current designs of slave flash units are, in the opinion of the writer, too complicated and may be simplified without any problems and without losing any of their usefulness as may be seen from the accompanying circuit diagram. This proposed circuit offers a number of advantages:

- no need for an additional power source, since power is derived via the sync contacts of the main flash unit;
- automatic reset (no need for a button);
- operates with new as well as older main flash units (contact voltage >100 V);

In spite of these proven practical properties, the design is simplicity itself. It is controlled by a low-current CMOS decimal counter IC1, a Type 74HC4017, which enables the entire circuit to be powered directly via the sync contacts of the main flash unit via resistor R1 and voltage limiter D1.

The control circuit based on transistor T1



also operates with minimal quiescent current. When a flash is detected, T1 provides a clock pulse to IC1. Depending on the position of switch S1, the low-power thyristor fires on the second or third flash pulse, so that it does not react to the preliminary flash that prevents the red-eye effect. After about 0.4 second, when the main flash unit is discharged, IC1 is reset via R4, C3 and T3. At that instant, the current drain of IC1 increases briefly and the voltage across C1 collapses. This is of no consequence, however, since after at most one second C1 is recharged to a level at which the circuit is operational again.

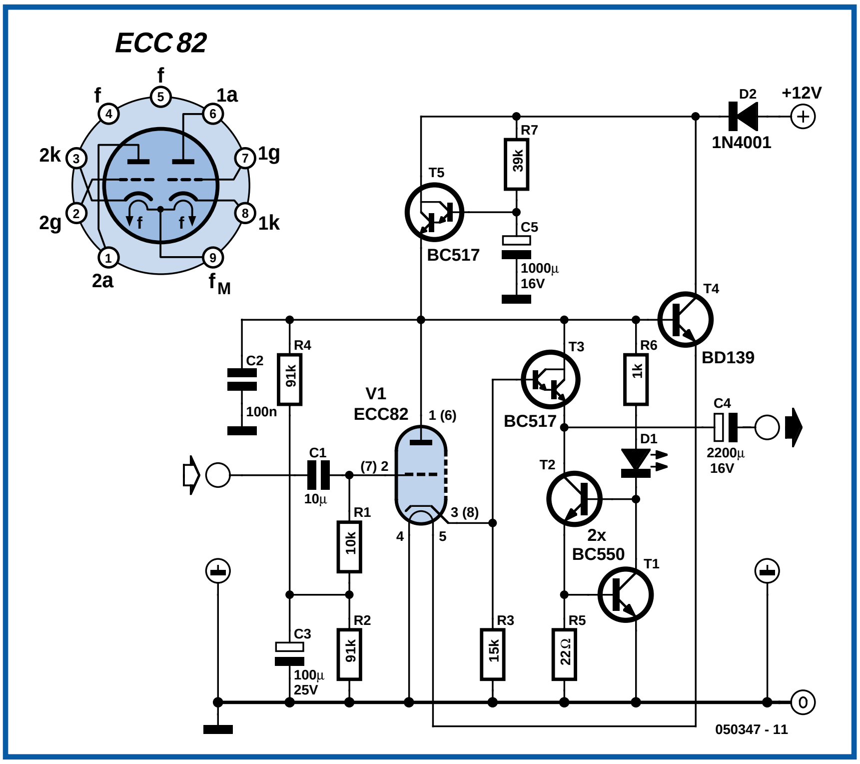
If the circuit is to be polarity-sensitive, connect a small bridge rectifier rated at 400 V between the contacts of the main flash unit and terminals JP1 and JP2.

(050047-1)

026

Hybrid Headphone Amp

Jeff Macaulay



Potentially, headphone listening can be technically superior since room reflections are eliminated and the intimate contact between transducer and ear mean that only tiny amounts of power are required. The small power requirement means that transducers can be operated at a small fraction of their full excursion capabilities thus reducing THD and other non-linear distortions.

This design of a dedicated headphones amplifier is potentially controversial in that (1) it has unity voltage gain and (2) employs valves and transistors in the same design.

Normal headphones have an impedance of 32 Ω per channel. The usual standard line output of 775 mV to which all quality equipment aspires will generate a power of

$$U^2 / R = 0.775^2 / 32 = 18 \text{ mW}$$

per channel across a headphone of this impedance. An examination of available headphones at well known high street emporiums revealed that the sensitivity varied from 96 dB to 103db/mW! So, in practice the circuit will only require unity gain to reach deafening levels.

As a unity gain design is required it is quite possible to employ a low distortion output stage. The obvious choice is an emitter follower. This has nearly unity gain combined with a large amount of local feedback. Unfortunately the output impedance of an emitter follower is dependent upon the source impedance. With a volume control, or even with different signal sources this will vary and could produce small but audible changes in sound quality. To prevent this, the output stage is driven by a cathode follower, based around an ECC82 valve (US equivalent: 12AU7). This device, as opposed to a transistor configuration, enables the output stage to be driven with a constant value, low impedance. In other words, the signal from the low impedance point is used to drive the high impedance of the output stage, a situation which promotes low overall THD.

At the modest output powers required of the circuit, the only sensible choice is a Class A circuit. In this case the much vaunted single-ended output stage is employed and that comprises of T3 and constant current source T1-T2. The constant current is set by the V_{be} voltage of T1 applied across R5. With its value of 22 Ω, the current is set at 27 mA. T3 is used in the emitter follower mode with high input impedance and low output impedance. Indeed the main problem of using a valve at low voltages is that it's fairly difficult to get any real current drain.

In order to prevent distortion the output stage shouldn't be allowed to load the valve. This is down to the choice of output device. A BC517 is used for T3 because of its high current gain, 30,000 at 2 mA!

Since we have a low impedance output stage, the load may be capacitively coupled via C4. Some purists may baulk at the idea of using an electrolytic for this job but he fact remains that distortion generated by capacitive coupling is at least two orders of magnitude lower than transformer coupling.

The rest of the circuitry is used to condition the various voltages used by the circuit. In order to obtain a linear output the

valve grid needs to be biased at half the supply voltage. This is the function of the voltage divider R4 and R2. Input signals are coupled into the circuit via C1 and R1. R1, connected between the voltage divider and V1's grid defines the input impedance of the circuit. C1 has sufficiently large a value to ensure response down to 2 Hz.
Although the circuit does a good job of rejecting line noise on its own due to the high impedance of V1's anode and T3's collector current, it needs a little help to obtain a silent background in the absence of signal. The 'help' is in the form of the capacitance multiplier circuit built around T5. Another BC517 is used here to avoid loading of the filter comprising R7 and C5. In principle the capacitance of C5 is multiplied by the gain of T5. In practice the smooth dc applied to T5's base appears at low impedance at its emitter. An important added advantage is that the supply voltage is applied slowly on powering up. This is of course due to the time taken to fully charge C5 via R7. No trace of hum or ripple can be seen here on the 'scope.
C2 is used to ensure stability at RF.
The DC supply is also used to run the valve heater. The ECC82 has an advantage here in that its heater can be connected for operate from 12.6 V. To run it T4 is used as a series pass element. Base voltage is obtained from the emitter of T5. T4 has very low output impedance, about 160 mΩ and this helps to prevent extraneous signals being picked up from the heater wiring. Connecting the transistor base to C5 also lets the valve heater warm up gently. A couple of volts only are lost across T4 and although the device runs warm it doesn't require a heat-sink.

(050347-1)

Antenna Height and Range

027

Gert Baars

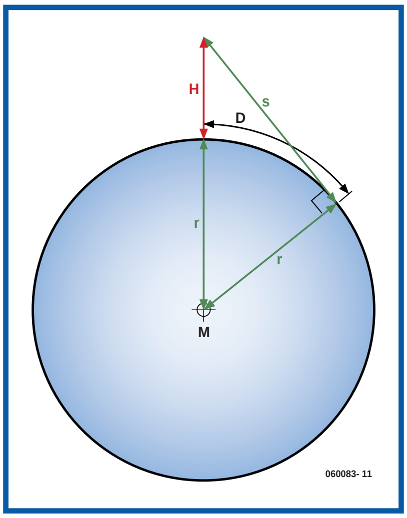
At frequencies below 30 MHz or so, radio transmitters can normally be received over great distances because ceratin layers of the ionosphere reflect radio signals with a certain frequency. These reflections normally do not take place at higher frequencies, so the maximum distance that can be covered is, in principle, limited to the visible horizon. How this theoretical distance can be calculated is explained here.
The accompanying figure indicates the various distances required. *M* is the centre point of the Earth, *r* is the radius, *H* is the height at which the antenna is placed, *s* is the length of the signal path between antenna and horizon and *D* is the distance across the Earth's curved surface. Because in practice *H* will be much smaller than *r*, *s* will be approximately equal to *D*. The signal path *s* between antenna and horizon is perpendicular to the radius of the Earth. This means that we can apply Pythagoras' Theorem to find the relationship between antenna height and distance to the horizon.
According to the Theorem:

$$r^2 + s^2 = (r + H)^2$$
$$= r^2 + H^2 + 2rH$$

Collecting terms results in:

$$s^2 = H^2 + 2rH$$

Because H^2 is much smaller than $2rH$ it can be left out. So it follows that:



$$s^2 = 2rH$$

or:

$$s = \sqrt{(2rH)}$$

The average radius of the Earth is 6,371 km. $\sqrt{(2r)}$ is therefore about 113. The formula can now be simplified to:

$$s = 113\ \sqrt{(H)}$$

where *s* and *H* have to be expressed in kilometres.
An example: a VHF FM antenna is positioned at a height of 15 m. the maximum distance at which a line-of-sight connection is possible amounts to:
113 $\sqrt{(0.015)}$ = 13.8 km.

In practice these distances turn out to be larger than those computed using the formula. This has to do with the propagation of electromagnetic fields. It appears that the wave is subject to reflection and does curve a little with the surface of the Earth. This is readily observed with so-called temperature inversion layers. The weather circumstances are such that hundreds of kilometres can be covered without problems using signal frequencies in the VHF range. But even without these special weather conditions the distances that can be covered appear to be larger than predicted by theory, as already mentioned. With the antenna height of 15 m assumed earlier, the distance that can be covered appears to be of the order of 40 km, instead of the calculated 13.8 km.
How the propagation of electromagnetic waves actually works is a complicated matter covered in many excellent books and publications. However, it is known that at frequencies in the GHz range the distance that can be covered becomes progressively smaller as the frequency increases. This is also the reason why parabolic antennas for SHF frequencies are positioned as high as is practicable. The amount of transmitter power plays a secondary role in all this.
What does matter however, is the height of the receiving antenna. The same formula can be used for this antenna (that is *s* = *113* $\sqrt{(H)}$). The theoretical total distance that can be covered is then the sum of both distances to the horizon.

(060083-1)

028 Simple Hybrid Amp

Frans Janssens

The debate still goes on as to which are better, valves or transistors. We don't intend to get involved in that argument here. But if you can't make your mind up, you should try out this simple amplifier.

This amplifier uses a valve as a pre-amplifier and a MOSFET in the output stage. The strong negative feedback makes the frequency response as flat as a pancake. In the prototype of the amplifier we've also tried a few alternative components. For example, the BUZ11 can be replaced by an IRFZ34N and an ECC83 can be used instead of the ECC88. In that case the anode voltage should be reduced slightly to 155 V. The ECC83 (or its US equivalent the 12AX7) requires 2 x 6.3 V for the filament supply and there is no screen between the two triodes, normally connected to pin 9. This pin is now connected to the common of the two filaments. The filaments are connected to ground via R5.

If you're keeping an eye on the quality, you should at least use MKT types for coupling capacitors C1, C4 and C7. Better still are MKP capacitors. For C8 you should have a look at Panasonic's range of audio grade electrolytics.

P1 is used to set the amount of negative feedback. The larger the negative feedback is, the flatter the frequency response will be, but the smaller the overall gain becomes. With P2 you can set the quiescent current through T2. We have chosen a fairly high current of 1.3 A, making the output stage work in Class A mode. This does generate a relatively large amount of heat, so you should use a large heatsink for T2 with a thermal coefficient of 1 K/W or better.

For L1 we connected two secondary windings in series from a 2x18V/225 VA toroidal transformer. The resulting inductance of 150 mH was quite a bit more than the recommended 50 mH. However, with an output power of 1 W the amplifier had difficulty reproducing signals below 160 Hz. The distortion rose to as much as 9% for a signal of 20 Hz at 100 mW. To properly reproduce low-frequency signals the amplifier needs a much larger coil with an iron core and an air gap. This prevents the core from saturating when a large DC current flows through the coil.

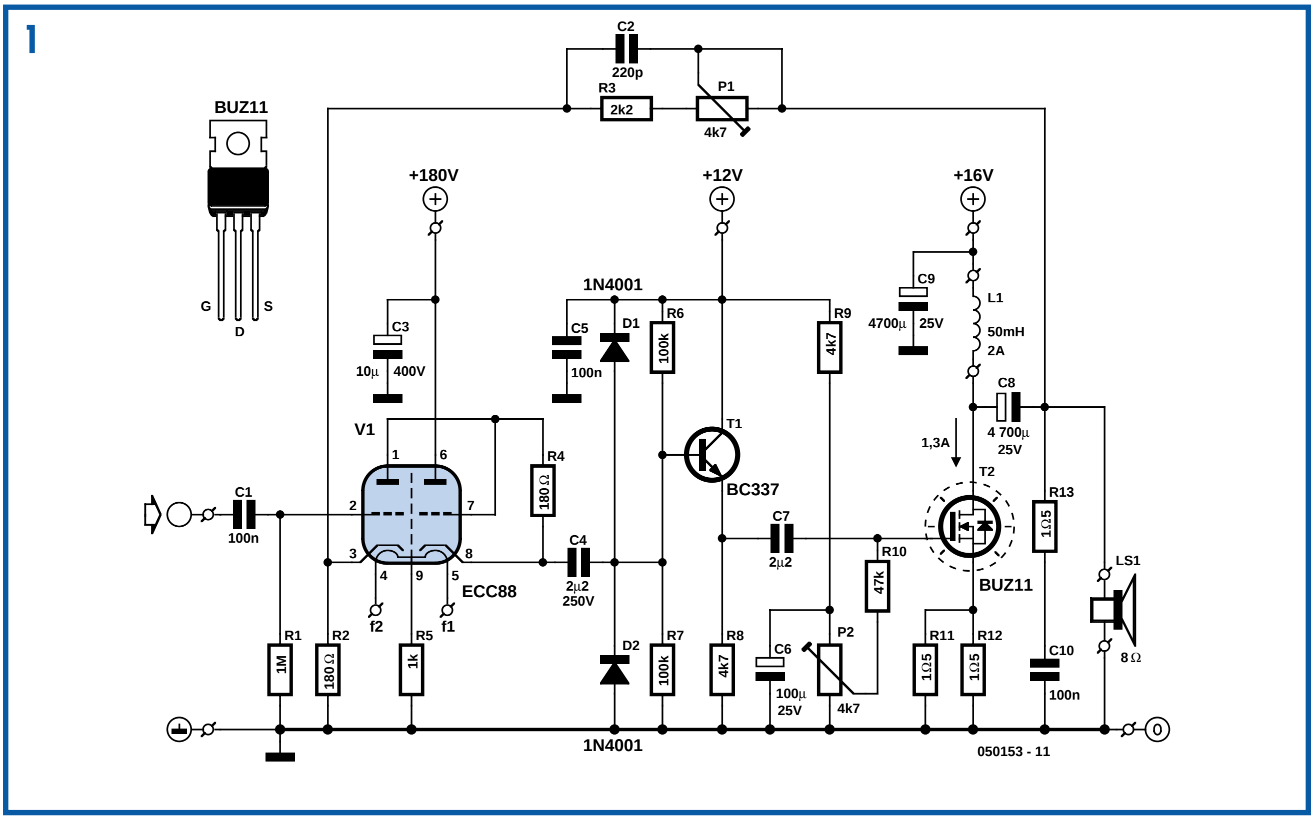
Such a core may be found in obsolete equipment, such as old video recorders. A suitable core consists of welded E and I sections. These transformers can be converted to the required inductor as follows: cut through the welding, remove the windings, add 250 to 300 windings of 0.8 mm enamelled copper wire, firmly fix the E and I sections back together with a piece of paper in between as isolation.

The concepts used in this circuit lend themselves very well to some experimentation. The number of supply voltages can be a bit of a problem to start with. For this reason we have designed a power supply especially for use with this

A few specifications

(IRFZ34N, ECC83, 155 V using 064011-1 and 064016-1, U_{ff} = 12.6 V_{DC}, 8 Ω load, T2 set to 1.3 A)

min. gain	12.3x
max. gain	31.6x
input sensitivity	0.64 V at min. gain
bandwidth	>200 kHz
LF roll-off	11 Hz
THD+N (1 kHz/1W/8Ω)	0.09% (BW = 80 kHz)
supply ripple (100 Hz)	–80 dB (at 1 W output)
P_{max} (1% THD)	7.6 W (1 kHz)
damping factor	17



COMPONENTS LIST

Resistors
R1 = 1MΩ
R2,R4 = 180Ω
R3 = 2kΩ2
R5 = 1kΩ
R6,R7 = 100kΩ
R8, R9 = 4kΩ7
R10 = 47kΩ
R11,R12,R13 = 1Ω5 5W
P1,P2 = 4kΩ7 preset

Capacitors
C1 = 100nF 250V MKT, lead pitch 15mm, dim. 7x18 mm max.
C2 = 220pF
C3 = 10µF 400V radial, lead pitch 5 mm ∅ 13mm max.
C4 = 2µF2 250V, lead pitch 27.5 mm, dim. 11x30 mm max.
C5,C10 = 100nF
C6 = 100µF 25V radial
C7 = 2µF2, lead pitch 5 or 7.5mm
C8,C9 = 4700µF 25V radial, lead pitch 7.5mm, ∅ 18mm max.

Inductors
L1 = ≥ 50 mH, not on board, see text

Semiconductors
D1,D2 = 1N4001
T1 = BC337
T2 = BUZ11 (or IRFZ34N)

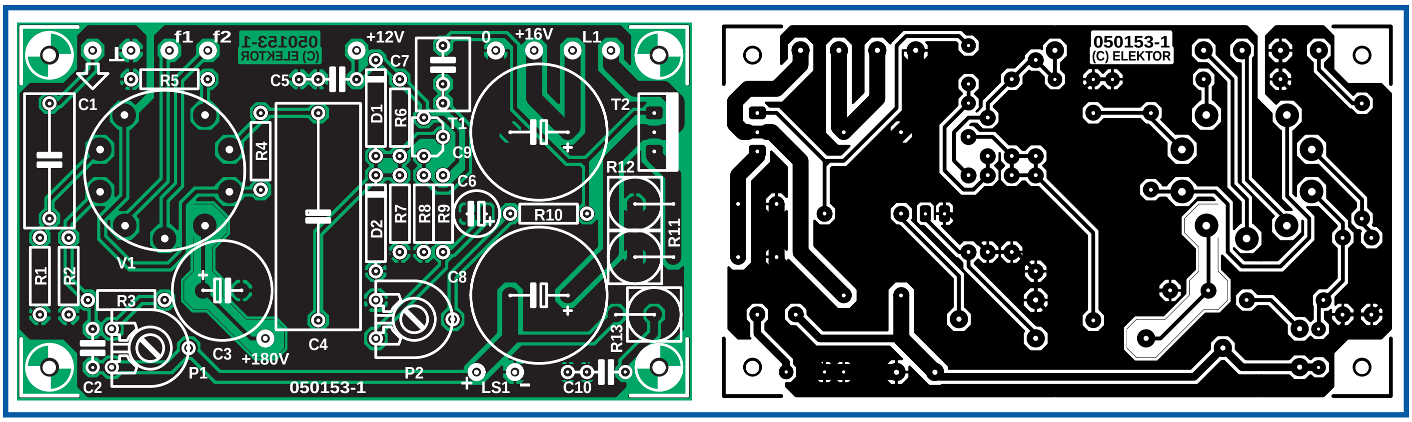
Miscellaneous
V1 = ECC88 with 9-pin valve socket (Chelmer Valve Company)
Heatsink for T2, ≤1 K/W
PCB, ref. 050153-1 from The PCBShop

amplifier (Quad power supply for hybrid amp). This can of course just as easily be used with other amplifiers.

The supply uses a cascade stage to output an unstabilised voltage of 170 V for the SRPP (single rail push pull) stage (V1). During initial measurements we found that the ripple on this supply was responsible for a severe hum at the output of the amplifier. To get round this problem we designed a separate voltage regulator (High-voltage regulator with short circuit protection), which can cope with these high voltages.

If you use a separate transformer for the filament supply you can try and see if the circuit works without R5. During the testing we used a DC voltage for the filament supply.

Although you may not suspect it from the test measurements (see table), this ampli-

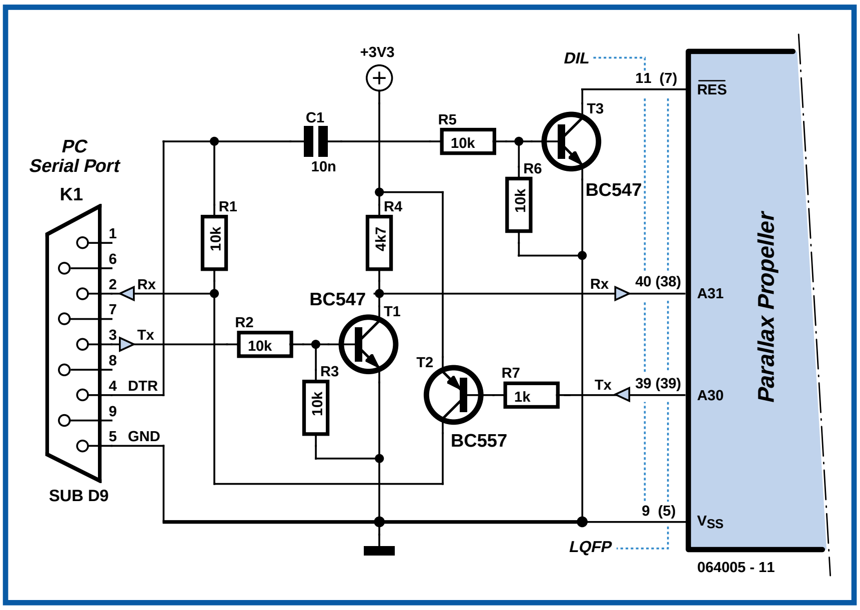


fier doesn't sound bad. In fact, it is easily better than many consumer amplifiers. The output power is fairly limited, but is still enough to let your neighbours enjoy the music as well. It is possible to make the amplifier more powerful, in which case we recommend that you use more than one MOSFET in the output stage. The inductor also needs to be made beefier. Since this is a Class A amplifier, the supply needs to be able to output the required current, which becomes much greater at higher output powers. The efficiency of the amplifier is a bit over 30%.

(050153-1)

029

Programming the Propeller IC



Parallax, well known for its successful Basic Stamp IC, has recently introduced the Propeller: a new microcontroller with a certain difference. It packs no less than eight 32-bit processors (referred to as COGs in Propeller jargon) into a single package with only 40 pins. That design makes genuine simultaneous multiprocessing possible, and the sophisticated internal structure of the device makes it relatively easy to implement video and signal-processing applications.

The Propeller can be programmed in assembly language or the high-level Spin language. The processor and the programming tools were developed entirely in-house by Parallax, with the hardware being designed from scratch starting at the transistor level. The basic idea behind that was to avoid becoming involved in all sorts of patent disputes with other manufacturers. The result is astounding, and for software developers it certainly requires a change in mental gears.
As is customary with modern microprocessors, the Propeller has a simple serial programming interface. The developer's toolkit from Parallax has a modern USB port for that purpose, but a reasonably simple alternative (illustrated here) is also possible for anyone who prefers to work with the familiar RS232 port. Don't forget that the Propeller works with a 3.3-V supply voltage.

(064005-1)

030

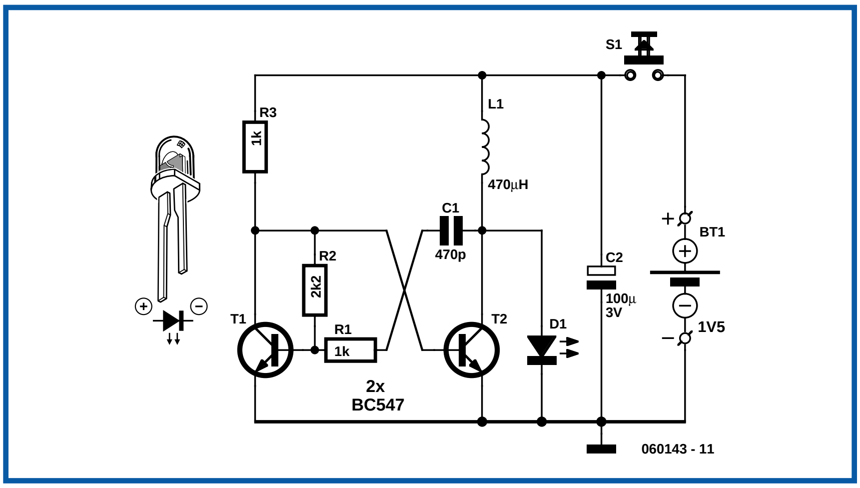
LED Phototherapy Unit

Jörg Trautmann

It is widely thought that light can be therapeutic for the human skin and soul. Light at the correct wavelength may also be effective against depression and allergies. There is a wide range of products on the market, at prices from a few tens of pounds to a hundred pounds or so, which are presented as universal remedies for dust allergies or hay fever. If we look at these devices in more detail, we find that their operation is relatively simple to explain.
Common to all the devices is that they emit intense red light with a wavelength of 660 nm. Some biophysicists claim that light of this wavelength can have a positive effect on the human body and can initiate healing processes. This so-called 'phototherapy' is a treatment which is claimed to have an effect against allergic reactions in the body, since it acts against free oxygen radicals and strengthens the immune system, reducing inflammation of the mucous membrane. Since this treatment does not take the form of a medicine, but rather the form of visible light, there is no risk of side-effects. There has been scientific research showing that this therapy does not work in every case, but success rates as high as 72 % have been reported. Since it

may not be possible to obtain these devices under the NHS or under private medical insurance, our thoughts naturally turn to do-it-yourself.

For the enclosure we decided to use an old nasal hair trimmer. These can be obtained new for a few pounds, or you may have an old one that can be recycled. The choice of enclosure also dictates the choice of battery: the unit contains a holder for an AA-size cell. The circuit must therefore not only be very compact (there is little spare room in the enclosure), it must also be able to drive a high-brightness red LED from a voltage between 1 V and around 1.6 V. Here again we can indulge in a little recycling: we can re-use the circuit from a Mini Project by Burkhard Kainka for driving a white LED, published in *Elektor Electronics* in June 2002. In this circuit the inductive voltage pulse is limited by the LED itself, ensuring that the output voltage will automatically match the forward voltage of the LED. The circuit is suitable as it stands for driving a high-brightness 660 nm red LED to make a do-it-yourself phototherapy unit.

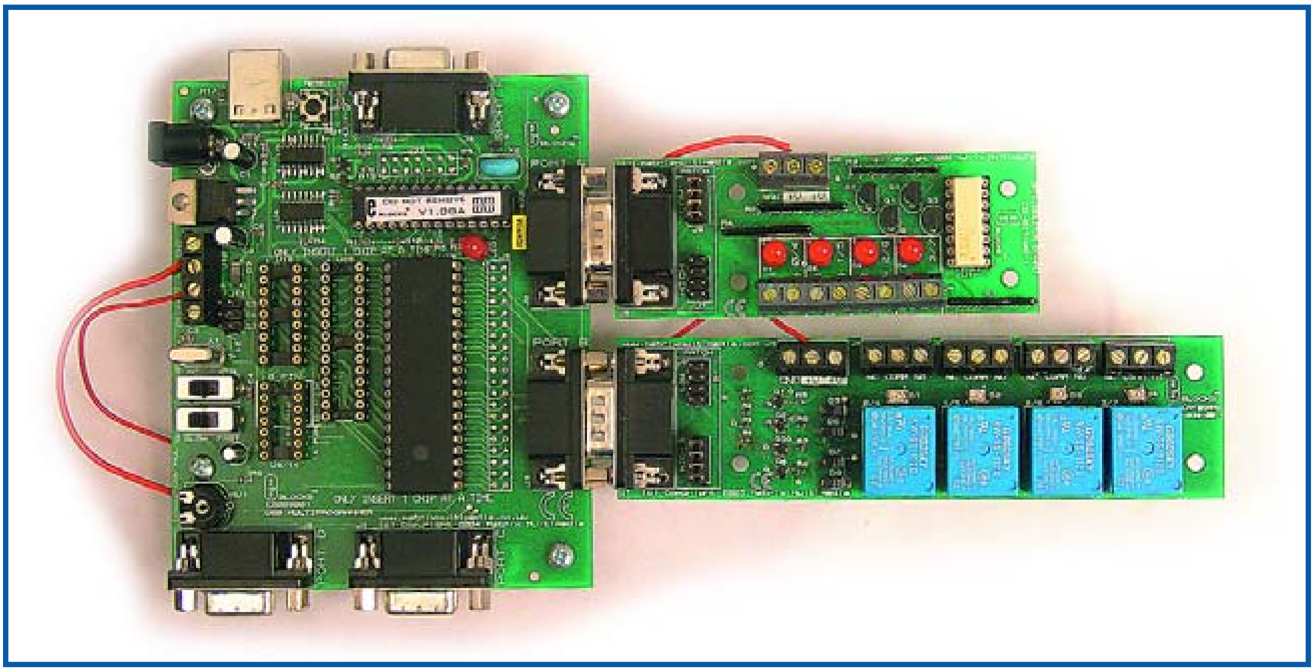


In view of the small number of components, the circuit can be assembled by soldering them together directly or by using a small piece of stripboard. The circuit can operate from a wide range of voltages, and so we can use either an alkaline AA cell or an AA-size NiMH rechargeable cell with a voltage of 1.2 V. The current consumption of the circuit is about 20 mA. Assuming the circuit has been built correctly, the red LED should light brightly as soon as power is applied. Five to ten minutes' use in each nostril every day should be sufficient to obtain noticeable benefit after two weeks of treatment.

(060143-1)

E-blocks = cheaper PLC design

031



John Dobson

If you are a habitual user of PLCs (programmable logic systems) then you may be frustrated with the fact that you are paying in excess of £ 100 for a simple system that (hardware-wise) contains only a couple of inputs and a couple of outputs which would cost you just over £ 10 if you put it together yourself. Well here is a suggestion that could help you develop your own PLC for a lot less.

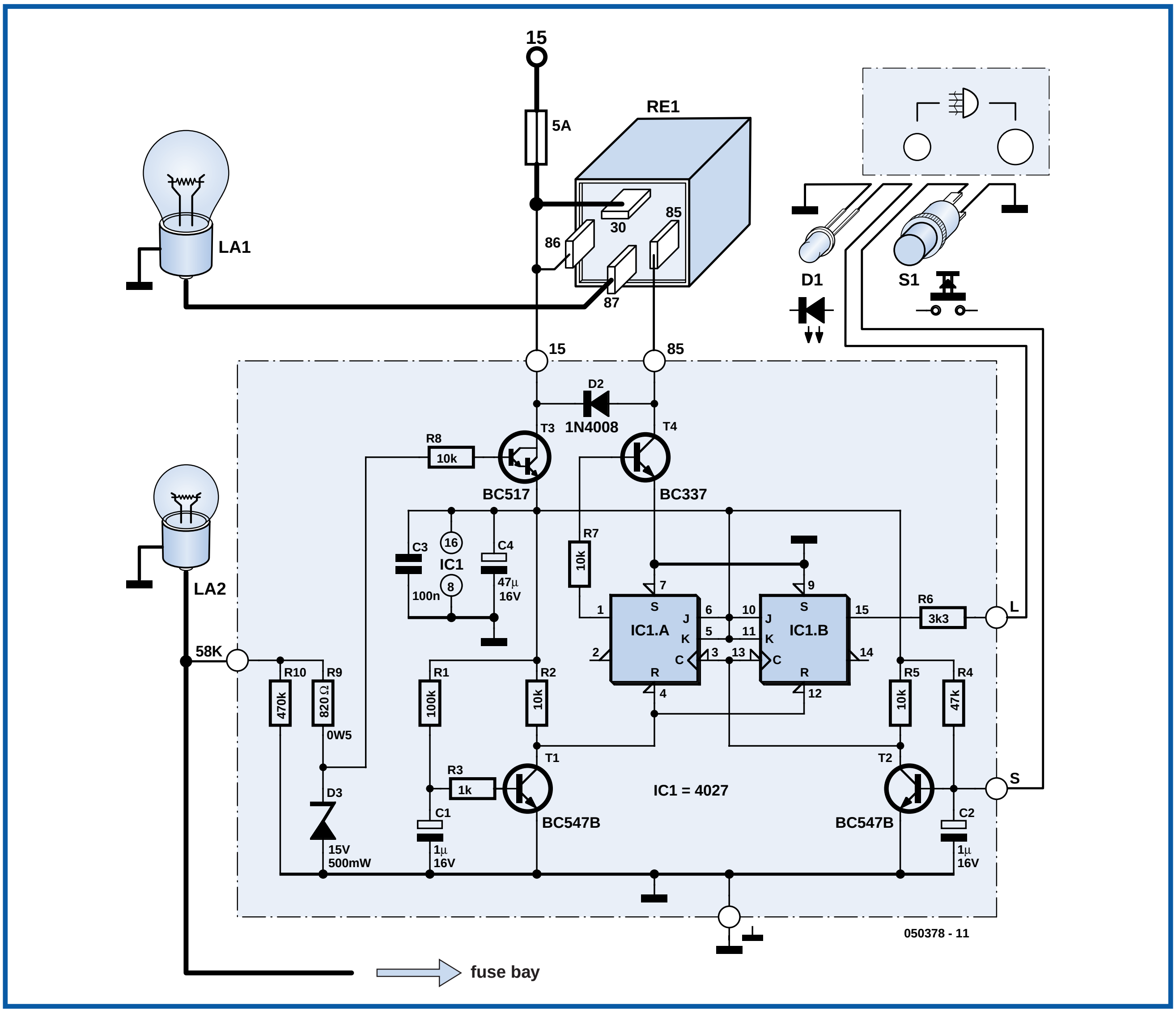
Hopefully you will by now have read about our E-blocks™ solution. There are two new E-blocks available: an opto-isolator board and a relay board. The photograph shows them connected to a PICmicro Multiprogrammer. The combination of a PICmicro programmer, opto-isolators and a relays is functionally equivalent to a PLC, and the flow chart driven program Flowcode, is an easy-to-use graphical development environment which you can use for driving your PLC. The hardware (i.e. circuit boards) are supplied with the complete circuit diagrams so with a little work you can make a circuit board with your own configuration of PLC on it. A motor driving board will be available shortly.

E-blocks modules, sensors and associated software are available through the Elektor Electronics SHOP, see www.elektor-electronics.co.uk

(060079-1)

032

Rear Fog Lamp for Vintage Cars



Eric Vanderseypen

According to current legislation in many countries, vintage cars must also be fitted with a fog lamp at the rear.
In modern cars, there is a bit of circuitry associated with the fog lamp switch to prevent the fog lamp from going on when the lights are switched on if the driver forgot to switch it off after the last patch of fog cleared up.
The circuit described here extends that technology back in time. The circuit is built around a dual JK flip-flop (type 4027).
T3 acts as an emitter follower, and it only supplies power to the circuit when the lights are switched on. For safety reasons, the supply voltage is tapped off from the number plate lamp (L2), because it is on even if you accidentally drive with only the parking lights on. The

wire that leads to the number plate lamp usually originates at the fuse box.
As the states of the outputs of IC1a and IC1b are arbitrary when power is switched on, the reset inputs are briefly set high by the combination of C1, R1 and T1 when the lights are switched on (ignition switch on). That causes both Q outputs (pins 1 and 15) to go low.
IC1a and IC1b are wired in toggle mode (J and K high). The Set inputs are tied to ground (inactive).

The driver uses pushbutton switch S1 to generate a clock pulse that causes the outputs of the flip-flops to toggle. The debouncing circuit formed by C2, R4 and T2 is essential for obtaining a clean clock pulse, and thus for reliable operation of the circuit. C1 and C2 should preferably be tantalum capacitors.
The Q output of IC1b directly drives LED D1 (a low-current type, and yellow according to the regulations). The Q output of IC1a energises relay Re1 via T4 and thus applies power to the rear fog lamp L1. Free-wheeling diode D2 protects T4 against inductive voltage spikes that occur when the relay is de-energised.
In older-model cars, the charging voltage of the generator or alternator is governed by a mechanical voltage regulator. These regulators are less reliable than the electronic versions used in modern cars. For that reason, a Zener diode voltage-limiter circuit (D3 and R9) is included to keep the voltage at the emitter of T3 below 15 V and thus prevent the 4027 from being destroyed by an excessively high voltage.
The supply voltage for the circuit is tapped off from the fuse box. An accessory terminal is usually present there. Check to make sure it is fed from the ignition switch.

Note
This circuit is only suitable for use in cars with 12-V electrical systems and negative ground.

The pushbutton switch must be a momentary-contact type (not a latching type). Ensure that the pushbutton and LED have a good ground connection. Fit the LED close to the button.
The following 'Bosch codes' are used in the schematic:

15 = +12 V from ignition switch
58K = number plate lamp
86 = relay coil power (+) IN
85 = relay coil power OUT
30 = relay contact (+) IN
87 = relay contact OUT

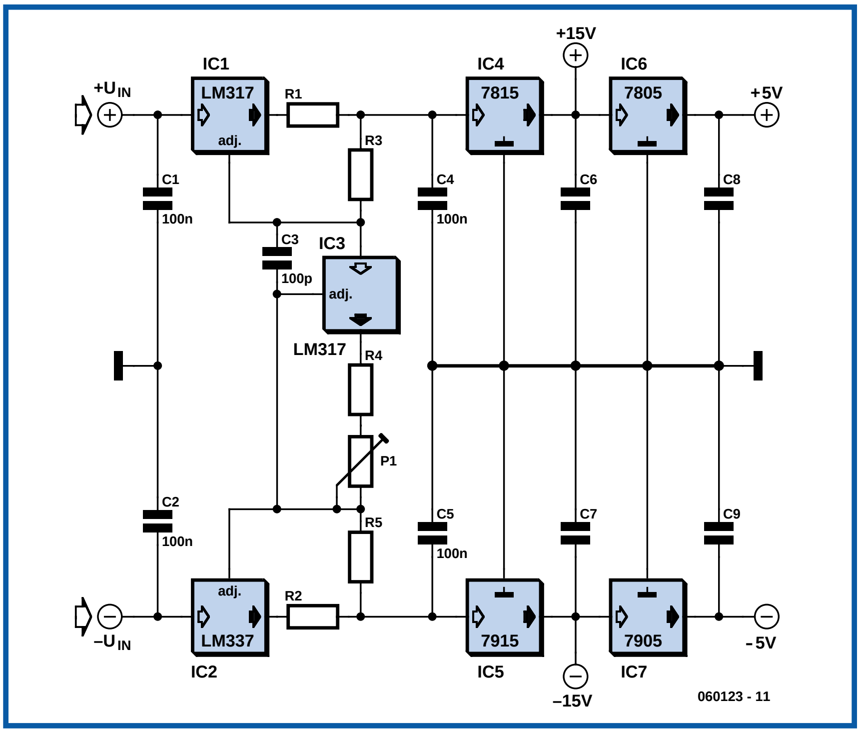
(050378-1)

Adjustable Current Limit for Dual Power Supply

033

Malte Fischer

This current-limiting circuit, shown in this example as part of a small bench power supply, could in principle be used in conjunction with any dual-rail current source. The part of the circuit to the left of the diagram limits the current at the input to the dual voltage regulator (IC4 to IC7) so that it is safely protected against overload. The circuit shown produces outputs at ±15 V and ±5 V.
The voltage regulators at the outputs (7815/7805 and 7915/7905) need no further comment; but the current-limiting circuit itself, built around an LM317 and an LM337, is not quite so self-explanatory.
The upper LM317 (IC1) manages the current limiting function for the upper branch of the circuit. The clever part is the combination of the two resistors R1 and R3 between the output and the adjust input of the regulator. In the basic LM317 configuration in current-limiting mode (i.e., as a constant current source), just one resistor is used here, across which the regulator maintains a constant voltage of 1.25 V. The current is thus limited to a value of 1.25 V/R. To obtain a maximum current of 1 A, for example, the formula tells us that the necessary resistor



value is 1.25 Ω. Unfortunately it is not practical to try to build an adjustable dual-rail current-limited supply in this way, as stereo potentiometers with a value of 1.2 Ω are extremely difficult, if not impossible, to obtain.

We can solve the problem using the technique of dividing the resistor into two resistors. Only the resistor at the output of the LM317 (R1) serves for current sensing. The second resistor (R3) causes an additional voltage drop depending on an additional (and adjustable) current. When the sum of the two voltages reaches 1.25 V current limiting cuts in. This makes it possible to adjust the current limit smoothly using the current in the second resistor (R3). This can be done simultaneously in the positive and negative branches of the circuit, as the diagram shows.

It would of course be wasteful to arrange for the current flowing in the second resistor to be of the same order of magnitude as the current in the main resistor. We therefore make the value of the second resistor considerably greater than that of the main one. If the main resistor (R1) has a value of 1.2 Ω (giving a maximum current of 1 A), and the second resistor (R3) a value of 120 Ω, the necessary voltage drop is achieved using an extra current of 10 ent limit will be 1 A.

For the negative branch of the circuit the LM337, along with resistors R2 (1.2 Ω) and R5 (120 Ω), performs the same functions.

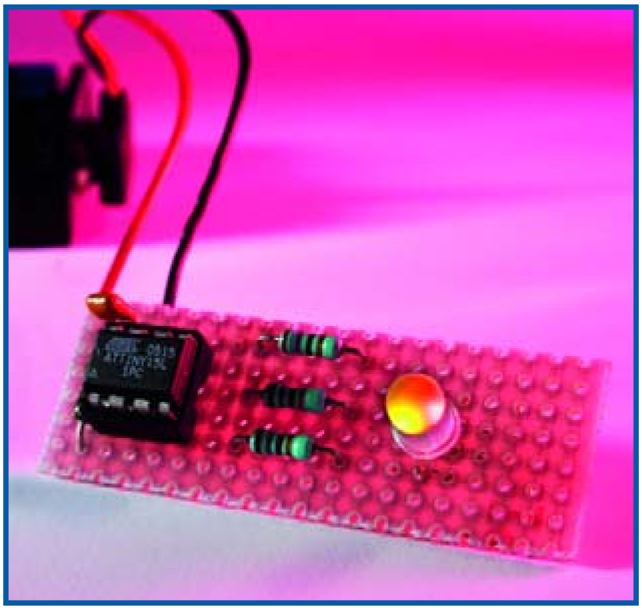
A further LM317 (IC3) is used to set the overall current limit point by controlling the additional current. The resistance used with this voltage regulator, wired as a current sink (R4 in series with P1) determines the additional current and therefore also the output current in both the negative and positive branches of the circuit. Since we also want the total resistance of R4 and P1 to be 120 Ω, we use a value of 22 Ω for R4 and 100 Ω for P1 to give a wide adjustment range for the output current from a few milliamps to 1 A.

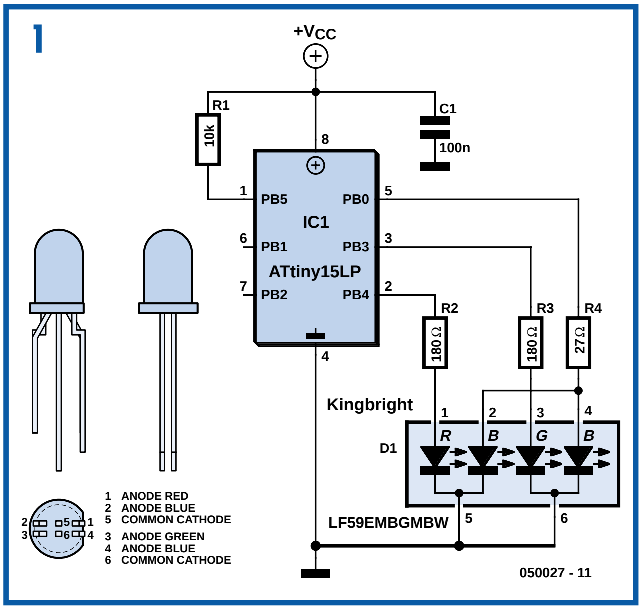
The minimum input voltage for the circuit depends on the desired output voltage and maximum output current. The input to the 7815 should be at least 18 V. We should allow approximately a further 1.2 V + 2.2 V for the voltage drops across IC1 and R1. If we allow a total of 4 V for the current limiting circuit in each branch, this means that the circuit as a whole should be supplied with at least ±22 V to produce well-regulated outputs at ±15 V and ±5 V.

If the symmetrical input voltage is to be provided using a single transformer winding, two diodes and two smoothing capacitors, it important to ensure that the capacitor values are sufficiently large, as there will be considerably more ripple than there would be with full-wave rectification. Depending on the application, capacitors C6 to C9 at the outputs of the fixed voltage regulators can be electrolytics with a value of 4.7 µF or 10 µF. To improve stability, electrolytic capacitors can also be connected in parallel with C1, C2, C4 and C5.

(060123-1)

034 Tiny RGB





Tobias Flöry

This circuit is a good example of a microcontroller design using the absolute minimum of external components. The ATTiny15L microcontroller from Atmel has three of its outputs connected to an RGB LED (or three individual red green and blue LEDs) and produces changing colour patterns. There are of course multicolour LEDs with a controller already built-in on the market but where would be the fun in the ready-built version? You will certainly learn much more by building and programming the design yourself.

The brightness of each LED is controlled using Pulse Width Modulation (PWM). This is accomplished in software and the source code is available to download from www.elektor-electronics.co.uk free of charge as file no. **050027-11.zip**. A pre-programmed controller (part no. **050027-41**) can also be ordered from the online shop at the same address.

The Kingbright RGB LED used in this circuit actually contains one red, one green and two blue LEDs. This helps compensate for the poorer output from the blue LEDs and for the relative insensitivity of our eye to the blue end of the spectrum. The light output thus can produce a better white colour balance. The forward voltage drop of the blue LEDs (4.5 V) is also quite a bit higher than green (2.2 V) or red (2.0 V) so the value of the series resistor (R4) needs to be almost ten times smaller than the series resistors R2 and R3 used for the other LEDs to maintain a similar drive current.

Maximum current consumption of the circuit is approximately 35 mA but the average will be around 25 mA. More information on this design together with some other interesting designs can be found on the author's website at www.floery.net and look for 'tobi's corner'.

(050027-1)

Gentle Breeze

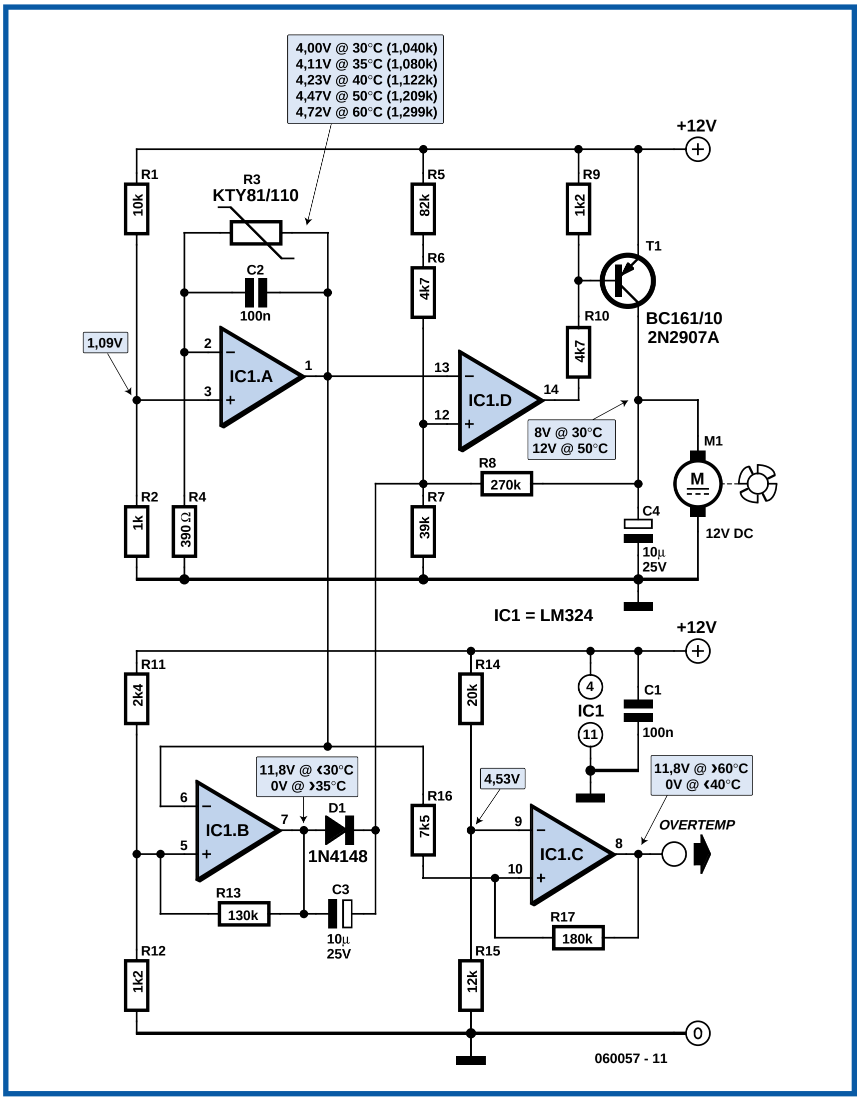
035

Rainer Reusch

Where there is heat, let us bring cooling: a fan will do the job, but unfortunately fans are usually noisy. In many cases there is no need for the fan to run continuously at full speed, and so it makes sense to control the fan speed in response to the temperature of the heatsink or device being cooled, switching the fan off entirely if it should fall to room temperature.

The circuit shown here does this and even offers a little more. The low-cost KTY81-110 is used as the temperature sensor, in a negative-feedback arrangement with an operational amplifier. The temperature-dependent voltage at the non-inverting input to opamp IC1.A leads to a voltage variation at the output (pin 1) from 4 V at 30 °C to 4.72 V at 60 °C. The second stage (IC1.D) converts this relatively small swing and inconvenient voltage offset into the range 8 V to 12 V suitable for the fan. The third operational amplifier works as a comparator. At room temperature its output sits at nearly 12 V and pulls the output of the second stage with it, switching transistor T1 off. If the temperature exceeds 35 °C the comparator switches; diode D1 blocks and the control circuit can operate as normal. The hysteresis of the comparator has been set so that the comparator state will only change again, turning off the fan, if the temperature falls below 30 °C. Capacitor C3 ensures that the fan is run at full voltage for about 0.7 seconds immediately after switch-on, so that the motor will start reliably.

The fourth opamp in the LM324, IC1.C, is used to create an over-temperature warning indicator. This is necessary in case the fan, even running at full speed, is not able to provide enough cooling, or, because of a fault, cannot reach full speed. This opamp is also configured as



a comparator. If the sensor temperature reaches a value of 60 °C, the comparator output goes high (to nearly 12 V). The output will only go low again (nearly 0 V) if the temperature falls below 40 °C. An LED (with series current-limiting resistor) can be connected to its output (pin 8); alternatively a transistor could be used to drive a relay.

The circuit is sufficiently accurate without adjustments, but metal-film resistors with a tolerance of 1 % should be used. Some of the values used are from the E24 series. The supply voltage is used as a reference throughout, and so should be well regulated: a 7812 voltage regulator is adequate.

(060057-1)

036 Toothbrush Timer

Friedrich Weigand

It has been known since Einstein that time is relative. This seems to apply particularly to children, who can make seconds and minutes seem like days and years when faced with unpopular chores like cleaning their teeth. To get the little dears to spend the three minutes recommended by experts on their teeth, parents concerned for the dental health of their children can resort to electronic means. And so much the better if you can get your children to help out with building the device!

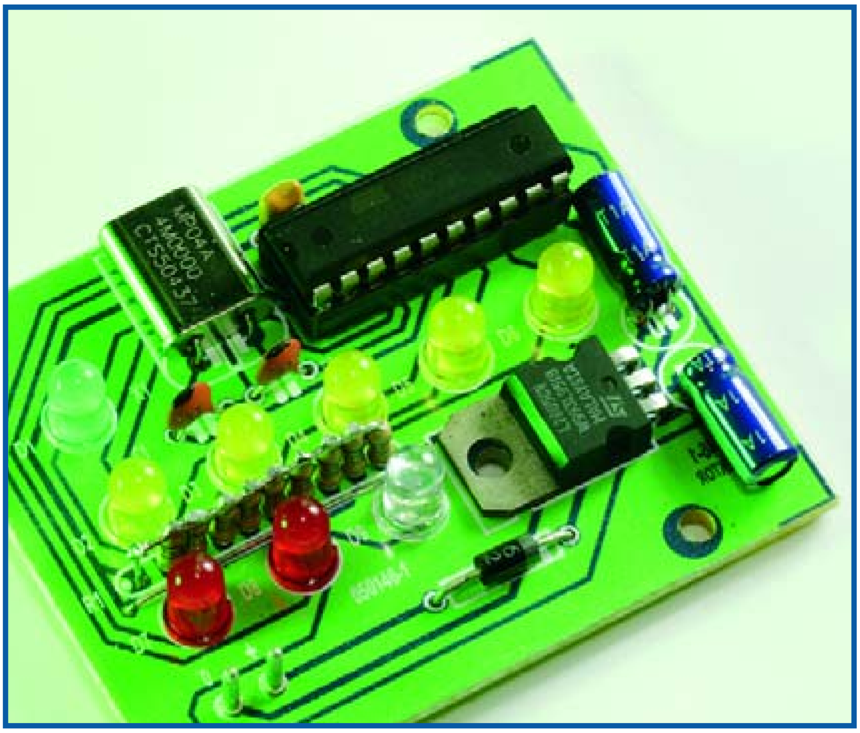
COMPONENTS LIST

Resistors
R1 = 9-way 1kΩ SIL array

Capacitors
C1,C2 = 22pF
C3 = 100nF
C4,C5 = 10µF, 63V, radial

Semiconductors
D1 = LED, green, low current, 5mm
D2-D6 = LED, yellow, low current, 5mm
D7,D8 = LED, red, low current, 5mm
D9 = LED, blue, 5mm
D10 = 1N4001
IC1 = AT90S2313-10PC (programmed, order code **050146-41**)
IC2 = 7805

Miscellaneous
X1 = 4MHz quartz crystal
Case: e.g. Bopla type BOS 503
1 wire link
PCB, order code **050146-1**



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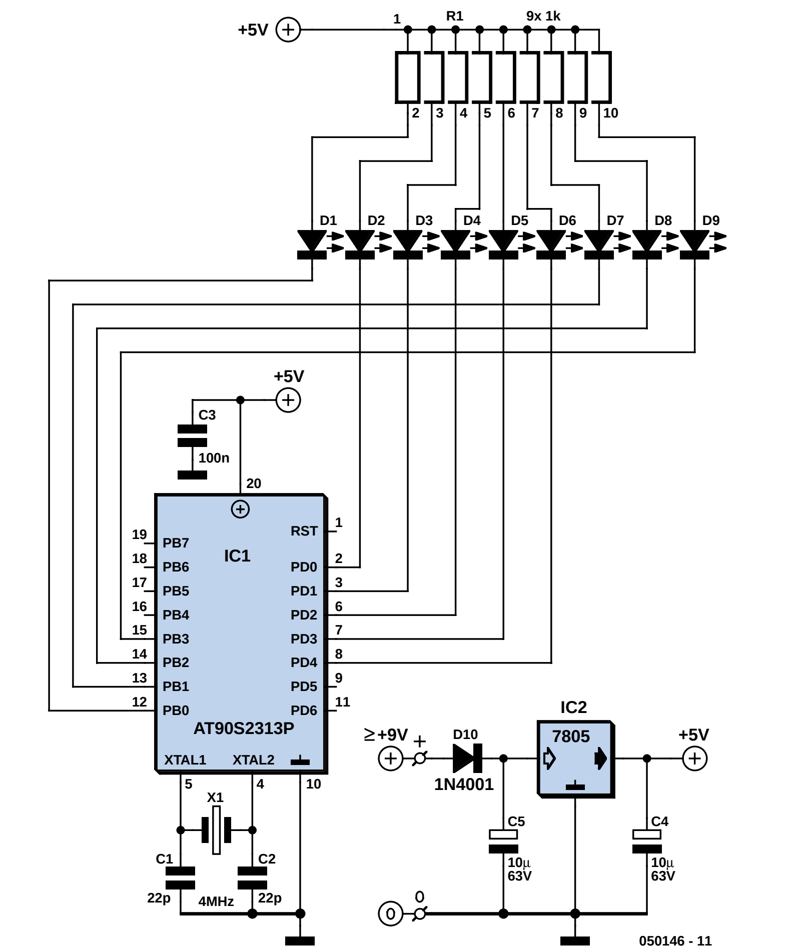
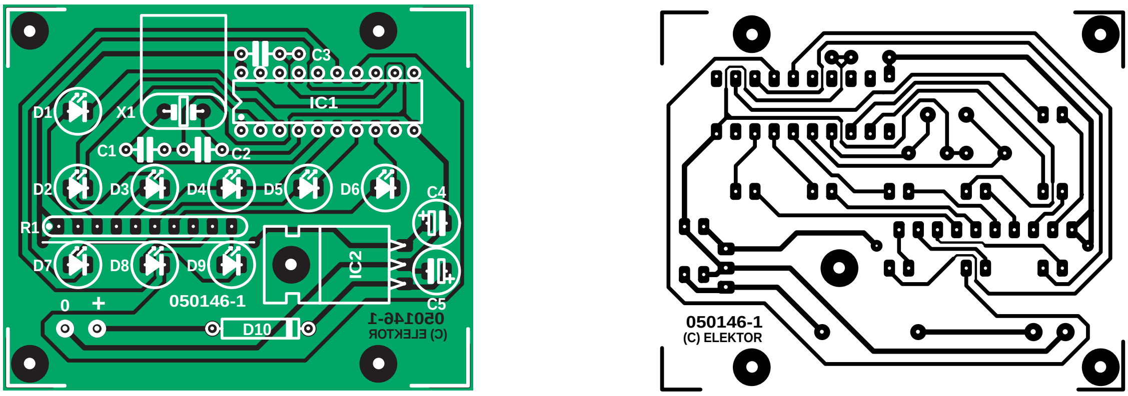


The circuit of the toothbrush timer (**Figure 1**) uses the familiar Atmel RISC AT90S2313 microcontroller, together with an oscillator formed by X1, C1 and C2. The microcontroller is available ready-programmed (order code **050146-41**). It drives a row of LEDs. Green LED D1 flashes every second. The green ten-second LEDs and the red one-minute LEDs light in sequence and remain on until three minutes have elapsed. Then all the LEDs go out and the blue 'finished' LED D9 starts flashing every second, indicating the end of brushing time. The port currents are limited to 2 mA to 3 mA by the array of 1 kΩ resistors: this is enough for the low-current LEDs, which are used in order to ensure a long battery life. A 5 V fixed voltage regulator (IC2) and decoupling and smoothing capacitors C3 to C5 round off the circuit. Diode D10 prevents damage should the 9 V PP3 (6F22) type battery be accidentally connected the wrong way around.

The whole circuit can be built on the printed circuit board shown in **Figure 2**. There are a few wire links near to the resistor array. The voltage regulator, crystal, C4 and C5 are mounted flat on the board to allow the LEDs to stand above the other components and poke through holes in the enclosure. A socket should be used for the microcontroller. Almost all the components are polarity-sensitive: check carefully before you solder!

(050146)

2



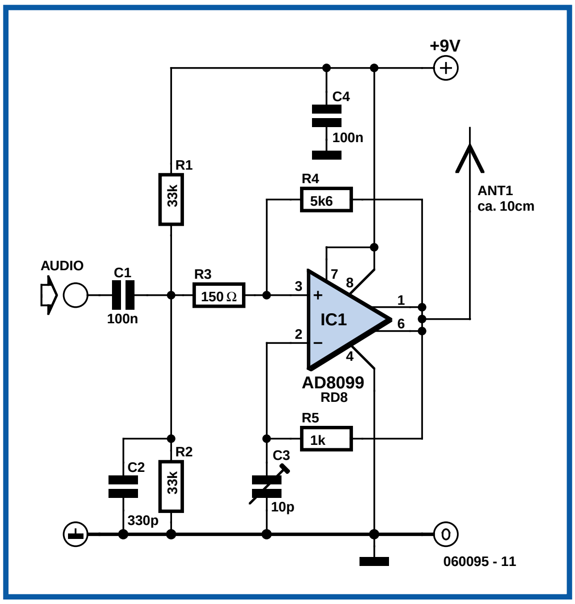
Opamp VHF FM Transmitter

037

Gert Baars

ICs that in the past were far too expensive for the hobbyist tend to be more favourably priced these days. An example of this is the AD8099 from Analog Devices. This opamp is available for only a few pounds. The AD8099 is a very fast opamp (1600 V/ms) and has high-impedance inputs with low input capacitance.

The bandwidth of the opamp is so large that at 100 MHz it still has a gain of nearly 40. This means that this opamp can be used to create an RC oscillator. The circuit presented here realises that.



The circuit has a few striking characteristics. Firstly, unlike normal oscillators that contain transistors this one does not have any inductors. Secondly, there is no need for a varicap diode to do the FM modulation.

The opamp is configured as a Schmitt trigger with only a small amount of hysteresis. The output is fed back via an RC circuit. In this way, the trimmer capacitor is continually being charged and discharged when the voltage reaches the hysteresis threshold. The output continually toggles as a consequence. This results in a square wave output voltage.

With a 10-pF trimmer capacitor the frequency can be adjusted into the VHF FM broadcast band 88-108 MHz). The frequency of the oscillator is stable enough for this. The output voltage is about 6 V_{pp} at a power supply voltage of 9 V. The transmitter power amounts to about 50 mW at a load of 50 Ω. This is about 20 times as much as the average oscillator with a transistor.

With a short antenna of about 10 cm, the range is more than sufficient to use the circuit in the home as a test transmitter. Because the output signal is not free from harmonics the use of an outdoor antenna is not recommended. This requires an additional filter/adapter at the output (you could use a pi-filter for this).

The FM modulation is achieved by modulating the hysteresis, which influences the oscillator frequency. An audio signal of about 20 mV_{pp} is sufficient for a reasonable output amplitude.

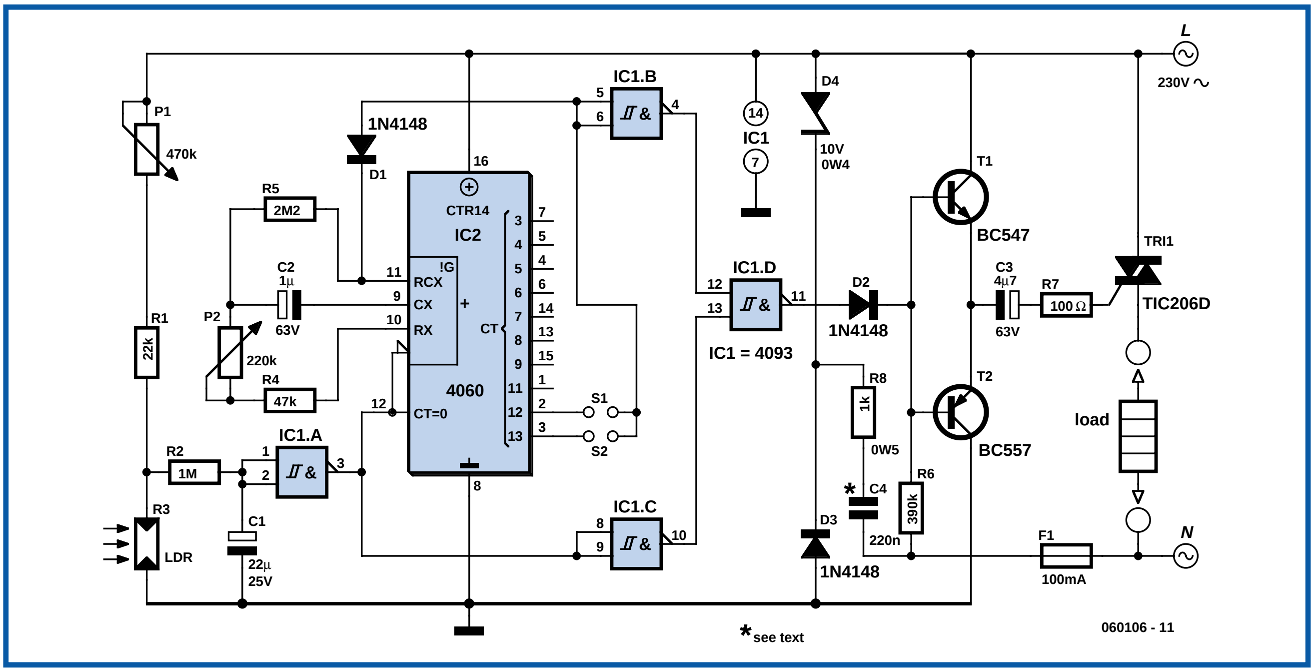
The package for the opamp is an 8-pin SOIC (provided you use the version with the RD8 suffix). The distance between the pins on this package is 1/20 inch (1.27 mm). This is still quite easy to solder with descent tools. If SMD parts are used for the other components as well

then the circuit can be made very small. If necessary, a single transistor can be added to the circuit to act as microphone amplifier. The power supply voltage may not be higher than 12 V, because the IC cannot withstand that. The current consumption at 9 V is only 15 mA.
As with all free-running oscillator circuits, the output frequency of this specimen is also sensitive to variations of the power supply voltage. For optimum stability, a power supply voltage regulator is essential.

As an additional design tip for this circuit, we show an application as VCO for, for example, a PLL circuit. When the trimmer capacitor is replaced with a varicap diode, the frequency range can be greater than that of an LC oscillator. That's because with an LC-oscillator the range is proportional to the square root of the capacitance ratio. With an RC oscillator the range is equal to the entire capacitance ratio. For example: with a capacitance ratio of 1:9, an LC oscillator can be tuned over a range of 1:3. With an RC oscillator this is 1:9.
For the second tip, we note that the circuit can provide sufficient power to drive a diode mixer (such as a SBL-1) directly. This type of mixer requires a local oscillator signal with a power from 5 to 10 mW and as already noted, this oscillator can deliver 50 mW. A simple attenuator with a couple of resistors is sufficient in this case to adapt the two to each other.

(060095-1)

038 Presence Simulator



Christian Tavernier

Among the many anti-theft devices that are available, presence simulators have a special role to play. In fact, while an alarm system generally reacts the instant the intrusion is detected, or sometimes a little afterwards, in all cases the damage has already occurred. The purpose of the presence simulator is to stop intrusions beforehand by making crooks think that someone is at home. Working from the principle that the majority of home burglaries, with break-in, happen particularly at night, a properly designed presence simulator turns on the lights as evening falls, then turns them off a few hours later, causing an observer with bad intentions to believe that the premises are occupied.
Creating such a function with a microcontroller is certainly very easy and has already been done many times in the past, but the project we are proposing now is intended for those among you who do not want to, or who cannot program this type of circuit. As a result, our diagram only includes very common logic circuits from the CMOS 4000 family, with quite respectable results.
Ambient light is measured using the LDR R3 and, when it goes below a threshold determined by the adjustable potentiometer (P1) setting, like when night falls, it drives the IC1.A gate output to a low level. This has the effect of triggering triac T3 through gates IC1.C, IC1.D and transistors T1 and T2. At the same time, this clears the reset input from IC2 which is none other than the classic 4060 in CMOS technology.
Considering the values of C2, R4 and P2, the internal continuous oscillator in IC2 functions at a frequency on the order of 5 Hz. Consequently, its output Q12 (pin 2) changes state at the end of approximately one to two hours (depending on the P2 setting) while Q13 (pin 3) does the same, but in two to four hours. Depending on whether a link has been installed on S1 or on S2, gate IC1.B output thus changes state after one to four

hours, having the effect of blocking triac TRI1 through IC1.D, T1 and T2. Simultaneously, diode D1 blocks the oscillator contained in IC2 and, therefore, the assembly stops in this state. It is dark, the light was lit for one to four hours, according to the setting of P2 and the wiring of S1 or S2, and it just went out. A return to the initial state can only happen after IC2 is reset to zero, which occurs when its input from reset to zero (pin 12) goes to high level, in other words at dawn and LDR R3 detects lights again.

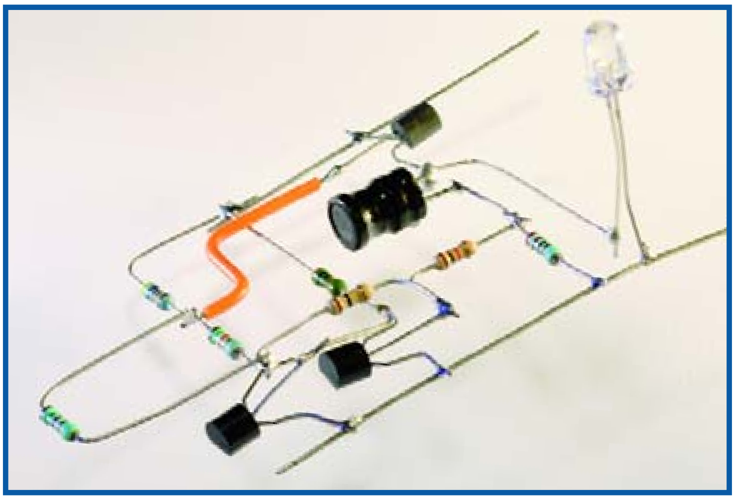
Thanks to its low consumption, this circuit can be directly powered by the mains using capacitor C4. The latter must be a class X or X2 model, rates for 230 VAC. Such a model, called a self-healing capacitor, is actually the only type of capacitor we should use for power supplies that are directly connected to the mains supply.

To ensure proper operation, we should pay careful attention to the placement of the LDR, to prevent the device being influenced not only by light from the house to be protected, but also by potential street lights, or even headlights of passing cars. Finally, since it is directly connected to the mains, the assembly must be mounted in an insulating housing, for obvious safety reasons.

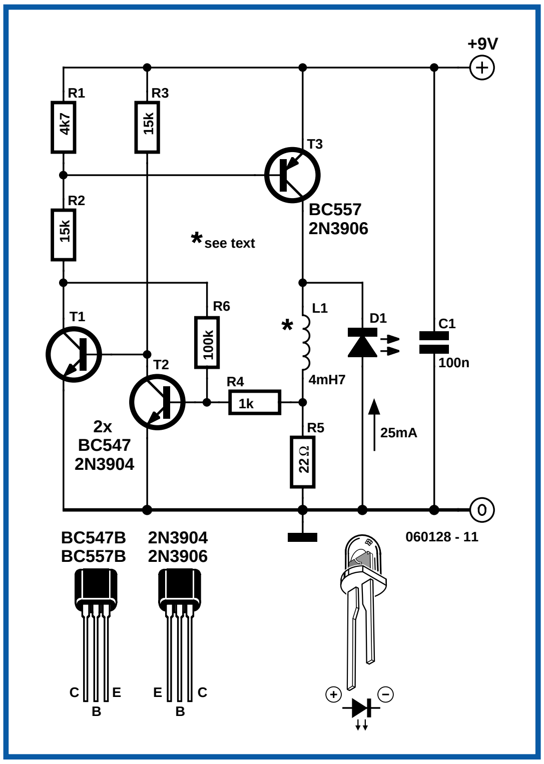
www.tavernier-c.com (060106-1)

Thrifty LED Protector

039



An LED is sure to fail if the current through it is too high. You will soon discover this after you have blown a few up. A simple resistor in series suffices to solve the problem and a better solution is almost inconceivable, because in this case you need only one additional cheap component. As the power supply voltage increases, an increasing amount of power is lost in the resistor. In particular with battery-powered equipment it is worthwhile to make a power-saving version, which does require a few more parts however.



The circuit shown in the figure has deliberately been designed with parts that everyone will have lying around, except perhaps the small coil.

In nearly all modern switching power supplies there is an attempt to monitor the current. It is generally the case that components will fail if the current or power is too high and this is very effectively avoided with this technique. It works like this. Resistor R5 measures the current through the coil and T2 'watches' to make sure it doesn't become too large. L1 will never go into saturation, which could cause T3 to give up the ghost. As soon as the current through R5 increases to about 25 mA, T2 will conduct, T1 will block and T3 will also block. The current cannot flow through T3 any more and will look for another path, in this case through LED D1, which will now light up. By placing D1 in this position it acts in fact as a free-wheeling diode, which is good for the efficiency.

As soon as the current drops, T2 will block again and T3 will conduct. R6 provides a small amount of hysteresis so that the switching frequency of about 50 kHz does not become unnecessarily high (which would increase the loss).

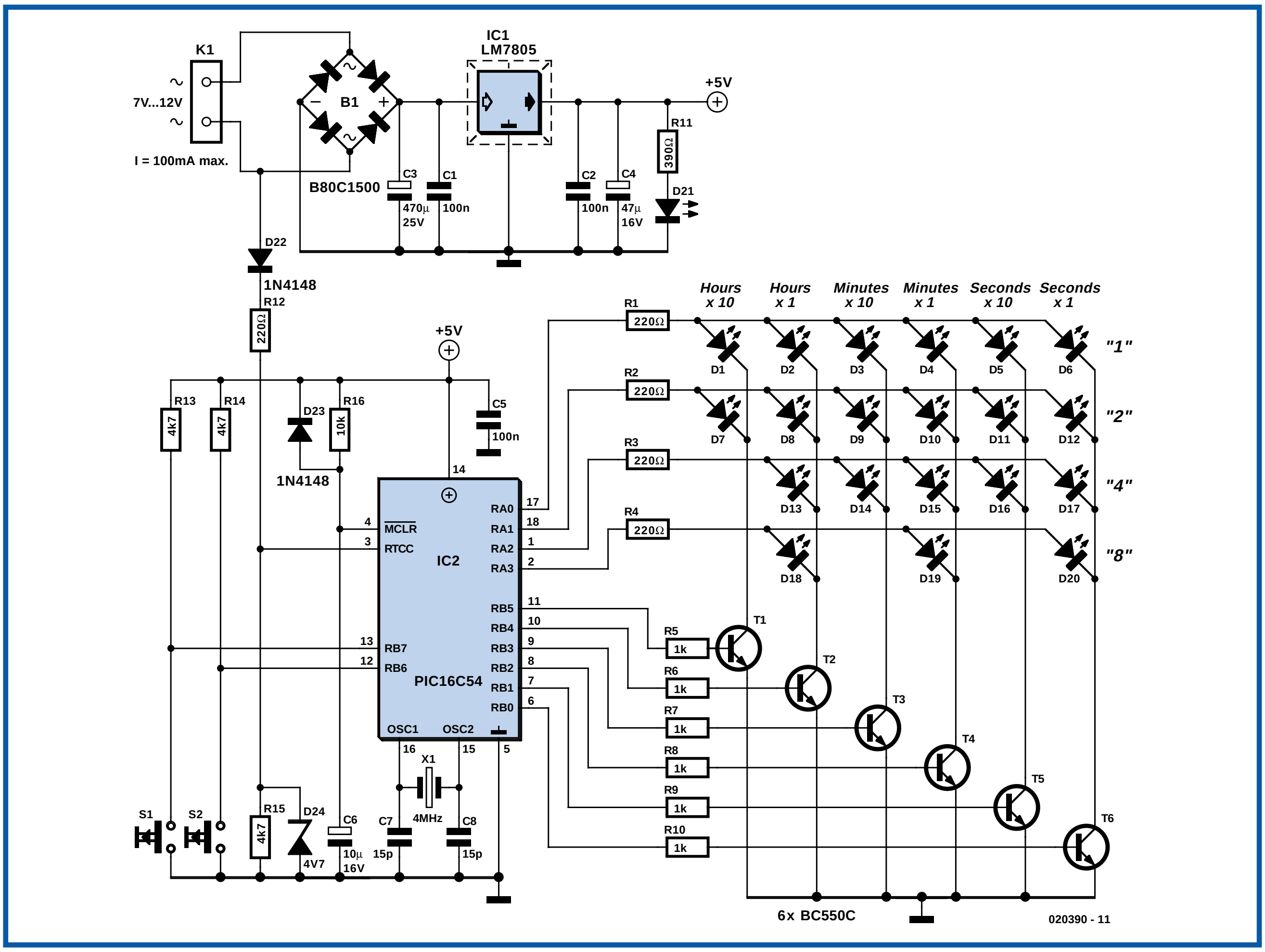
The circuit works from about five volts, depending on the forward voltage of the LED. From about 9 V you will clearly notice the improvement in efficiency. The circuit is suitable for all types of LEDs, including the blue and white ones that need 3.5 V. The voltage that is generated by the coil will automatically adapt. The maximum power supply voltage is 24 V.

A little clarification regarding the choice of coil: the value is not critical, it could just as easily be 3.9 mH or 6.8 mH. Even 10 mH can be used, especially if the power supply voltage is greater than 9 V. The coil does need to be suitable for at least 25 mA. You can usually take a guess based on the physical dimensions of the coil. The coil will have to be at least 15 mm long and have a diameter of 7 mm. Incidentally, there have been great advances regarding coils in the least few years. Modern SMD-coils are much smaller and can nevertheless handle high currents. Unfortunately they are not usually available in values over 1 mH.

(060128-1)

040

Binary Clock

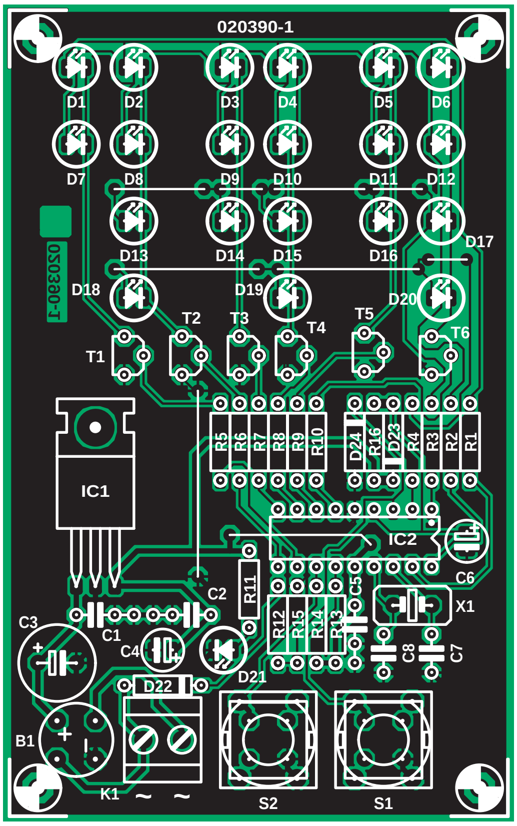


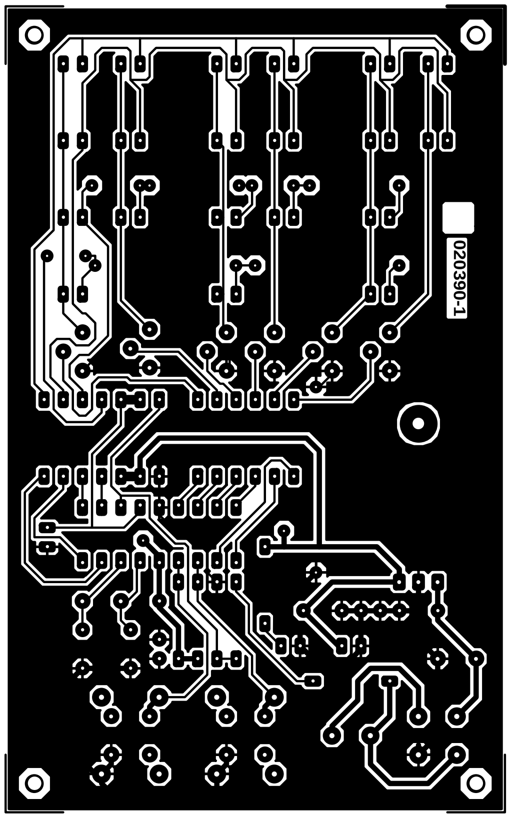
Marco Freitag

Unusual clocks are not uncommon in *Elektor Electronics*. The version presented here is based on the binary clock (not yet on display) in the new Museum of Mathematics in Gießen, Germany (www.mm-gi.de/htdocs/mathematikum/index.php?513), but it is entirely compatible with an ordinary living room. However, the hours, minutes and seconds have been further divided into units and tens to make them easier to read, which yields six columns: tens of hours, units of hours, tens of minutes, units of minutes, tens of seconds, and units of seconds. The values are read row by row from top to bottom: one, two, four, and eight — in other words, binary. With a bit of practice, it's even possible to quickly and easily read the time in a single glance.

The supply voltage for the circuit comes from a simple mains adapter with an ac output voltage of 8–15 V at a maximum output current of 300 mA. The voltage **must not** be rectified, since the microcontroller uses the frequency of the ac voltage (50 Hz) as a clock signal with long-term stability. As PIC16C54 does not have enough output ports to individually drive all of the LEDs, and doing so would also require several additional components, the display is multiplexed. In order to nevertheless make the low-current LEDs nice and bright, the magnitude of the current pulses is made significantly higher than the rated current.

Buttons S1 and S2 can be used to set the time. If you press S2, you will arrive at the setting menu after a brief LED test (all LEDs on). The value of the first column can now be set to any desired value using S2. Pressing S1 takes you to the next column. This continues in the same manner until the configuration mode is exited after the





COMPONENTS LIST

Resistors:
R1-R4,R12 = 220Ω
R5-R10 = 1kΩ
R11 = 390Ω
R13,R14,R15 = 4kΩ7
R16 = 10kΩ

Capacitors:
C1,C2,C5 = 100nF
C3 = 470µF 25V radial
C4 = 47µF 16V radial
C6 = 10µF 16V radial
C7,C8 = 15pF

Semiconductors:
B1 = B80C1500 (80V piv, 1.5A)
D1-D20 = LED, low current, colour to personal taste
D21 = LED
D22,D23 = 1N4148
D24 = zener diode 4.7V, 0.5W
IC1 = LM7805
IC2 = PIC16C54-04/P (programmed, order code **020390-41**)
T1-T6 = BC550C

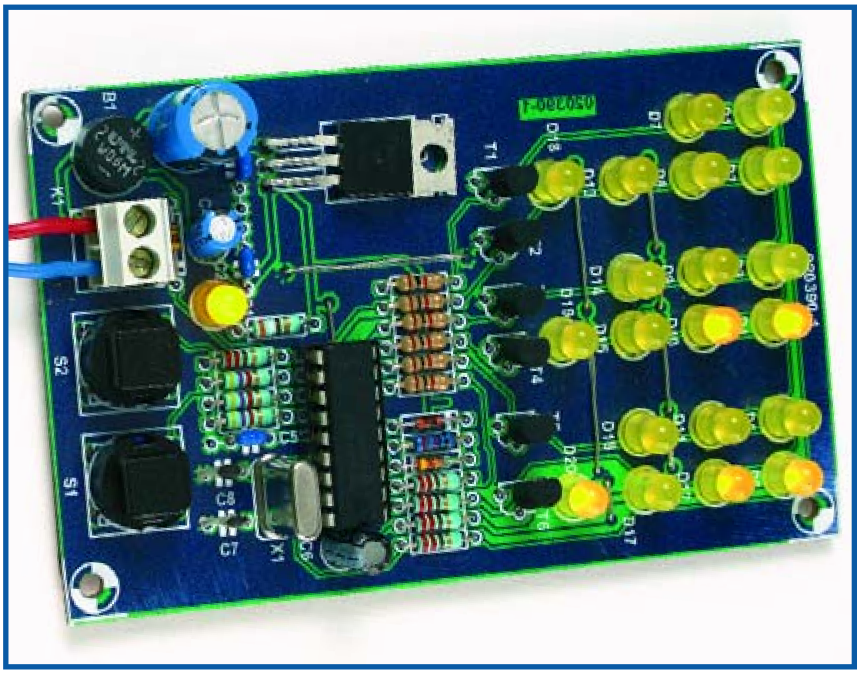
Miscellaneous:
K1 = 2-way PCB terminal block, lead pitch 5mm
S1,S2 = pushbutton, 1 make contact
X1 = 4MHz quartz crystal
Project software on disk: order code **020390-11** or Free Download
PCB, order code 020390-1 from The PCBShop

final column. The clock will continue to run, starting with the newly set value.

We have designed a printed circuit board layout for the binary clock. Fitting the components to the board couldn't be easier, although you mustn't overlook the set of nine wire bridges. As one of them is underneath the microcontroller, the latter must be fitted with a socket. The LEDs should initially be fitted with only one lead soldered in place, after which they must be aligned. The remaining leads should only be soldered after the LEDs are all nicely lined up.

The board can be displayed 'bare' or fitted into a small plastic enclosure. A transparent enclosure is quite practical, since it eliminates the need to drill holes for the LEDs.

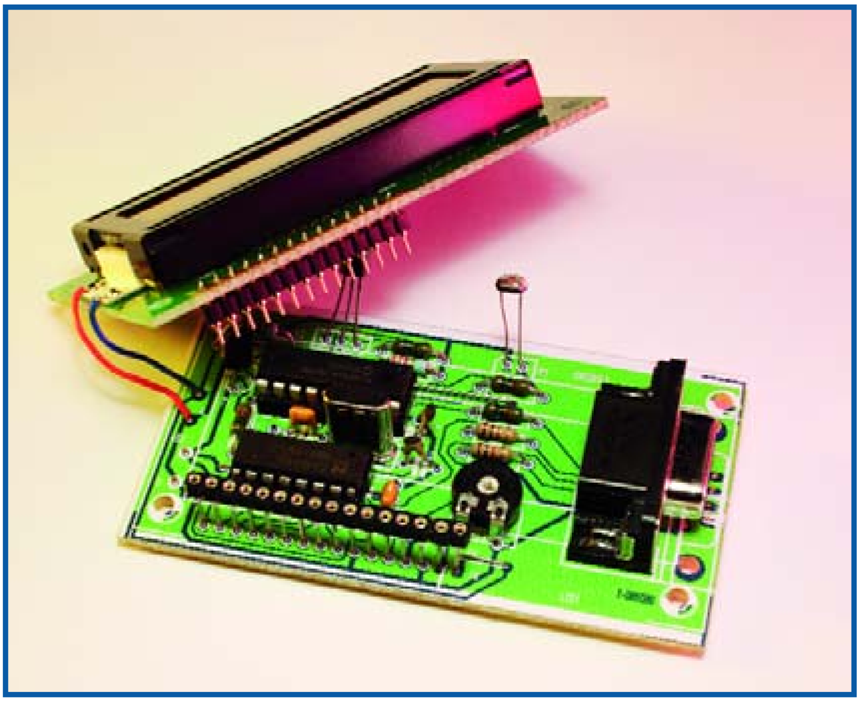
(020390-1)



041

1-Wire Thermometer with LCD

Heino Peters



Although accurate digital thermometers are now available at low cost, it remains exciting and instructive to build one yourself. The present circuit is particularly intended to help the reader in the use of a PIC processor Type PIC16F84 (see www.microchip.com), a temperature sensor with 1-Wire protocol Type DS1820 (see www.maxim-ic.com), an LCD screen with 2x16 characters (HD44780 compatible) and a light sensor with an LDR that determines whether the background lighting of the LCD should be on.

The circuit is provided with a 9-way sub-D connector that enables it to be linked to the COM gate of the PC. This connection also enables the circuit to be programmed as appropriate.
Quartz crystal X1 in combination with capacitors C1 and C2 ensures that the

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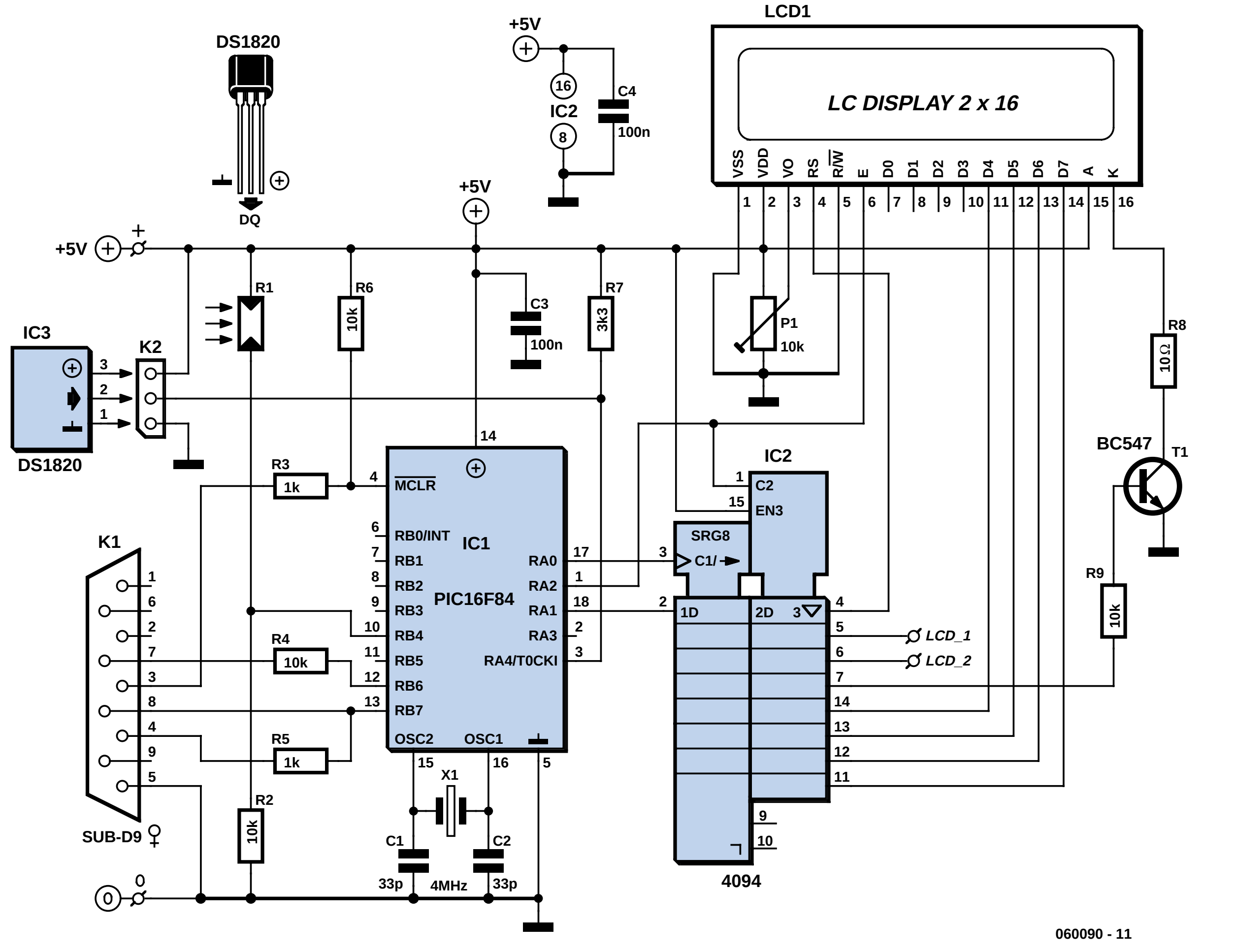
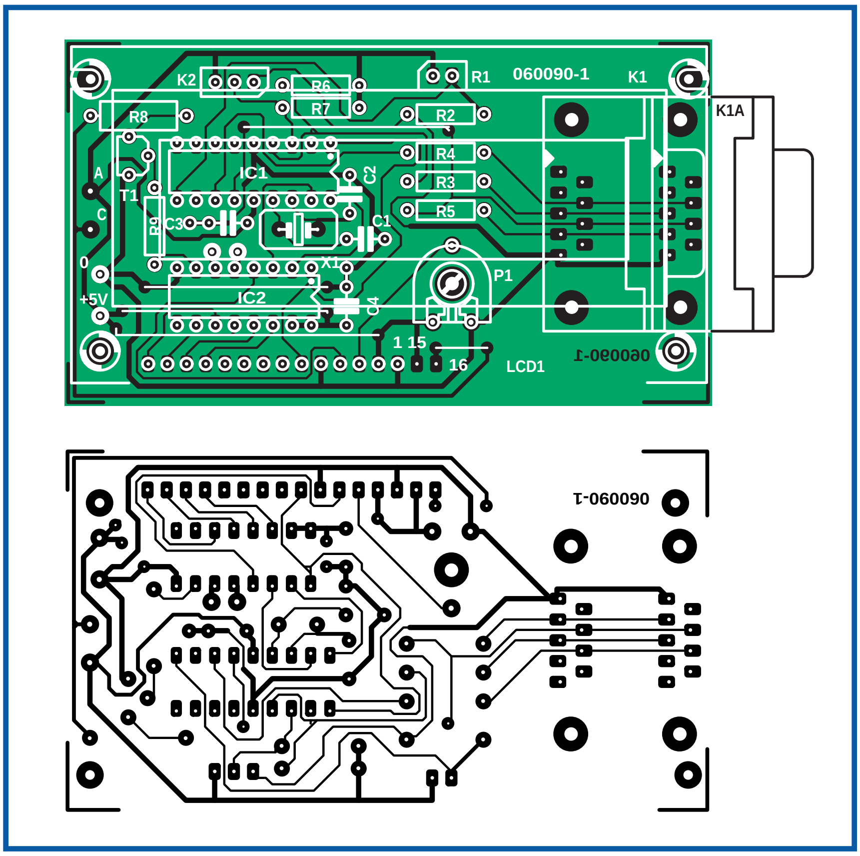


PIC16F84 Configuration bits

Oscillator XT (01)
WDTE off (0)
PWRTE on (0)
CP off (1) (all bits)



PIC processor, IC1, runs at a frequency of 4 MHz and that each instruction in the program lasts exactly 1 μs. This is useful for the timing in the program, which, by the way, is available as a free download on the *Elektor Electronics* website (file no. **060090-11.zip**). Resistors R3, R4 and R5 enable IC1 to be programmed directly by a PC via connector K1. Resistor R1, which may any type of LDR, and R2 form a potential divider that, depending on the ambient light, sets a '0' or a '1' on input RB4 of IC1. The data line of temperature sensor IC3 is connected to terminal RA4 of IC1. This terminal is the only open-collector one of IC1 and is exactly what is needed for the 1-wire data line. Resistor R7 'pulls up' the data line in quiescent operation.

The right-hand section of the diagram enables the display of the temperature. To limit the number of connections to the processor, the LCD is controlled via the series/parallel converter in IC2. The LCD proper is driven in the 4-bit mode (DB4–DB7). Also, the Register Select, RS, and the backlight must be provided with the appropriate signals. IC2 converts the 8 bits provided serially by IC1 into 8 parallel bits. The rising edge of the strobe signal from RA2 instructs IC2 to set the previously received eight bits at the outputs. The falling edge clocks them to the screen via enable input E of the LCD. Since only six of the eight bits are needed, individual extensions may be accommodated at outputs LCD1 and LCD2: for instance, a buzzer or an LED. The combination of R9, T1 and R8 provides a current of 100–200 mA from output Q3 (pin 7) of IC2 to the backlight of the LCD. The contrast of the display may be adjusted with P1.

The associated program is written in assembly code; it may be adapted as needed by downloading development area MPLAB from www.microchip.com Design a project in MPLAB and within this, load the source code available at the Elektor website (the .ASM file). After you have added your own adaptations, make a .HEX image by clicking on the BUILD icon. Then, use the free program NTPICPROG.EXE from Andres Hansson (http://www.geocities.com/CapeCanaveral/7706/ntpicprog.zip) to program the .HEX file in the PIC via the COM gate of the PC. The 5-V supply rail must remain connected during programming. Do not program the PIC with a notebook, but use a desktop PC, since the voltage levels at the COM gate of a notebook often are only 3–5 V, whereas a minimum of 10 V is needed. Also, do not use a USB/RS232 converter, because that usually confuses the timing.

Once you have this setup working, the step to other applications is easy.
The circuit is readily constructed on the printed-circuit boards shown. Start with the wire links, so that they are not overlooked at a later stage. If you do not want to program the PIC yourself, a programmed one may be ordered from Elektor (order code **060090-41**). A power source of 5 V capable of providing a current of up to 100 mA is required.

Note that the circuit does not provide protection against polarity reversal or too high a supply voltage.

(060090-1)

COMPONENTS LIST

Resistors
R1 = LDR (small model)
R2,R4,R6,R9= 10kΩ
R3,R5 = 1kΩ
R7 = 3kΩ3
R8 = 10Ω
P1 = 10kΩ preset, horizontal

Capacitors
C1,C2 = 33pF
C3,C4 = 100nF

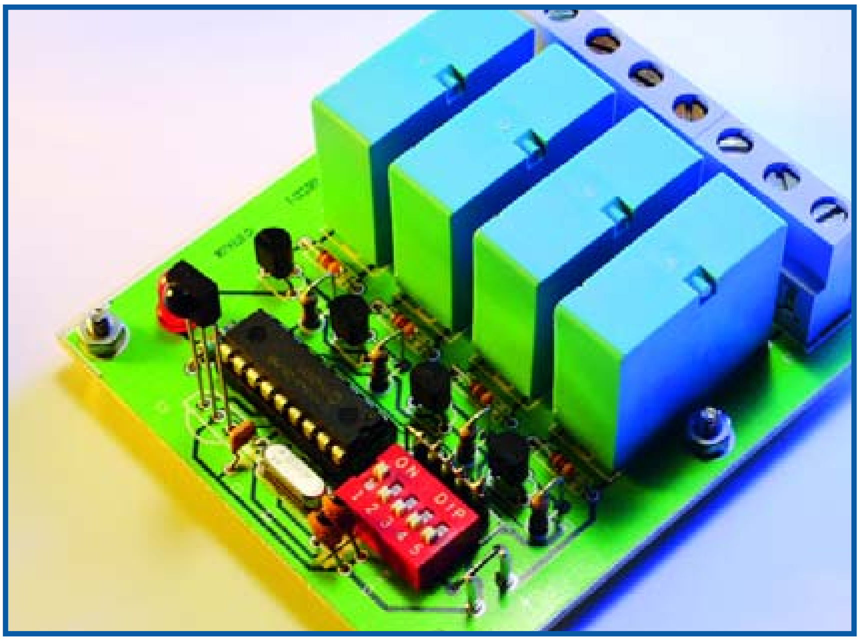
Semiconductors
T1 = BC547
IC1 = PIC16F84A-04CP (programmed, order code **060090-41**)
IC2 = 4094
IC3 = DS1820, DS18S20
LCD = alphanumerical LCD, 2x16 characters, 44780-compatible

Miscellaneous
K1 = 9-way sub-D socket (female), angled, PCB mount
K2 = 3-way SIL pinheader
X1 = 4MHz quartz crystal, parr. cap. 32pF, HC49 case
5 wire links
PCB, ref. 060090-1 from The PCBShop
Source and hex code files, ref. **060090-11**, free download from www.elektor-electronics.co.uk

042

Easy Home Remote Control

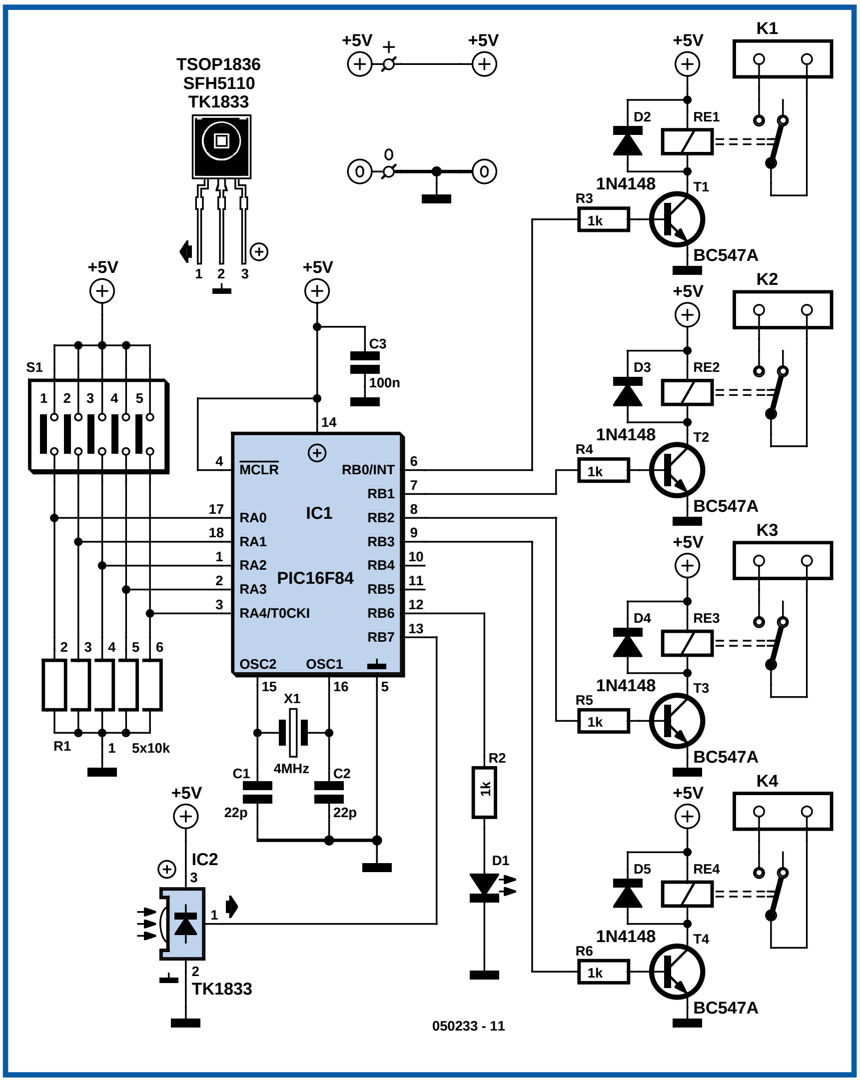
Carlos Ferreira

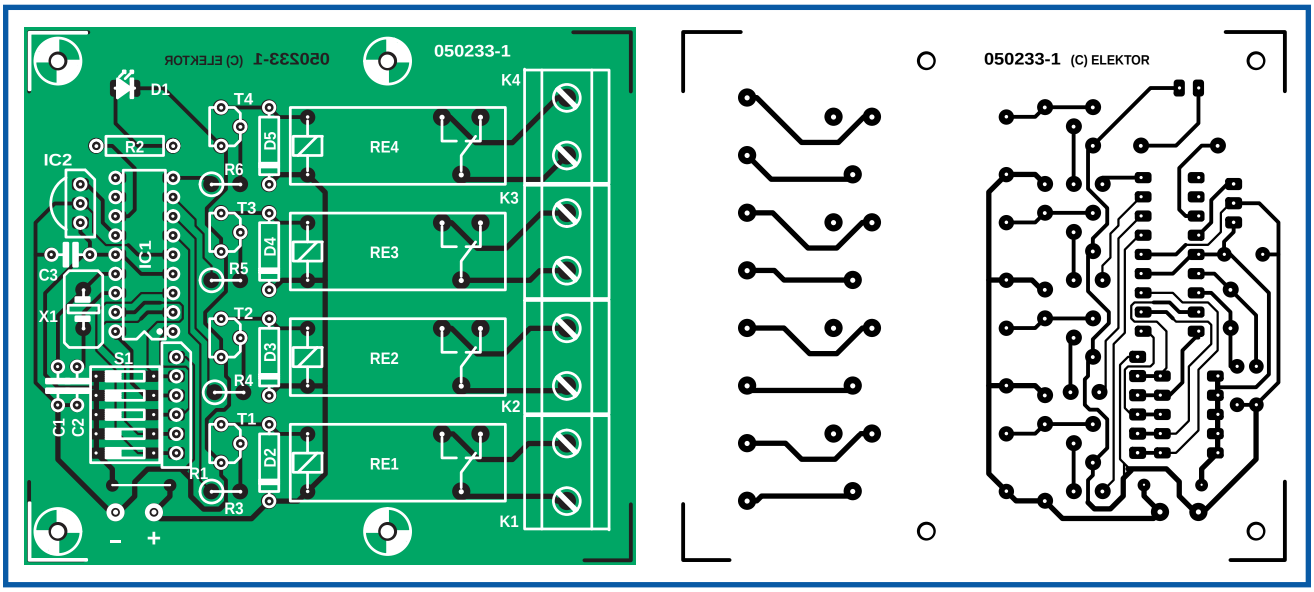


Happens to everyone! You're comfortably installed on your sofa watching TV and then all of a sudden you need to get up to turn the lights on or off, or to draw the curtains. Many living rooms these days have a double head-up ceiling light, a floor lamp and an electric window/curtain control. The idea is to control all these devices, and more, with the TV remote control.

The circuit designed for *maximum indolence in front of the telly* is built around the PIC16F84. The 'F84 was chosen mainly because of its internal EEPROM, which is necessary to store the user-programmable infrared codes. To control such devices as mentioned above, four relays are used, working together with lamp switches in a two way configuration.

Looking at the circuit, the DIP switch block and the associated resistor array connected to microcontroller port A are used to program the IR codes and to select the operation mode for all the outputs (described further on). The IR sensor is connected to port line RB7 on the PIC. The lower nibble (set of 4 bits) of port B is used to control the output relays via 1-k resistors and BC547 transistors. It is also used to control multifunction indicator LED D1 on port line RB6.
Components C1, C2 and X1 generate the microcontroller clock signal while C3 helps to keep the supply voltage as clean as possible.
The circuit should be powered by a 5-V regulated supply capable of providing enough current for the four relay coils (approximately 140 mA per relay) plus a few mA for microcontroller, IR sensor and LED.
The circuit is designed to respond to infrared commands coded to the Philips RC5 protocol. The protocol consists in a frame of 14 bits. The first two bits, always at '1', are used to start the frame. The third bit is the flip bit, this bit indicates when a key is pressed repeatedly. The next five bits are used to identify de system which the message is sent. The last six bits represent the sent command. Note that in RC5 speak a logic '1' is a transition from 0 V to Vcc, and logic '0'





is a transition from Vcc to 0 V, where the period of one bit is 1.7778 ms. Many articles on RC5 have appeared in this magazine.

The software developed for the project is stored in the PIC microcontroller. It allows four different RC5 codes to be saved and used to control the four outputs. For example, your TV remote may be able to control five systems: TV (default), VCR, DVD, AMP, SAT. If, for example, you do not have VCR then the relevant IR codes are available for Easy Home Control. If your remote control is not compatible with RC5 codes, you can buy a cheap universal remote control to do the job.
To avoid the relays changing state owing to a power cut in your home, the state of the relays is saved in the microcontroller EEPROM and retrieved every time the PIC re-initialises.
The actuation of electric curtains differs from lamps as it's necessary to send a short pulse to the relays.
To make the home control more versatile it is possible to control all relays (configurable by the DIP switches) in one of two modes:

- toggle between ON and OFF positions with memory for lamps;
- output pulse for other devices like electric windows-curtains.

If you're a keen energy saver, it is also possible to program an IR code to turn off all the relays (and save 5 V·140 mA = 0.7 watts per relay).

The Easy Home Remote Control is configured as follows.
1. Switch the circuit on with all DIP switches set to OFF.
2. Flip ON switch #5 (switch connected to RA4/TOCK1) to enable programming mode. Using **Table 1**, set the other switches as required to save desired IR codes in EEPROM.
3. Flip OFF switch #5 to select working mode. Using **Table 2**, configure the other switches to select the desired relay mode.

In working mode a fast-blinking LED (D1) means reception of IR codes with no associated function; 1-second blink means programmed IR code was received and corresponding action was

COMPONENTS LIST

Resistors
R1= 5-way 10kΩ SIL array
R2-R6 = 1kΩ

Capacitors
C1,C2 = 22pF
C3 = 100nF

Semiconductors
D1= LED, low current
D2-D5 = 1N4148
IC2 = IR receiver module, e.g., TSOP1836, SFH5110 or TK1833
T1-T4 = BC547

Miscellaneous
X1 = 4MHz quartz crystal
IC1 = PIC16F84, programmed, order code **050233-41** (see Elektor SHOP pages or website)
PCB, ref. 050233-1 from The PCB Shop
Re1-Re4 = PCB mount relay, 5V coil, 140mA.

Table 1. Programming Mode

DIP switch ON (S1)	DIP switch OFF (S1)	Set code for
#1	#2, #3, #4	relay 1
#2	#1, #3, #4	relay 2
#3	#1, #2, #4	relay 3
#4	#1, #2, #4	relay 4
#1, #2	#3, #4	All relays OFF
Note: LED blinks 1 second after code set.		

Table 2. Working Mode

DIP Switch (S1)	OFF = Toggle Mode	ON = Pulse Mode
#1	toggle relay 1	1-second pulse at relay 1
#2	toggle relay 2	1-second pulse at relay 2
#3	toggle relay 3	1-second pulse at relay 3
#4	toggle relay 4	1-second pulse at relay 4
Notes: Led blinks 1 second after any action on relays. Fast blinking of the LED means bad RC5 reception or correct RC5 code but no action associated with it.		

performed. In programming mode, the 1-second blink means the IR code was saved in the microcontroller EEPROM.
The assembly code file for the PIC used in this project is available as a free download from the *Elektor Electronics* website. File number **050233-11.zip** may be found by clicking on Magazine → 2006 → July/August. The PIC is also available ready-programmed from the Publishers as order code **050233-41**.

(050233-1)

Warning
Screw contacts on K1-K4 and PCB tracks to the relay contacts may carry the mains voltage. All relevant precautions must be observed in respect of electrical safety

043

Recycling Flasher Lights

Gérard Guilhem

During the Christmas holidays, you lose count of the number of homes lit up like Christmas trees, like fireflies by the thousands which twinkle and flash, outlining words, the shape of designs, characters, or animals.

We are proposing a garland of lights you will not find at your neighbour's house and at the same time to do something good for the environment— because we are going to recycle. The string described here is only composed of electronic photo flasher lights. Only the richest municipalities have the potential to buy this type of decoration due to its hefty price tag, but we are going to make the same at a ridiculously low price.
First step: go to a photographer's shop and kindly ask the shop owner or staff to set aside some used, disposable flash cameras. Staff will normally be very happy to do that because, in any case, these units end up in the trash after being processed. You will need about twenty at least, preferably of the same type, that will make the task easier.
Second step: open each camera, remove the battery, discharge the capacitor (one never knows) and finally, remove the electronic flasher board. Two possibilities: the printed circuit is small and can therefore be used as such after a small modification, or the printed circuit is too big which will force you remove the components you'll be using on a board of your own design.
You should start by copying the diagram and identifying the components. 95% of flasher boards are designed based on the diagram in **Figure 1**.
There are several variations, some surprisingly complex for a disposable module, including a measurement cell and a thyristor, for example. Do not use that kind of model.
It is difficult to imagine a simpler diagram. Transistor T1 is the only active component. Helped by TR1 and R1, it produces approximately 300 V from 1.5 volts supplied by the alkaline battery.
C1 charges progressively and the neon miniature 'Ready' lamp La2 lights up to signal that the energy stored is sufficient to obtain a good flash.
In parallel, and even more rapidly, C2 is charged via TR2 and R3. All that's left to do is wait for the amateur photographer to press button S1, which has the effect of discharging C2 into TR2 that produces the high-voltage pulse necessary to fire neon flashlight La1.
That is precisely what we need, in detail: we are not going to spend the entire evening pressing different buttons to trigger the flash. Therefore, we have to find an automated technique for this process by giving it a somewhat random character.
The result of all these reflections take the shape of the diagram in **Figure 2** which, as compared with the first diagram, has three new components (after having lost two, now useless!).
Thyristor TH1 will be charged from triggering, as soon as the voltage at C3 terminals, charged via R3, exceeds the fir-

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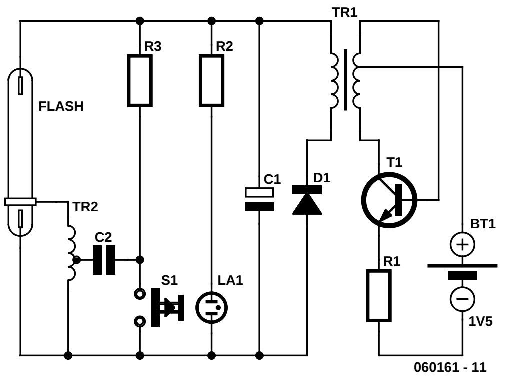

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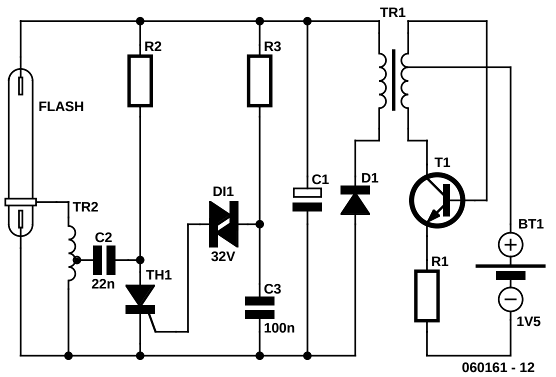
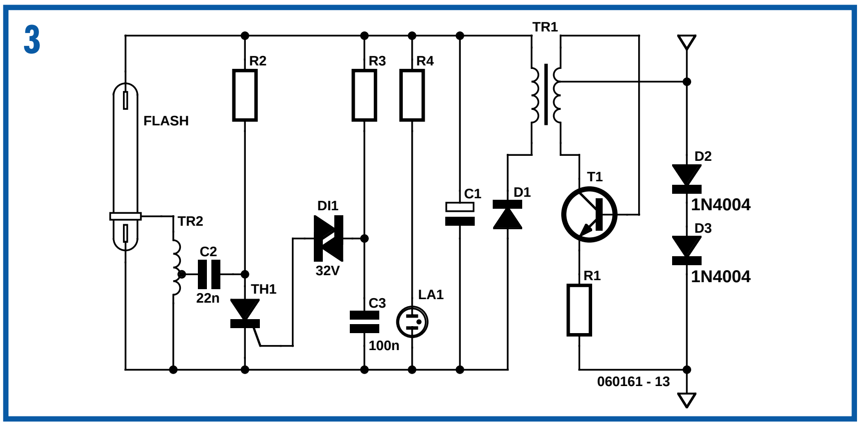


ing threshold of the diac DI1 which supplies the trigger current.

A judicious choice of values for R3 and C3 makes it possible to have one flash per second. In order to avoid too high energy consumption, the value of C1 is adjusted to 4.7 µF, even 10 µF, for nicely padded flashes without using too much current.

You will, no doubt, have noticed the absence of the neon miniature bulb and its resistor which are no longer useful.

Last problem to solve: the power supply. We are not going to interrupt the New Year's Eve party to replace used batteries. It is out of the question to power the setup from 1.5 V as the number of flashes we are dealing with, the current would be too high. It would be better to supply 1.5-V voltage to each module, the modules being mounted in series, taking care to limit the current to approximately 500 mA. As illustrated in the partial diagram of **Figure 3**, we will provide each module with a pair of 1N4001 diodes that will produce a drop in voltage between 1.3 V and 1.4 V, and that works out perfectly. The flashers are mounted in series on a wire whose two end points are connected to a DC power supply. We should account for about 1 V per module. We can actually consider that the majority of flashes will occur during charging and will only reach the 1.4 V level a few tenths of a second before the actual flash, the average voltage being around 1 V.



It's reasonable to reserve 24 V for 20 flasher units, with a protection resistor of about 10 Ω to limit the current surges, not forgetting a 1-amp fuse.

The best result will be obtained using an adjustable constant current power supply between 0.5 and 1 A, which allows us to play with the flash frequency. The number of flashes is obviously a function of the current supplied.

It is recommended, for safety reasons, to stay below 40 volts. This corresponds to close to 40 flashlamps (and a few evenings to set them up), but since we still have quite a few months before the holiday season...

What remains is the 'packaging'. Everything depends on the size of the finished module. You could potentially use housing for translucent film in which you drill two holes to force the wires through and ensure an airtight seal.

Another option is translucent heat shrink tubing of the proper size. We will cut an adequate length of tubing, or 4 cm more than the length of the module. The wires are coated with a drop of heat shrinkable glue, then the tubing is retracted. The end is immediately flattened using a flat clamp until totally cooled. Repeat for the other end. This should make for a good airtight seal.

A purposely designed printed circuit will allow you to reduce the size of the module to a minimum.

Average consumption is approximately 12 watts for 20 flasher modules, which is perfectly reasonable and the result obtained is surprising, original and superb.

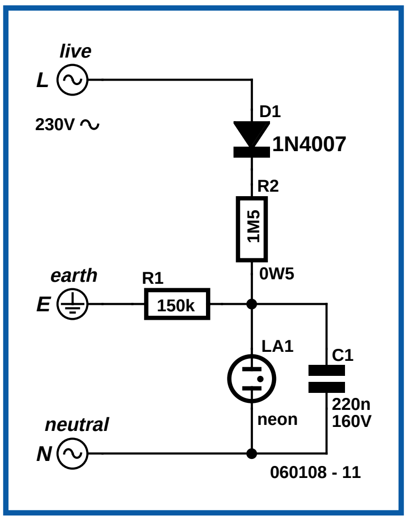
(060161-1)

Earth Fault Indicator

044

Christian Tavernier

The security of many electrical devices depends today on the availability of an earthed mains outlet. We should remember that these are connected to the frame or to the metal housing of the equipment and so it routes to the protective earth (PE) connections. In this setup, mains voltage, however small, will cause the differential circuit breaker to trip. The circuit breaker is part of any modern electrical installation. This type of security device may however become defective due to common corrosion as we have seen many times on various older household devices, as well as on construction sites. Actually, since these devices are frequently in wet conditions, the screw and/or lug used to connect the earth wire to the device frame corrodes gradually and ends up breaking or causing a faulty contact. The remedy is then worse than the problem because the user, thinking that he/she is protected by earth, does not take special precautions and risks his/her life.



However, all that's needed is an extremely simple system to automatically detect any break in the earth connection; so simple that we ask ourselves why it is not already included as part of all factory production for appliances that carry any such risk, as we have discussed above. We propose it as a project for you to build using this schematic.

The live wire (L) of the mains power supply is connected to diode D1 which ensures simple half-wave rectification which is sufficient for our use. The current which is available is limited to a very low value by resistor R2. If the appliance earth connection to which our circuit is installed is efficient, this current is directed to earth via resistor R1 and the rest of the circuit is inactive due to insufficient power.

If the earth connection is disconnected, the current supplied by D1 and R2 charges up capacitor C1. When the voltage at the terminals of the capacitor reaches about 60 volts, neon indicator light La1 is turned on and emits a flashing light which discharges capacitor C1 at the same time. This phenomenon is reproduced indefinitely as long as the earth connection has not been restored, and the neon light continues to flash to attract attention in case of danger.

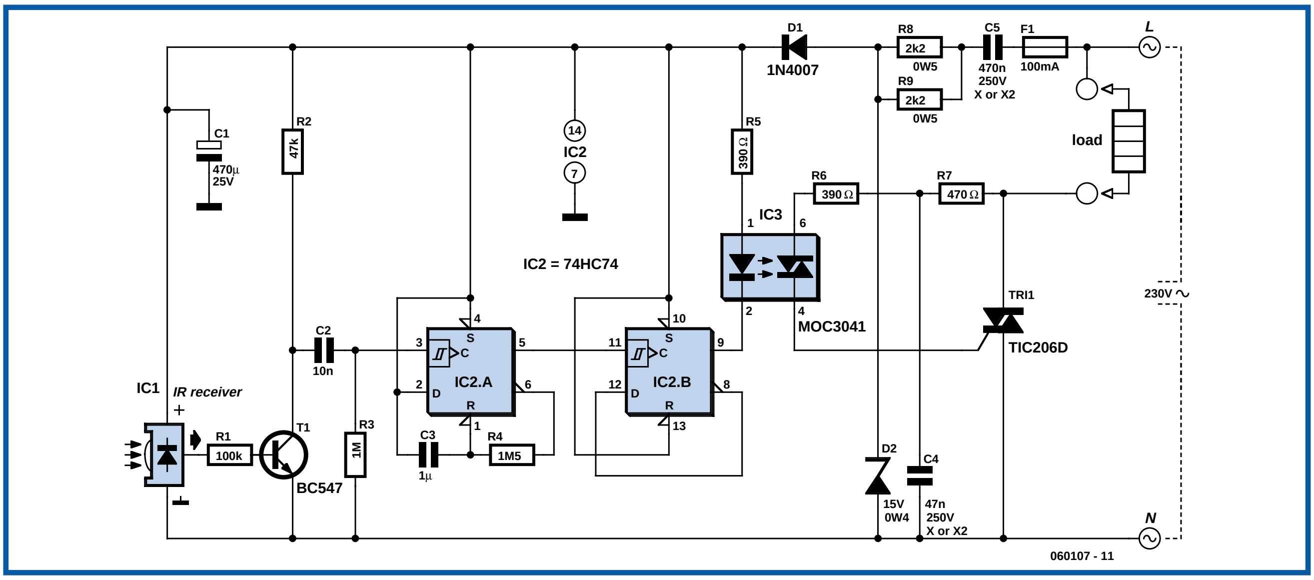
Building the project is not particularly difficult but, since it is a project aimed at human safety, we must take the maximum of precautions concerning the choice of components utilised. Therefore, C1 must have an operating voltage of at least 160 volts while R2 must be a 0.5-watt resistor, not for reasons of power dissipation, but in order to maintain the voltage. The neon light can be any type, possibly used, or it may be part of an indicator light to make it easier to attach to the protected appliance. In the second case, we must obviously get rid of its series resistor which would prevent proper operation here.

During installation of the circuit in the appliance to be protected, we should also clearly mark Live (L) and Neutral (N) (for example, seek Live with a simple screwdriver) because inverting these two wires at this point will disable proper operation. The final point, which is self-evident considering the principle used here: the earth connection for our setup must be hooked up to the frame of the appliance to be protected at a different point than where the normal earth wire is connected.

www.tavernier-c.com (060108-1)

045

On/off Infrared Remote Control



Christian Tavernier

Most homes today have at least a few infrared remote controls, whether they be for the television, the video recorder, the stereo, etc. Despite that fact, who among us has not cursed the light that remained lit after we just sat down in a comfortable chair to watch a good film? This project proposes to solve that problem thanks to its original approach. In fact, it is for a common on/off switch for infrared remote controls, but what differentiates it from the commercial products is the fact that it is capable of working with any remote control. Therefore, the first one you find allows you to turn off the light and enjoy your movie in the best possible conditions.

The infrared receiver part of our project is entrusted to an integrated receiver (Sony SBX 1620-52) which has the advantage of costing less than the components required to make the same function. After being inverted by T1, the pulses delivered by this receiver trigger IC2a, which is nothing other than a D flip-flop configured in monostable mode by feeding back its output $\overline{Q}$ on its reset input via R4 and C3. The pulse that is produced on the output Q of IC.2A makes IC.2B change state, which has the effect of turning on or turning off the LED contained in IC3. This circuit is an opto triac with zero-crossing detection which allows our setup to accomplish switching without noise. It actually triggers the triac T2 in the anode where the load to be controlled is found. The selected model allows us to switch up to 3 amperes but nothing should stop you from using a more powerful triac if this model turns out to be insufficient for your use.

In order to reduce its size and total cost, the circuit is powered directly from the mains using capacitor C5 which must be a class X or X2 model rated at 230 volts AC. This type of capacitor, called 'self-healing', is the only type we should use today for power supplies that are connected to ground. 'Traditional' capacitors, rated at 400 volts, do not really have sufficient safety guarantees in this area. Considering the fact that the setup is connected directly to the mains, it must be mounted in a completely insulated housing. A power outlet model works very well and can easily be used to interspace between the grounded wall outlet and that of the remote control device. Based on this principle, this setup reacts to any infrared signal and, as we said before, this makes it compatible with any remote control. On the other hand, it has a small disadvantage which is that sometimes it might react to the 'normal' utilization of one of these, which could be undesirable. To avoid that, we advise you to mask the infrared receiver window as much as possible so that it is necessary to point the remote control in its direction in order to activate it.

www.tavernier-c.com (060107-1)

Charlieplexing

046

Do you think it is possible to drive an 8-digit, 7-segment display with only nine (9) connections? Yes certainly, and here we show you how it's done.

Normally speaking, a 7-segment display has eight LEDs (including the decimal point) that have to be controlled with eight inputs and one common output. The corresponding segments of all the displays are connected together and only one display is activated at a time because each display has its own common anode (or cathode) connection. This requires 8 + 8 = 16 connections, as shown in **Figure 1**. But it is certainly possible to do this with only nine connections, provided the multiplexing is done a little smarter. The notable feature in **Figure 2** is that the common output of each display is also connected to a segment (but each to a different segment). In addition it is necessary that the drive electronics is capable of both sourcing current and sinking current. This works as follows:

To keep things simple we've drawn only two displays in **Figure 3**. CC0 drives both a segment (of display 1) as well as a common cathode (of display 0). When this line is logic zero, the segments from display 0 can be illuminated when they are supplied with current. The segments of display 1 would also like to light up, but there is nowhere for their current to flow. This current has to flow via a segment (the leftmost one in this case) but that segment is connected in the reverse direction! Display 1 remains dark therefore and the same applies to the other six displays.

In **Figure 4** you can see what the path of the current is when CC1 is logic low. The segments from display #1 can now be illuminated.

(060124-1)

You can find more information in application note 1880 from Maxim:
www.maxim-ic.com/appnotes.cfm/appnote_number/1880

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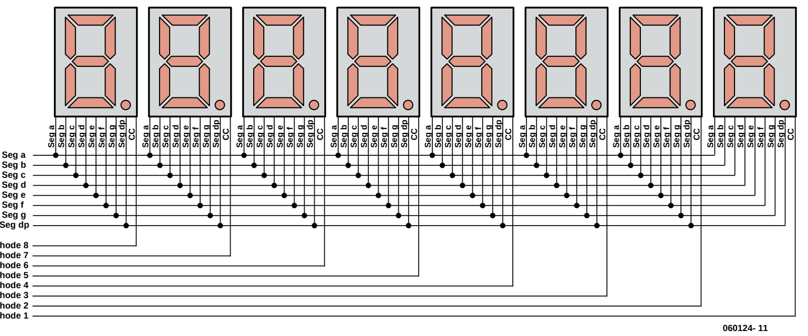

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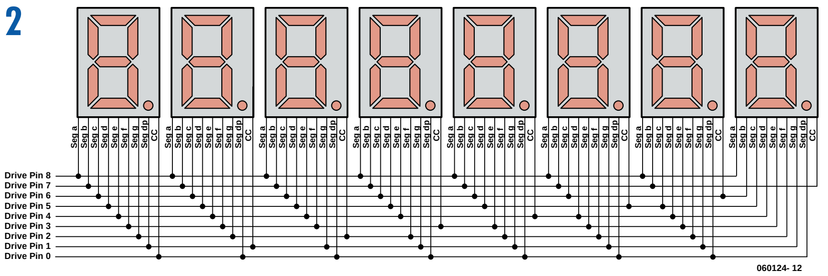

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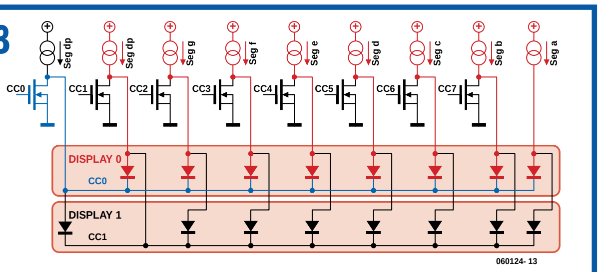

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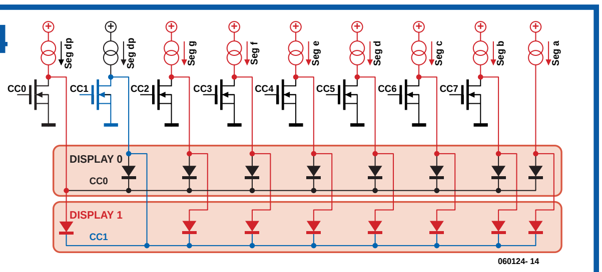


047

R8CKey

Jean Brunet

The small board shown in the photograph will conveniently replace the installation of several components when using the R8C 16-bit Tom Thumb module for programming.

In **Figure 1**, you'll find the transistors and their corresponding resistors, the Reset button and the Mode switch, all from our first article on the R8C/13.

The R8Ckey is powered by the setup using the K2 6-pin connector which is plugged into socket K3 that normally holds the R8C module. This is used to bypass various components, specifically those which made up the original power supply. The advantage here, of course, is to enable a much easier insertion of the R8C module.

Mounting the R8CKey board

There isn't a lot to say about making the R8Ckey board. The PCB artwork (**Figure 2**) shows that installing the components is extremely easy. Adding a switch, a button and a few passive and active (two transistors) components should not be too difficult.

Begin by soldering the gold-plated single-row 6-contact connector. Solder it with its plastic base in order to retain the proper spacing, then forcefully slide out the plastic part to remove it.

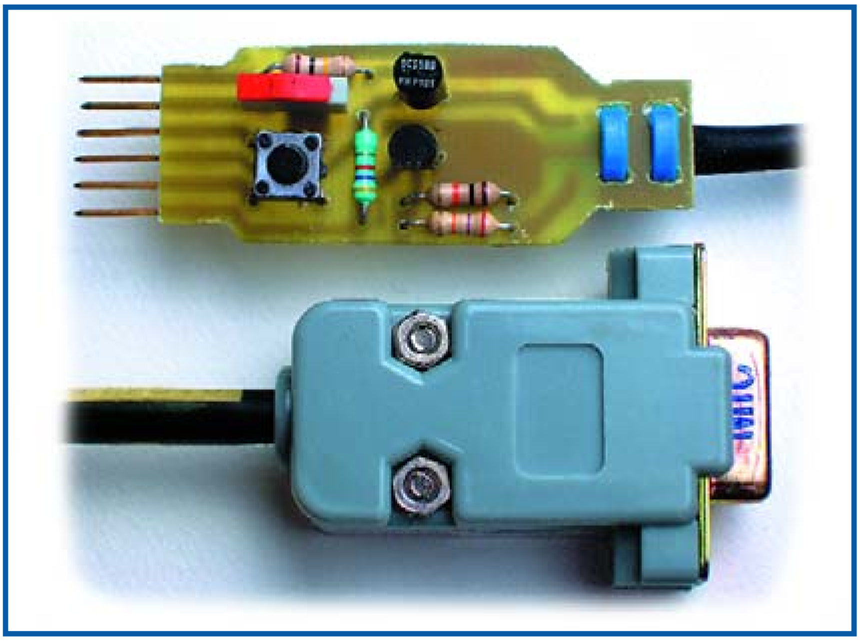
Solder the resistors, the transistors, the Reset button and the slide switch S2.

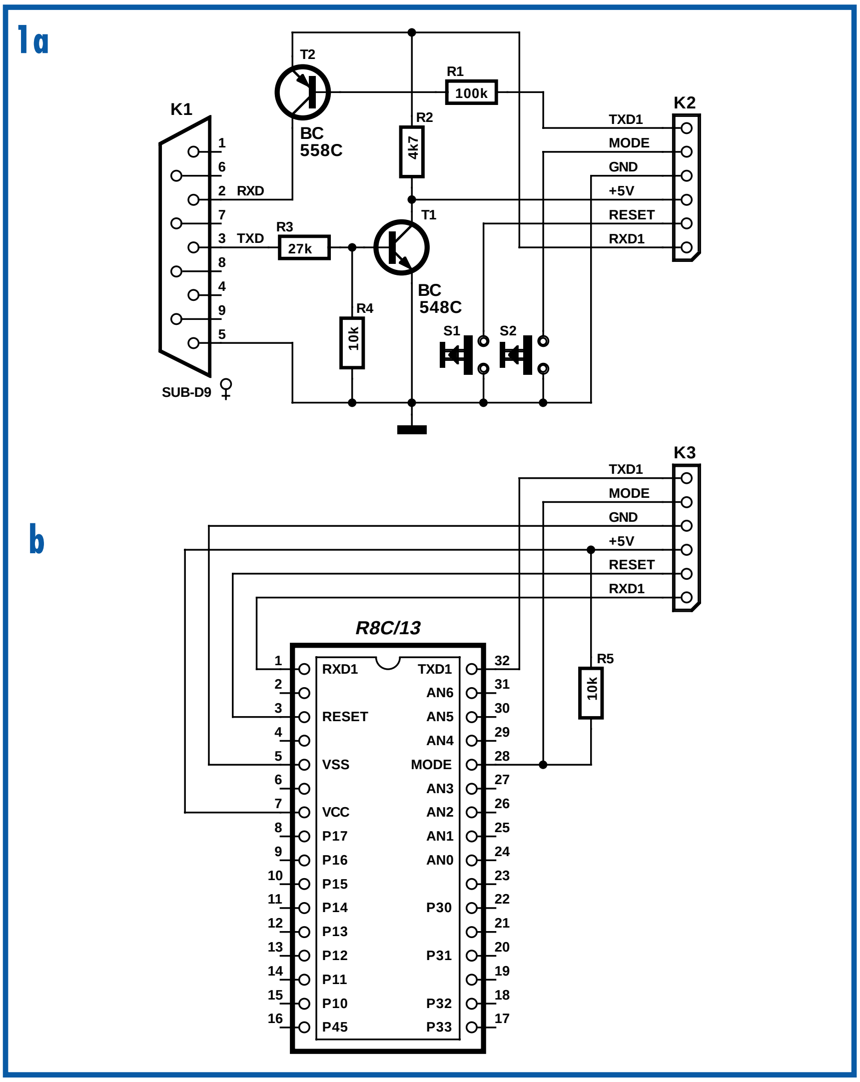
The cable is soldered on the R8Ckey with the braided ground wire directly on the ground layer of the board. Two nylon self-locking cable ties keep the cable in place. At the end of the cable, pin 2 of the RS-232 port corresponds to RxD on the board, while, on the copper side, pin 3 corresponds to TxD, and pin 5 carries ground.

Implementation of the R8CKey

Warning: Make sure the R8Ckey is properly oriented in socket K3. It must be positioned with the copper side toward the R8C. Inversion will destroy the transistors on the board.

The R8Ckey is very easy to use. You only have to insert it into its socket in front of the R8C, respecting the orientation, as we were saying above, the 'copper' side





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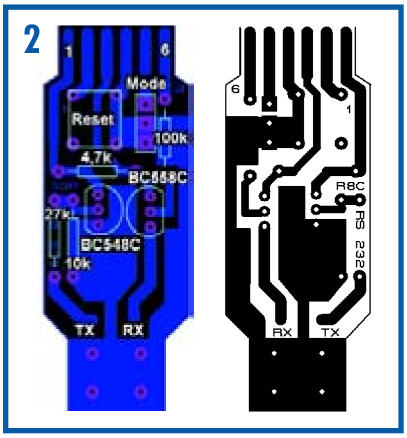

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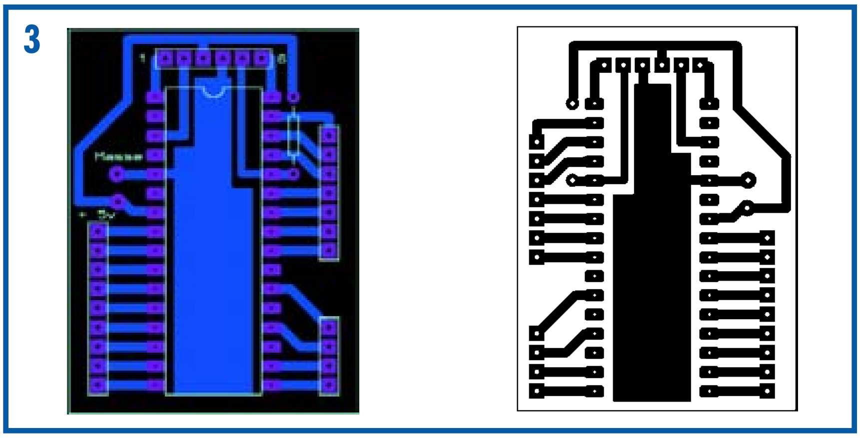


facing toward the R8C. Then, connect the 9-way sub-D plug to the RS232 port on the PC. Turn the setup on, slide the Mode switch toward the top, and push the Reset button. Now, all that's left to do is start programming the chip.

Installation at the top of the R8C/13

The diagram given in **Figure 1b** is practically 'transparent' because it is limited to a simple 6-pin connector. We propose the component mounting plan for this second board and its track design in **Figure 3**. Making the second printed circuit, the one for the R8C side is very simple, as can be seen in this example.

The only thing to solder on the board being tested is the 10 kΩ resistor connected between the Mode pin (pin 28) of the R8C board socket and the +5 V line.

The PCB artwork was produced in Proteus ARES format and can therefore be used 'as is' with this printed circuit design program. The relevant files can be downloaded from the author's website: http://perso.wanadoo.fr/asnora/R8C/r8ckey.htm

(060175-1)

COMPONENTS LIST

Resistors
R1 = 100kΩ
R2 = 4kΩ7
R3 = 27kΩ
R4 = 10kΩ

Semiconductors
T1 = BC548C
T2 = BC558C

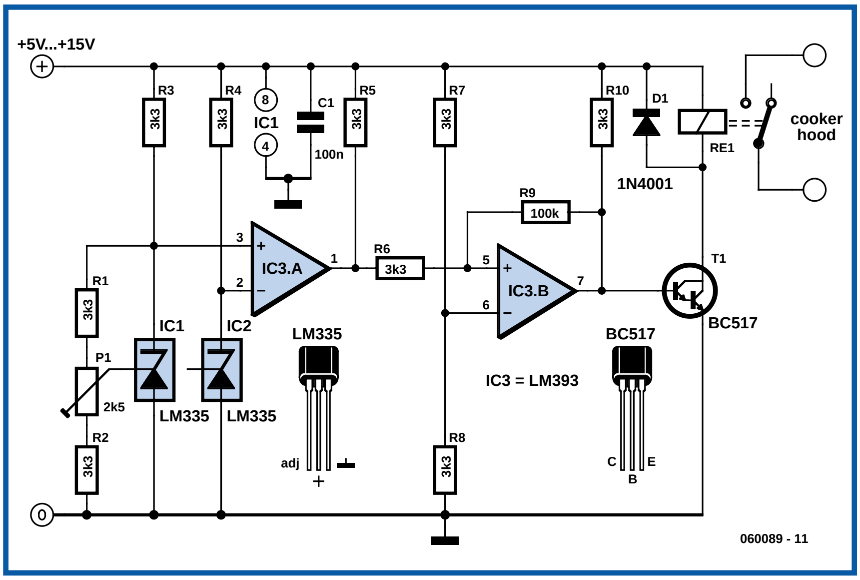
Miscellaneous
S1 = pushbutton (Reset)
S2 = slide switch, PCB mount (Mode)
K1 = 9-way sub-D socket (female) for cable mounting (RS232)
K2 = 6-way gold-plated SIL pinheader
1 m shielded cable with 2 conductors

Automatic Range Hood

048

Heino Peters

Come to think about it, it's a bit strange that range hoods in our kitchens don't switch on and off automatically. After all, a simple temperature sensor under the hood can detect whether a burner is on. The circuit described here goes a step further and compares the temperature under the hood with the temperature just outside the hood. At a certain (adjustable) temperature difference, the hood will be switched on, possibly along with the lamp under the hood. After the burners are shut off, the hood fan and lamp will switch off again by themselves. The advantage of using two sensors is that the hood will have the same switching characteristics in the summer as in the winter.



When building the circuit, it's important to ensure that IC1 is located beneath the hood in the middle and IC2 is located next to the hood or above it. If the temperature under the hood is higher than the temperature outside it, the open-collector output of IC3 will be pulled up to the supply voltage by R6. The combination of IC3 and R7–R10 forms a Schmitt trigger, which we need because the output of IC3a does not change immediately from 0 V to the supply voltage (or vice versa) in the transition region. The output of the IC3b will thus be at the supply voltage, which will switch on T1 via R10. That causes the relay to engage and switch on the fan and lamp of the range hood. P1 can be used to adjust the output voltage of IC1 over a range of approximately 0.1 V, which corresponds to around 10 °C. It's a good idea to use a supply voltage that matches the operating voltage of the relay. It's also convenient to fit the relay in a small box with an electrical outlet and plug so it can be easily and safely inserted between the plug and outlet of the range hood.

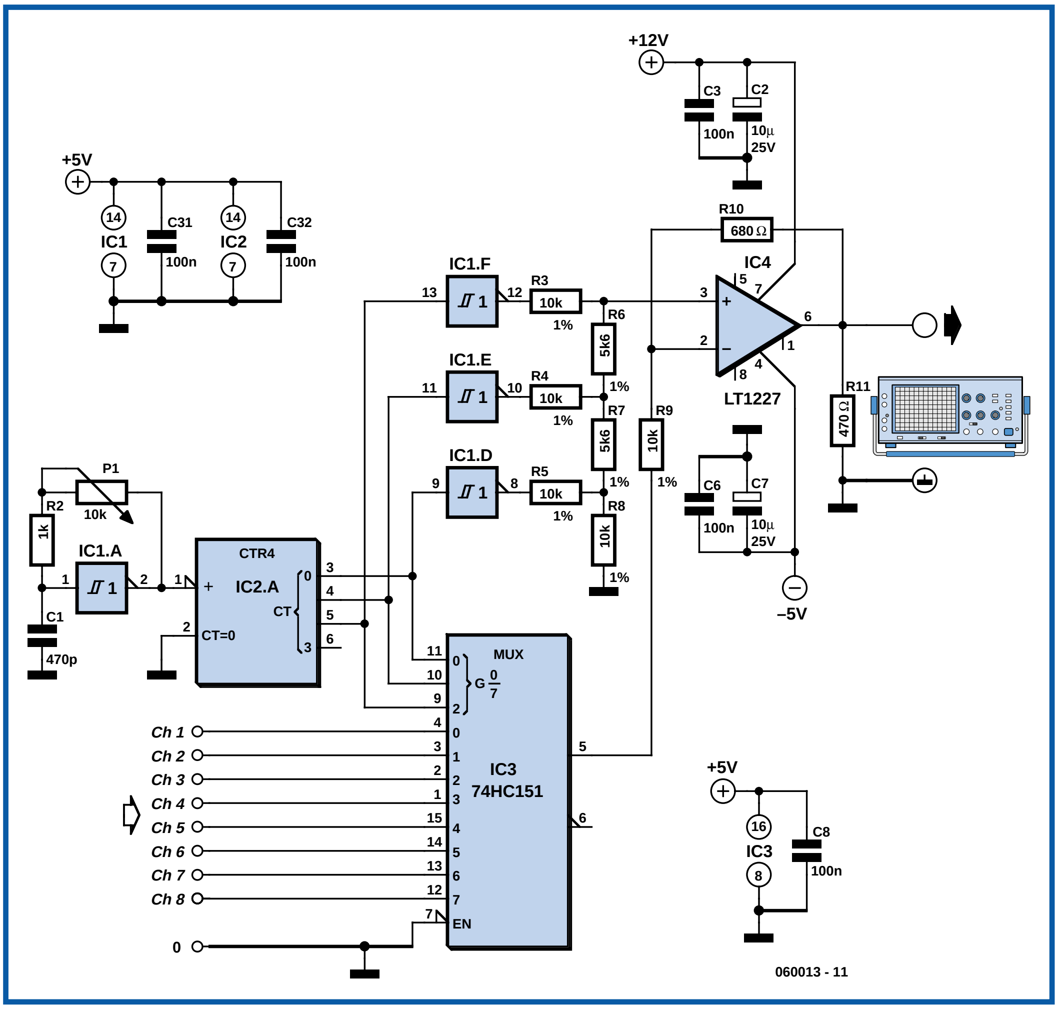
The circuit works best with a gas cooker, because the heat rises immediately after a burner is lit. With a ceramic or inductive cooking top, it takes a bit longer for the relay to be actuated.

(060089-1)

049

Eight-channel Scope Input

H. Steffes



Two channels are usually sufficient to perform the majority of circuit measurements carried out at the test bench but sometimes it would be useful to be able to see what is going on in more than two places simultaneously. The price of multichannel oscilloscopes however dictates that these are for professional users only. The circuit described here shows that with a little ingenuity it is perfectly possible to expand the numbers of input channels to eight. The circuit has been designed with simplicity in mind and can only be used for viewing digital waveforms.

There are two basic blocks to the circuit diagram; an N to 1 multiplexer and a staircase waveform generator with N output level steps. All the common logic families contain a multiplexer chip in their ranks and the type 74HCT151 (IC3) used in this design is a low-cost eight to one multiplexer which switches any one of the eight input signals through to the common output. If this output was displayed on an oscilloscope the screen would show all eight signals superimposed on each other so it is necessary to separate them vertically. This output signal is therefore mixed with the output of a staircase waveform generator which switches in time with the channel multiplex signal so that each channel is displayed as a different horizontal trace on the screen. Providing the staircase waveform remains in synchronism with the channel multiplexing, each of the eight inputs will be redrawn in the same position one above the other on the screen.

The display is useful for analysing the timing behaviour of simple digital circuits

and its eight bit wide input is ideal for monitoring the data bus and input/output ports of a low-speed microprocessor system. The circuit actually is useful as a rudimentary logic analyser for digital circuits using slow clock speeds.
The staircase waveform is generated by an *R*/2*R* type of resistor network (R3 to R8) driven by the three binary coded outputs of the counter which also switch the multiplexer (IC3). The multiplexer output signal and staircase waveform are now mixed at the inputs of the fast opamp IC4. The oscillator frequency can be adjusted by P1 from 100 kHz to approximately 1.8 MHz. This allows adjustment of the multiplex frequency to suit the type of signal under measurement.
With a switching frequency in the order of 2 MHz it is necessary to display the eight channel outputs on an oscilloscope which has a minimum input bandwidth of around 20 MHz.

(060013-1)

84x48-pixel Graphics LCD

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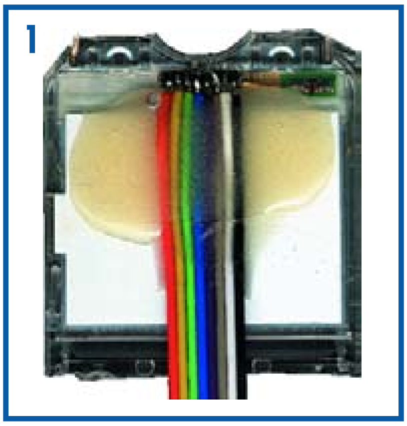

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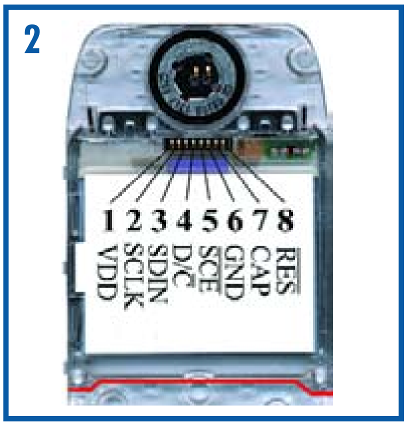

for just a few pounds!

Marcel Cremmel

Alphanumeric displays (having ? lines of *n* characters) are very popular. Reasonably priced, they are rather easy to implement. However, here we are proposing to replace them with a graphics LCD that scores better on a number of aspects:

- it's graphic! (84x48 pixels);
- can be used to display up to 6 lines of 14 characters (8x5 matrix);
- anyone can create his/her own character font;
- easy to drive (5-wire synchronous serial connection);
- superior contrast;
- only consumes 110 µA at 3.3 V
- can be backlit
- and what's more it only costs from 2 to 4 pounds, new!

But where can we find this LCD with such an unbeatable price/quality ratio? Actually, we are referring to a part in a widely-distributed product: the LCD in a Nokia 3310 mobile telephone (the 3410 can also be used, the resolution is then 96x64 pixels). You can find numerous sites on the web which sell this product (new or used) as a one-off or in bulk.
After such praise, what is there to criticise? Any difficulty in implementation is due to the connections. The connector is composed of gold-plated 'spring' blades (on the LCD) which rest on solder pads (in the telephone) to establish contact. Two DIY solutions are possible:
1. we solder an 8-wire ribbon cable to the pads (**Figure 1**). Don't forget, the pitch is 1.14 mm !
2. we reproduce the original connection system. Tests have shown excellent reliability with tin-plated solder pads. Inter-

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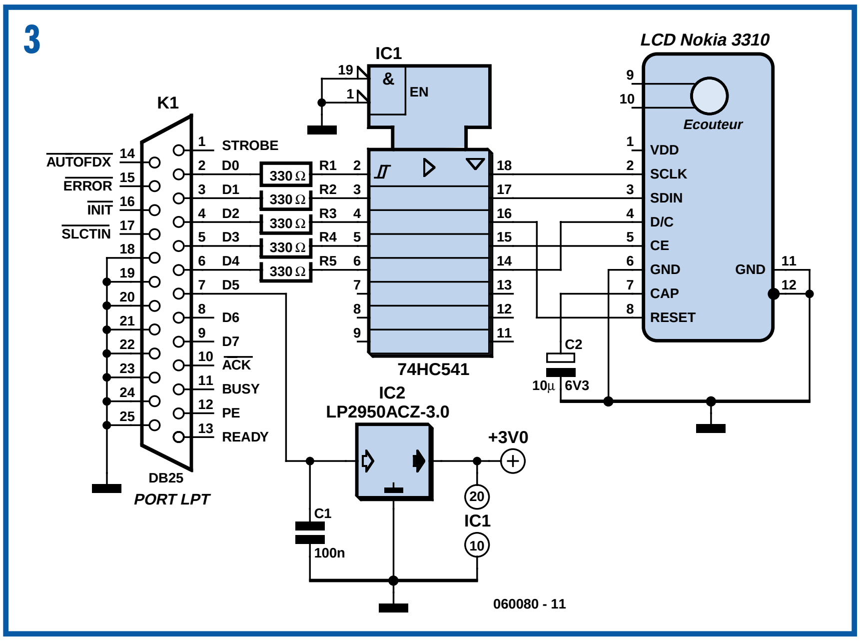


ested readers will find artwork for PROTEL software on the Elektor website.

Connector

Do not attempt to extract the display from its plastic casing as the display also includes part of the telephone keyboard. You can get rid of it with a plastic cutout (the red line on the photo in **Figure 2**). Do not cut out the top part if you are planning to use the original connection system — the securing screws can be used to maintain contact pressure.

Power supply

All you need to do is apply a supply voltage of between 2.7 and 3.3 V to the display. The display has its own the DC-DC converter which produces the required current for the LCD, decoupled by C2 (see diagram in **Figure 3**).

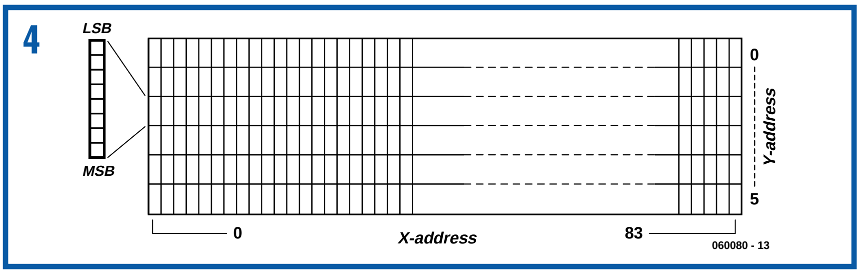
Programming

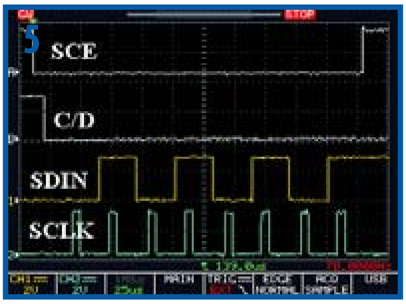
The LCD uses a controller type PCD8544 from Philips [1]. Full documentation is available on the web. The circuit has a screen memory organised into six lines of 84 bytes, or 504 bytes. The eight bits of a byte represent the states of eight vertical pixels corresponding to the screen (state 1 = black pixel, see **Figure 4**). In order to display text, for example, the program should 'draw' each letter in the screen memory.

Assigning registers for the PCD8544 configuration and for the 'screen' RAM is carried out by a synchronous serial connection:

- SCE : selection of the circuit (5)
- SDIN : serial input output (3)
- SCLK : synchronous clock (2)
- D/C : given selection/command (4)
- RES : Reset (8)

Figure 5 shows the typical timing diagram for writing a command.





You will find a test program in C on the Elektor website (ref. **060080-11.zip**) that has the most common functions: initialisation, write text (two font sizes) and simple drawing (pixel and straight track). It is written for the MSP430 family in the free IAR environment [2] but is easily adaptable to other microcontrollers because it does not rely on hardware from a specific resource (SPI coupler, among other things).

Furthermore, a program called Test_LCD_Nokia_3310 is available (see **Figure 6**). It runs on the PC and is used to test the display connected to the parallel port as shown in the diagram in Figure 3.

The installation of this program is simple: copy the executable to any folder and the TVicLPT.sys file to C:\Windows\System32\Drivers.

Available functions:

- free drawing with the mouse;
- text drawing;
- variable speed scrolling in 4 directions;
- saving the drawing.

The low current consumption of the LCD means it can be powered from the printer output port. However, a 3 V regulator and buffer gates have been added to avoid any risk of damaging or overloading the LCD electronics. For example, the LCD does not seem to like voltages applied to logic inputs in the absence of the supply voltage.

(060080-1)

Internet Links

[1] www.semiconductors.philips.com/products/

[2] MSP430, 4K KickStart Edition v3.40A on www.iar.com

The archive file 'LCD_Nokia' containing all of the files mentioned in this article can be downloaded free of charge from www.elektor-electronics.co.uk

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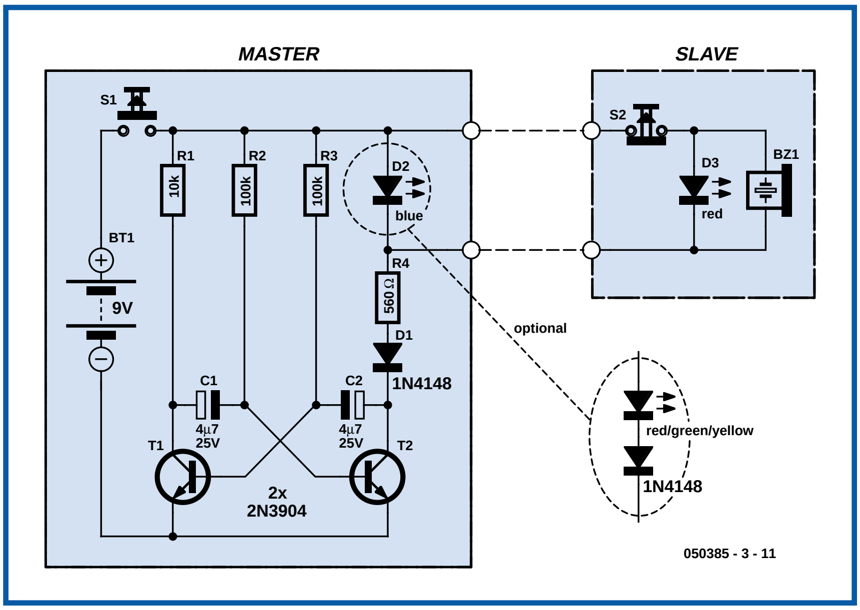
Call Acknowledged!

Bart Trepak

This circuit could be used (depending on your circumstances) by a gentleman to summon his butler, a manager his secretary or as in the author's case to call the kids down to dinner without having to shout above the level of the CD player/TV/games console in their bedroom. Rather than resorting to a full-blown intercom system, a simpler solution was envisaged and while a buzzer could easily fulfil this function, this circuit has the advantage of providing a visual indication of a call as well as confirming to the caller that the 'message' has been received. This is especially useful in the latter case, as the call may be easily drowned out by the music playing in the headphones.

The circuit, which requires no complicated switching, uses a simple two-wire

connection between the two stations and utilises the fact that the forward voltage drop of a blue (or white) LED is greater than that of a red, green or yellow one. The circuit is based on a two-transistor multivibrator which is used to pulse a red LED (D3) as well as the buzzer Bz1 on and off at about 1.5 Hz when push button S1 is closed. This frequency may of course be altered if required by changing the values of the capacitors. The diode D1 in series with the collector of transistor T2 is required to isolate the output from the effects of the buzzer circuitry, which would alter the multivibrator frequency.
In principle, the multivibrator could be dispensed with but a pulsed buzzer/flashing led is much more noticeable than a continuous signal especially in noisy conditions. Since the voltage across a red LED is typically about 1.5 V while a blue LED requires at least 2.5 V to 3 V to light, the blue LED will remain off when the call button S1 is pressed. Despite being rated for operation at 3-12 V, most piezo sounders can still produce a piercing sound from the pulsed 1.5-V available across the red LED which should get the attention of even the most



preoccupied teenager.
When the recipient presses the acknowledge (push to break) switch S2, the red LED/buzzer are disconnected allowing the blue LED to flash at the sending station indicating to the caller that his call has been received. Alternatively, if a blue LED is not available, a red or green type in series with a forward biased silicon diode to raise its forward voltage above that of the red LED in the receiver could be used instead.
The circuit may be powered by a 9-V battery, a mains power supply being unnecessary in view of the low power consumption and infrequency of use of the circuit.

(050385-3)

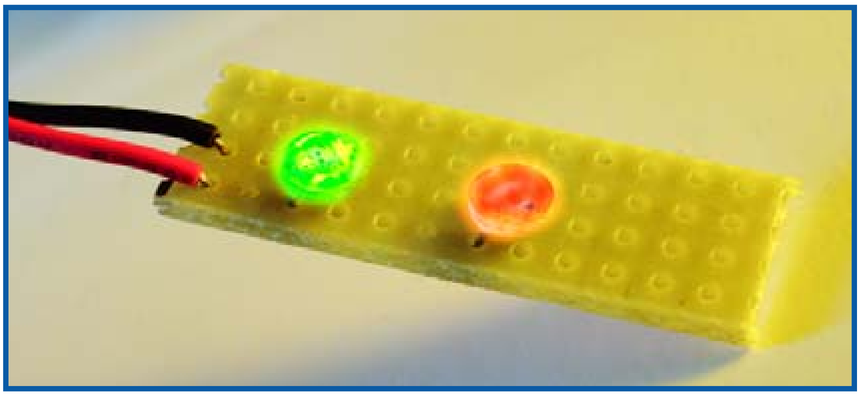
Multi-Colour Flashing LED

052

Light effects have always been popular. Now that LEDs are available in all sorts of shapes, sizes and colours for reasonable prices, a whole gamut of possibilities has become feasible. Examples are case modding (embellishing PC cases with all kinds of lights, windows, etc.), adorning scooters, motorcycles and cars with various light ornaments, mood lighting in different colours and we could go on.

In *Elektor Electronics* we also regularly feature circuits with LEDs. One circuit flashes LEDs, another drives multi-coloured LEDs. On one occasion standard logic (counters, shift registers, etc.) is used to drive the LEDs, on another occasion a microcontroller is used. But there are also solutions that do not require additional driving electronics.

Ordinary flashing LEDs that require no more than a series resistor have been



around for donkey's ages. They are quite nice, but spectacular they are certainly not. The company I.C. Engineering offers something much nicer: a three colour LED in a package with a diameter of 5 mm, which also contains all the control electronics. This 'LED' only requires a power supply voltage of 3 V to give a continuous 'light show'. The colours blend slowly from one to another. This effect is even nicer if the components are used next to each other. Because of small variations between LEDs, one LED will change colour a little faster than another, which results in a colourful play of lights. This 'LED' is eminently suitable to make a nice light ornament without too much effort.

(064014-1)

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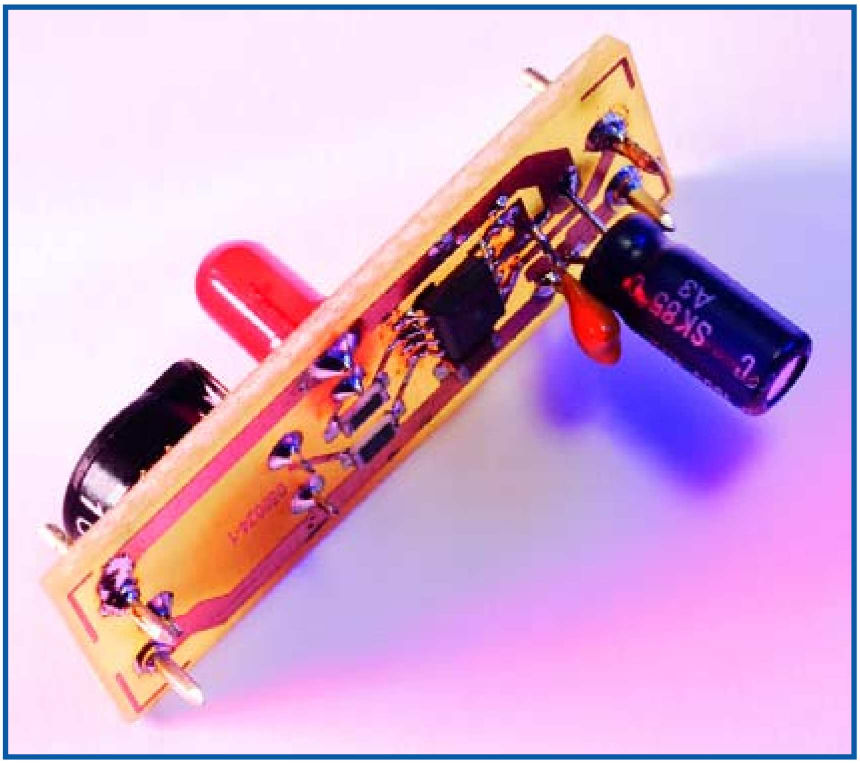
USB Fuse

Andreas Köhler



Life in the 21st century would be almost unbearable without some of the computer peripherals that PC users now look on as essentials — take for example the USB powered teacup warmer; this device is obviously an invaluable productivity tool for all users but it could prove a little tiresome if the extra current it draws from the USB port is sufficient to produce a localised meltdown on the motherboard. In a slightly more serious vein a similar situation could result from a carelessly wired connector in the design lab during prototyping and development of a USB ported peripheral. What's needed here is some form of current limiting or fuse to prevent damage to the motherboard.

The MAX1562 shown in **Figure 1** is a purpose-built USB current limiter from the chip manufacturers Maxim. The device operates with a supply voltage from 4.0 to 5.5 V with an operating current of typically 40 µA or 3 µA in standby mode. The circuit introduces a very low resistance in the power line (typically 26 mΩ but guaranteed less than 50 mΩ) from an internal MOSFET. The FET gate bias voltage is generated on-chip from a charge pump circuit.

The chip can distinguish between an overload and a short circuit condition in the supply line by measuring the voltage drop across its internal resistance; if the voltage is less than 1 V a short circuit is assumed and the chip pulses a (limited) output current every 20 ms in an effort to raise the output voltage. This approach will eventually be successful if the short

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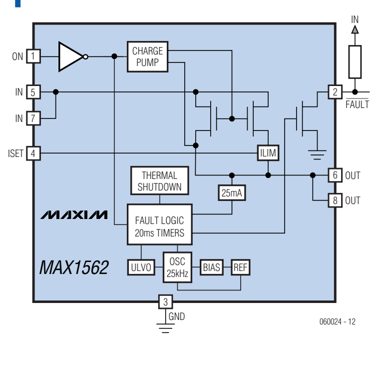

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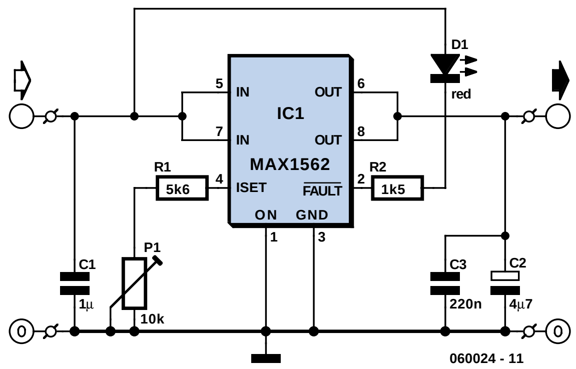

COMPONENTS LIST

Resistors
R1 = 5kΩ6 (SMD 1206)
R2 = 1kΩ5 (SMD 1206)
P1 = 10kΩ preset

Capacitors
C1 = 1µF (SMD 1206)
C2 = 4µF7 10 V, tantalum
C3 = 220nF (SMD 1206)

Semiconductors
D1 = LED, low current
IC1 = MAX1562ESA
PCB, ref. 060024-1

3

circuit was caused by a large value capacitor across the USB supply pins or an external hard drive which have a high in-rush at start up. If the supply rail is not pulled up within the first 20 ms the FAULT output (pin 2) is driven low.
The output current limit is set by a single resistor on pin 4 (ISET):

$I_{LIM} = 17120 \ / \ R_{SET}$.

The circuit diagram shows a fixed 5.6 kΩ resistor in series with a 10 kΩ preset giving an adjustable current limit between 1.097 and 3.057 A. This range should be sufficient for the majority of applications. Increasing the preset resistance reduces the current limit level. Any intermittent connection in the preset (caused by a dirty track etc.) will switch the chip into shut down. The MAX1562 also contains a thermal cut out which turns off the output when the chip temperature exceeds 160 degrees C.

Figure 2 shows a diagram of the manufacturer's application circuit. The FAULT output drives an LED via a series limiting resistor which reduces the LED current to 2 to 3 mA. The MAX1562 is available in a HESA variant (with an active high ON signal) or ESA version (with an active low ON signal). The chip is packaged in an 8-pin SMD outline. **Figure 3** shows a small PCB layout for the circuit using mostly SMD components.

(060024-1)

Electronic Torricelli Barometer *

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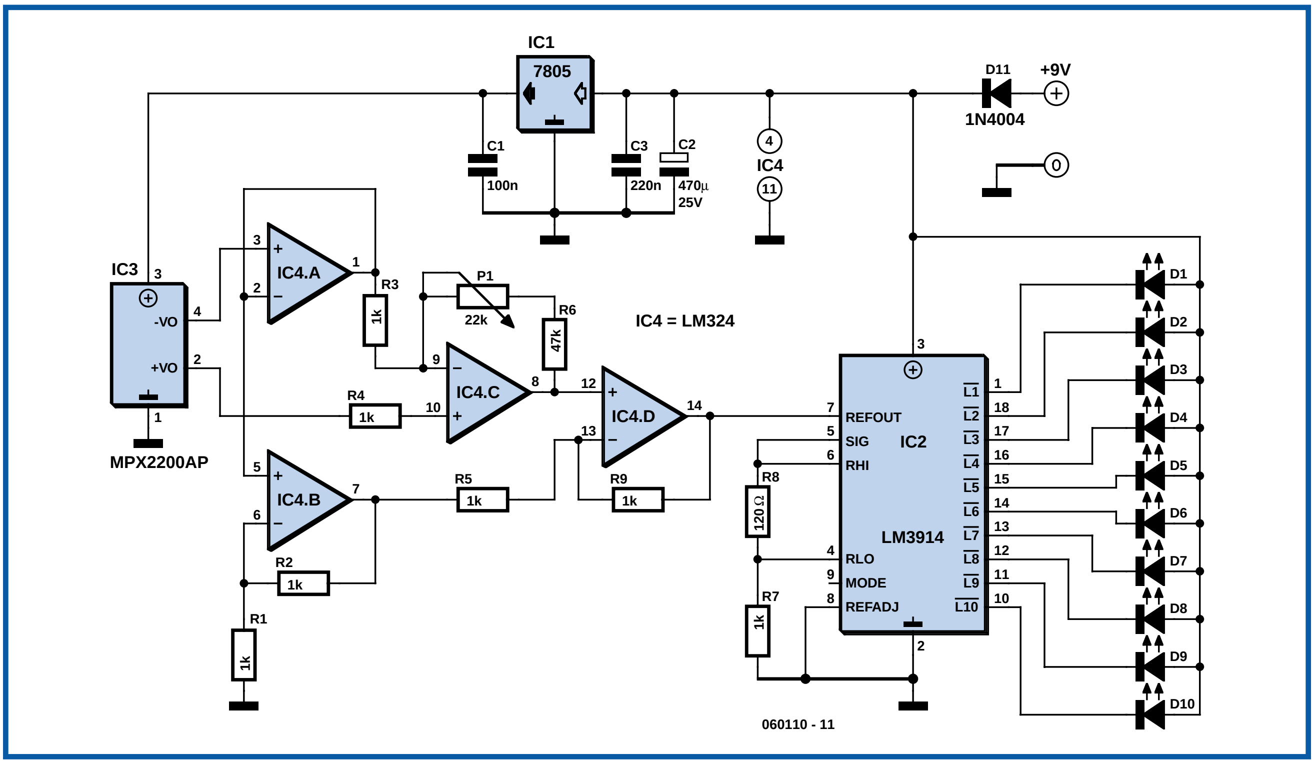


Christian Tavernier

Although it does not have the same charm as real mercury barometers with long glass tubes on pieces of carved and polished wood, the Torricelli barometer discussed here is a functional equivalent and electronic replica of the Torricelli barometer. Actually, rather than displaying the atmospheric pressure on the traditional digital displays, we preferred to reproduce the general look of this respected predecessor of electronic barometers. The mercury tube is, of course, replaced by a simple LED scale which, if not as beautiful, is still less toxic for the environment in case of breakage.
As indicated on the drawing, the pressure sensor utilized is a Motorola MPX2200AP. This circuit is adapted for measuring absolute pressure and has a range well suited for atmospheric pressure. Without entering too deep into the technical details, such sensors deliver an output of voltage proportional not only to the measured pressure but, unfortunately, to their supply voltage as well. Hence they must be powered from a stable voltage which is ensured here by the use of IC1.
Since the output of the MPX2200 is differential and at a very low level, we had to resort to the use of four operational amplifiers IC4.A to IC4.D, contained in one LM324, to obtain levels that can be processed easily. As long as potentiometer P1 is adjusted correctly, this group of operational amplifiers delivers a voltage of 1 volt per atmospheric pressure of 1,000 hPa to the LM3914. Since the atmospheric pressure will be within the range 950 to 1040 hPa at sea level, we need to make an expanded-scale voltmeter with this LM3914 in order to better exploit the 10 LEDs that it can control. That is the role of resistors R7 and R8 which

artificially raise the minimum voltage value the chip is capable of measuring.
Consequently, we can 'calibrate' our LED scale with one LED per 10 hPa and thus benefit from a measurement range which extends from 950 hPa to 1040 hPa. In principle, you should not have a need to go beyond that in either direction.
The circuit may be conveniently powered from a 9-volt battery but only if used very occasionally. Since this is usually not the case for a barometer, we advise you to use a mains adaptor instead supplying approximately 9 volts.
Calibration basically entails adjusting the potentiometer P1 to light the LED corresponding to the atmospheric pressure of your location at the time. Compare with an existing barometer or, even better, telephone the closest weather station. They will be happy to give you the information.

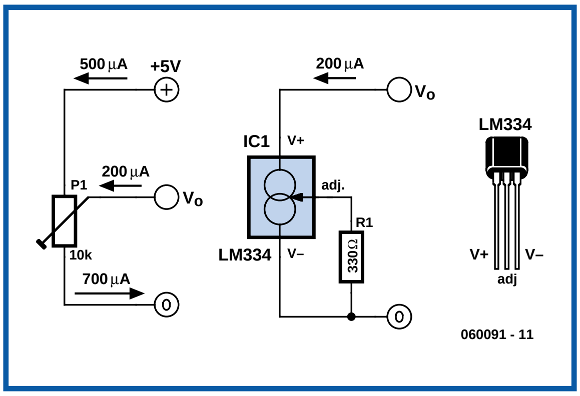
(060110-1)

*** After Evangelista Torricelli, 1608-1647, Italian physician who proved the existence of atmospheric pressure and invented the mercury barometer.**

055 Contrast Control for LCDs

Heino Peters

The adjustment control for the contrast of an LC-Display is typically a 10-k potentiometer. This works fine, provided that the power supply voltage is constant. If this is not the case (for example, with a battery power supply) then the potentiometer has to be repeatedly adjusted. Very awkward, in other words. The circuit described here offers a solution for this problem.
The aforementioned potentiometer is intended to maintain a constant current from the contrast connection (usually pin 3 or V_o) to ground. A popular green display with 2x16 characters 'supplies' about 200 µA. At a power supply voltage of 5 V there is also an additional current of 500 µA in the potentiometer itself. Not very energy efficient either.
Now there is an IC, the LM334, which, with the aid of one resistor, can be made into a constant current source. The circuit



presented here ensures that there is a current of 200 µA to ground, independent of the power supply voltage. By substituting a 2.2-kΩ potentiometer for R1, the current can be adjusted as desired. The value of R1 can be calculated as follows:

$R1 = 227\times10^{-6} \times T / I.$

Where T is the temperature in Kelvin and I is the current in ampères. In our case this results in:

$R1 = 227\times10^{-6} \times 293 / (200\times10^{-6})$
$R1 = 333\ \Omega$

Note that the current supplied by the LM334 depends on the temperature. This is also true for the current from the display, but it is not strictly necessary to have a linear relationship between these two. Temperature variations of up to 10° will not be a problem however.
This circuit results in a power saving of over 25% with an LCD that itself draws a current of 1.2 mA. In a battery powered application this is definitely worth the effort! In addition, the contrast does not need to be adjusted as the battery voltage reduces.
When used with LCDs with new technologies such as OLED and PLED it is advisable to carefully test the circuit first to determine if it can be used to adjust the brightness.

(060091-1)

056 Protection for Telephone Line

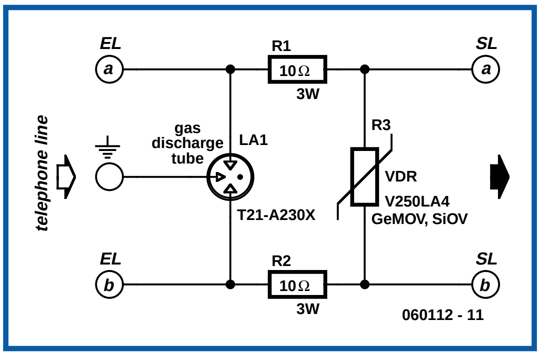
Christian Tavernier

A long time ago when telephones were so simple almost nothing could go amiss from an electrical point of view, Telecom operators installed surge protection on all telephone lines exposed to storm risks.
Paradoxically, now that we are hooking up delicate and expensive equipment such as telephones filled with electronics, fax machines, (A)DSL modems, etc., this protection has disappeared.
However, if you have the good fortune to live in the countryside in a building served by overhead telephone lines, there's an obvious risk of very high voltages being induced on the lines during thunderstorms. While we have lost count today of all of the modems, fax machines and other telephones that have been destroyed by a 'bolt of lightning', surpris-

ingly you only have to invest a few pounds to get a remarkably efficient protection device like the one we are proposing here.

During a storm, often with lightning striking near a telephone line, the line carries transient voltages up to several thousands of volts. Contrary to the HV section of television sets or electrical fences, on which practically no current is running, in the case of lighting striking current surges of thousand of amps are not uncommon.

To protect oneself from such destructive pulses, traditional components are not powerful or fast enough. As you can see on our drawing, a (gas-filled) spark gap should be used. Such a component contains three electrodes, insulated from each other, in an airtight cylinder filled with rare gas. As long as the voltage present between the electrodes is below a certain threshold, the spark gap remains perfectly passive and presents an impedance of several hundreds of MW. On the other hand, when the voltage rises above this threshold, the gas is very rapidly ionized and the spark-gap



suddenly becomes a full conductor to the point of being able to absorb colossal currents without being destroyed. The one we are using here, whose size is of the same magnitude as an ordinary one watt resistor, can absorb a standardized 5,000 amps pulse lasting 8/20 ms!

Since we are utilizing a three-electrode spark gap, the voltage between the two wires of the line or between any wire and ground, cannot exceed the sparking voltage, which is about 250 volts here. Such protection could theoretically suffice but we preferred to add a second security device made with a VDR (GeMOV or SiOV depending on the manufacturer), which also limits the voltage between line wires to a maximum of 250 volts. Even if this value seems high to you, we should remember that all of the authorized telephone equipment, carrying the CE mark must be able to withstand it without damage. This is not always the case however with some low-end devices made in China, but that's an entirely different problem.

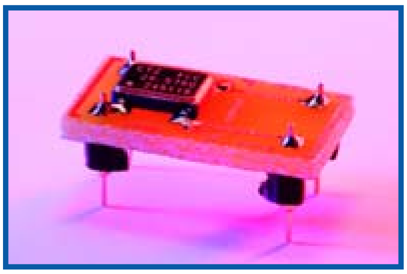
Since pulses generated by lightning are very brief, the ground connection of our assembly must be as low-inductance as possible. It must therefore be short, and composed of heavy-duty wire (1.5 mm^2 c.s.a. is the minimum). If not, the coil, composed of the ground connection, blocks the high frequency signal that constitutes the pulse and reduces the assembly's effectiveness to nothing.

Finally, please note that this device obviously has no effect on the low frequency signals of telephones and fax machines and it does not disturb (A)DSL signals either.

(060112-1)

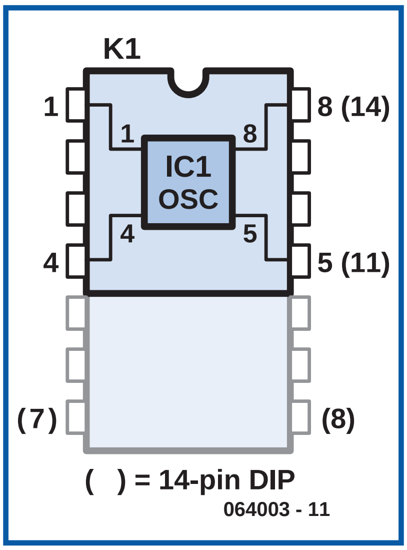
SMD Crystal-Adapter

057



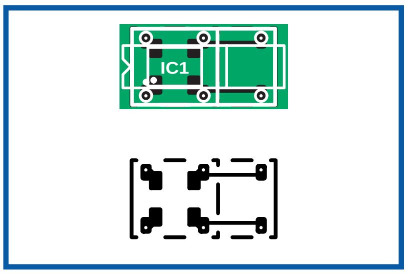
Ton Giesberts

The idea for this adapter was really born out of necessity. The 24.576-MHz crystal oscillator that is used in the Audio ADC 2000, (24 bit/96 kHz, March 2001) is not (easily) available any more. A colleague who was interested in the circuit and was keen to try out the prototype realised that a 25 MHz oscillator was used at the time. In order to create useful recording material it is of course necessary to use the correct sampling frequency, 48 kHz, that is. This requires 512 times



48000 Hz, or 24.576 MHz. Fortunately this frequency is available as part of a series of oscillators from Citizen, the CSX-750FC series, to be more specific.

These oscillators are housed in a very



small SMD package. We originally used the SG531P-series from Seiko Epson in the design for the A/D-converter. This comes in a kind of 8-pin DIL package. So, to nevertheless enable us to use the Citizen version, we designed a very small circuit board that adapts the SMD device with 4 pins to the footprint for the 8-pin DIP version. The connection pin order is the same. In addition, we have made the PCB also suitable for the 14-pin version (SG531P series). This requires two additional pins. These are located at pins 7 and 8 of the 14-pin package and are connected to pins 4 and 5 respectively of the 8-pin package. Pin 1 is in both cases the enable pin and pin 8 (8-pin) and 14 (14-pin) are +5 V. Pay close attention when ordering the oscillator. It so happens that there are also 3.3-V versions (CSX-750FB and FJ). You need a 5-V version for the Audio-DAC. There is also a third letter after the type number, which indicates the accuracy: C or F for 100 ppm and B for 50 ppm.

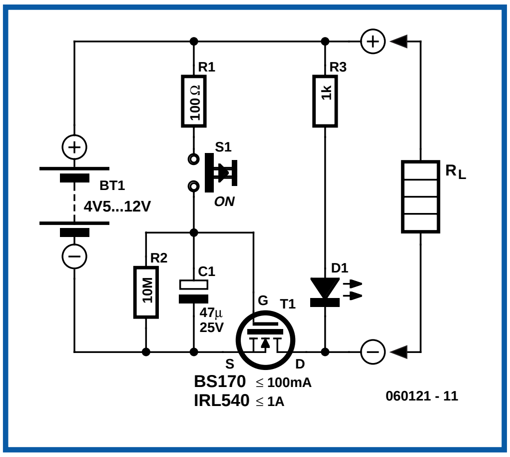
If the PCB is to be used in place of an 8-pin oscillator then you can trim the board along the line that is clearly visible on the solder side of the board. The solder side (copper side) is the top side. Just to be clear: the dot on the package of the CSX750FCC is pin 1 of the oscillator. We used thin pin headers for the connections so that the small adaptor can be fitted into an IC-socket or soldered directly onto a PCB.

The IC is available from Digi-Key.

(064003-1)

058 Battery Saver

This circuit performs a similar function to the 'sleep' button on a radio alarm clock; pressing the button connects the battery supply to some external equipment or circuit (represented by RL) for a preset time period. The period can be extended by pressing the button again before 'time out'. The circuit will avoid the situation where you forget to turn off some battery powered equipment and return to find the battery is flat. Unlike a digital alarm clock sleep function the circuit here is based on a simple analogue timer which uses very few components. Pressing button S1 rapidly charges C1 via R1. When the voltage on C1 exceeds the threshold voltage at the gate of FET T1 it conducts and switches the battery to RL. The drain-source voltage drop introduced by the FET is negligible for the two types of FET specified (for a maximum load current of either 100 mA or 1 A).



T1 remains conducting as long as the voltage on C1 is greater than the FET gate threshold voltage (around 2 V for the FET types specified). The length of the 'on' period depends on three factors; firstly the value of R2 which governs the capacitor discharge current, secondly the capacitance of C1 and finally the supply voltage from the battery BT1. When C1 is charged to a higher voltage it takes longer to fall below the threshold level. The component values given will produce an 'on' time of around 10 minutes with a supply of 5 V. The FET turns off relatively slowly at the end of the 'on' period; this should not cause a problem if the switched equipment uses only analogue circuitry but can lead to a momentary malfunction if the equipment contains digital circuitry.

(060121-1)

059 Electronic Touch Switch

Heino Peters

Mechanical contacts have the disadvantage that they wear out. That is why it is practical to use an electronic 'touch switch' in some situations. With such a touch switch the resistance of the human skin is used for the switching action.

The schematic shows the design of a circuit that senses the resistance of the skin and converts it into a useful switching signal. The touch switch contacts can be made from two small metal plates, rivets, nails, etcetera, which are placed close together on a non-conducting surface. In this circuit a comparator of the type LM393 has been used.

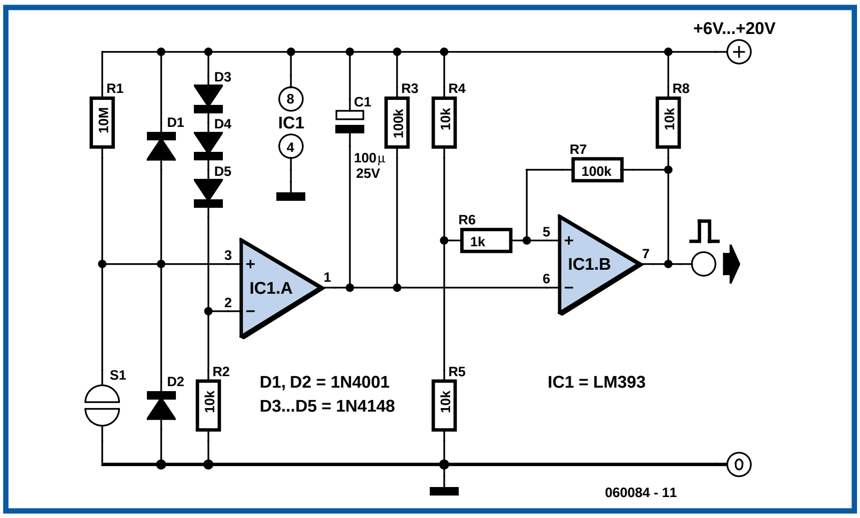
In the idle state there is, via R1, a voltage equal to the power supply voltage on the non-inverting input of IC1a. Because the inverting input of IC1a is set with R2 and D3 to D5 at the supply voltage minus 1.8 V, the open-collector output of IC1.a is, via R3, equal to the power supply voltage. This voltage is inverted by IC1.b.

The voltage at the non-inverting input of IC1.b amounts to half the power supply voltage (through voltage divider R4 and R5) and is lower than the voltage on the inverting input. The output of IC1.b is therefore a '0'.

If the two touch contacts are bridged with a finger, the voltage at the non-inverting input will become low enough to cause the comparator to toggle state. The moistness of the skin results in a resistance of 1 to 10 MΩ.

If this circuit is used in the vicinity of equipment that's connected to the mains, then it can be sufficient to touch only the upper contact to operate the switch, provided that the circuit has been earthed. The body then acts as an antenna which receives the 50 Hz (or 60 Hz) from the mains. This is enough to toggle IC1.a at the same 50 Hz. C1/R3 prevent this 50 Hz from reaching the input of IC1b and provide a useable 'pulse' of about 10 s at the output of IC1.b.

Note that a fly walking across the touch switch conducts enough to generate a switching signal. So do not operate important things with this circuit (such as the heating system or the garage door). Do not make the wires between the touch contacts and the circuit too long to prevent picking up interference.



The power supply voltage for the circuit is not very critical. Any regulated DC voltage in the range from 6 to 20 V can be used.

(060084-1)

Audible Flasher Warning

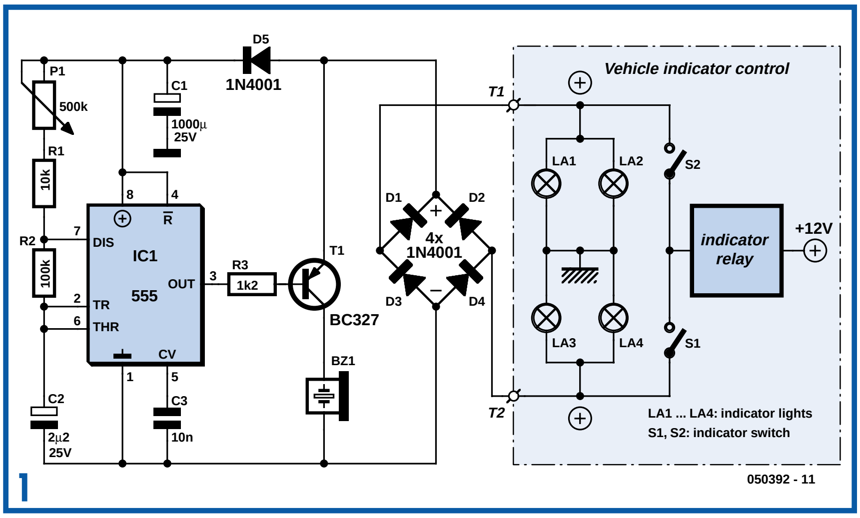
060

Udo Burret

If you're a biker or scooter rider you'll know how easy it is to forget to cancel your flashing indicators after turning without an audible reminder. Constantly glancing at indicator lamps is hardly an option; your eyes should be on the road ahead! The simple circuit shown here provides an audible reminder. The clever bit is the way it doesn't annoy you by beeping the instant you activate the flashers but only after a preset time, in other words when your indicators are active longer than normal.

Supply to the circuit is through the flasher relay. With the indicators activated a squarewave voltage reaches bridge rectifier D1-D4 via terminal T1 or T2, with the other terminal remaining grounded through the indicator lamp that's inactive. The pulsed DC voltage is stored and smoothed in C1, with D5 preventing the electrolytic from discharging during the periods when the flasher voltage is off. This also provides an adequately clean supply voltage for the 555 timer whenever the indicators are operating.

Timer IC1 is used here as an oscillator and controls a piezo sounder by means of transistor T1. The output of the 555 is active Low, meaning that initially the transistor is blocked and the sounder is silent.



1

The timer always charges and discharges capacitor C2 to a level between a third and two-thirds of the operating voltage, producing an interval of

0.7 x C2 x (R2 + R1 + P1) [s]

The preset enables you to set this delay up to a second or so. The initial delay, before the sounder first operates, is significantly longer, however, because the electrolytic has zero charge. Only after this delay is the output active, for the pulse duration of 0.7 x C2 x R2 (equivalent to about 0.15 seconds), enabling the sounder to operate. This applies only when +12 V is present at the collector of transistor T1, which is the situation when the flasher relay is just switched on and the indicator bulbs light up.

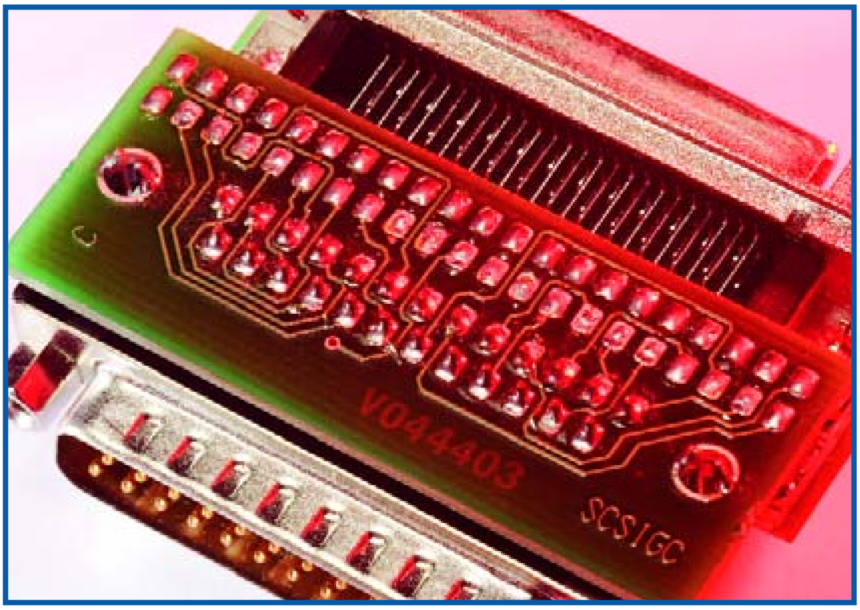
The circuit is built inside a splash-proof enclosure, installed on your machine in a position that's out of harm's way. The audible sounder can be positioned anywhere outside the enclosure if it's a waterproof type. The audible control unit requires only two cable connections, which can be made at any convenient access point.

(050392-1)

061

SCSI Adapter

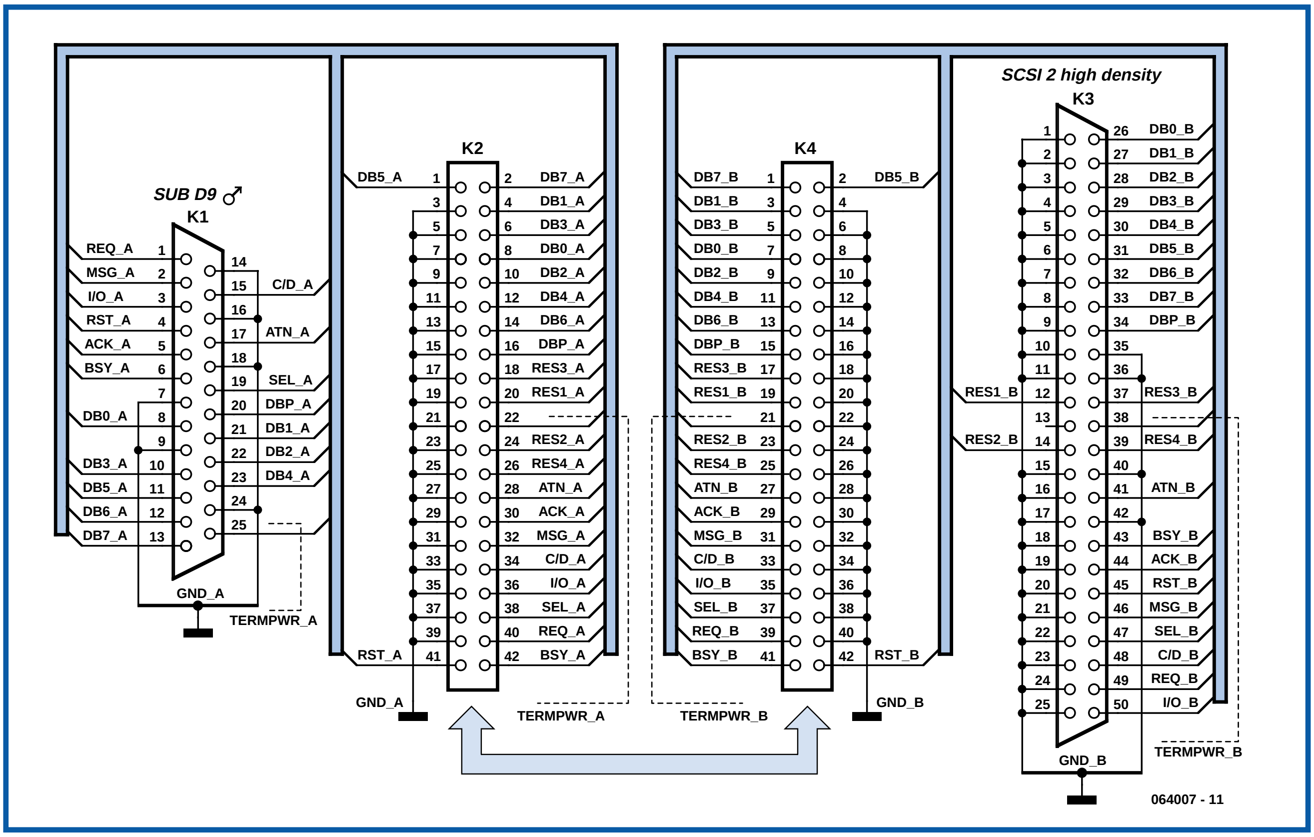
Ton Giesberts

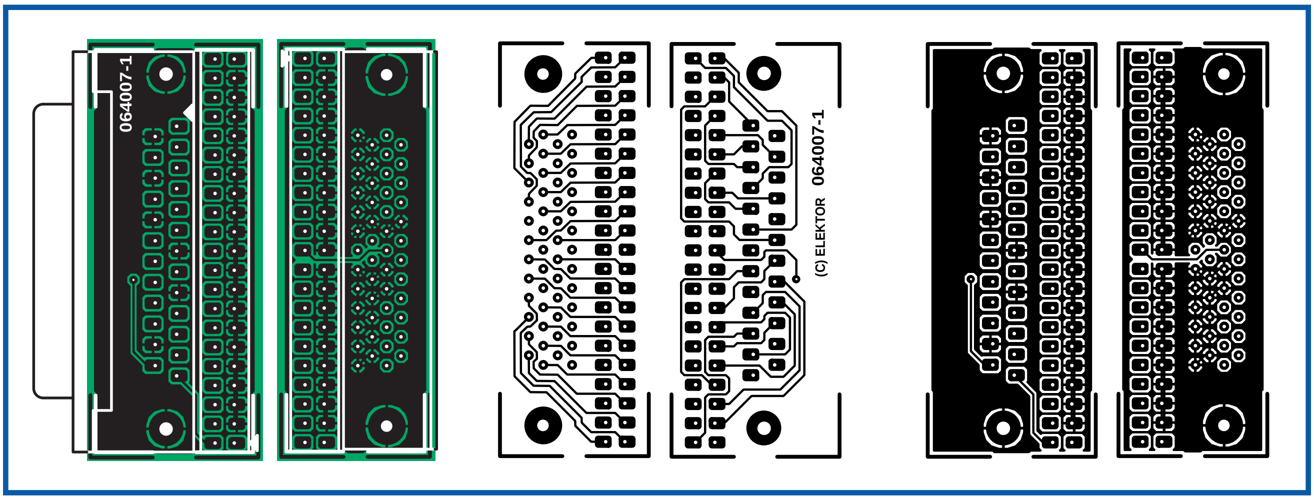


This circuit (admittedly a big word for three connectors), was born out of necessity. Many years ago, when reliable scanners were still being made, there were faster and more expensive models with a SCSI interface. In many cases, as part of the package, a proprietary SCSI controller for the PC was delivered with it. This was typically an ISA bus controller. When upgrading to another SCSI controller (PCI-bus), and also motivated by being able to connect better hard disks and other peripherals, a new cable was required to connect the high-density connector of the new controller to the older 25-way sub-D or 50-way Centronics connector.

In these days of SATA2 and FireWire, the use of SCSI as a fast interface to devices is no longer required, unless you happen to have, for example, a very good quality scanner with SCSI interface. There are converters that can connect a SCSI device to the USB-bus. These have a male high-density connector for the SCSI interface, while the controllers internal to the PC have a female connector. The new cable that you bought cannot be used and you will have to look for another solution. One of these is to make an adaptor, which allows the USB/SCSI converter to be connected directly to the scanner. For the scanner we assumed a 25-way sub-D and for the converter a high-density connector. The schematic shows the necessary connections and their names. We don't discuss this any further, there is plenty of information available on the Internet.

The PCB consists of two parts. One is for





fitting the right-angle 25-way male sub-D connector and the other for the high-density connector. The PCB has been designed in such a way that the two component sides can be connected together via a double row pin header (2?21 pins). By selecting the spacing between the boards just right, so that the height of the connectors is about the same, a robust and compact adapter can be made. The photo shows what the intention is. There is really no opportunity for mistakes. K2 is also K4 and there is therefore only one pin header required. You may have to take into account the locking screws of the male sub-D connector. These are probably already present on the scanner and you will have to remove them from the adapter. The adapter is held in place firm enough without the locking screws.
Unfortunately it turned out that the software for the scanner could not cope with the USB driver for the converter, but that is another story.

(064007-1)

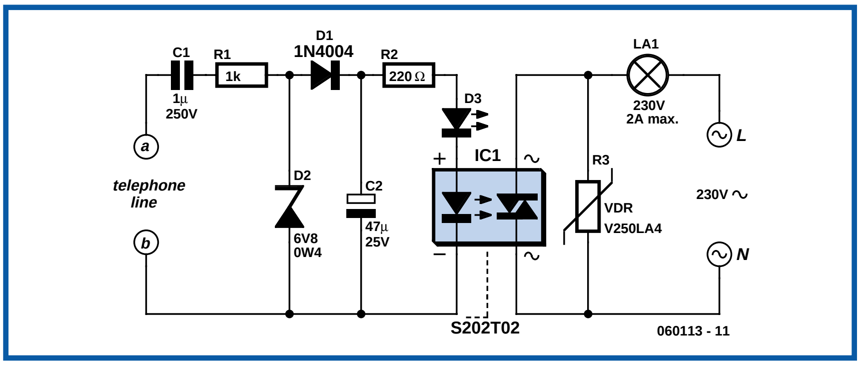
COMPONENTS LIST

K1 = 25-way sub-D plug (male), angled pins, PCB mount
K2,K4 = 2x21-pins pinheader (see text)
K3 = 50-way angled SCSI-2 high-density connector, PCB mount (e.g., Farnell # 369-3752 or # 854-037)
PCB, ref. 064007-1

Telephone Ringer

062

Christian Tavernier



If you are lucky enough to have a big house, a large garden, and small children, this project just might interest you. It's actually a telephone ringer capable of making any mains-powered device work from the ringer of your fixed line. With it, you will be able to control a high-powered siren or horn, as you like, in order to relay and amplify the low-level sound of your telephone (making it audible in a big house or in a large garden)! Alternatively, you can make a lamp light (or an indicator light) and so create a 'silent ringer' (helpful when small children are napping). The other interesting part of this simple and inexpensive project is that it doesn't require a power supply, contrary to similar items on sales in the shops.
Before examining the drawing and understanding the principle involved, it is important to know that the ringer voltage on a fixed telephone line is pretty high. Since Europe and the EU Commission have not yet interfered, the exact value of this voltage and its frequency varies according to the country, but that's not important here. The line carries direct current whether unoccupied or occupied. Moreover, no more than a few hundred mAs needs to be stolen from an unoccupied telephone line to make the PSTN exchange believe the line is occupied.
Therefore, capacitor C1 has the dual role of insulating this project with respect to direct current present on the line while unoccupied, or while occupied, while also allowing the ringer current to pass. The latter is rectified by D1 and clipped by D2 which makes about 6 V DC available to the C2 terminals when a ringer signal is present. This voltage lights LED

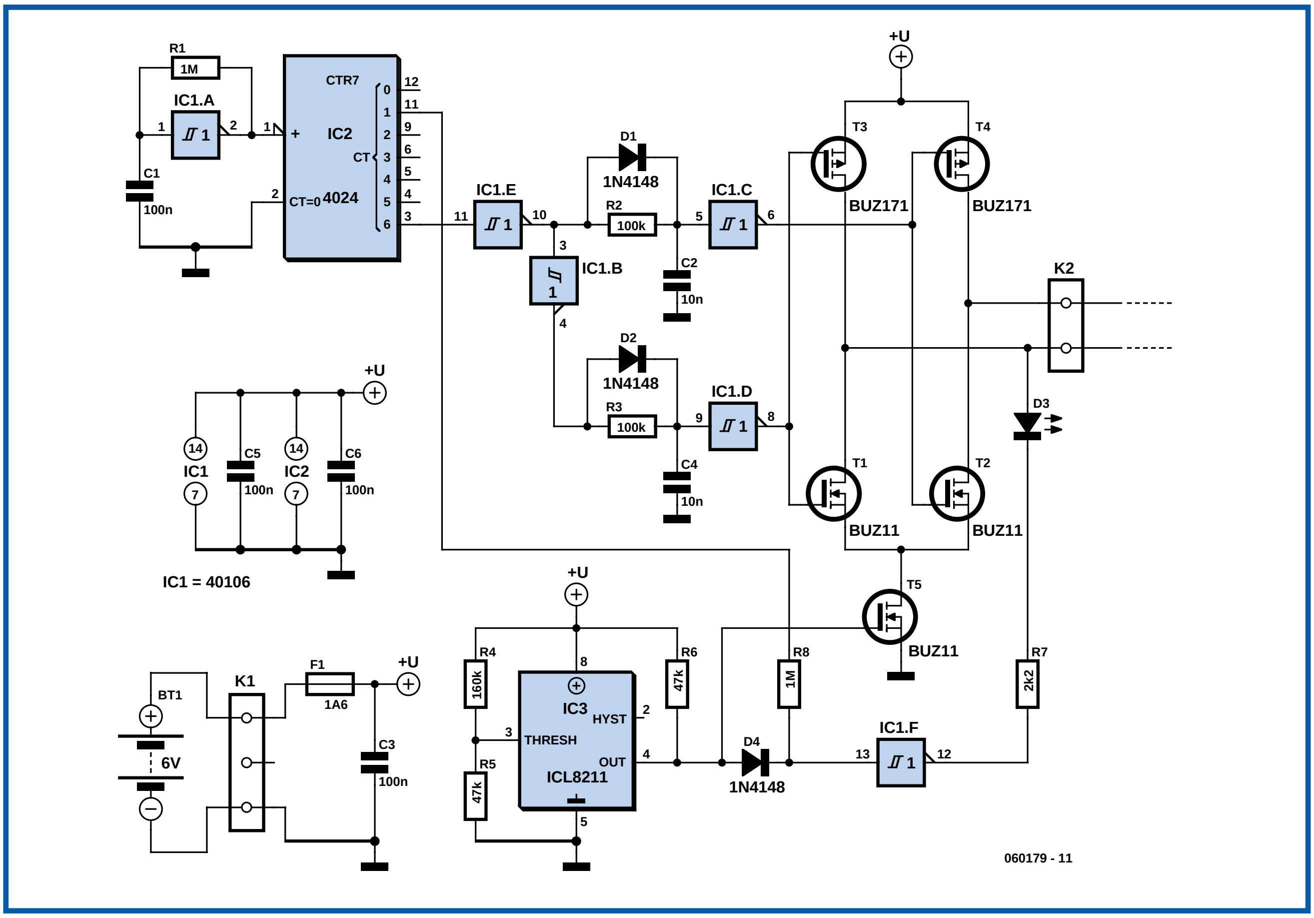
D3 which only serves as a visual indicator of proper operation as does the LED contained in IC1. This is a high-power photo triac with zero crossing detection from the mains, which allows it to switch the load it controls without generating even the lowest level of noise. This component, that we might just as well call a solid-state relay, was selected because it is comes in the form of a package similar to a TO220, a little bigger, and equipped with four pins. The pinout will not cause confusion because the symbols shown on our diagram are engraved or printed on the packaging. Since this circuit is not yet very common, we need to mention that it's available from the Conrad Electronics website (www1.uk.conrad.com).

For the purpose of safe operation, the circuit is protected by a GeMOV on the mains side, called Varistor, VDR or SiOV depending on the manufacturer. The model indicated here is generally available. The load will be limited to 2 A, considering the model selected for IC1, which is more than sufficient for the application planned here.

Finally, since a number of components in this circuit are connected directly to the mains power supply, the assembly should be placed in a completely insulated housing for obvious safety reasons.

(060113-1)

063 Slug Repellent



Uwe Kardel

Anyone who has a vegetable garden knows the problem. As soon as the strawberries start to get some colour, a net needs to be placed over the plants to prevent birds from eating the harvest. But what emerges the next morning? Someone still has had a nibble from the nicest strawberry. The culprit is usually still in the neighbourhood: A large brown slug.

Something should be done about this, any right-minded electronics engineer is never going to admit defeat. Special ridges are available from garden centres to stop slugs and there is also a special ribbon shaped material with wires woven in. The power supply comes from a 9-V battery. A practical experiment indicated that slugs were not the least bothered by these current-carrying wires: they nonchalantly climbed right across the ribbon.

A second experiment was done based on a home-made design: Square pieces of PCB material of 5x5 mm were glued on the four corners of a large printed circuit board. Copper wire with a diameter of 1 mm was soldered on the little squares so that the surface of the PCB was completely enclosed. A voltage of 6 V was applied to the copper wire. This worked much better. Two slugs that acted as guinea pigs stayed the entire night on the

PCB. They were, despite the rain, not able to beat the electronic obstacle. Unfortunately, by the morning the copper wire was already badly oxidised.
The search was now on for a practical mechanical construction for this system in the garden. Moreover, AC has to be used for the power supply to limit the corrosion. The first choice was an L-shaped tinplate profile of 12x165 mm. The long side of the metal was pushed deep into the ground to prevent the slugs from crawling underneath. Every 15 cm small pieces of PCB of 10x10 mm were glued on top (250 pieces in total), with the copper wire soldered on top of that. The distance between the tin sheet and the copper wire was about 1.5 mm. The results were excellent: not a single slug dared to cross the barrier. They crawled up to the copper wire and then turned back.
Except, this barrier does not work against flying slugs. Flying slugs? Certainly! These are the slugs that the neighbour finds in his garden and throws across the fence.
After a few months, it was noticed that the battery was exhausted quite quickly and there was also some corrosion. Measurements indicated that during heavy rain the current could increase to about 1 A because of droplets on the copper wire. So, another solution was required. The wires had to be suspended, just like the overhead conductor of a tram.
In the next experiment, a square of 1x1 m was surrounded by a slug barricade where the wire was fastened on the underside of the horizontal piece of tin sheet. Ten slugs were placed inside the square. Nothing happened at first: the slugs sleep during the day. At the fall of dusk they started to move and they appeared to be able to escape the square without effort. They did this by stretching themselves out at a right angle and bypass the copper wire without touching it. This was obviously not a good solution. Therefore, another, new construction was required.
The solution was found by suspending the wire outside the tin sheet, at a distance of about 5 mm. The slugs are then unable to pass without touching the wire and water droplets hang straight down from the wire where there is no tin sheet.
The wires are again soldered to small PCBs, which are screwed to the tin sheet angle profile. For this purpose a hole of 3.2 mm diameter was drilled in the tin sheet every 15 cm. First, the PCBs are screwed to the tin profile, the profile is placed in the garden and bent into the correct shape to enclose the strawberry field. The final step is to attach the wire to the PCBs. During assembly, it is wise to keep a conduction tester at hand and check frequently for short circuits. The smaller the distance between the wire and the tin sheet, the better it works, even against small snails, but as the distance is decreased, the risk of short circuits is increased.
This installation has proved itself in a practical experiment lasting two years. During this time it functioned without problems and keeps slugs out of the vegetable garden.
The AC voltage power supply consists of a clock generator, a driver stage in bridge configuration and an under-voltage detector. The clock generator is formed by R1, C1 and IC1a. No great demands are placed on the clock circuit, except one: Only when the duration of the positive voltage is exactly identical to the duration of the negative voltage is the corrosion of the wires effectively suppressed. That is why IC2 divides the generated frequency by two and in this way guarantees a duty-cycle of exactly 50%. The buffer stages are built around IC1b, c, d and e and provide for a small delay in the drive signal for the driver stage. This prevents that T1 and T3, and T2 and T4 respectively are driven simultaneously. Otherwise the current consumption of the circuit is too high. The circuit alternately turns on T1 and T2 at the same time, or T3 and T4. In this way, a square wave AC voltage of 12 V_{pp} is generated at the output.
IC3, an ICL8211, provides the under-voltage protection. The LED flashes slowly while the battery is in good condition. When the voltage becomes too low, the LED will flash faster. In addition, transistor T5 will block, so that no voltage is applied to the slug barrier any more. This is only necessary if the circuit is powered from a rechargeable battery. If ordinary batteries are used to power the circuit, T5 can be omitted and replaced with a wire link. With a battery power supply it is also a good idea to connect a switch in series with the LED, which is then only turned on when checking the battery voltage. This improves the life expectancy of the battery. This reduces the current consumption from 1.5 mA to 0.4 mA. During damp weather the current consumption increases considerably.

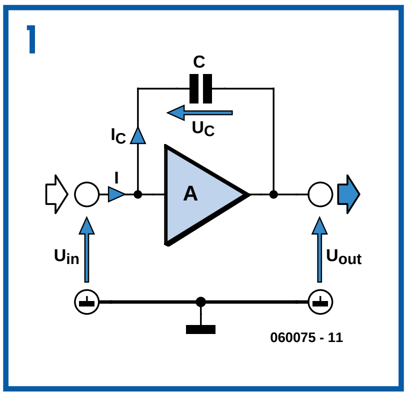
(060179-1)

Miller Capacitor

064

Gert Baars

There are amplifier circuits that have capacitance between the input and output. If the gain is positive, this can lead to oscillations. If the gain is negative, another outcome is the result. We can deduce this from the following theoretical circuit.
An amplifier with a negligibly low output impedance, an infinitely high input impedance and gain A has feedback in the form of capacitor *C* (refer **Figure 1**). The gain *A* is negative. In addition, input current *I*, input voltage *U* and output voltage U_o are also drawn in. The input current *I* is equal to I_c and the input voltage *U* is equal to $U_c + U_o$. U_o in turn is equal to the product $A\ U$. From this follows that



$$U_c = U – U_o = U\,(1 – A).$$

Substituting into the formula the current that flows through a capacitor, $I_c = C(dU_c/dt)$ results in

$$I = C \cdot \frac{dU(1-A)}{dt}$$

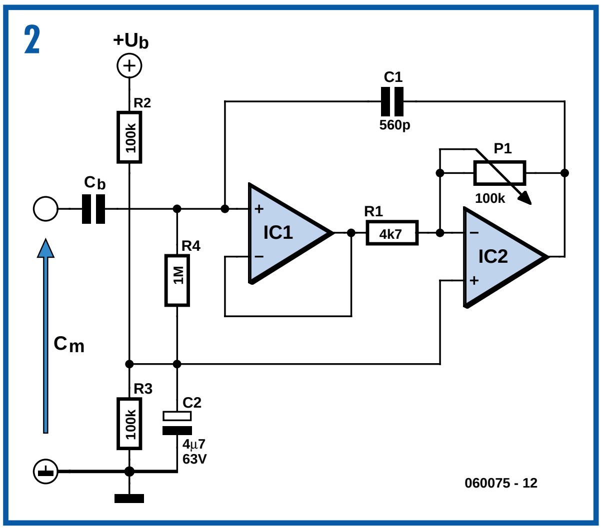
We rearrange this as

$$I = (1-A) \cdot C \cdot \frac{dU}{dt}$$

Now we can see that the gain determines the relationship between *I* and *C*. *C* appears to be larger by a factor of (1–*A*) (note: if *A* is negative, you can actually speak of a factor 1+*A* larger).

This is called the Miller effect. The apparent (larger) capacitance is called the Miller capacitance. When designing signal amplifiers you need to take this capacitance into account. We can actually use this Miller capacitance in other ways. If we make *A* variable, with an adjustable resistor for example, we create a variable capacitor. For this purpose we conceived the following schematic (see **Figure 2**).

C_m is the apparent capacitor between the input of the circuit and ground. If we connect a signal generator via a series resistor to the input and measure the input voltage with an oscilloscope, we can easily determine the corner frequency.



JFET-opamp A1 is necessary to prevent R1 from appearing in parallel with C_m and affecting the corner frequency. A2 is the actual (inverting) amplifier. The gain of A2 is equal to P1/R1. *C* is the capacitor which is enlarged artificially. The remaining components only serve to set the operating point of the circuit. C_b blocks any DC voltages and needs to be relatively large, for example 25 times the maximum C_m.

From the test results it appears that C_m is indeed equal to (1+P/R1) *C*. C_m can be varied with a potentiometer from about 560 pF to 12 nF.

As is usually the case, there are a few limitations in practice. The input signal may not be too large. Otherwise, the AC voltage across C_m will cause clipping at the output of the second opamp. At maximum C_m, the gain of A2 is about 20 times. The peak-to-peak value of the input voltage may therefore not be more than about $^1/_{20}$ of the power supply voltage. The circuit will always work well for smaller signals, provided the frequency is not too high.

For A1 and A2 we used an LF356 and TL081 respectively. These are mainly used for frequencies not exceeding 100 kHz. Very fast JFET opamps could extend the useful frequency range to applications in the RF-range. For LF applications we could also use a dual opamp for A1 and A2, such as the TL082.

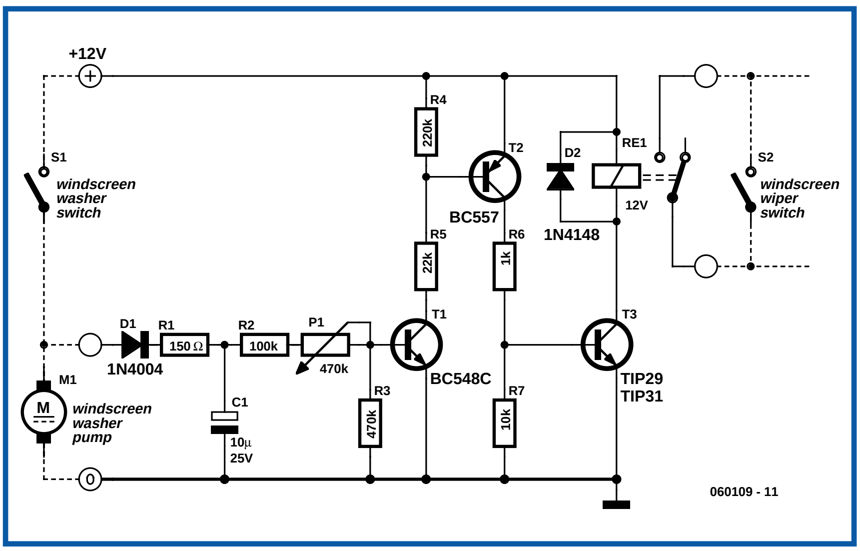
The value of capacitor C can be changed to suit the application. With opamps of the type AD8099 with a C of 22 pF we can make a (tuning) capacitor with a value from 22 to 440 pF, for use up to 30 MHz. The alternative, a varicap diode that can be varied in capacitance over a range of 20 times (or more) is not used in practice very much any more. Other applications for this circuit are, for example, adjustable LC-filters for audio applications.

(060075-1)

065

Automatic Windshield Washer Control

Christian Tavernier



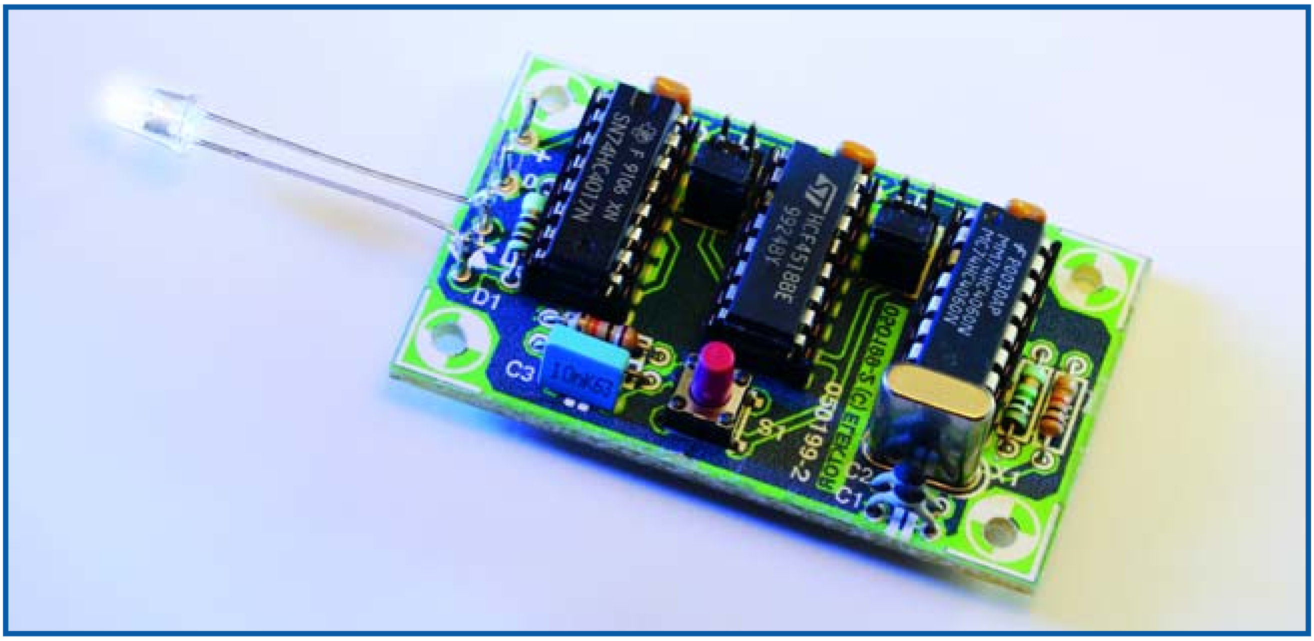
Most, if not all, recent cars have an impressive amount of electronics, whether it be ABS brake systems, engine control with injection calculators, airbag activation, or other various functions, called comfort functions. Among them is one which we tend to forget because it has become so common today. It turns on the windshield wipers automatically for a few seconds after the windshield cleaner. This practice is almost indispensable because it avoids any dripping of excess rinse product right in the middle of a just-cleaned windshield. Unfortunately, many 'low end' cars or some of the older cars are not equipped with this automatic function which is a very nice convenience to have. So, since all that is required is a handful of components that any electronics hobbyist worthy of the name already has in his/her drawer, we will discuss the circuit proposed here.

This project is super simple and simply keeps the windshield wiper activated for a few seconds after the windshield washer control contact has been released.
While the windshield washer pump is operating, the 12 volts delivered by the battery are present at the terminals and are therefore charging capacitor C1. Once the windshield washer has stopped, this capacitor can only discharge through R2, P1, R3, and the T1 emitter-base junction, due to the presence of diode D1.
It thus keeps T1 in the conductive state during a certain time, the exact period of which depends on the setting of P1. T1 in turn saturates T2, which then does the same for T3. The Re1 relay is therefore connected which maintains the windshield wiper in operation because its work contact is wired in parallel to the control switch. Once C1 is sufficiently discharged, T1 is blocked, which then blocks T2 and T3 and deactivates relay Re1.
The type of components is not really critical, even if we indicate specific reference numbers for T3, any low-power npn transistor with a gain over 25 will work. However, considering the amount of power consumed by the windshield wiper motor, relay Re1 will imperatively be an 'automobile' relay. You can find very low-priced ones at many car accessory shops (and even at some component retailers). These relays maintain contact under 12 volts and often do not have more than one work contact but they are, in general, capable of cutting off about 20 amps.
Finally, the only delicate point of this project is to properly identify the control wire for the windshield pump on one hand, and the windshield wiper motor on the other. Observing what is happening at the various connections with a simple voltmeter, should get it right without too much difficulty.

www.tavernier-c.com (060109-1)

Optical Pulse Generator

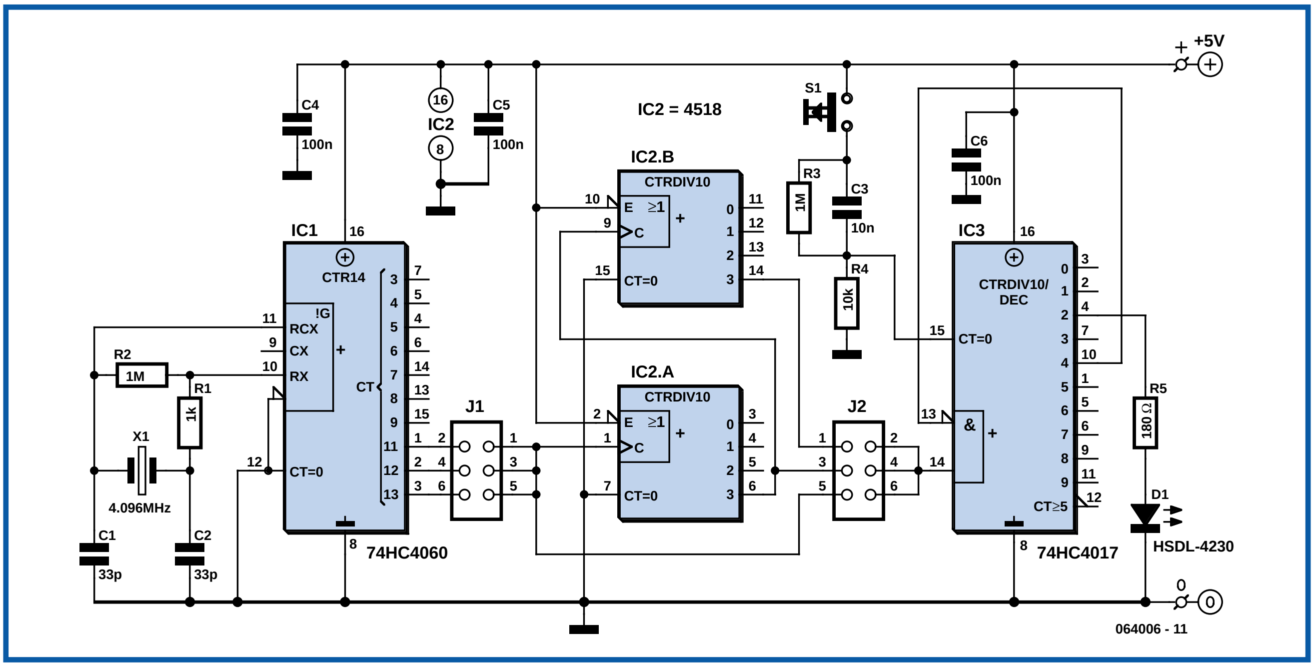
066



This little aid was originally designed to test the Shutter Time Meter from the January 2006 issue. This meter was specifically designed for 'analogue' SLR cameras.

In order to measure the exposure time of a camera accurately, it will first have to be checked with a well-defined signal first. This circuit was designed for that purpose. But the circuit can also be used if you need a well-defined pulse for some other purpose.

The circuit is build around a trio of standard logic ICs. Firstly a 74HC4060 (IC1) is used to provide a quartz crystal accurate reference for the duration of the pulses. For the crystal frequency we choose the common 4.096 MHz value. To test all the ranges of the shutter time meter, we choose three different pulse lengths in three different decades, namely: 1 / 2 / 4 / 10 / 20 / 40 / 100 / 200 / 400 ms.
With jumper J1 you select a frequency of 1000, 500 or 250 Hz (see table). The frequency is then passed on to J2 and the dual decade counter IC2 (a 4518). This does not need to be a fast HC-type, since the frequency is at most 1 kHz. With J2 the frequency can be reduced by 1, 10 or 100 times. This frequency is then applied to IC3 (a 5-stage Johnson-counter). This has been set up in such a way that in the end there appears only one single pulse at the output. The advantage of the Johnson-counter is that each



output is free from glitches and has a duration that is exactly equal to the period of the clock input.

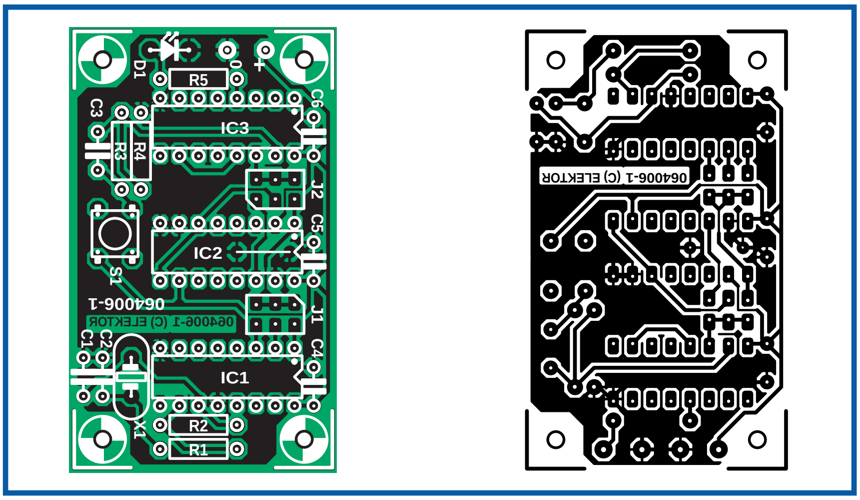
We choose Q2 as the output. Q4 is used to stop the counter. Q0 is only active if we push the reset-button S1. IC3 will then start to count. To ensure that the reset does not affect the duration of the pulse, a differentiating RC-network R4/C3 generates a short reset pulse. R3 ensures that C4 is discharged after releasing S1. Also, just to be sure, we don't use the second counter output but use the third one instead. For the same reason, to stop the counter we use the fifth output. Especially with longer times you will notice that the pulse will arrive at the output a short time after pressing the switch.

R5 drives a current of nearly 20 mA through D1. D1 provides sufficient light for this application to trigger the receiver diode in the shutter time meter. An unusually fast type was selected for the LED, which, with a switching time of 40 ns, has practically no influence on the length of the pulse. If you would like to use another LED then you will have to look closely at the switching time. This needs to be small compared to the duration of the pulse. If you want to use the circuit with a logic level output then you can just omit D1.

If necessary, the pulse lengths can be changed be selecting another crystal frequency. The current consumption in the idle state is less than 2 mA. In our prototype, while the circuit is delivering a pulse, the current consumption increases briefly to about 18 mA.

Do not forget the wire link under IC2 when assembling the circuit.

(064006-1)



J1	J2	Pulse (ms)
1-2	5-6	1
3-4	5-6	2
5-6	5-6	4
1-2	3-4	10
3-4	3-4	20
5-6	3-4	40
1-2	1-2	100
3-4	1-2	200
5-6	1-2	400

COMPONENTS LIST

Resistors
R1 = 1kΩ
R2,R3 = 1MΩ
R4 = 10kΩ
R5 = 180Ω

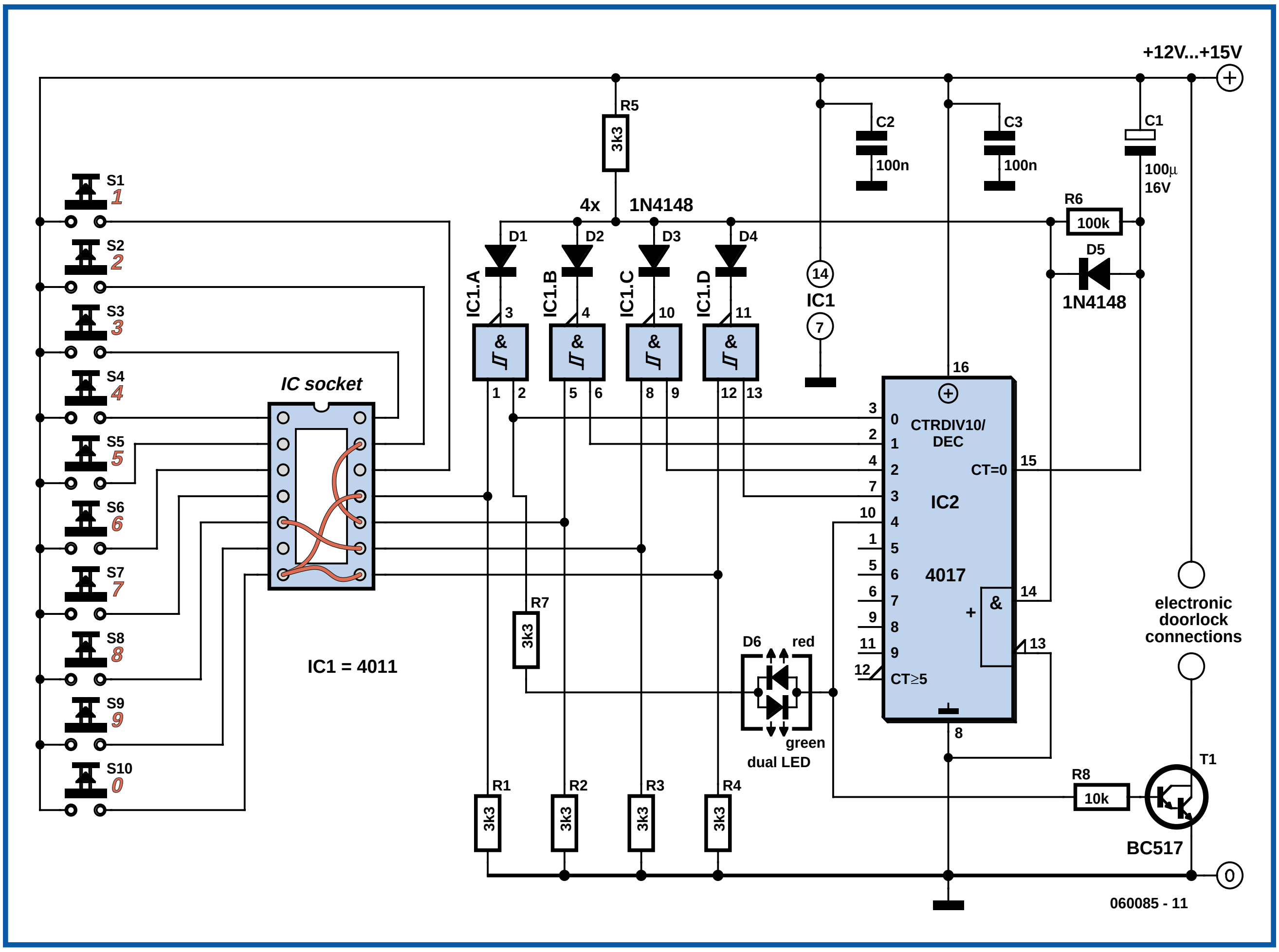
Capacitors
C1,C2 = 33pF
C3 = 10nF
C4,C5,C6 = 100nF ceramic, lead pitch 5mm

Semiconductors
D1 = HSDL-4230
IC1 = 74HC4060
IC2 = 4518
IC3 = 74HC4017

Miscellaneous
S1 = pushbutton, make contact, 6mm
J1,J2 = 3-way pinheader with jumper
X1 = 4.096MHz quartz crystal
1 wire link.
PCB, ref. 064006-1

Hard-Wired Code Lock

067



Heino Peters

Installations with restricted access are often protected using an access code. If you don't have particularly demanding requirements regarding modifying the code, you can manage quite nicely with a static design with the access code fixed in the hardware.

The access code can be set by inserting wire links in the IC socket shown at the left in the schematic diagram. The code '0280' is shown configured in the drawing. The user enters the code with S1–S10. The most important components in this circuit are the four NAND gates (4011 CMOS IC) and the counter with ten decoded outputs (4017 CMOS IC). R1–R4 hold the four pushbutton inputs at ground level if no button is pressed. No measures need be taken to debounce the switch signals, since the circuit simply ignores repeated button presses. In the quiescent state, a '1' is applied to the reset input (pin 15) of IC2, which causes output Q0 (pin 3) of IC2 to be the only output with a '1' level. All other counter outputs are at the '0' level. Dual LED D6 will be on and red to indicate that a code can be entered. If the button for the first digit of the preset code is now pressed (in this case the '0' button), the output of IC1a will go to '0' and the reset input of IC2 will also go to '0' via D1 and D5. When the button is released, a rising edge appears at the clock input of IC2, which causes the counter to be incremented by 1. Thanks to R6 and C1, the reset input of IC2 remains low for around 10 seconds. Output Q1 (pin 2) of the counter is now '1' as a result of the clock pulse, and IC1b is waiting for the second button ('2') to be pressed. If that doesn't happen within 10 seconds, C1 discharges via R5 and R6 to a level that causes IC2 to be reset. Dual LED will again become red, and the user must start entering the code again. However, if the buttons for the each of the remaining digits of the code are pressed correctly within 10 seconds, the Q4 output (pin 10) will ultimately go to '1' and the dual LED will change to green. After 10 seconds, C1 will again be discharged and the dual LED will change back to red. The Q4 output can be used to switch something, such an electronic door latch.

If you want to change the code, you only have to change the configuration of the wire jumpers in the IC socket.

The combination of diodes D1–D4 and R5 acts as an AND gate. If the output of one of the four NAND gates in IC1 is '0' (which is always the case if a correct button is pressed), a '0' is applied to the clock input of IC2 as long as the button is held pressed. If you find a delay of 10 seconds too long, you can reduce the value of R6 or C1. The time is approximately equal to the product of R6 and C1 (R6 x C1).

(060085-1)

068

LM35 to ADC

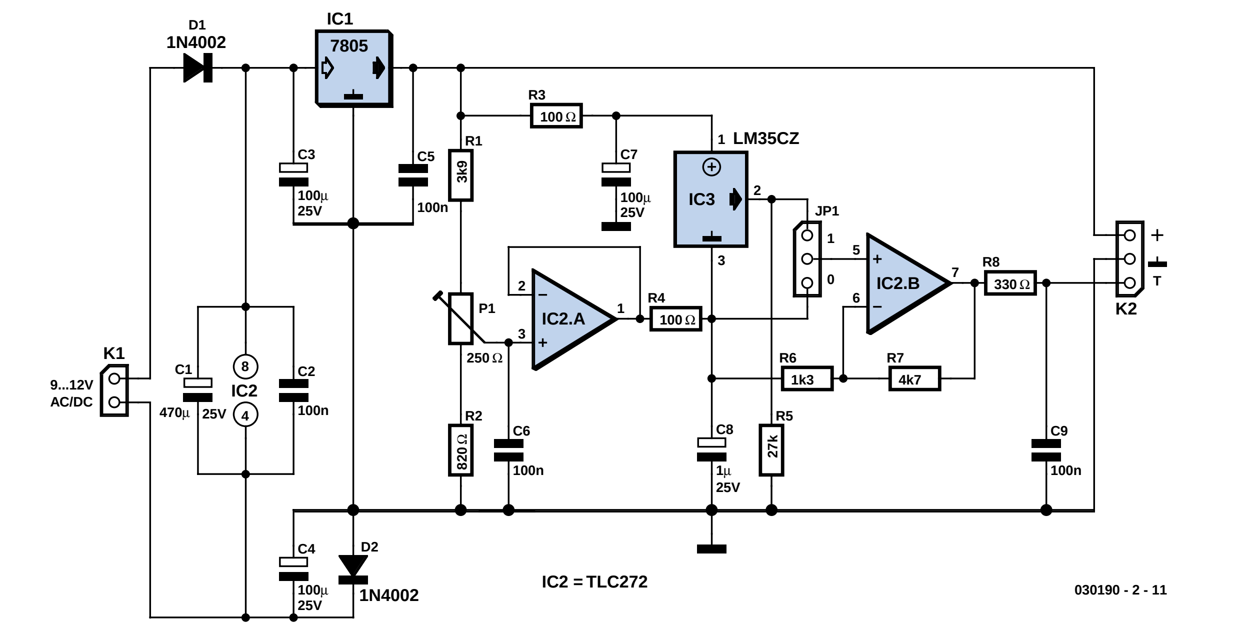
Uwe Reiser

The circuit described here is designed to be used with the 'LED Thermometer' (elsewhere in this issue), but can also be used as a signal conditioner for connection to any analogue-to-digital converter (ADC). The circuit is sufficiently interesting in itself that we have decided to describe it separately. The familiar and popular LM35 temperature sensor produces an output voltage that varies by 10 mV per Kelvin over a temperature range of –55 °C to +150 °C. This is not suitable for driving an ordinary unipolar input of an analogue-to-digital converter with an input range of 0 V to 5 V: we need to add an offset to the sensor voltage and then amplify it.

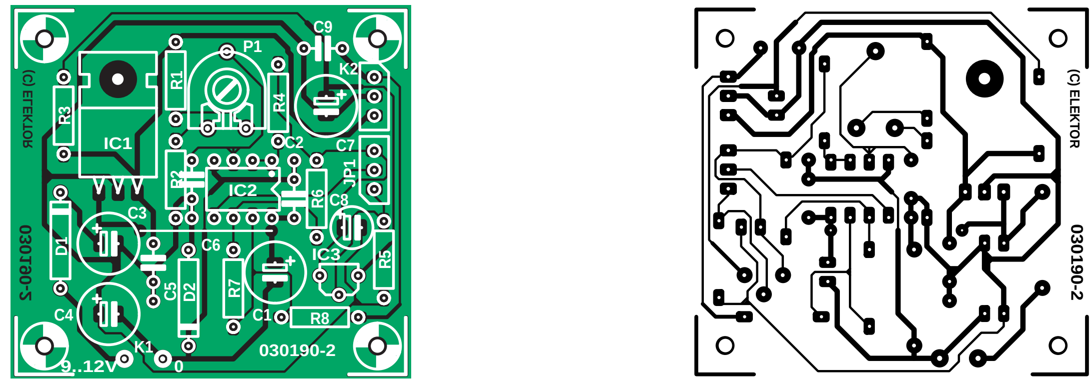
That covers the two main parts of the circuit diagram shown in **Figure 1**. The circuit is designed to allow a measurement range of –24 °C to +84 °C. Over this range, the output voltage of the sensor varies from –240 mV to +840 mV. Both these values must be shifted by a further 0.5 K (or 5 mV) to allow for an extra half a degree at either end of the range. This gives a total voltage range of 1090 mV, and hence a necessary gain of A = 5000 mV / 1090 mV = 4.587. Amplification is done by IC2.B, whose gain is given by A = R7 / R6 + 1. The voltage offset is generated by IC2.A, which shifts the ground of the LM35, to which its output is referred, to a potential of 245 mV × 4.587 = 1124 mV relative to the circuit ground. Overall, this means that the voltage at the output of IC2.B is exactly 0 V at a temperature of –24 °C and 5 V at +84 °C.

These two formulae can be used to select component values for any desired temperature range. Calculating suitable values for the voltage divider formed by R1, P1 and R2 is straightforward. Jumper JP1 allows the circuit to be calibrated: connecting the output of the offset opamp IC2.A directly to the input of amplifier IC2.B simulates the condition of being at the lower extreme of the temperature range.

1



2



COMPONENT LIST

Resistors
R1 = 3kΩ9
R2 = 820Ω
R3,R4 = 100Ω
R5 = 27kΩ
R6 = 1kΩ3
R7 = 4kΩ7
R8 = 330Ω
P1 = 250Ω preset

Capacitors
C1 = 470µF 25V
C2,C5,C6,C9 = 100nF
C3,C4,C7 = 100µF, 25V
C8 = 100µF, 25V

Semiconductors
D1,D2 = 1N4002
IC1 = 7805
IC2 = TLC272
IC3 = LM35CZ

MIscellaneous
K1 = 2 solder pins
K2,JP2 = 3-way pinheader
1 Jumper

The circuit is powered from a mains adaptor with an output of 9 V to 12 V (either AC or DC). Although the current consumption is only around 50 mA, a 1 A fixed voltage regulator is used to produce a stable 5 V supply, since no heatsink is then required. The regulator directly supplies the voltage divider for IC2.A and can also provide power for a connected ADC circuit. The supply for the sensor is decoupled from the rest of the circuit by R3 and C7 to reduce interference. Diode D1 operates either as a rectifier (when an AC supply is used) or as protection against reverse polarity (when a DC supply is used). To avoid the need to use rail-to-rail opamps, diode D2 is used to lift the circuit ground to approximately 0.7 V above the IC's negative supply.

The sensor electronics can be built on the small printed circuit board shown in **Figure 2**. There is a single wire link, between C3 and IC2. It is worth pointing out that not only the sensor, but also all the other components, must be capable of operating over the desired temperature range. The 'C'-suffix versions of the sensor are specified to work from –40 °C to +110 °C, while the 'D' versions are specified to work from 0 °C to +100 °C.

The overall accuracy of the thermometer is highly dependent on the precision of the components used. In particular, R6 and R7 should be as close as possible to their calculated values. The output voltage of the regulator is also important if it is used as the reference voltage for the A/D converter. Deviations from nominal values will result in an expansion or a compression of the overall temperature scale.

(030190-II)

Internet link

www.national.com/pf/LM/LM35.html

ZigBee Switching for Remote Control

069

Richard Hoptroff

The ZigBee standard defines data formats known as 'profiles'. These ensure that products produced by different manufacturers are interoperable.

One of the first data formats to be developed out was the Home Controls–Lighting (HC-L) profile. This is designed for sending simple on/off messages, and its main purpose is designed to remove the need to run cables to wall-mounted light switches in buildings. However, that's not to say that you can't use it for switching anything else, for example, to add ZigBee remote control to your projects.

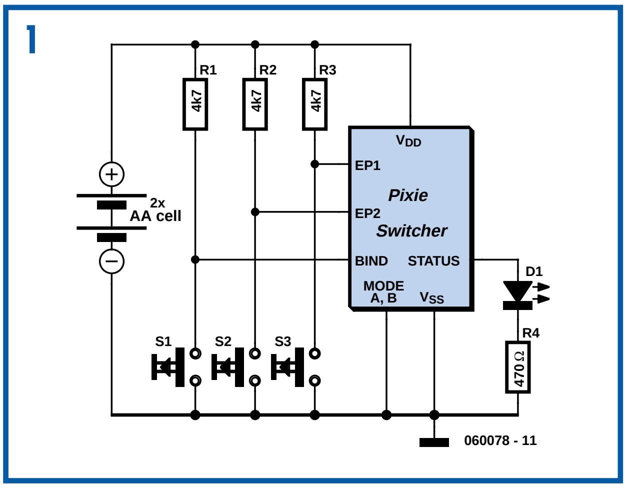
The Pixie Switcher from Flexipanel (www.flexipanel.com) is a commercially available HC-L switching module with integral antenna and up to 8 switching control lines known as endpoints (EPs). When configured as an input, the endpoint voltage is monitored. If it changes state, a message is generated as required. 'On', 'off' and 'toggle' messages are supported by all devices using the HC-L profile. When configured as an output, the endpoint's digital output corresponds to the last message received from a switching input.

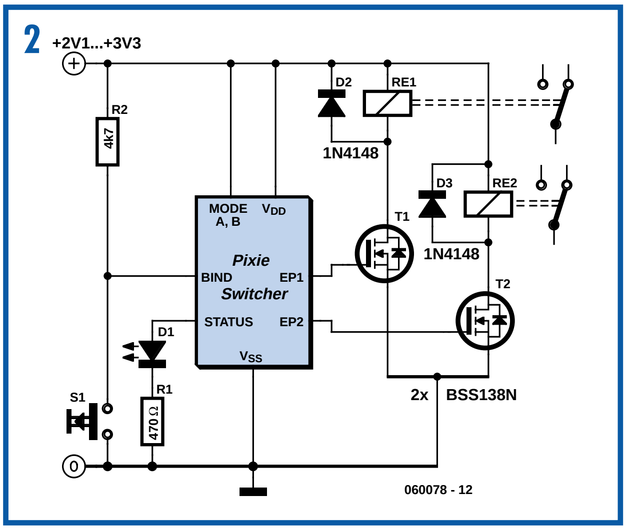
Input endpoints to output endpoints correlation is managed by one-time setup procedures called 'joining and binding'. When first powered up, a device will look for a ZigBee network to join. Security permitting, any router node can then allow the new node to become its neighbour in the network.

Once the new node has become a member of the network, its inputs and outputs must be 'bound' to corresponding outputs and inputs on other nodes in the network. This is achieved by pressing the 'bind' button on both devices at the same time. One input can control multiple outputs and vice versa. For example, it would be quite feasible for a bedside or hallway switch to turn off all the lights in the house.

A typical application circuit is shown in the schematics, where one Pixie Switcher unit has been configured to have two inputs and the other to have two outputs. This configuration must be done prior to placing the modules in the circuit shown, using the RxD and TxD serial interface pins (not shown).

Figure 1 shows the transmitter. The ModeA and ModeB pins are grounded, so the transmitter will operate in sleep mode and only wake up when a button is pressed. The modules can run at anything between 2.1 V and 3.3 V, so it can be connected directly to two AA batteries.





The Bind input and Status LED are only used during joining and binding. When the push-buttons connected to EP1 and EP2 are pressed, messages are transmitted to the receiver.

Figure 2 is the receiver. By setting ModeB high, it is configured as a router. This means it can allow battery powered sleeping devices (such as the transmitter) to join it as a neighbour. Routers, however, must be always-on and so are not really suited to battery powering. ModeA is also wired High, indicating that this router is in fact a coordinator. The difference between the two is that when a coordinator powers up, it starts a new network instead of looking for an existing one to join. Every ZigBee network has one coordinator. If further routers nodes were added to this network, they would have to have the ModeA pin low. EP1 and EP2 on the receiver are connected to relays via MOSFET driver transistors. The relay contacts can then be connected to any project circuit.

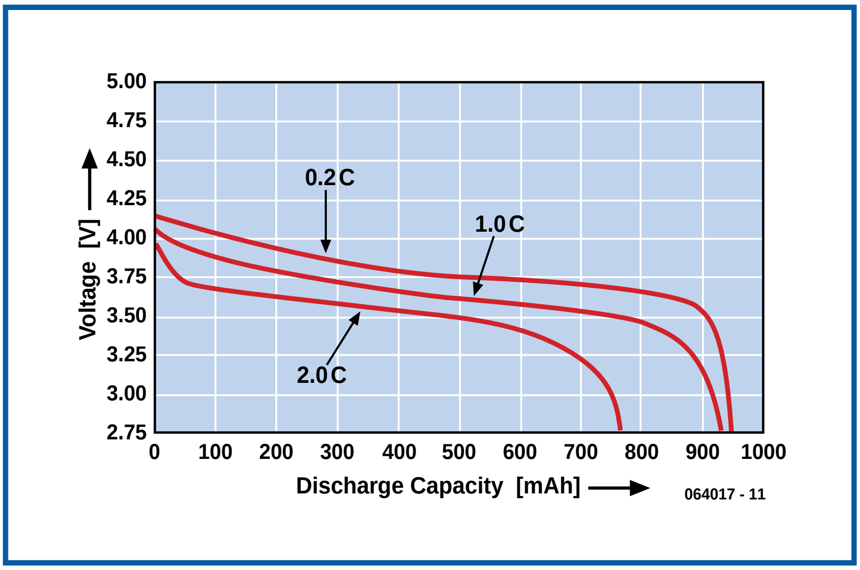
(060078-1)

070

Measuring Battery Charge

It is not generally known that it is possible to ascertain the extent of charge of a battery with a standard digital voltmeter. It does not apply to all kinds of battery, but it does to, for instance, Lithium-ion batteries.

Although there are quite a few different types of Li-ion batteries, it is possible to generalize to a degree. The graphs in the figure (from Panasonic) show clearly that the terminal voltage of the cell drops in direct relation to the diminution of the charge. This means that a simple voltage measurement suffices to determine the state of charge of the battery. Note that the figure shows three graphs each relating to a given load. This means that the



output voltage must be measured under load conditions to obtain a satisfactory result. Moreover, the value of the load must be known. Also, the battery must be under load for at least a minute.

There are two ways to proceed. If the load is known and constant as, for instance, in a pocket torch, measure the voltage and read the corresponding charge from the graph. If there is no load, or it is not known or variable, apply a temporary load in the form of a resistor. If the value of this is 20 Ω, for instance, use the upper graph (0.2 *C*, 180 mA). If a single resistor is used, this will get quite hot, because it has to dissipate 0.66 W, whereas most standard resistors are only rated at 0.25 W to 0.33 W. It is therefore wise to use a number of resistors in parallel, for example, five of 100 Ω each.

To obtain more exact measurements, first draw the graph of your particular battery. Charge it fully and then connect the load, for instance, the five 100 Ω resistors. Measure the output voltage every five minutes and enter the results on an Excel sheet to give a nice curve. If the 5-minute intervals are not exact, enter the real times and choose 'spread' as curve. Only this type of sheet can cope with irregular measurement intervals. Moreover, Excel is able to transpose the time on the horizontal (*x*-) axis into charge.

Calculate the current during an interval by dividing the mean voltage (start voltage plus final voltage divided by 2) by the resistance. The charge is the current thus computed times the elapsed time.

The graph shown applies to a battery of 900 mAh. A current of 0.2 *C* is then 0.2 x 900 = 180 mA; 1 *C* is 900 mA; 2 *C* is 2 x 900 = 1.8 A.

The proposed method is not suitable for NiCd or NiMH batteries, but it is for lead-acid batteries, provided that the temperature is constant. Bear in mind that an old lead-acid battery has a slightly different graph from a new one.

(064017-1)

High-voltage Regulator

071

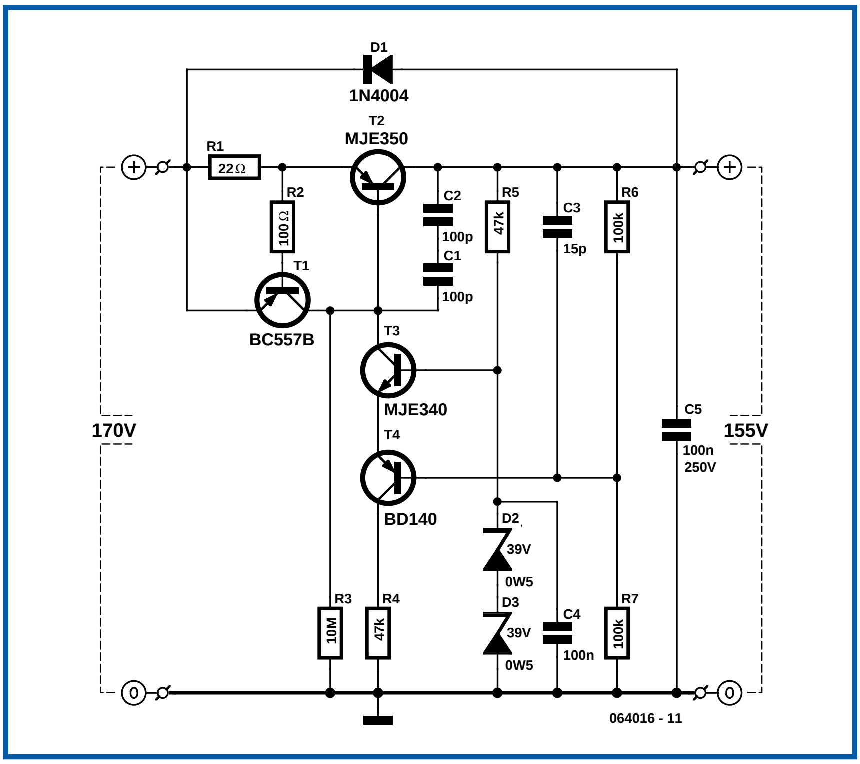
with Short Circuit Protection

Ton Giesberts

There are many circuits for low voltage regulators. For higher voltages, such as supplies for valve circuits, the situation is different. That's why we decided to design this simple regulator that *can* cope with these voltages. This circuit is obviously well suited for use in combination with the quad power supply for the hybrid amp, published elsewhere in this issue.

The actual regulator consists of just three transistors. A fourth has been added for the current limiting function. The circuit is a positive series regulator, using a pnp transistor (T2) to keep the voltage drop as low as possible.

The operation of the circuit is very straightforward. When the output voltage drops, T4 pulls the emitter of T3 lower. This drives T2 harder, which causes the output voltage to rise again. R4 restricts the base current of T2. C1 and C2 have been added to improve the stability of the circuit. These are connected in series so that the voltage across each capacitor at switch-on or during a short circuit doesn't become too large. You should use capacitors rated for at least 100 V for C1-C3. D1 protects T2 against negative voltages that may occur when the input is short-circuited or when large capacitors are connected to the output.



We use two zener diodes of 39 V connected in series for the reference voltage, giving 78 V to the base of T3. Because R6 is equal to R7 the output voltage will be twice as large, which is about 155 V. T4 acts as a buffer for potential divider R6/R7, which means we can use higher values for these resistors and that the voltage is not affected by the base current of T2 (this current is about the same as the emitter current of T3). This is obviously not a temperature compensated circuit, but for this purpose it is good enough.

The current limiting section built around T1 couldn't be simpler. When the output current rises above 30 mA the voltage across R1 causes T1 to conduct. T1 then limits the base-emitter voltage of T2. R2 is required to protect T1 against extremely fast peak voltages across R1.

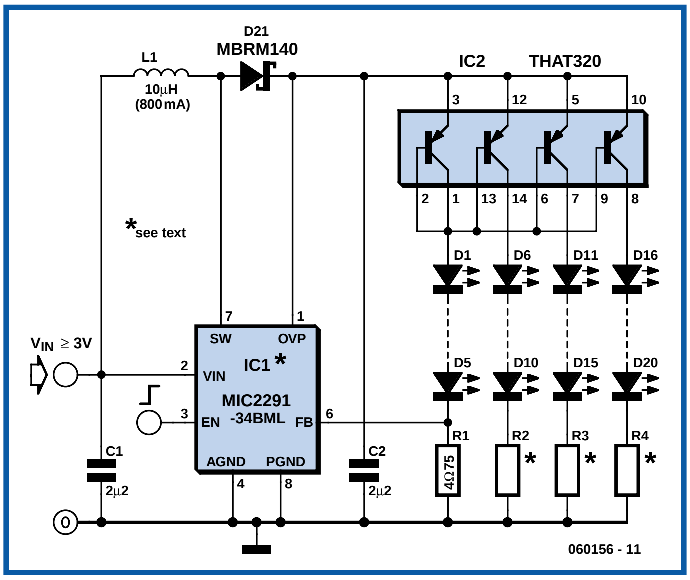
R3 is needed to start the regulator. Without R3 there wouldn't be a voltage at the output and hence there wouldn't be a base current in T2. R3 lets T2 conduct a little bit, which is sufficient for the regulator to reach its intended state.
During normal operation with a voltage drop of 15 V across T2 and a current of about 30 mA there is no need for extra cooling of T2. The junction temperature is then 70 °C, which means you can burn your fingers if you're not careful! The lower the input voltage is, the more current can be supplied by this regulator. This current is determined by the SOAR (Safe Operation ARea) of T2. During a short circuit and an input voltage of 140 V the current is about 30 mA and T2 certainly requires a heatsink of at least 10 K/W in those conditions.
To increase the output voltage you should use a larger value for R6. If you want to use a higher reference voltage, you should replace T4 with a MJE350. If you only ever need to draw a few milli-amps there is no need to include T4 and R4. The potential divider (R6/R7) can then be connected directly to the emitter of T3.
The ripple suppression of the circuit is about 50 dB. The quiescent current is 2.5 mA and for small currents the dropout voltage is only 1.5 V.

(064016-1)

072 Driver for 20 LEDs

Eberhard Haug

If we wish to use a step-up switching regulator to run several LEDs from, for example, a 3 V battery, we find that the maximum usable mark-space ratio limits us to driving just a few LEDs in series. If we have seven white LEDs in series the total forward voltage will be about 7 times 3.4 V, or 23.8 V, requiring a mark-space ratio of around 90 %. This is the upper limit for many switching regulators. If we want to drive more LEDs, we must divide them into a number of parallel strings, for which the regulator will of course have to supply the necessary current.
There are various ways to drive a parallel array of series-connected LEDs. The simplest approach is to wire a number of chains, each consisting of the same number of LEDs and a series resistor, in parallel, hoping that the total forward voltage of the LEDs in each chain is approximately the same. We can sense the current in a single chain using a sense resistor R, and thereby deliver the same current to the other chains as well. Unfortunately, the assumption that the total forward voltage of the LEDs in each chain is the same is not always borne out in practice.
To get around this problem we can use a multi-way current mirror, which can, for example, be constructed using a bipolar transistor array such as the THAT320. This contains closely-matched PNP transistors. The current mirror function is implemented in the first (regulated) chain by connecting the base and collector of its transistor together; the base and emitter connections of all the transistors are also wired in parallel. Since there will be a small effect on the currents in the other chains, it is best not to dispense with their series resistors R, in the interests of improved current matching.



The circuit shows a type MIC2291 PWM step-up LED driver from Micrel driving a four-by-five LED array. This arrangement leaves the device a little headroom in terms of mark-space ratio and total power. The voltage at the output will be at most 18 V in normal operation. A particular advantage of the MIC2291 in this circuit is its low feedback voltage of 95 mV, which makes for a correspondingly high efficiency. The current in each chain is calculated as follows:

$$I_{LED} = 95\ \text{mV}/R1 = 95\ \text{mV}/4.7\ \Omega = 20\ \text{mA}.$$

The circuit can operated from voltages from 3 V to 10 V. If fewer than five LEDs are used in each chain, or if LEDs with a lower forward voltage are used, the battery voltage may need to be reduced: it must be lower than the total forward voltage drop of the chain. Otherwise, as with any boost converter, an unregulated and potentially damaging current will flow continuously through the LEDs. Also, if the chains contain different numbers of LEDs or if different colour LEDs are used, care must be taken to ensure that the sum of the LED forward voltages is greatest in the first (regulated) chain.
The EN input allows the LED array to be turned on (EN>1.5 V) or off (EN<0.4 V), or dimmed using a PWM signal. An alternative (analogue) dimming technique is also described in the MIC2291 data sheet.
The Schottky diode must be a fast-switching type with a low capacitance and low voltage drop, such as the MBRM140 or SS14. Ceramic capacitors C1 and C2 should be XSR or X7R types with a suitable working voltage. The 10 µH coil must have a rated current of at least

600 mA without saturating, and it should also have as low a resistance as possible. And of course, when building an LED driver circuit with a switching speed of 1.2o the layout and construction of switching regulators should be observed. The MIC2291-34BML and its lead-free counterpart the MIC2291-34YML in a 2 mm by 2 mm MLF package have a 34 V overvoltage protection circuit (and an extra OVP pin); the MIC2291YDS in a 5-pin SOT-23 package is a low-cost version without overvoltage protection. Since we would otherwise have to implement this protection externally, the MLF type is preferred.

(060156)

Internet links

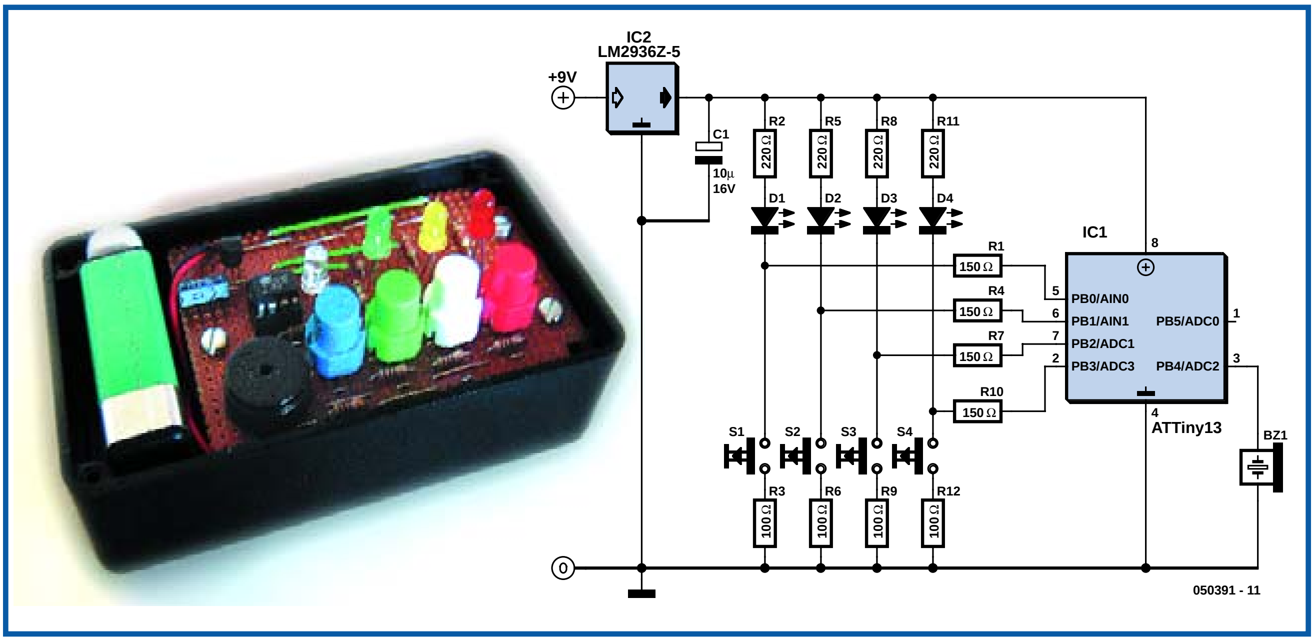
MIC2291 data sheet:
www.micrel.com/_PDF/mic2291.pdf

Application example:
www.micrel.com/_PDF/App-Hints/ah-59.pdf

THAT320:
www.thatcorp.com/300desc.html

Tiny Simon

073



Clive Graham

The 'Tiny Simon' game is based upon the 'Simon says…' sequence following game which has proved popular over the years. Although not particularly original in concept, this implementation of the game, put together for use by playschool children, has a number of noteworthy features.

The game uses sound (via a piezo-sounder) and light (via four LEDs) to display an extending sequence to the player, who has to follow and repeat back the sequence via a set of four press-switches. If the sequence is remembered correctly, a celebratory tune is played (with light show) and the sequence extended by a further element. If not, the player is shown the correct sequence and, after a short 'jingle', is invited to play again.

The circuit is built around an ATtiny13 microcontroller running software written for the project. As you can see from the circuit diagram, the ATtiny13 chip in its 8-pin case does not require much in the way of external components to make an attractive little game that hopefully will keep children busy for a while.

The software was coded in AVR assembler using the freeware Atmel AVR Studio4. It is available free of charge from the Publishers' website as file number **050391-11.zip**. Careful use of modular programming allows for easy changing of music generated during the game (stored in EEPROM) and other features. An 8-stage maximal length pseudo-random number generator (in software) is used to produce a varied and easily checked light sequence. Feedback taps can be altered in software to produce a different sequence. Each starting point for a sequence is saved in EEPROM, so if power is lost, a new starting point is automatically selected upon power-up. Dynamic I/O switching is used to reduce pin-count — the LEDs and push-buttons are conected to the same pins on the ATTiny13!

The game runs from a 9-volt PP3 type battery. The low quiescent current of less than 8 µA is due to the use of a micropower regulator type LM2936Z-5 and extensive power saving features on the ATtiny13 (the micro draws less than 1 µA!).

Construction is very simple and the parts are inexpensive and easily obtained. The component count is so small that construction of the circuit on a piece of Veroboard is a perfectly acceptable option. The photograph shows an experimental construction of the game is an ABS box. The small, hand-held construction allows easy operation for those with small fingers!

(050391-1)

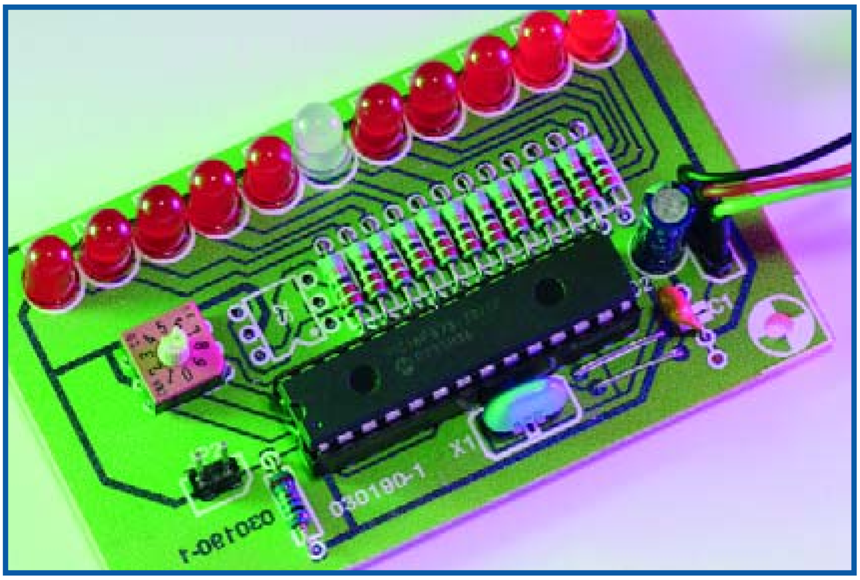
074

LED Thermometer

Uwe Reiser

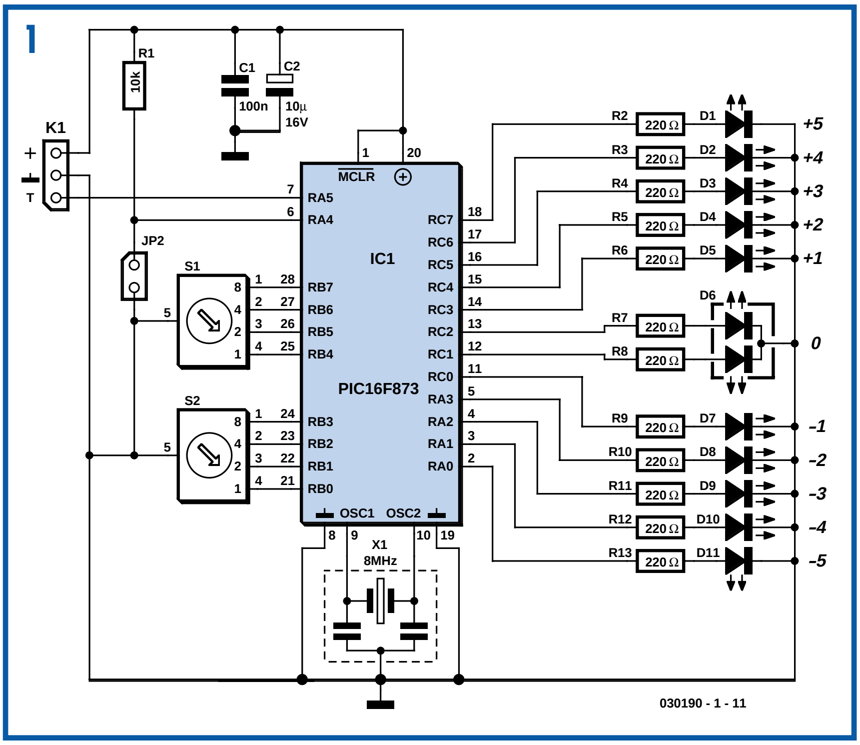
The circuit described here is the digital and display section of a thermometer; the analogue circuitry and signal conditioning required to use an LM35 temperature sensor are described elsewhere in this issue ('LM35 to ADC'). The analogue-to-digital converter used here is hidden inside a PIC16F873 microcontroller behind the RA5 port pin. It has a resolution of 10 bits (1024 steps), allowing a temperature range of 128 °C to be divided into steps of exactly 128 °C / 1024 = 0.125 °C. Displaying a range of 1024 steps of one eighth of a degree, or even just 128 steps of one degree, on a row of LEDs is hardly practical. A better plan is to specify a desired temperature value and allow the microcontroller to indicate deviations from that temperature over a small range; effectively moving a magnifying glass over the temperature scale.

The BCD-encoded switches are used to set the desired centre temperature. When the measured temperature is equal to this value the centre two-colour LED D6 will light green. If the temperature deviates from this value, the LED will light yellow. LEDs D1 to D5 indicate positive deviations and LEDs D7 to D11 indicate negative deviations in steps of one degree. If the overall measurement range is from –24 °C to +84 °C we can therefore set the centre point between –19 °C and +79 °C. Half-degree steps are indicated by two neighbouring LEDs lighting simultaneously. For example, between 19.75 °C and 20.25 °C just one LED will light; between 20.25 °C and 20.75 °C the next LED will also light; and between 20.75 °C and 21.25 °C just the second LED will light. If just the top or bottom LED is lit, it means that the temperature is outside the displayable range. The BCD-encoded switches (S1 for the tens digit and S2 for the units) used to set the centre value have the advantage that there is no need for mental acrobatics converting between decimal and hexadecimal when setting or checking the value. Since negative numbers cannot be set using the switches, the value is expressed as the offset from the bottom of the temperature range. The software updates the displayed value every second if JP2 is fitted; if, however, port RA4 is high (jumper not fitted) a 900 ms delay loop in the software is bypassed and the display is updated at full speed.

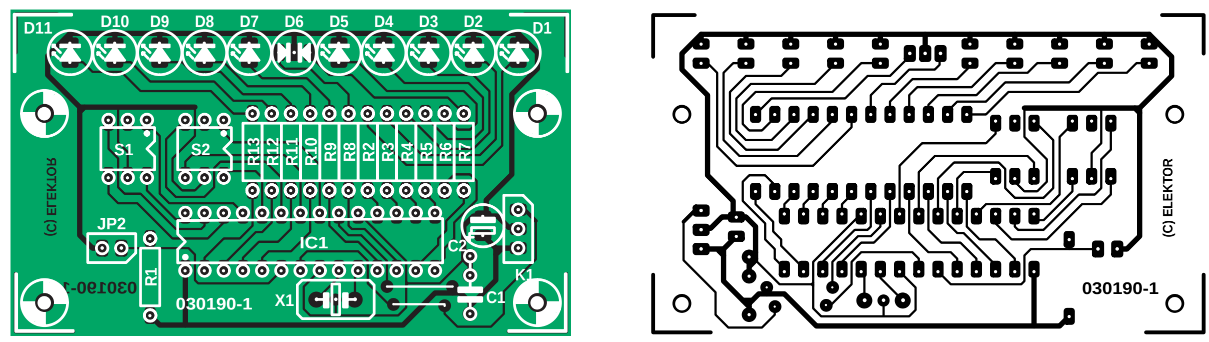


A printed circuit board layout is available for the digital section of the thermometer (see **Figure 2**). The two BCD switches are in 6-pin DIL packages and can easily be fitted in sockets so that they can protrude through the lid of an enclosure. If the microcontroller is also be fitted in a socket it may become necessary to stack two or more sockets for the switches. The LEDs are situated at the edge of the board so that their leads can be bent through 90 ° if desired. When the board is populated (not forgetting the wire links near the resonator!) and the soldering has been checked on both boards, JP2 can be fitted and the circuit can be tested.

During initialisation the microcontroller will run a power-on self test: the row of



2



COMPONENTS LIST

Resistors
R1 = 10kΩ
R2-R13 = 220Ω

Capacitors
C1 = 100nF
C2 = 10µF 16V radial

Semiconductors
D1-D5,D7-D11 = LED, 5mm
D6 = TwinLED (DuoLED) green/yellow
IC1 = PIC16F873-20/SP, programmed, order code **030190-41**

Miscellaneous
X1 = 8MHz ceramic resonator (3 pins)
S1,S2 = BCD complement switch (APEM PT65-702)

LEDs is lit in sequence from bottom to top. Each of the 23 possible display patters is shown for 100 ms. Finally the two-colour LED flashes yellow twice, and the unit starts to display the temperature.

Now switch off the power supply, remove JP1 on the digital board and set the BCD switches to the zero position. On the analogue board connect the LM35's ground to the amplifier input (JP1 in position 0). Apply power and adjust P1 until LED D11 lights; this corresponds to the lower limit of the temperature measurement range.

(030190-I)

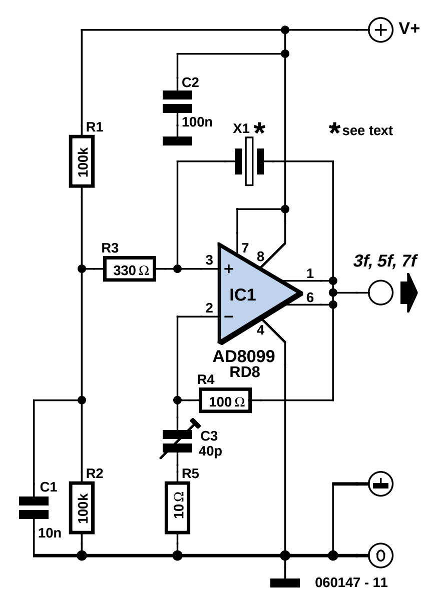
Harmonic Generator with Single Opamp

075

Gert Baars

Quartz crystals have the property that their amplitude/phase characteristic repeats itself at frequencies that are an uneven multiple of the fundamental frequency. There are so-called overtone crystals that are cut in such a manner that they possess this property to a greater extent. However, in principle, any crystal may be used on one or more of its harmonic frequencies. Harmonic generators based on transistors may operate satisfactorily on the 3rd harmonic, but if the 5th or 7th harmonic are wanted, the circuit becomes less reliable and requires frequent adjustment.

This circuit is based on a single, fast opamp and oscillates readily at the 3rd, 5th or 7th harmonic. The opamp is set up as a non-inverting amplifier with the quartz crystal connected between its output and the non-inverting input. The circuit amplification, which in principle must be unity to ensure oscillation, is determined by the network formed by R4, R5 and trimmer capacitor C3. This network is frequency-dependent such that the amplification increases as the frequency rises. The network gain is adjustable with C3. The setting of the capacitor must be such that the gain is too small for oscillation at the fundamental frequency, but sufficient for, say, the 5th or 7th harmonic.



The author uses a standard computer crystal of 10 MHz. Depending on the setting of C3, the circuit provides a stable output at frequencies between 50 and 70 MHz. It should be noted that these frequencies are multiples of the series fundamental frequency of the crystal.

Tuning is carried out simply with a

frequency counter. The output frequency is varied with C3. When the capacitor is roughly at the correct setting, the frequency 'locks' as it were at the harmonic. The area where locking occurs is not well-defined, however, so that the setting of C3 is not critical. When tuning is completed, the output frequency is crystal-stable.

In principle, the circuit may be used for frequencies of up to 100 MHz, when the values of R4 and R5 may need to be reduced. When a crystal with a higher fundamental frequency, say, 15 MHz, is used, the circuit may be tuned to the 3rd harmonic, that is, 45 MHz.

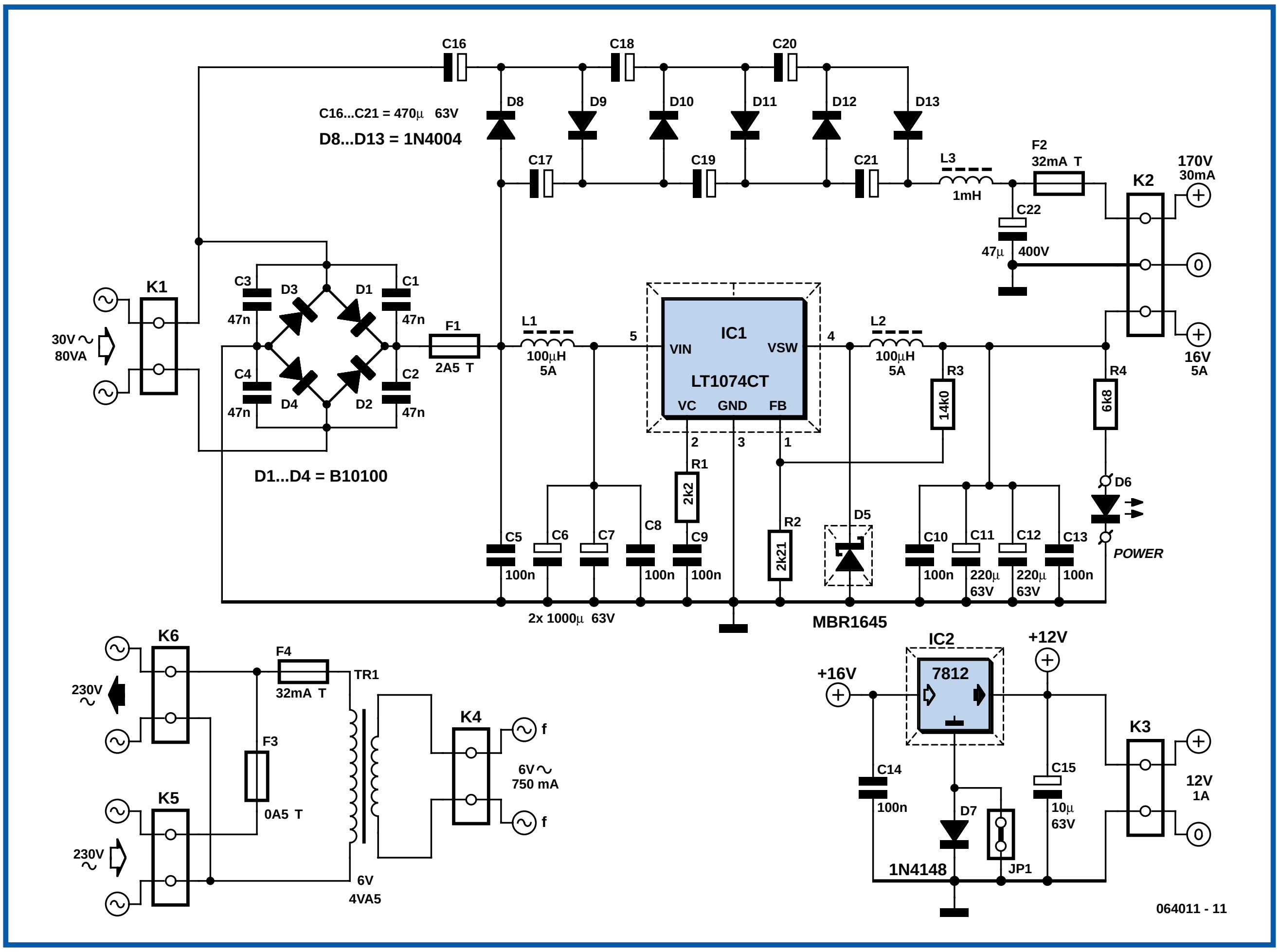
The circuit should be tested with a supply voltage of 5–9 V (the maximum supply voltage for the IC is 12 V).

The peak to peak output voltage has a value of about that of the supply voltage less a few volts. The output can provide a current sufficient to drive relatively low-impedance loads.

(060147-1)

076

Quad Power Supply for Hybrid Amp



Ton Giesberts

This power supply was designed for use with the 'Simple hybrid amp' published elsewhere in this issue. It is of course suitable for use in other applications as well.

We've used a cascade generator for the 170 V, a switch mode supply for the 16 V, a series regulator for the 12 V and a separate transformer for the 6.3 V filament supply.

We've chosen an LT1074CT (IC1) for the regulator, which means that the circuit can be built with relatively standard components and will have a high efficiency. The power loss is less with this device compared to a linear voltage regulator. This allows us to use a higher transformer voltage and a smaller cascade section to generate the 170 V (which is required for the SRPP stage in the amplifier). The lower input current also results in smaller losses in the bridge rectifier (D1 to D4).

A standard 12 V regulator (IC2) turns the 16 V into a stabilised voltage for the buffer stage.

When an ECC83 (12AX7) is used in the hybrid amp we could use this 12 V to power the filaments in the valve as well, although we really need 12.6 V. The current taken by the valve is about 150 mA, which means that the 12 V regulator needs to be fitted with a heatsink. This can be a small version of an SK129 heatsink from Fischer (38.1 mm, 6.5 K/W). To increase the voltage by 0.6 V

we've added diode D7 to the ground connection of the regulator. If an output voltage of 12 V is required you should close JP1, which shorts D7.
IC1 and D5 require a little more cooling and for this the 63.5 mm version of the SK129 will suffice (4.5 K/W). Both components can be mounted on opposite sides of the heatsink. You have to make sure that they are electrically isolated from each other and the heatsink! You should take a look at the website of Linear Technology (www.linear.com) and take note of the layout recommendations regarding the use of an LT1074.
You can use standard chokes for L1 and L2, rated at 5 A. If you want to remove more of the residual 100 kHz switching frequency you could always add an extra LC filter at the output. The diodes in the bridge rectifier are B10100's. These are Schottky rectifiers, which have a low forward voltage drop (only 0.7 to 0.8 V at 10 A). We have chosen diodes with a reverse voltage rating of 100 V so we have the option of using an LT1074HVCT instead. This can work with an input voltage of up to 60 V, which means we could use a 40 V_{AC} transformer. The same cascade circuit can then easily generate 220 V_{DC}. The standard LT1074CT can cope with up to 45 V, so we're using IC1 fairly close to the limits of its specifications in this circuit.
A cascade circuit generates the HT supply for the valve. It would also have been possible to use a separate transformer with a bridge rectifier and smoothing capacitor to generate this voltage. But then we'd have to find a 4.5 VA transformer with a 40 V secondary and connect it the 'wrong' way round. As this isn't exactly a standard transformer we dropped that idea.
The source for the cascade generator is now an 80 VA transformer. The capacitors in the cascade circuit have higher values than are strictly necessary. This makes it easier to calculate the expected output voltage. In our case this is 4 x 30 x $\sqrt{2}$ V for the no-load voltage, which comes to nearly 170 V. L3 and C22 filter out any HF interference coming from IC1. When the cascade supplied 20 mA the output voltage dropped to 140 V. At heavier loads we recommend that you use a smaller cascade circuit and a higher transformer voltage (and also use an LT1074HVCT because of the higher input voltage).
The filament voltage for the valve is generated by a 4.5 VA transformer, which in practice had an output a bit above 6 V and therefore came closer to the required 6.3 V. Another solution is to use a special transformer or a stabilised 6.3V_{DC} supply. Any of these will work, so it's down to your own preference which of these you'll use.
It is in principle possible to use the supply for two channels. However, if you use the ECC88 in the amplifier you may find it's necessary to use a separate cascade generator for each channel.

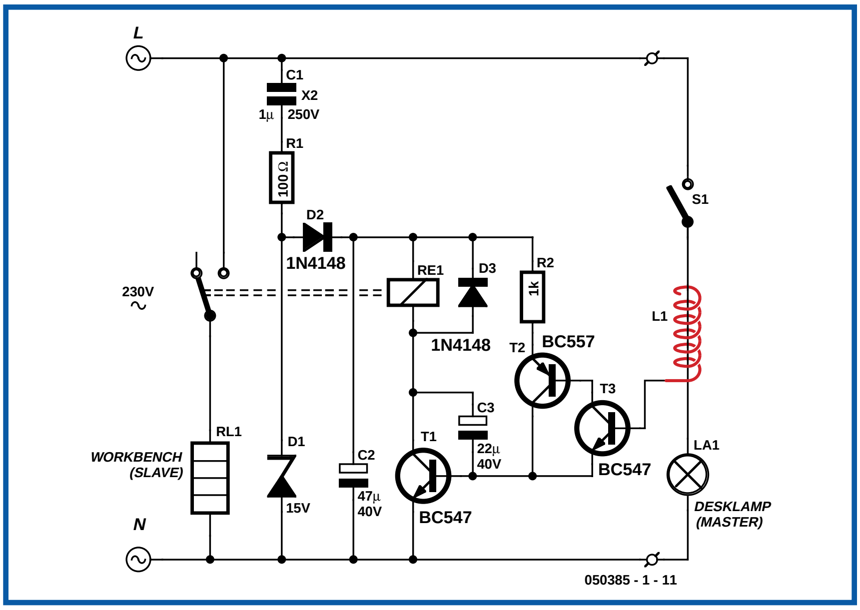
(064011)

Mains Slave Switcher I

077

Bart Trepak

There are many situations where two or more pieces of equipment are used together and to avoid having to switch each item on separately or risk the possibility of leaving one of them on when switching the rest off, a slave switch is often used. Applications which spring to mind are a computer/printer/scanner etc or audio amplifier/record deck/tuner combinations or perhaps closest to every electronics enthusiast's heart, the work bench where a bench power supply/oscilloscope/soldering iron etc are often required simultaneously. The last is perhaps a particularly good example as the soldering iron, often having no power indicator, is invariably left on after all the other items have been switched off. Obviously the simplest solution is to plug all of the items into one extension socket and switch this on and off at the mains socket but this is not always very convenient as the switch may be difficult to reach often being behind or under the work bench.



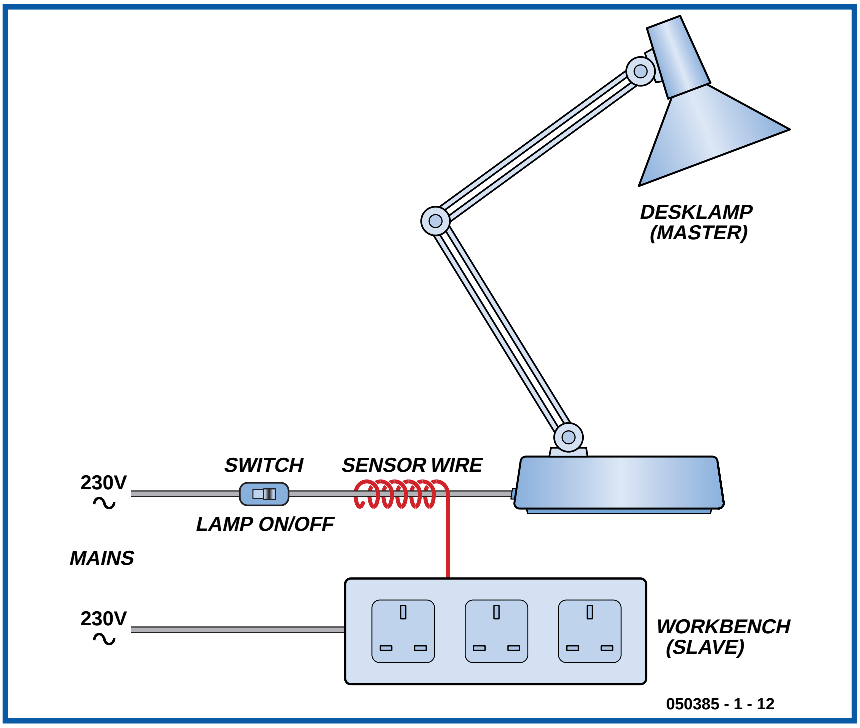
Slave switches normally sense the current drawn from the mains supply when the master unit is switched on by detecting the resulting voltage across a series resistor and switching on a relay to power the slave unit(s). This means that the Live or Neutral feed must be broken to allow the resistor to be inserted. This circuit, which is intended for switching power to a work bench when the bench light is switched on, avoids resistors or any modifications to the lamp or slave appliances by sensing the electric field around the lamp cable when this is switched on. The lamp

Warning

The circuit itself is not isolated from the mains supply so that great care should be taken in its construction and testing. The sensor wire must also be adequately insulated and the circuit enclosed in a box to make it inaccessible to fingers etc. when it is in use.

then also functions as a 'power on' indicator (albeit a very large one that cannot be ignored) that shows when all of the equipment on the bench is switched on.

The field, which appears around the lamp cable when the mains is connected, can be sensed by a short piece of insulated wire simply wrapped around it and this is amplified by the three stage amplifier which can be regarded as a single super-transistor with a very high gain. The extremely small a.c. base current results in an appreciable collector current which after smoothing (by C3) is used to switch on a relay to power the other sockets. Power for the relay is obtained from a capacitor 'mains dropper' that generates no heat and provides a d.c. supply of around 15 volts when the relay is off. The output current of this supply is limited so that the voltage drops substantially when the relay pulls in but since relays require more current to operate them than they do to remain energised, this is not a problem.



Since the transistor emitter is referenced to mains Neutral, it is the field around the mains Live which will be detected. Consequently, for correct operation the Live wire to the lamp must be switched and this will no doubt be the case in all lamps where the switch is factory fitted. In case of uncertainty, a double-pole switch to interrupt both the Live and Neutral should be used. The sensitivity of the circuit can be increased or decreased as required by altering the value of the T2 emitter resistor. The sensing wire must of course be wrapped around a section of the lamp lead **after** the switch otherwise the relay will remain energised even when the lamp has been switched off.

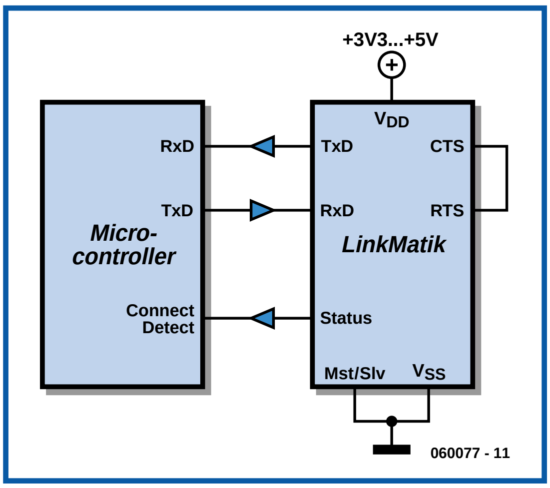
The drawing shows the general idea with the circuit built into the extension socket although, depending on the space available an auxiliary plastic box may need to be used.

(050385-1)

078 Serial to Bluetooth

Richard Hoptroff

When computer makers switched from RS232 to USB, one of the collateral benefits was TTL compatibility with regard to the supply voltage as well as signal levels. Unfortunately, there was also collateral damage, primarily in the form of an enormous increase in the complexity of the data transmission process. All you need for connection to an RS232 serial port is a level converter, but USB requires an extra IC (such as the Cypress CY7C68000 or a special-purpose microcontroller, such as the PIC18F4550) to make data transmission possible. That sounds like a zero-sum game, which raises the question: if you already have to use an extra IC, why not go directly to Bluetooth? And in fact, there are already several Bluetooth modules available, complete with an integrated antenna and simple serial inputs and outputs. However, many of them have the disadvantage that they are controlled using AT commands, which makes it necessary to use an additional controller.



However, there are also autonomous models available, such as the new LinkMatik module (www.flexipanel.com). If its Mst/Slv pin is held low, it waits until something wants to connect to it. If the pin is high, the module actively searches for devices that are ready to establish a connection. That means you can set up a short-range radio link without using a computer by simply coupling two modules together. However, generally speaking you will probably want to control an external device from a PC. In that case, you can let your PC search for devices that are ready to establish a connection. When the PC finds a module, it lists its available services.

The service known as 'Serial Port Profile' (SPP) is the appropriate service of the LinkMatik module. If the security function is enabled, you will have to enter the PIN code of the module (set to '0000' when first delivered). Once a connection has been established, the Status pin of the module goes to a high level to indicate that it is ready for bidirectional data transmission. Now you can simply use the familiar TxD and RxD lines to transmit serial data. The RTS and CTS lines are also available for controlling the data flow. If you do not need that function, you can simply connect these two lines together. However, this wireless serial interface does not allow you to use these lines for purposes other than their intended use, as is often done with 'normal' serial interfaces.

As the data is buffered in the module before and after wireless transmission, RTS and CTS are generated locally. These two signals only control data flow to or from the module, but not over the wireless link.

It is generally not possible to have more than one serial link via Bluetooth per PC. However, Bluetooth-2.0 compatible modules have recently become available, and they allow up to four serial links to be used concurrently along with other functions.

(060077-1)

Thunderstorm Predictor

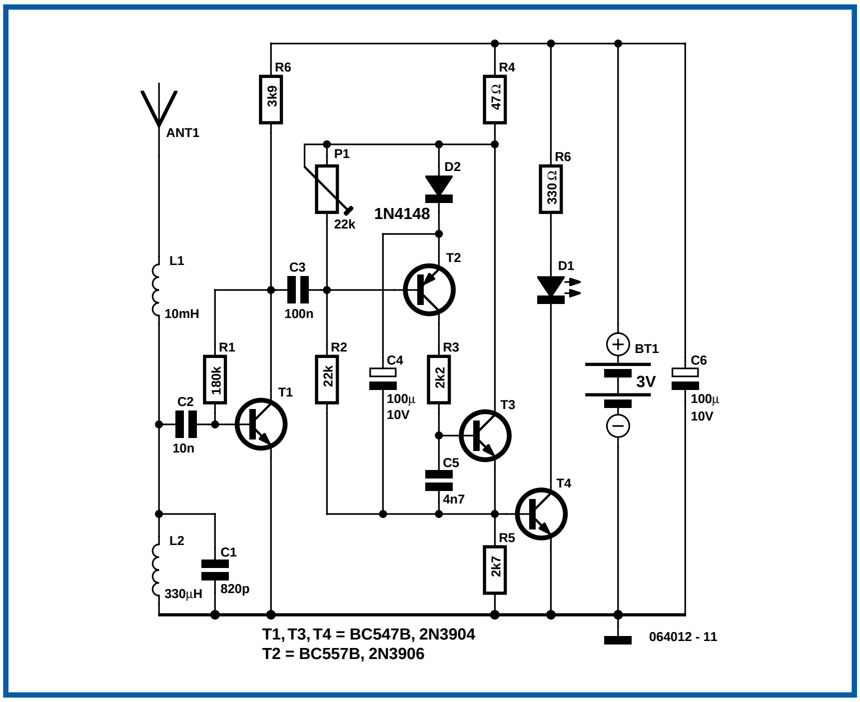
079

Karel Walraven

Sure, listening to VHF FM has great advantages over MW/LW AM from the old days — now we have bright stereo free from interference, fading and noise! However, your FM radio will no longer predict the arrival of a thunderstorm as did the AM radio many years ago — reliably and hours before the trouble was upon you! The crux is that AM detection will faithfully reproduce the effects of lightning and other massive static discharges approaching in a very simple way: they're audible as slight crackling noises in the loudspeaker, almost irrespective of the tuning of the radio!

Assuming no AM radio is available anymore, a dedicated VLF receiver tuned to about 300 kHz can faithfully detect the crackle of approaching lightning. The simple receiver shown here consists of a loosely tuned amplifier driving a kind of flasher circuit that blinks an LED in synchronicity with the lightning bolts. The frequency and intensity of the LED activity indicates the intensity and distance of the storm respectively.

Looking at the circuit diagram, the LED driver is not biased to flash until a burst of RF energy, amplified by T1, arrives at the base of T2. The receiver works off 3 volts and has a negligible standby current of about 350 microamperes which will hardly dent the shelf life of a couple of 1.5-V D-size cells. T2 and T3 form a monostable generator triggered by sudden drops in T1's collector voltage. Preset P1 is adjusted until the LED remains off when you're sure there's no thunderstorm around for a few hundred miles. The value of the LED series resistor is subject to experimentation and LED current. L2, C1 and the antenna are coarsely tuned for resonance at about 300 kHz. Frequency-wise, lightning is a fairly broadband phenomenon so any tuning to between 200 and 400 kHz will be fine for the circuit but make sure you're not accidentally tuned to a nearby VLF transmitter! The input signal is obtained from a 70-cm long piece of stiff wire, with coil L1 inserted for impedance matching and lengthening the antenna electrically.



Warning

This circuit and in particular the antenna must not be used to attract lightning. Consequently, neither the circuit nor the antenna may be used outdoors and/or powered from the mains.

(064012-1)

080

Active Antenna

Stefan Delleman

Short-wave listeners often are not able to, or allowed to, install a long-wire antenna or other large dimension antenna in or around the home. In such cases, the present active antenna, intended for the frequency range 3–30 MHz, may be found useful. The author used a 1-metre long rod or brass tube with a diameter of 2–6 mm.

The circuit consists of two parts, one to be located close to the antenna, while the other should be placed in the associated power supply of the receiver. The two sections may be connected by a coaxial cable of up to 20 m long without causing any discernible attenuation.

The antenna signal is pre-amplified by a two-stage combination, T1-T3. The main amplification is provided by the input transformer, formed by L3, L4, and L5, in the receiver section. This is followed by a switch that enables the frequency range to be selected (3–10 MHz in position LOW, and 9–30 MHz in position HIGH). The signal strength may be adjusted to suit the receiver with potentiometer P1.

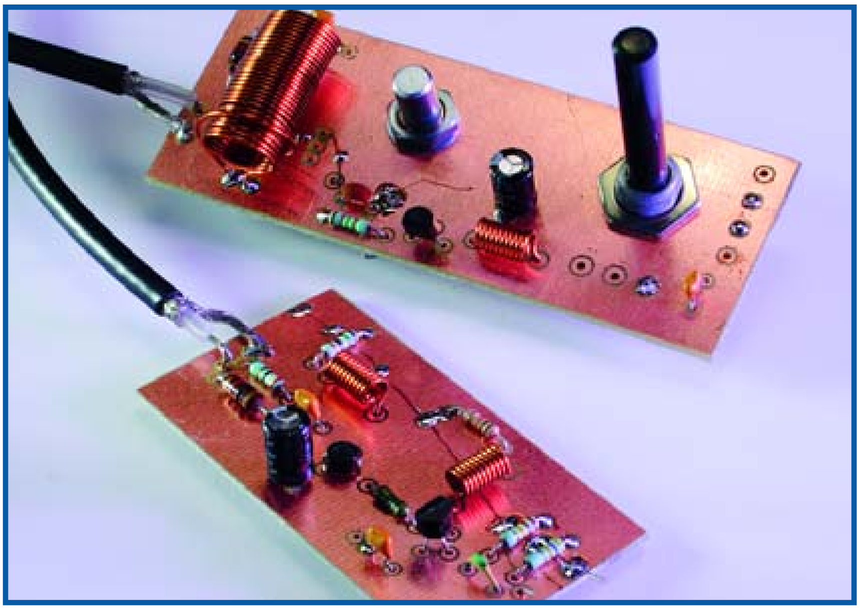
The active antenna is readily constructed with the aid of the two printed circuit boards shown.

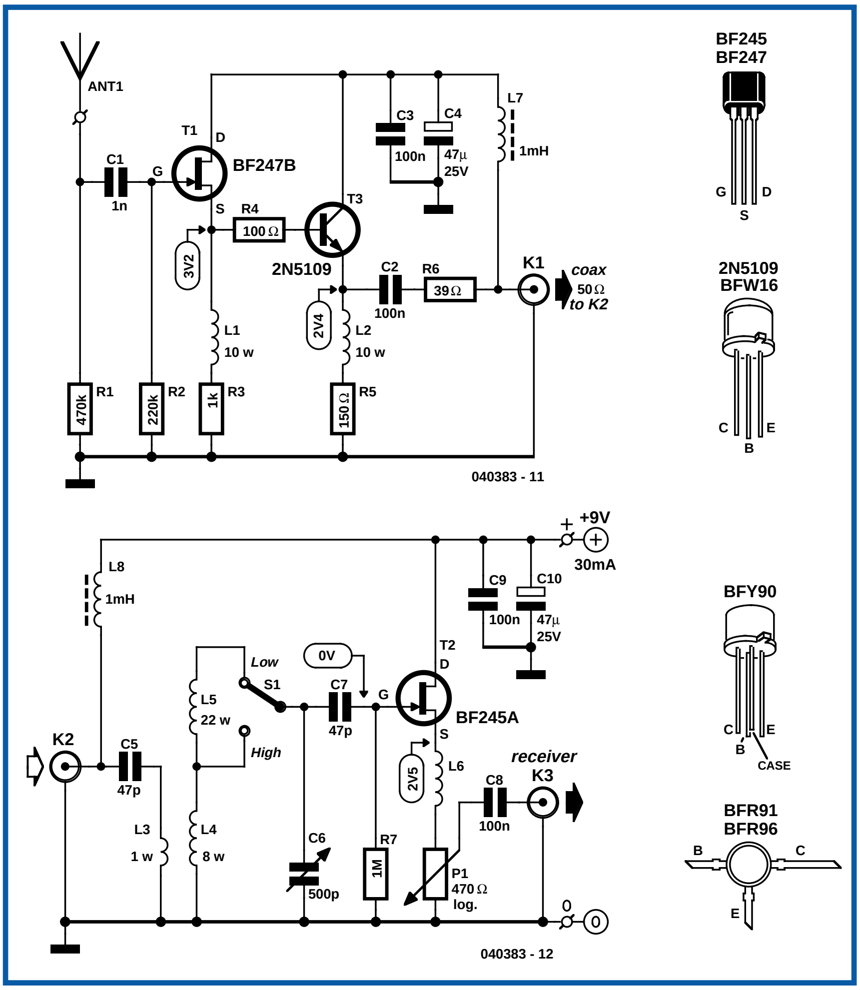
Since we are concerned with only relatively low radio frequencies, the choice of components is not too crucial. Various types of FET may be used: BF245, BF246, BF256, or the SMD variants of these, but do mind their connections! The same applies for the transistors: BFW16, BFY90, BFR91, BFR96; any of these will do.

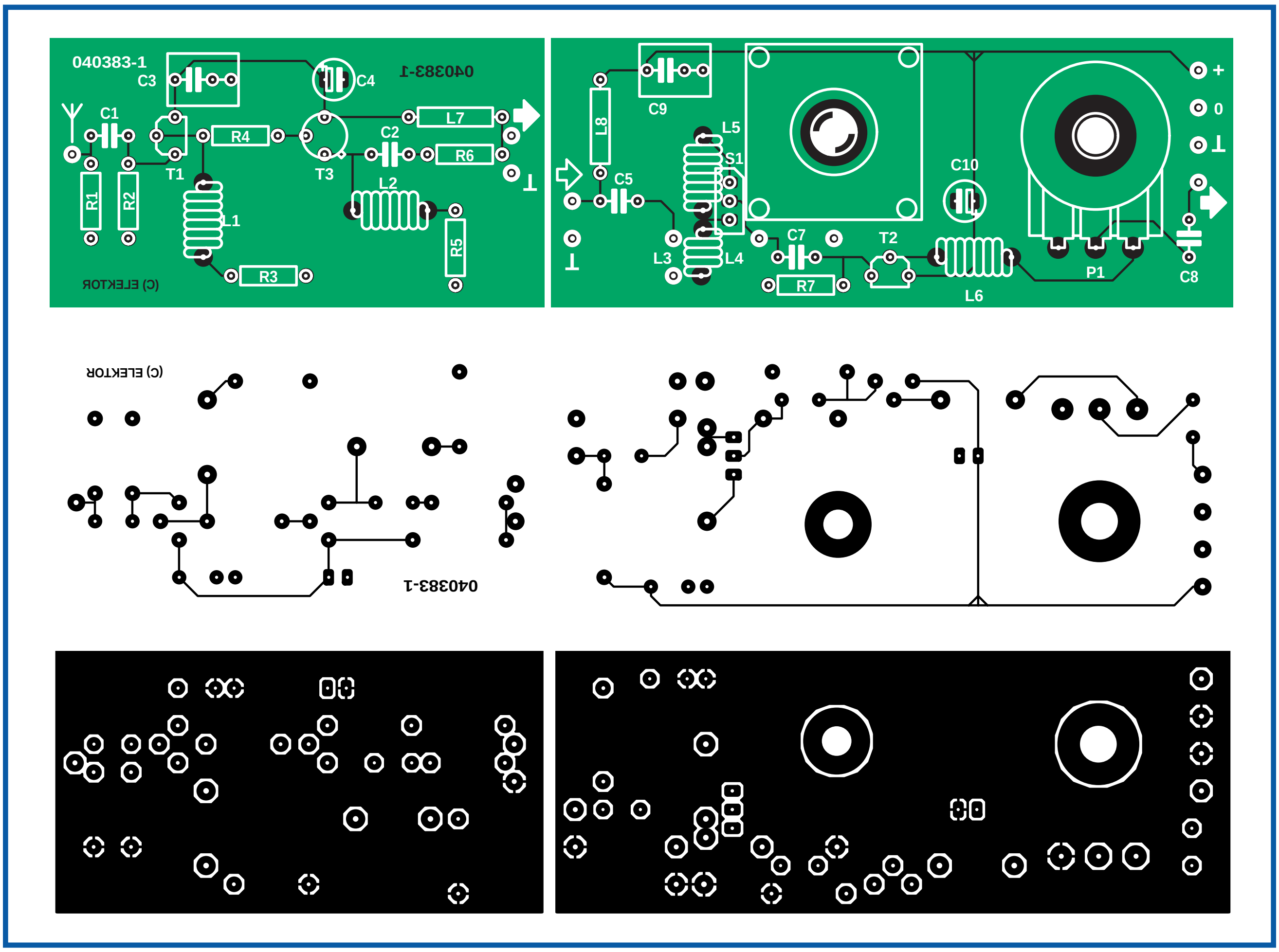
A few hints for readers who conduct their own experiments. A lower value of capacitor C1 results in a somewhat looser coupling to the antenna, but also in lower signal strength. It may be worthwhile to replace the capacitor with a variable type. Inductor L6 ensures that the output voltage at higher frequencies (30 MHz) is not much higher than at lower frequencies (3 MHz). This is because the Q factor of coils L4 and L5 increases at higher frequencies, which leads to higher amplitudes. This is compensated by L6. This inductor may be omitted and replaced by a wire bridge, but then the output voltages at higher frequencies increases.

Aim at obtaining as tight a coupling as feasible between L4 and L5. Because of this, it is better to wind the two coils as one, that is, 30 turns with a tap than to wind two separate coils (see photograph).

(040383-1)







COMPONENTS LIST

Resistors
R1 = 470kΩ
R2 = 220kΩ
R3 = 1kΩ
R4 = 100Ω
R5 = 150Ω
R6 = 39Ω
R7 = 1MΩ
P1= 470Ω logarithmic

Capacitors
C1 = 1nF
C2,C3,C8,C9 = 100nF
C4,C10 = 47µF 25V radial
C5,C7 = 47pF
C6 = 500pF tuning capacitor

Inductors
L1,L2,L6 = 10 turns 0.7mm ECW, 4mm diameter (wind on 3.5mm drill bit)
L3 = 1 turn 0.7mm ECW, around L4
L4 = 8 turns 0.7mm ECW, 12mm diameter (wind on 10 mm drill bit)
L5 = 22 turns 0.7mm ECW, 12mm diameter (wind on 10mm drill bit)
L7,L8 = 1mH miniature choke

Semiconductors
T1 = BF247B
T2 = BF245A
T3 = 2N5109

Miscellaneous
PCB, ref. 040383-1 from The PCBShop

Alternative Halogen Supply

081

Stijn Coenen

Readers who do not care to modify the power supply of an old PC into a suitable halogen power source (see our April 2006 issue), may find the present design a welcome alternative.
The circuit does not need any changes to the power supply. It allows the halogen lamps to be initially powered from the 5-V rail of the supply via RE2, so that they are preheated. Subsequently, they are powered from the 12-V rail via RE1, while at the same time the 5-V rail is disconnected. This ensures that the current surge through the lamps is so small that the protection in the power supply does not react.

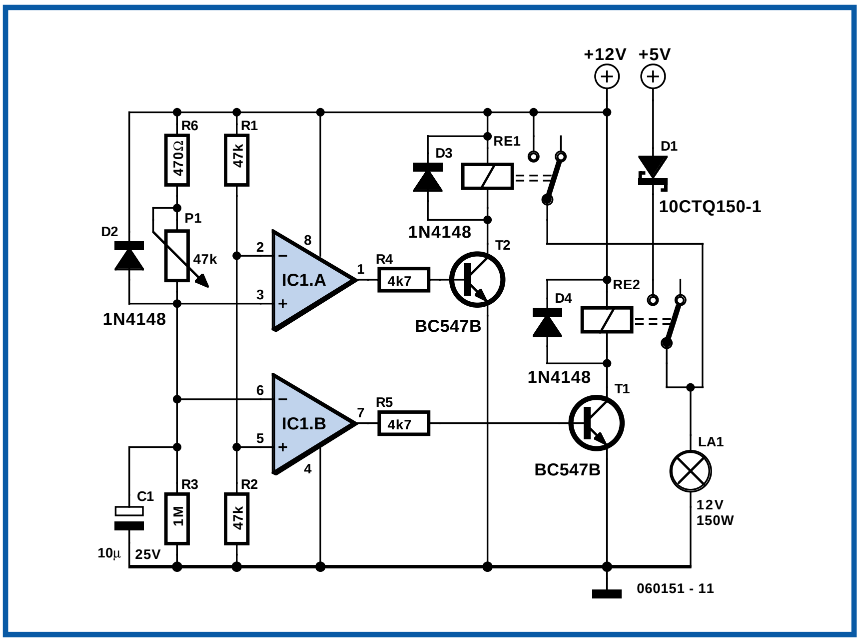
Operation of the circuit is as follows. As soon as the PC supply provides power, IC1.B drives T1 into conduction and RE2 closes. The potential at the non-inverting input of IC1.B is 6 V, while that at the inverting input rises from 0 V. Lamp LA1 is then connected to the 5-V rail.
After a short span of time, the voltage across C1 has risen to a value where

IC1.B changes over, whereupon T1 is cut off. At the same time, IC1.A drives T2 into conduction. The circuit is then decoupled from the 5-V rail and connected to the 12-V terminal. The 5-V rail in the PC power supply is protected against spikes on the 12-V line by D1.

Diode D2 protects IC1 against over-voltage on its inputs should the 12-V rail fail. Resistors R4 and R5 limit the base currents of the transistors. D3 and D4 are quenching diodes.

The time during which lamp LA1 is powered by 5 V is preset with potentiometer P1. The maximum time span is about 0.33 s and the minimum 3.3 ms. The latter is perhaps rather short, but it also depends to some extent on the type of power supply used. Some experimentation may be worthwhile!

(060151-1)



082

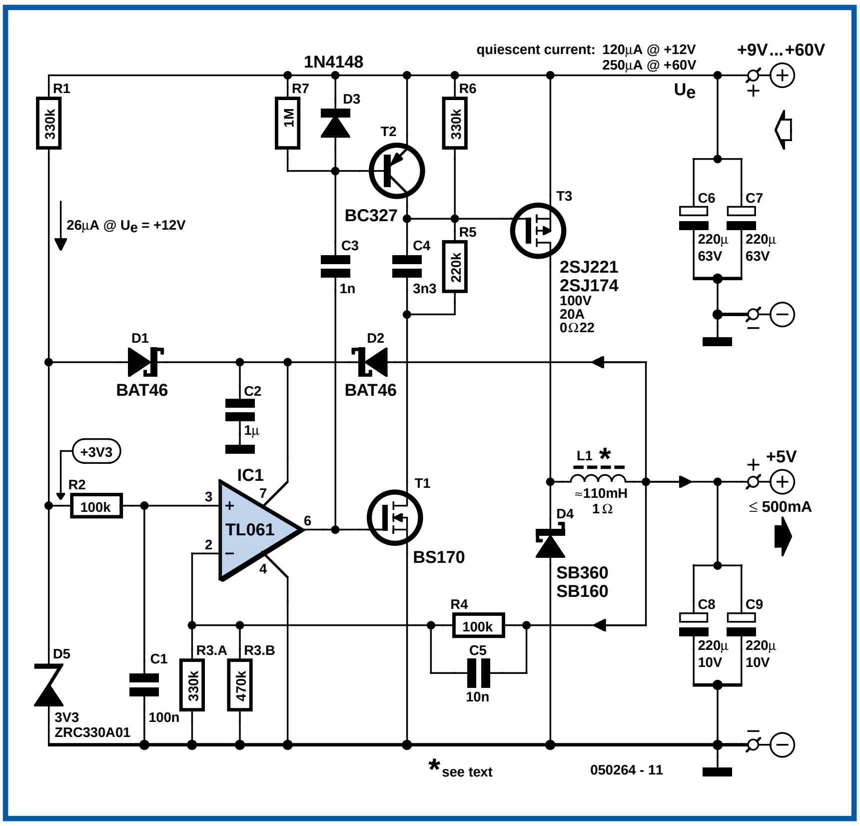
Low Loss Step Down Converter

Michel Franke

This circuit arose from the need of the author to provide a 5 V output from the 24 V battery of a solar powered generator. Although solar power is essentially free it is important not to be wasteful especially for small installations; if the battery runs flat at midnight you've got a long wait before the sun comes up again. The basic requirement was to make an efficient step-down converter to power low voltage equipment; the final design shown here accepts a wide input voltage from 9 to 60 V with an output current of 500 mA. The efficiency is very good even with a load of 1 mA the design is still better than a standard linear regulator. The low quiescent current (200 µA) also plays a part in reducing losses.

Some of the components specified (particularly the power MOSFET) are not the most economical on the market but they have been deliberately selected with efficiency in mind.

When power is applied to the circuit a reference voltage is produced on one side of R2. D1 connects this to the supply (pin 7) of IC1 to provide power at start-up. Once the circuit begins switching and the output voltage rises to 5 V, D2 becomes forward biased and powers the IC from the output. Diode D1 becomes reverse biased reducing current through R1. When the circuit is first powered up the voltage on pin 2 of IC1 is below the reference voltage on pin 3, this produces a high level on output pin 6. The low power MOSFET T1 is switched on which in turn switches the



power MOSFET T3 via R5 and the speed-up capacitor C4, the output voltage starts to rise.
When the output approaches 5 V the voltage fed back to the inverting input of IC1 becomes positive with respect to the non inverting input (reference) and switches the output of IC1 low. T1 and T3 now switch off and C3 transfers this negative going edge to the base of T2 which conducts and effectively shorts out the gate capacitance of T3 thereby improving its switch off time.
The switching frequency is not governed by a fixed clock signal but instead by the load current; with no load attached the circuit oscillates at about 40 Hz while at 500 mA it runs at approximately 5 kHz. The variable clock rate dictates that the output inductor L1 needs to have the relatively high value of 100 mH.
The coil can be wound on ferrite core material with a high AL value to allow the smallest number of turns and produce the lowest possible resistance. Ready-made coils of this value often have a resistance greater than 1 Ω and these would only be suitable for an output load current of less than 100 mA.
The voltage divider ratio formed by R4 and R3 sets the output voltage and these values can be changed if a different output voltage is required. The output voltage must be a minimum of 1 V below the input voltage and the output has a minimum value of 4 V because of the supply to IC1.
A maximum efficiency of around 90 % was achieved with this circuit using an input voltage between 9 and 15 V and supplying a current greater than 5 mA, even with an input voltage of 30 V the circuit efficiency was around 80 %. If the circuit is used with a relatively low input voltage efficiency gains can be made by replacing D4 with a similar device with a lower reverse breakdown voltage rating, these devices tend to have a smaller forward voltage drop which reduces losses in the diode at high currents. At higher input voltage levels the value of resistor R1 can be increased proportionally to reduce the quiescent current even further.

(050264-1)

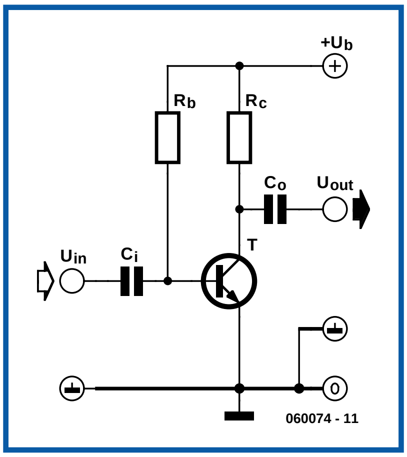
10,000x with One Transistor

083

Gert Baars

For a collector follower with emitter resistor, you'll often find that the gain per stage is no more than 10 to 50 times. The gain increases when the emitter resistor is omitted. Unfortunately, the distortion also increases.

With a ubiquitous transistor such as the BC547B, the gain of the transistor is roughly equal to 40 times the collector current (I_c), provided the collector current is less than a few milliamps. This value is in theory equal to the expression q/KT, where q is the charge of the electron, K is Boltzmann's constant and T is the temperature in Kelvin. For simplicity, and assuming room temperature, we round this value to 40.
For a single stage amplifier circuit with grounded emitter it holds that the gain U_{out}/U_{in} (for AC voltage) is in theory equal to SR_c. As we observed before, the slope S is about $40I_c$. From this follows that the gain is approximately equal to $40I_cR_c$.
What does this mean? In the first instance this leads to a very practical rule of thumb: that gain of a grounded emitter circuit amounts to $40 \cdot I_c \cdot Rc$, which is equal to 40 times the voltage across the collector resistor. If U_b is, for example, equal to 12 V and the collector is set to 5 V, then we know, irrespective of the values of the resistors that the gain will be about 40?(12–5) = 280.



Notable is the fact that in this way the gain can be very high in theory, by selecting a high power supply voltage. Such a voltage could be obtained from an isolating transformer from the mains. An isolating transformer can be made by connecting the secondaries of two transformers together, which results in a galvanically isolated mains voltage. That means, that with a mains voltage of 240 V_{eff} there will be about 340 V DC after rectification and filtering. If in the amplifier circuit the power supply voltage is now 340 V and the collector voltage is 2 V, then the gain is in theory equal to 40 x (340–2). This is more than 13,500 times!
However, there are a few drawbacks in practice. This is related to the output characteristic of the transistor. In practice, it turns out that the transistor does actually have an output resistor between collector and emitter. This output resistance exists as a transistor parameter and is called 'h_{oe}'. In normal designs this parameter is of no consequence because it has no noticeable effect if the collector resistor is not large. When powering the amplifier from 340 V and setting the collector current to 1 mA, the collector resistor will have a value of 338 kΩ. Whether the 'h_{oe}'-parameter has any influence depends in the type of transistor.
We also note that with such high gains, the base-collector capacitance in particular will start to play a role. As a consequence the input frequency may not be too high. For a higher bandwidth we will have to use a transistor with small C_{bc}, such as a BF494 or perhaps even an SHF transistor such as a BFR91A. We will have to adjust the value of the base resistor to the new h_{fe}.
The author has carried out measurements with a BC547B at a power supply voltage of 30 V. A value of 2 V was chosen for the collector voltage. Measurements confirm the rule of thumb. The gain was more than 1,000 times and the effects of 'h_{oe}' and the base-collector capacitance were not noticeable because of the now much smaller collector resistor.

(060074-1)

084

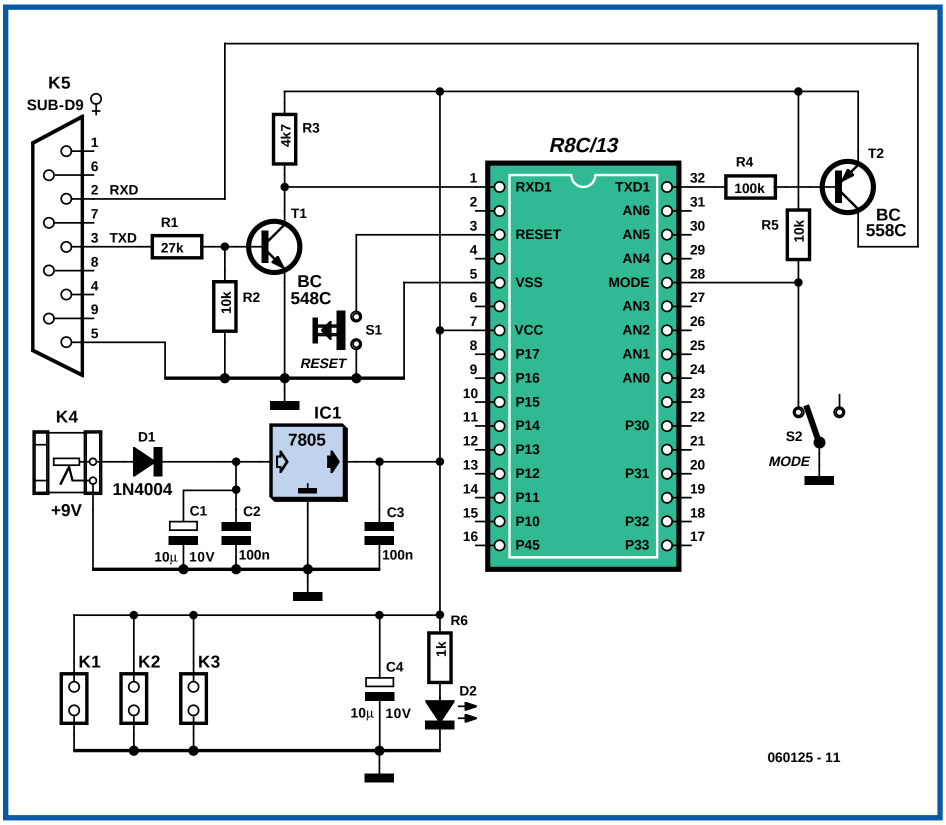
Programmer Board for the R8C/13

Jean Brunet

This board is a spin-off of the 10-pound 'R8C Tom Thumb' project published in the February 2006 issue of *Elektor Electronics*.

The author has added an LED behind the 5-V regulator and three small connectors (ground (0V); +5 V on the bottom left) to supply power to potential daughterboards. Connectors are linked to the R8C/13 output ports.

The layout of components has been selected in order to ensure easy manipulation. The connections are arranged in the upper area of the board, while the Reset button and Mode switch are found in the lower area. Enough space has been left at around module board so that it is easier to extract it without a special tool.



Following the advice of specialists on Elektor's R8C Forum, the author opted for a 7805 regulator.

The BC558C transistor (upper right) is shifted to the right so as not to complicate handling the R8C/13 Tom Thumb module. In this way, it's easy to install the module on the carrier board, as well as to remove it.

Installation of components

The component type codes and characteristics can be found in the component list; a glance at the photo lets you identify everything, as does the overlay for the components, on the other page.

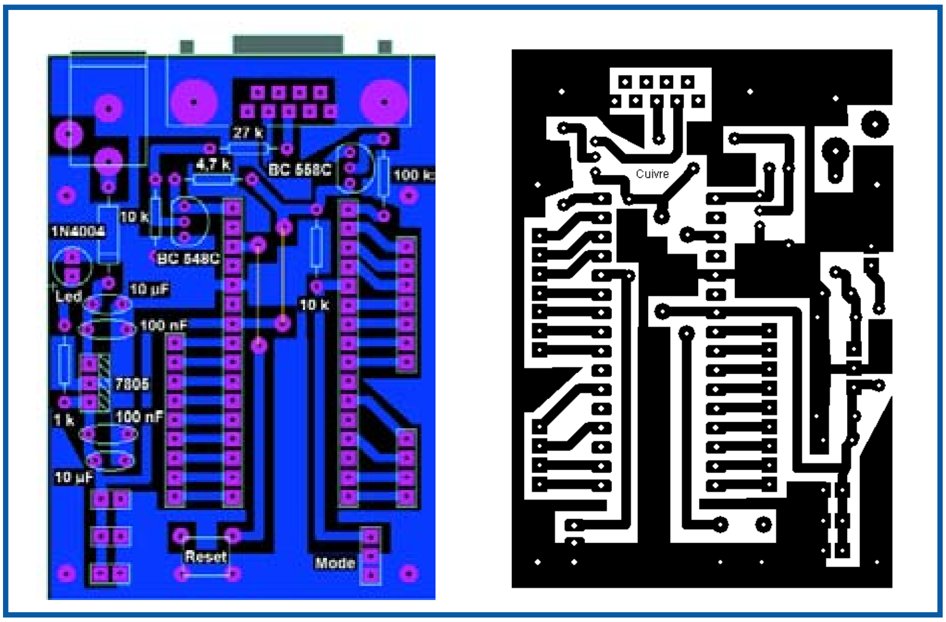
Do not forget to install the wire links and resistor R5 between the links for the R8C module before plugging in the latter.

The reset pushbutton is found on the bottom, slightly shifted to the left, and the programming switch is found on the right.

Pay attention to the direction of the switch. It is more practical for the off position to be directed toward the bottom. A test with a simple ohmmeter will help avoid an error in direction. Do the same verification for the reset button. Test and verify that it is actually open when in rest position before soldering it in the correct direction.

Connectors linked to the R8C module are male but there is nothing to stop you from using female connectors, even though the male connectors seem to be sturdier. For the Tom Thumb module, use IC socket strip that can be sectioned.

The component overlay and other PCB artwork (Proteus format) are available on



the author's web page devoted to this project. Lots of other information on the project may be found on the R8C Service Page at

www.elektor-electronics.co.uk/Default.aspx?tabid=110

There the artwork is reproduced in a slightly different form from what you are used to, but it works very well for making your own board. The dimensions of the PCB are 51 x 71.5 mm.

In the file download, this diagram is a mirror image so that the ink comes into contact with the copper, which is preferable during UV illumination. If you are using the diagram printed in the magazine, you should mirror it to obtain the same result.

The author uses an inkjet printer and stacks three transparencies.

To utilise this board, all you need to do is insert the R8C/13 module in its socket, making sure the quartz crystal is turned toward the RS-232 base, as in the photo. Connect the RS-232 cable to the computer and then apply the supply voltage (adaptor supplying between 9 and 12 V).

Testing the board

To test the board, load the program *toggle_all.mot* or compile the program below, whose purpose is to make all of the R8C/13 ports blink.

Now you are fully equipped to better discover the possibilities of the R8C/13 module and to conjure up super applications from this minimal configuration.

Programming

To program the module, all you need to do is to move switch S2 toward the bottom and press the pushbutton to reset the module. Start the FDT Simple interface. In the menu, as an option, check *Autodisconnect* and *Erase device before program*.

Load *toggle_all.mot* and click on *program flash*.

After confirming programming, move the Mode switch up and press S1 (reset).

With the help of an LED and a 1-kΩ resistor in series, verify the operation of the R8C outputs one by one. If one of them does not produce LED flashing, you should verify the soldering.

The author, who contributed to a series of pages in the R8C section on the French Elektor site, has his own website at the following address:

http://perso.wanadoo.fr/asnora/R8C/platine_de_programmation.htm

(060125-1)

COMPONENTS LIST

Resistors

R1 = 27kΩ
R2,R5 = 10kΩ
R3 = 4kΩ7
R4 = 100kΩ
R6 = 1kΩ

Capacitors

C1,C4 = 10µF/10V
C23,C3 = 100nF

Semiconductors

D1 = 1N4004
D2 = LED, red, dia. 3mm or 5 mm
T1 = BC548C
T2 = BC558C
IC1 = 7805

Miscellaneous

S1 = pushbutton (reset)
S2 = slide switch, lead pitch 2.5 mm (programming)
K1,K2,K3 = 2-way pinheader
K4 = mains adaptor socket
K5 = 9-way sub-D socket (female), PCB mount
2 lengths of 16-way IC socket strip (for R8C module socket)

Program listing: toggle_all.mot

```
#include "sfr_r813.h"

long t;

void main(void)
{
/*————————————————————————————-
- Change on-chip oscillator clock to Main clock -
—————————————————————————————-*/

prc0 = 1;               /* Protect off */
cm13 = 1;             /* Xin Xout */
cm15 = 1;             /* XCIN-XCOUT drive capacity select bit
: HIGH */
cm05 = 0;             /* Xin on */
cm16 = 0;             /* Main clock = No division mode */
cm17 = 0;
cm06 = 0;             /* CM16 and CM17 enable */
asm("nop");           /* Waiting for oscillator to stabilise
*/
asm("nop");
asm("nop");
asm("nop");
ocd2 = 0;             /* Main clock change */
prc0 = 0;              /* Protect on */

prc2 = 1;             /* Protect off  to write on pd0 */
pd0 = 0xFE;    /* bits 1 à 7 sur p0. an0 = p0_7, an1 = p0_6
... an6 = p0_1. p0_0 is not present in the device.
pd1 = 0xFF;      /* Set Ports be used for output*/
pd3 = 0x0F;    /* just p3_0 ... p3_3
pd4 = 0x20;    /* just p4_5

while (1)       /* Loop */
  {
  p0 = 0xFE;
  p1 = 0xFF;
  p3 = 0x0F;
  p4_5 = 0x01;
  for (t=0; t<50000; t++);
  p0 = 0x00;
  p1 = 0x00;
  p3 = 0x00;
  p4_5 = 0x00;
  for (t=0; t<50000; t++);
  }
}
```

085 Intelligent Interface for 1 to 8 Servos

Christian Tavernier

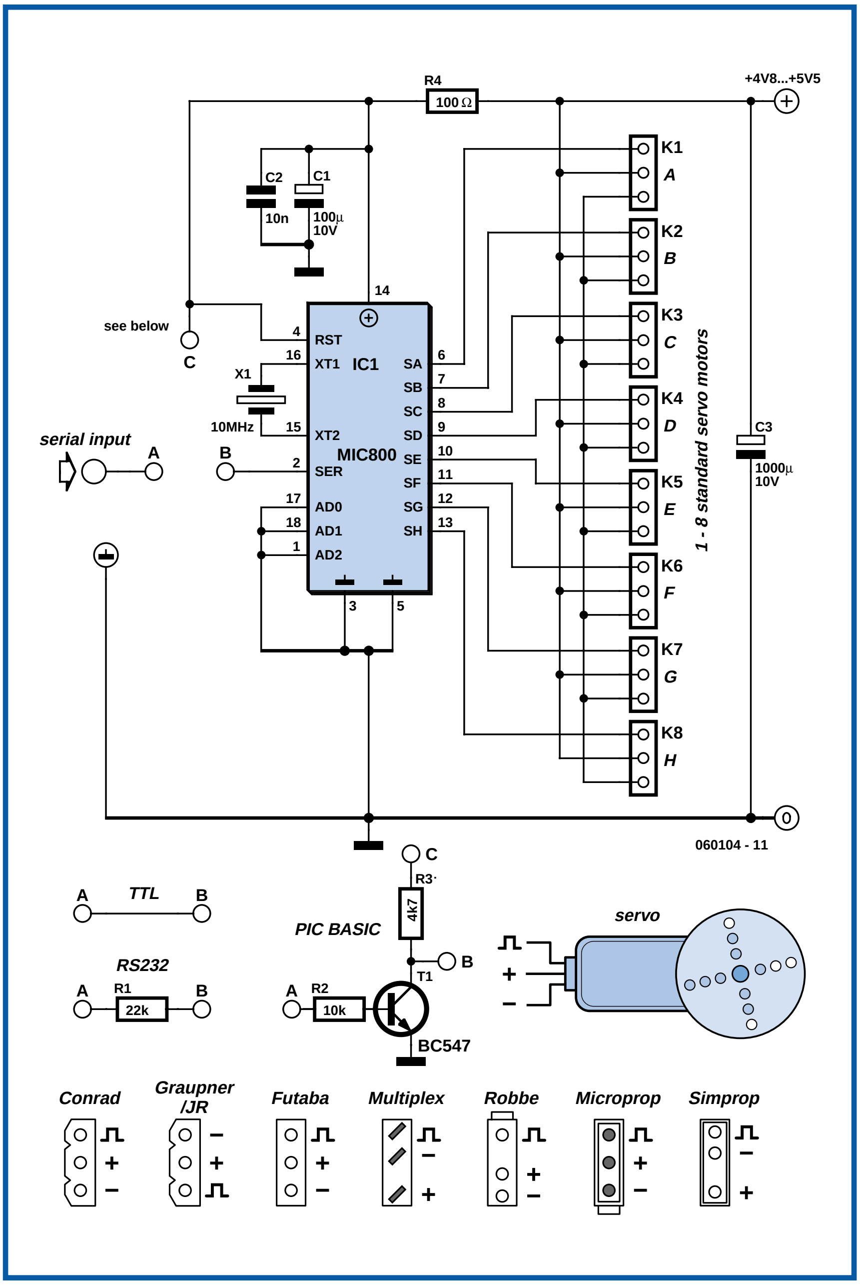
Today, radio-controlled (RC) servos are very common in robotics and there are often many present in one robot. In general, a hexapod utilizes at least three servos, while a simple arm can use between six or seven of them. If the control of such servos remains theoretically easy to produce with a microcontroller, having several within the same robot causes the microcontroller to overload very quickly, spending more time in the end managing servos than doing the calculations necessary to properly operate the robot. In fact, we should remember that a radio control servo is operated with pulses whose width varies from 1 to 2 ms and defines its position. The problem is that these pulses must be repeated at least every 20 ms if we want the servo to stay in position. It is precisely this repetition, multiplied by the number of servos being controlled, that ends up overloading the microcontroller that controls them.

Therefore, we propose a fix for this problem using a specialised circuit capable of controlling one to eight standard radio control servos via very simple controls transmitted by a common asynchronous serial connection. We are referring to the MIC800 from Mictronics (www.mictronics.com). The application schematics could not be simpler.

Not counting a simple quartz crystal (X1) and the usual loading capacitors (C1 and C2), the circuit is directly connected to 1-8 servos it will control. Concerning the serial connection, three different possibilities are offered, depending on what's connected to points A and B are in the diagram:

- one direct connection when there is a TTL control signal from a microcontroller with a UART and capable of supplying serial signals in inverse logic (one Basic Stamp, for example);
- one 22 kΩ resistor, if there is a serial connection with true RS-232 levels;
- one transistor with inverted wiring in the case of TTL control by a microcontroller having a UART, but unable to provide serial signals in inverse logic (PICBasic, for example).

In fact, the MIC800 was designed in order to be directly controlled by any true serial RS232 connection. It thus accepts



input signals in negative logic (a logic 1 corresponding to a Low level and vice versa). In the case of a direct TTL connection, and depending on the possibilities of the UART contained in the related microcontroller, it is sometimes impossible to generate such signals. Therefore, we must should an inverter transistor.

Dialogue with the MIC800 occurs at 2,400 baud on 8 data bits, without parity. The syntax of the commands to be sent for controlling the servos is extremely simple and is composed of the next group of coded characters in ASCII *m n xxx* where:

- *m* is a letter included between S and Z which corresponds to the MIC800 address. In fact, if you consult the datasheet available on the Mictronics site (www.mictronics.com), you'll soon notice that you can place up to eight MIC800s on a single serial connector and control up to 64 servos in this way. This option is not utilized here and the address is set to S using pin grounding AD0 to AD2.
- *n* stands for a letter between A and H indicating the servo to control in compliance with the marks, as indicated in our

drawing at the connectors (K1 corresponding to A, and K8 to H).

- *xxx* is a number between 001 and 128 which indicates the position required for the servo, 001 corresponding to the extreme counter-clockwise position and 128 to the extreme position in the other direction.

From a Basic Stamp, all you need to do is write it as shown in the following example:

SEROUT Pin, 16780, [″S″, ″X″, DEC Pos, CR]

where Pin is utilized for the serial port, X is the letter identifier of the servo included between A and H (K1 to K8) and Pos is the desired position included between 1 and 128.

With a PICBasic (www.comfiletech.com) and the same text as below, we would write:

SEROUT Pin, 138, 0, 0, [″S″, ″X″, DEC (Pos), 13]

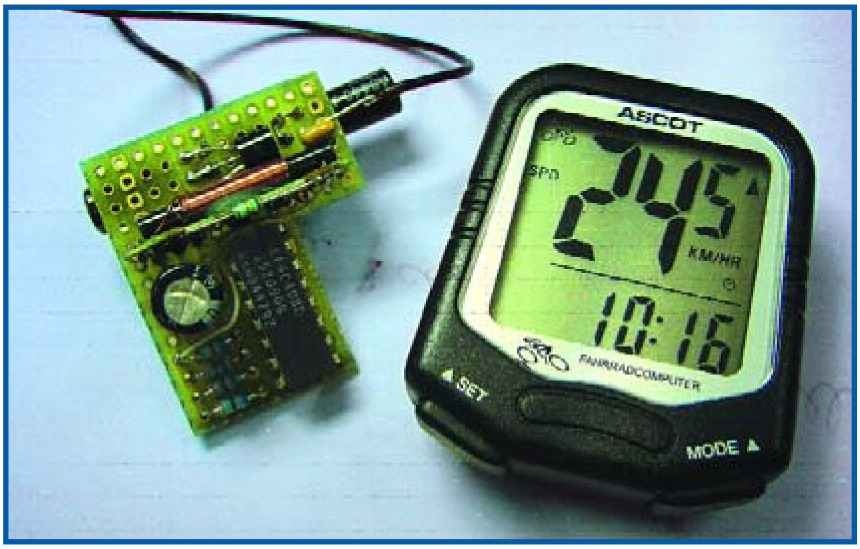
After turning on the MIC800, all outputs of the servo control are inactive. Then, as soon as a command has been sent to a servo destination, the corresponding output automatically generates the pulses required to maintain its position as long as the circuit remains on.

www.tavernier-c.com (060104-1)

Bicycle Speedometer with Hub Dynamo

086

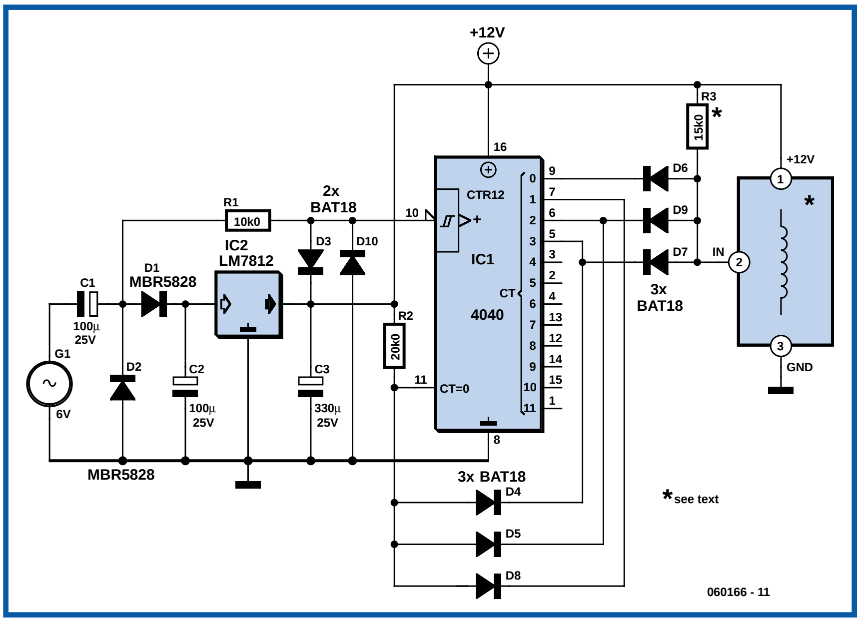
Hans Michielsen



The idea for this circuit came when the author had problems with the wireless speedometer on his bicycle. Such a device consists of two parts: the cycle computer itself and a transmitter that is mounted on the front fork. A small magnet is attached to the spokes so that the transmitter sends out a pulse for every revolution of the wheel (as long as everything has been fitted properly). Since the range of the transmitter is limited (about 75 cm), you'll be lucky if it works straight away. And when the voltage of the battery starts to drop you can forget it. The following circuit gets round these problems.

A Shimano NX-30 hub dynamo has 28 poles. This results in 14 complete periods of a 6 V alternating voltage per revolution (when loaded by a lamp; under no load the voltage is much higher). C1, C2, D1 and D2 double the voltage of the AC output. Regulator IC2 keeps the voltage to the transmitter and the divider IC at a safe level (12 V, the same as the original battery). The divider chip (IC1) divides the frequency of the signal from the dynamo by 14, so that a single pulse goes to the transmitter for every revolution of the wheel. This pulse enters the circuit at the point where the reed contact was originally.

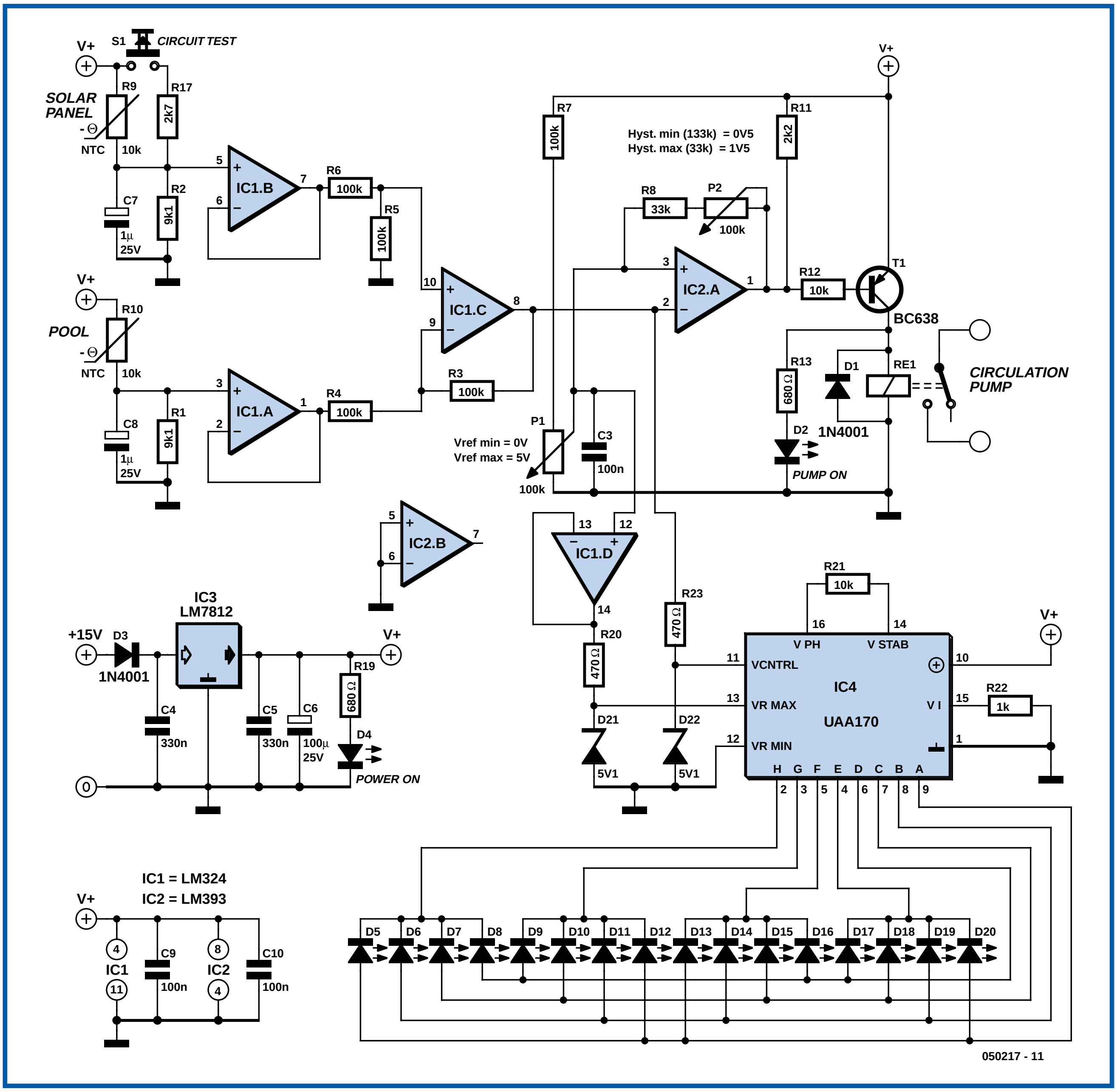
The circuit is built inside the front light, since it has enough room and a cable from the dynamo is already present. The distance to the cycle computer is smaller as well in that case.



The following tip can be used if you want to save yourself a few components. In the author's prototype the counter divided by 16 and the setting for the size of the wheel was adjusted to 16/14th of the real size in the setup of the cycle computer. In that case you can leave out D4, D5 and D8.

(060166-1)

087 Temperature Sensitive Switch for Solar Collector



Tom Henskens

This circuit can be used to turn the pump on and off when a solar collector is used to heat a swimming pool, for example. This way the water in the collector has a chance to warm up significantly before it is pumped to the swimming pool. A bonus is that the pump doesn't need to be on continuously.

The basis of operation is as follows. When the temperature of the water in the solar collector is at least 10 °C higher than that of the swimming pool, the pump starts up. The warm water will then be pumped to the swimming pool and the temperature difference will drop rapidly. This is because fresh, cool water from the swimming pool enters the collector.

Once the difference is less than 3 °C the pump is turned off again.

R10/R1 and R9/R2 each make up a potential divider. The output voltage will be about half the supply voltage at a temperature around 25 °C.

C7 and C8 suppress any possible interference. The NTCs (R9 and R10) are usually connected via several meters of cable, which can easily pick up interference.

Both potential dividers are followed by a buffer stage (IC1a/IC1b). IC1c and R3, R4, R5 and R6 make up a differential amplifier (with unit gain), which measures the temperature difference (i.e. voltage difference).

When both temperatures are equal the output is 0 V. When the temperature of the solar collector rises, the differential amplifier outputs a positive voltage. This signal is used to trigger a comparator, which is built round an LM393 (IC2a). R7 and P1 are used to set the reference

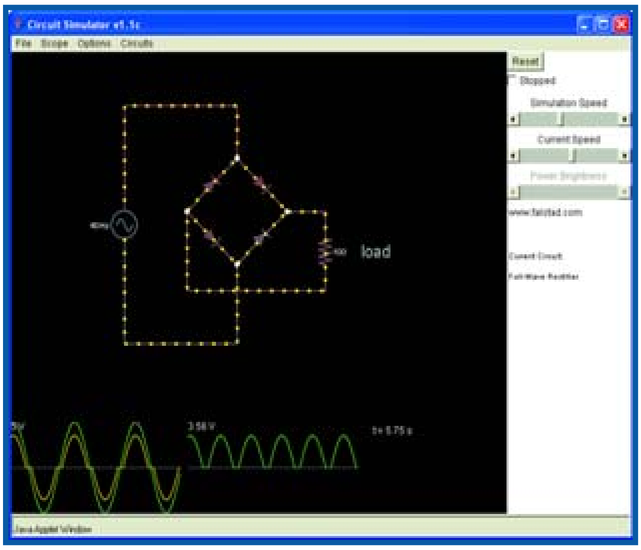
voltage at which the comparator changes state. R8 and P2 provide an adjustable hysteresis. R11 has been added to the output of IC2a because the opamp has an open collector output.
A power switch for the pump is created by R12, T1 and Re1. D1 protects T1 against voltage spikes from the relay coil when it is turned off.
A visual indication of the state of the controller is provided by IC4 (UAA170), a LED spot display driver with 16 LEDs. The reference voltage for the comparator is buffered by IC1d and fed to input VRMAX of the UAA170. R20/D21 and R23/D22 limit the input voltages of IC4 to 5.1 V, since the maximum permissible input voltage to the UAA170 is 6 V.
When there is no temperature difference, LED D20 turns on. As the temperature difference increases the next LED turns on. The full scale of the LED bar is equal to the reference voltage of the comparator. This means that when the last LED (D5) of the UAA170 turns on, the comparator switches state. This is also indicated by D2.
The power supply has been kept fairly simple and is built around a LM7812 regulator. The circuit is protected against a reverse polarity at the input by D3. You have to make sure that the input to the regulator is at least 15 V, otherwise it won't function properly.

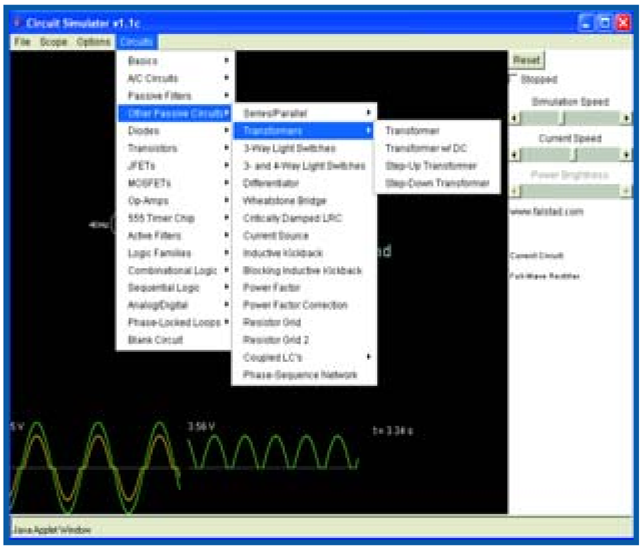
There are a few points you should note regarding the mounting of the NTCs.
NTC R9 should be placed near the output of the solar collector. You should choose a point that always contains water, even when some of the water flows back a little. NTC R10 should be mounted inside the filter compartment (where it exists), which continually pumps the swimming pool water. This will give a good indication of the temperature of the water.

The way the circuit has to be set up depends how it has been installed and is very much an experimental process. To start with, set hysteresis potentiometer (P2) halfway. Then set the reference voltage to about 1.5-2 V with P1.
On a sunny day you can measure the voltage difference to get an idea as to which reference voltage needs to be adjusted.
The hysteresis setting determines how long the pump stays on for, which is until the minimum temperature difference has been reached.

(050217)

Simulation Applets





Simulation programs for analogue circuits come in all shapes and sizes, and at various prices. It is often much easier to test a circuit on a PC instead of reaching for the soldering iron.
The website of Paul Falstad contains a free Java applet that illustrates how various basic analogue and digital circuits work. Voltages and currents can be brought to life in simulated scope screens; circuits can be modified by the addition, removal or alteration of components. Unfortunately, the addition of components has not (yet?) been fully implemented in the program: you'll see the added component appear in the circuit diagram, but it won't have any effect in the operation of the circuit. But don't let that spoil your fun. Its usefulness is increased by the addition of a large library of example circuits, which makes this applet educational as well. Each simulation is accompanied by a short description.
The simulations aren't limited to just electronics; other subjects such as physics and mathematics have also been extensively covered. There's more than enough on this website to keep you happily occupied for a few hours...

(060196-1)

Web link

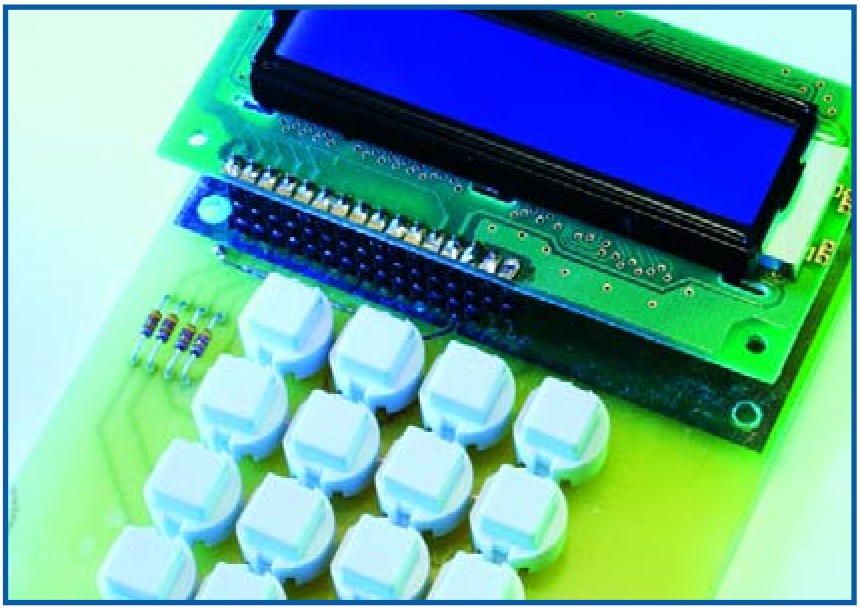
www.falstad.com/mathphysics.html

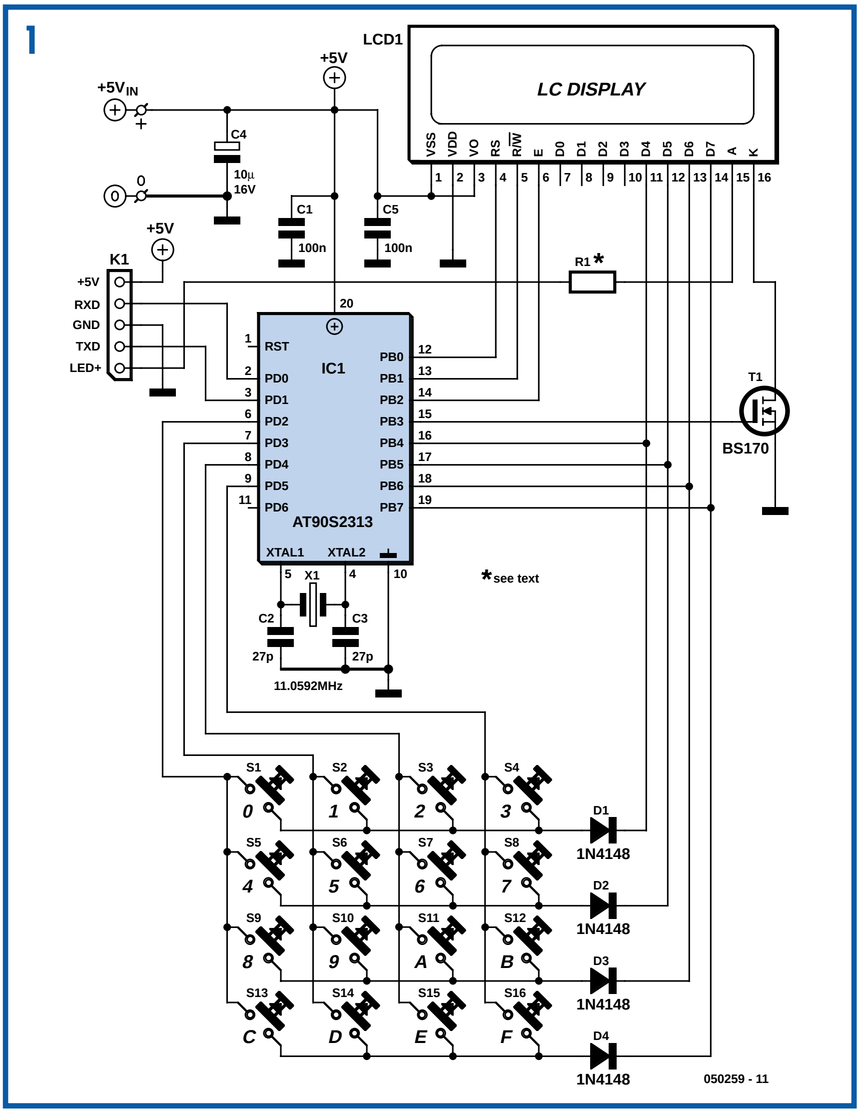
The electronics simulation can be found under Electrodynamics/Analog Circuit Simulator Applet

089

Universal LCD Module

Ullrich Kreiensen





Interfacing an LCD to a microcontroller system is daily bread and butter for the average electronics engineer. There are innumerable variants and many circuit suggestions for interfacing the six to seven LCD signals to a microcontroller system. In an effort to prevent continual reinvention of the wheel the author of this design used this simple formula:

(LCD module + Atmel controller) +
(a touch of software)
= (universal display module)

to design this versatile display unit and PCB.

There are no surprises in the circuit diagram in **Figure 1.** A low cost controller type AT90S2313 takes commands from the serial interface and controls a standard 2x16 LCD display module. The controller also decodes key presses on the 4x4 keypad. This configuration is usually sufficient for most applications requiring just a basic user input/output device.

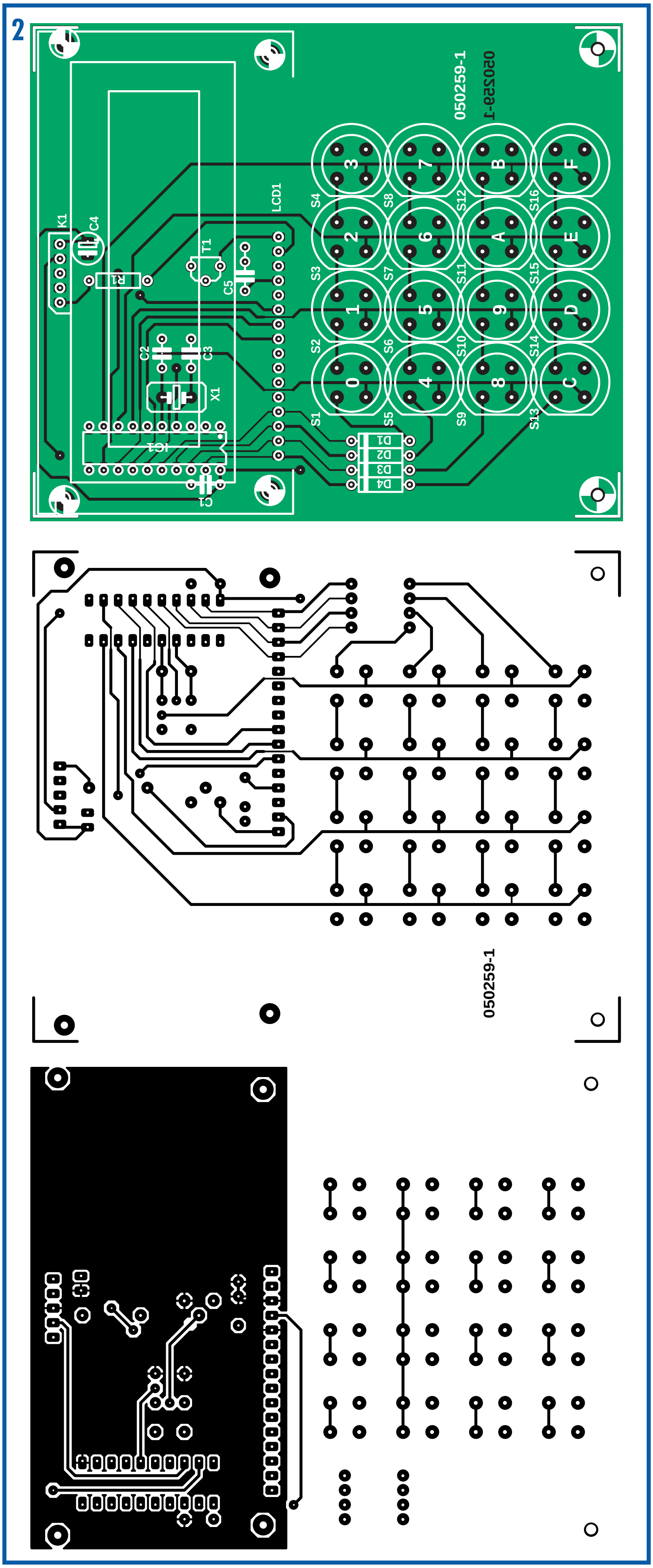
From a hardware perspective there is not too much to describe because all of the functions are performed in software. Transistor T1 controls the brightness of the LED backlight using Pulse Width Modulation (PWM), the average LED current is given by:

$$U_{R1} / R1 \times t_{ON} / t_{ON} + t_{OFF}$$

Where U_{R1} is the voltage at LED+ on K1 minus the voltage drop across A and K on the LCD controller pins and t_{ON}/ $t_{ON} + t_{OFF}$ is the mark-space ratio of the PWM drive signal produced by IC1. The maximum permissible LED current is specified in the display module data sheet.

Software for IC1 can be downloaded from www.elektor-electronics.co.uk for free, the file number is 050259-11.zip.

Figure 1.
The universal LCD interface circuit basically consists of a programmed Atmel controller, an LCD module and 16 keys.



COMPONENTS LIST

Resistors
R1 = see text

Capacitors
C1,C5 = 100nF
C2, C3 = 27pF
C4 = 10µF 16V radial

Semiconductors
D1-D4 = 1N4148
T1 = BS170
IC1 = AT90S2313, order code **050259-41**

Miscellaneous
X1 = 11.0592MHz quartz crystal
S1-S16 = pushbutton type D6
LCD module, 2x16 characters
PCBs, ref. 050259-1

A preprogrammed controller can also be ordered from the site shop as item 050259-41. The CodeVision AVR compiler was used for software development. A demo version is available on the Internet but this version contains a restriction of 500 bytes on the maximum code size. A 'modification' in the code gets round this by specifying the larger 8515 controller and then resetting the stack pointer to the correct value for the 2313, the overall effect is to increase the code space to 2 kBytes.

The complete module can be controlled by sending 'escape sequences' to the serial communication port. These consist of an ASCII 'escape' character (27 in decimal) followed by a command character. A list of these commands is given in table 1; they can also be used for control by a general purpose terminal program to facilitate the process of software development and debugging. In addition the display has a 'RAW' mode which writes all subsequent characters directly to the display. An 'Esc N' sequence switches it back to normal

Figure 2.
The finished PCB provides a neat, universal input/output module.

mode. Finally special characters can be created and used for display dimming; further details are contained in the downloadable PDF file.

Figure 2 shows the populated double-sided PCB. The LCD module and keypad are mounted on one side while the controller and all the other components are fitted to the reverse. Fit a good quality socket for IC1 so that it can be easily removed for software updates.

(050259-1)

Table 1. Command character function in 'N' mode.

Dec.	ASCII	Function
8	BS	clear the character on the left of the cursor
9	TAB	move the cursor to position 0 or 8
10	LF	Line Feed – change line
11	HOME	cursor to top left hand corner
12	CLR	clear the display
13	CR	cursor to the start of the line
27	ESC	begin the command sequence
28	RIGHT	shift cursor one position right
29	LEFT	shift cursor one position left
30	UP	change the line the cursor is on (like LF)
31	DOWN	change the line the cursor is on (like LF)

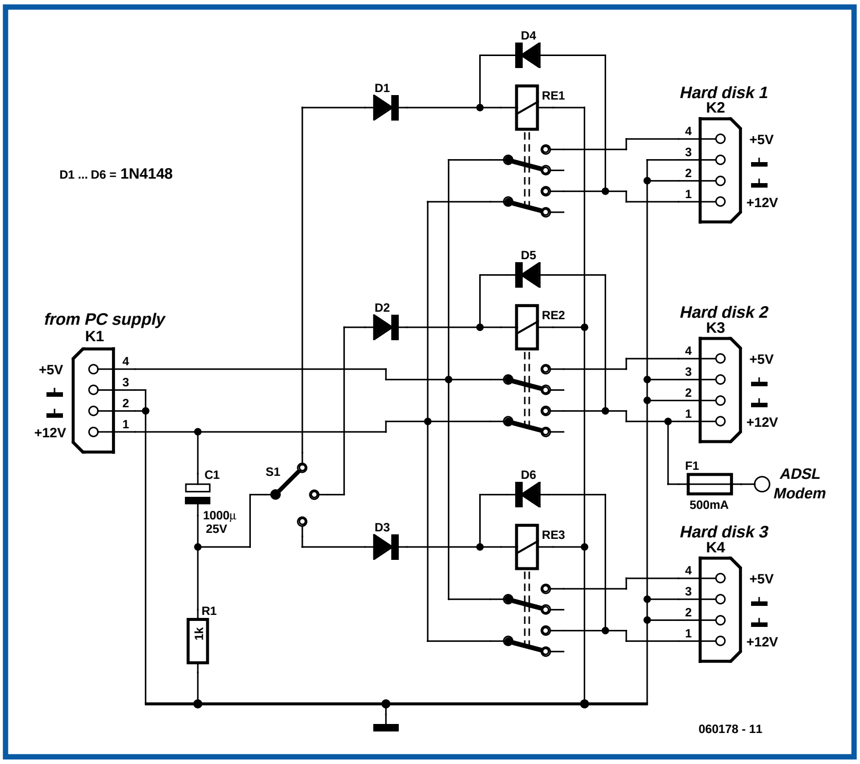
090

Hard Disk Switch

Uwe Kardel

In these times with viruses and other threats from the Internet it would be nice to have reassurance that the PC cannot be infected. That is why this circuit was designed. It makes it possible to install multiple hard disks inside the case of a PC, which are separated in such a way that viruses cannot move from one disk to another.

In this case there are three drives installed, one for use of the Internet via ADSL, one for working with email and one for other applications. If data from the Internet never arrives on the third disk, it is effectively protected against viruses. The solution outlined here has been in satisfactory use for a couple of years. There is an additional benefit: if there are ever any problems with the operation of the computer, then it is very easy to change to another hard disk to check if the problem manifests itself there as well. In this case, fault finding can be made much easier.
The circuit operates by only switching over the power supply voltages (5 V and 12 V) of the hard disks. The hard disk is out of service without a power supply. This works without a problem with S-ATA disks. With IDE disks this only works with modern drives. There may only be a combination of hard disks on the relevant port and no CD-ROM, DVD-drive, CD-burner or something similar.



The selection of the desired hard disk is done with a rotary switch. This has to be set to the correct position before the computer is switched on. When the power supply is turned on, one of three relays is driven via diode D1, D2 or D3. The relays are provided with a hold circuit via a second diode (D4, D5 and D6). In this way the selected relay remains energised as long as the power supply voltage is present. After switching on, electrolytic capacitor C1 is charged via R1, so that the common contact of the rotary switch is quickly at 0 V. This prevents an accidental change of hard disk while the computer is in operation.
The ADSL modem is powered from the PC. This power supply voltage is only present if hard disk number 2 is selected. This prevents the use of the Internet if one of the other disks is selected.

(060178-1)

How to! connect your project to the PC

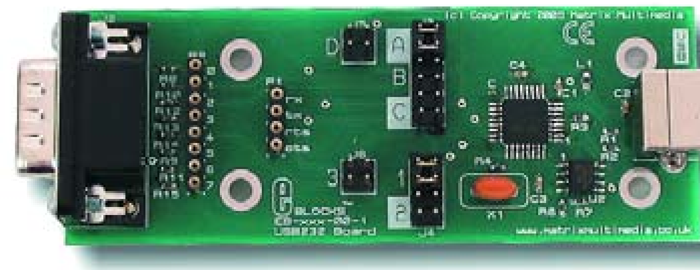
091

John Dobson

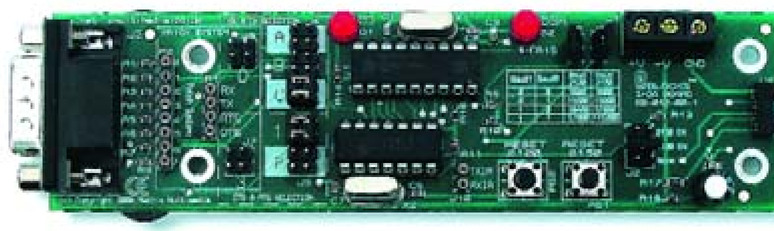
Connecting a project to your computer used to be a simple affair – your microcontroller would have a UART (Universal Asynchronous Receiver Transmitter) which was compatible with the RS232 protocol. You would then simply put a MAX232 converter chip onto the microcontroller and a 9-way D-type socket which linked your design using a standard lead directly to your PC. From an application like Visual Basic, you could then communicate directly to your project using Windows COM routines. Alternatively, you used the parallel port and simply waggled individual pins using the old BASIC [outp] command.

Then **USB** came along to make all our lives "easier". Due to the non-trivial coding required to tame the USB interface in microcontrollers having internal USB connectivity, alternative solutions have emerged – most notably the FTDI chip that acts as an interface between RS232 and USB. You can see this solution on the E-blocks USB232 board in **Figure 1**.

1



2



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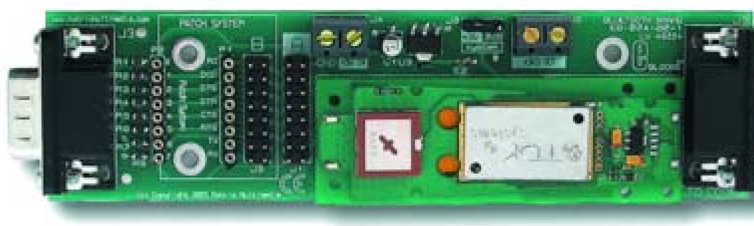


The FTDI device takes care of all the tricky USB negotiation for you and provides a link between a TTL level UART interface on the microcontroller and the USB port on your PC. On the PC side you are supplied with a virtual COM port driver which you can drop into your Visual Basic application, providing compatibility with older programs that worked on the serial port. The FTDI devices also provide DLLs for faster non-com port compatible communication.

Almost all laptop PCs have an **IrDA** port. IrDA is an internationally defined standard for infrared communication that's used on laptops, mobile phones, and PDAs. Implementing the IrDA standard is as difficult as you want to make it: the infrared techniques at the basic physical layer are not that hard, but the actual coding and decoding of data is very complex. Fortunately Microchip offer an IrDA decoder chip or 'stack' which sits between the infrared transceiver and your microcontroller. What's more, an E-blocks module is available (**Figure 2**). On the PC side you will find that Windows has a native infrared COM driver which can be used by Visual Basic or your other development system.

Bluetooth was originally specified to replace the cables round the back of your PC. The system has some great advantages: it is a wireless system with a range of up to about 100 meters, and transmission through walls. A number of off the shelf modules are available like the TDK one on the E-blocks Bluetooth module shown in **Figure 3**. This converts Bluetooth into a TTL compatible data stream which can interface directly with any old microcontroller UART. To transfer data or commands, you will need some understanding of the Bluetooth AT protocols. If your laptop does not have Bluetooth then it is possible to buy a low-cost PCMCIA compatible card, or a Bluetooth adaptor for the USB port.

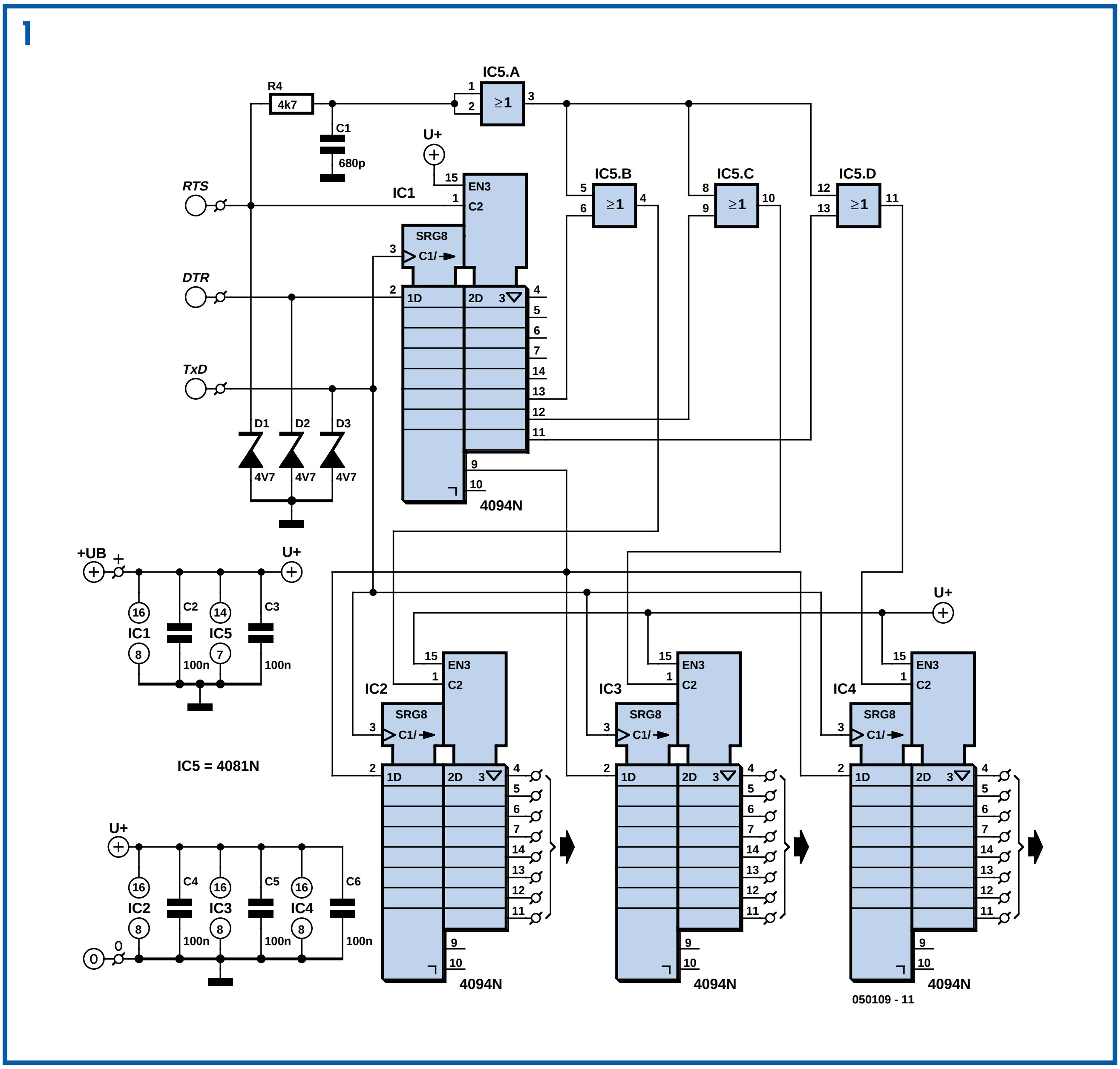
The obvious choice for replacing the RS232 link between hardware projects and your PC would be USB — but this system is currently too complex to implement in a microcontroller. The FTDI drop-in chip will be the easiest choice for replacing the RS232 link, but designers should also consider alternative wireless/infrared solutions which present some significant advantages to the end user.

E-blocks modules and associated software are available through the Elektor Electronics SHOP, see www.elektor-electronics.co.uk

(065122-1)

092

Expansion for Universal Interface



Roland Plisch

The 'Universal Interface for Windows' designed by Burkhard Kainka (*Elektor Electronics*, December 1999 Supplement, page S2) provides for a range of input interfaces along with eight digital outputs, all under direct control of a PC's serial port. The program (available for free download from http://www.elektor-electronics.co.uk under 'Magazine') uses the TXD signal to clock eight data bits from the DTR signal into a 4094 shift register. On the positive-going edge of the RTS strobe it transfers these bits simultaneously to its outputs. This arrangement can easily be extended by adding further shift registers in cascade, allowing data words of (in theory) any desired size to be built up byte by byte.

The circuit in **Figure 1** shows shift register IC1 connected as before to the PCs interface. The serial data pass through this device first, and then, via its serial cascade output (pin 9) to three further 4094s. The last (i.e., eighth) bit of the shift register appears on this cascade pin. The three shift registers IC2, IC3 and IC4 receive their strobe pulses, slightly delayed by R4 and C1, via AND gates IC5.B, IC5.C and IC5.D when the corresponding output (Q6, Q7 and Q8 respectively) of the first shift register is active. The software sends a 16-bit word containing the address and a data byte in a single transfer. For example, to select Q6 and hence IC2, it is necessary simply to add 2048 to the eight-bit data value; for IC3 add 4096, and for IC4 add 8192. The circuit can be extended in similar fashion using the spare outputs of IC1 (pin 4 to pin 7 and pin 14) to control further 4094s.

(050109-1)

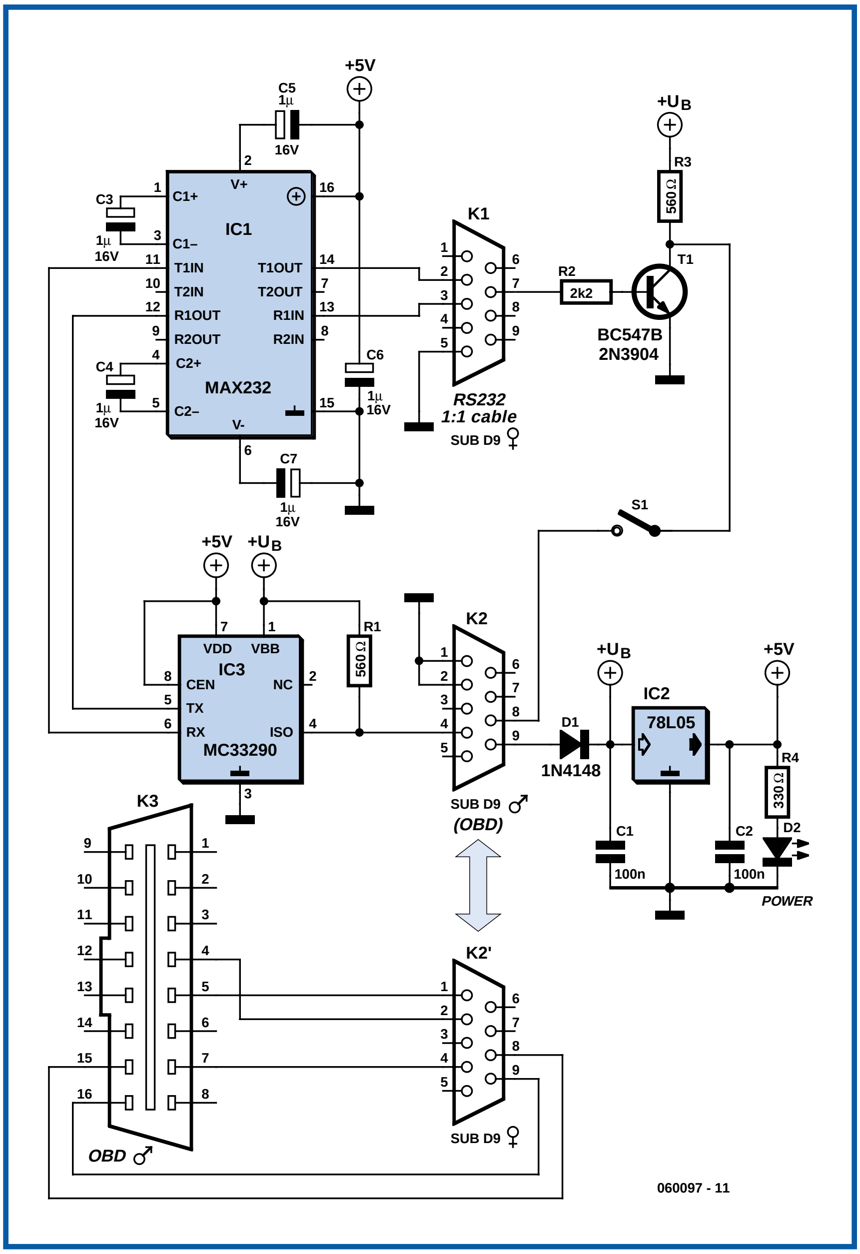
093

New KW 1281 Interface

Florian Schäffer

Cars made by the Volkswagen/Audi group (VAG) are easy to interface to using the OBD-2 connector: the VAG-COM software allows values to be read out from the car and parameters to be set. The communications protocol used is called KW 1281. Versions of VAG-COM up to 311 require the use of an isolated interface connected to the PC's serial port to protect both the car's computer systems and the PC itself from possible damage. A popular and rather minimal design for the circuit is 'Jeff's interface'; however, this employs optocouplers which are not always readily available from electronic component shops. Also, the optocouplers are run at a rather infelicitous operating point, entailing the use of several trimmer potentiometers and correspondingly complicated adjustments.

The problem can be solved with the use of two interesting ICs: the L9637D from ST Microelectronics and the Motorola/Freescale MC33290D. Both include an ISO 9141-compliant interface. The L9637D, at a price of two pounds or so, is the more expensive, but can withstand voltages of up to 36 V, making it suitable for use with commercial vehicles that use a 24 V supply. At 58 kbit/s it is also too slow to connect to the CAN bus, which can operate at up to 500 kbit/s. The MC33290D is only specified for operation up to 18 V, but is fast enough for OBD over CAN and is therefore the better choice for our circuit. As far as VAG-COM is concerned the difference is not significant, as KW 1281 operates at a maximum speed of just 10400 bit/s.



This chip is responsible for the OBD side of the circuit; on the serial port side we use a MAX232. The MAX232 converts the serial signals between the levels used on the interface and TTL levels, while the MC33290 converts between TTL levels and the ISO levels. The circuit draws power from the car's 12 V supply over the OBD cable. A simple voltage regulator produces the +5 V supply voltage, whose presence is indicated by the LED. To ensure that the circuit remains compatible with older cars, separate provision must be made for connection to the L-line as the ISO interface chip only supports the K-line. We have therefore added a transistor to drive the L-line: the direction of data transfer on this line is only from the PC to the car. Most cars use only the K-line and do not require the L-line at all. We have therefore also added a switch to allow the signal to be isolate from the OBD connector. This allows testing of whether the car uses the L-line for initialisation or not. A straight-through (not a crossed-over null modem) cable is used to connect to the PC.

The components are readily available; the ISO interface chip can be obtained from Farnell or Segor Electronics. No adjustments are required to the circuit, since all the devices used are standards-compliant. The author has made a printed circuit board layout available on his homepage, as both an Eagle file and a PDF. The page also contains much other information, including details of the software.

(060097-1)

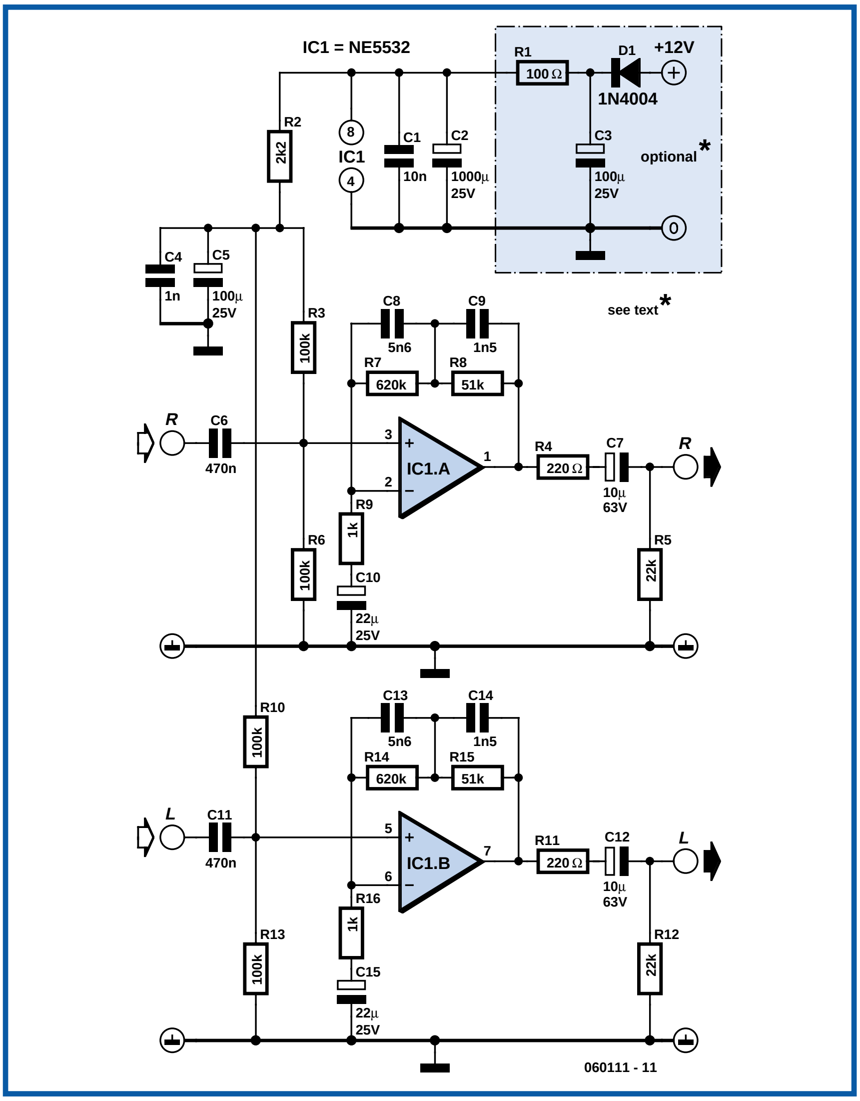
Internet link

http://www.blafusel.de

094

Multimedia RIAA Preamplifier

Christian Tavernier



Even if a large number of album titles once available on vinyl are now, little by little, being proposed as CDs, not all are available and far from it. You may have treasures in your collection that you would like to burn on CDs. First, preserving a CD is easier than preserving a vinyl record, and second, we have to admit that turntables are disappearing, even on fully-equipped Hi-Fi systems. From a point of view of software and PCs, converting from vinyl to CD is not a problem. A large number of programs, whether paid for freeware, are available to re-master vinyl records with varying degrees of success and to eliminate pops, crackles and other undesirable noises. All of these programs work with the sound card of your PC and that, admittedly, is where the problem starts. Most high-quality turntables are equipped with a magnetic cartridge which typically delivers just a few mV. The cartridge signal requires a correction of a specific frequency, called RIAA correction. If our older readers will perfectly recall what RIAA is all about, others from the CD generation may not know what the acronym RIAA stands for, guessing it may have something to do with illegal downloading of music on the Internet.

For mechanical reasons related to the vinyl engraving procedure, high-boost frequency correction is carried out while respecting a very precise curve defined a long time ago by the RIAA (*Recording Industry Association of America*) and, which therefore, quite naturally, was baptized RIAA correction.

Reversing the correction is the role of to the preamplifier for the magnetic cartridge. Since this correction boosts the lowest frequencies, such a preamplifier is very sensitive to all undesirable noises, hums, including, of course, the one coming from the 50-Hz (or 60-Hz) mains power supply. It is important to take that into account while making this project which must be done carefully with respect to grounding and shielding.

The schematic of our preamplifier is very simple because it uses a very low-noise dual operational amplifier. Here the NE5532 is used, whose response curve is modelled by R7, R8, C8, and C9 (or R14, R15, C13, and C14 respectively) in order to match the RIAA correction as closely as possible.

The input has an impedance of 47 kΩ, which is the standardized value of magnetic cartridges, and its 1,000-Hz gain is 35 dB which allows it to supply an output level of a few hundred mV typically required by for the line input of a PC sound cards.

The connection between the cartridge and the input of the amplifier requires shielded wiring to avoid the hum problems discussed above. Likewise we recommend fitting the assembly in a metal housing connected to the electric ground.

With respect to the power supply, three solutions are proposed: If you are a purist and you want to rule out any noise whatsoever, you will utilize a simple 9-V battery. Then, the components outlined with a dotted line will not be useful. Since the circuit only uses a few mA, such a solution is acceptable unless your collection of vinyls is impressive...

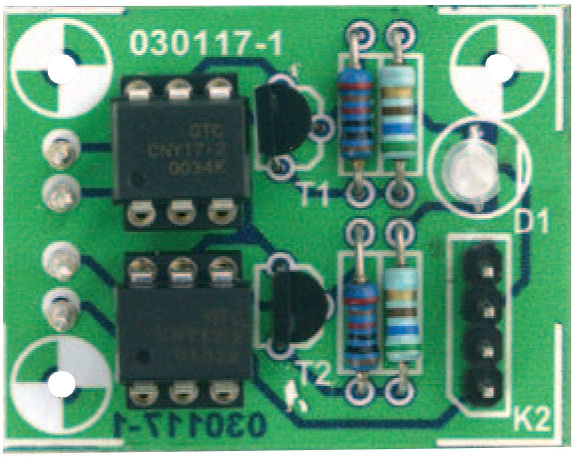
If you desire a more elegant technical solution that might sometimes cause more undesirable noise on the signals, you may want to wire up the components within in the dotted lines and you can steal the 12 V positive voltage available from your PC. A Y-connector inserted on the power supply of one of the internal drives or peripherals will work very well for that.

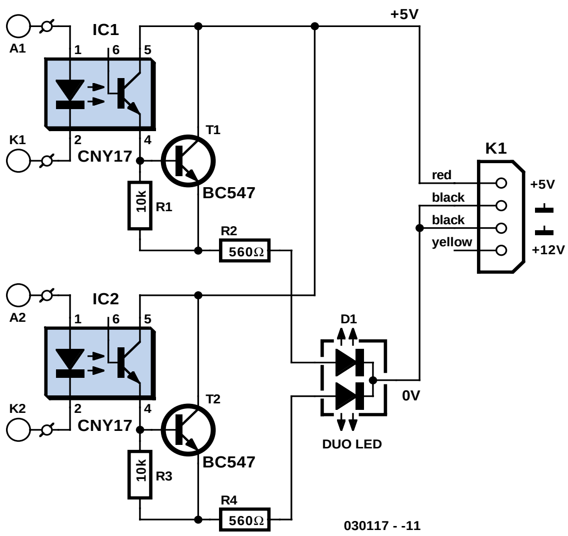
Finally, you may also use a mains adapter set to 12 V and connect it to the +12-volt point of the drawing in order to benefit from additional filtering, which is not a luxury for some.

(060111-1)

Multicolour HD LED

095





Andreas Köhler

Most PC enclosures provide only a single LED to indicate hard disk access, with the LED being connected to the motherboard via a two-pin connector. However, this LED only works with IDE drives, and if a SCSI disk controller is fitted, its activity will not be visibly noticeable. This small circuit remedies that problem using a multicolour LED.

The activity LED for the IDE interface is usually driven by a connected device via one or more open-collector stages. It illuminates if either of the two possible IDE drives is activated. The shared series resistor limits the current and also provides short-circuit protection. Even if the LED is shorted out due to faulty wiring, the current is restricted to a safe level.

An obvious solution would be to have the IDE and SCSI disks drive a shared dual LED, but unfortunately the current flows from the positive supply line through a series resistor, the LED and a transistor to ground. The dual LED would thus have to have a common anode, but no such device exists. All known multicolour LEDs have a common cathode lead. That means they cannot be connected directly, but we're not that easily defeated.

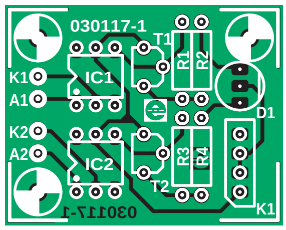
Only a small additional circuit is needed to allow the LED to be driven by the different interfaces.

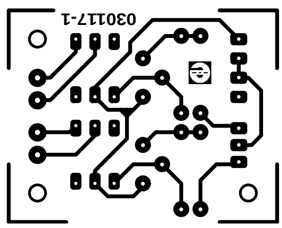
In this circuit, each of the drive signals from the two controllers is fed to an optocoupler, which acts nearly the same as the original LED. The somewhat lower voltage drop of the infrared LED results in a somewhat greater current, but there's hardly any need to worry about overloading. The optocouplers eliminate the problems with the different voltages. On the output side, a Darlington transistor consisting of the phototransistor and a BC547 drives the multicolour LED. The 10-kΩ resistor (whose value of is not critical) provides secure cut-off of the driver transistor. The base of the phototransistor in the CNY17 is left open.

The series resistors for the individual LED elements are dimensioned using the standard formula. It may be necessary to adjust their values slightly, depending on the relative brightness levels. The circuit can also operated from the +12-V line of the power supply if the values of the series resistors for the LEDs are suitably modified. If necessary, a third optocoupler stage can be added to allow a three-colour LED (red, green and blue) to be driven.

The circuit board has been designed to be so small that the components can be fitted in a few minutes and everything can be suspended from the LED in the PC enclosure. A drop of hot-melt glue will prevent the circuit board from becoming dislodged due to vibration. The supply voltage reaches the circuit via a normal small drive connector, to make it easy to obtain the necessary plug. Otherwise, you can also use ordinary solder pins.

(030117-1)





COMPONENTS LIST

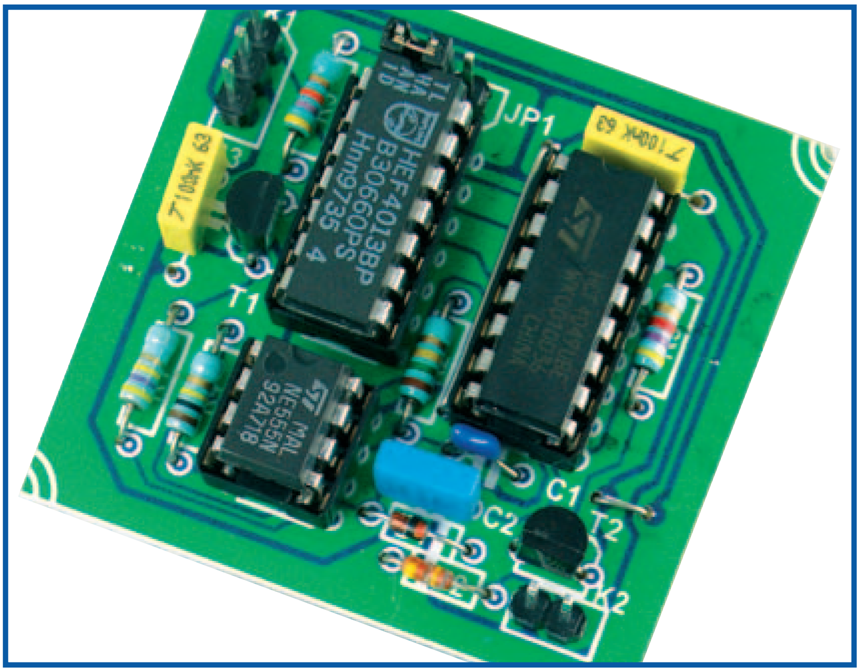
Resistors:
R1,R3 = 10kΩ
R2,R4 = 560Ω

Semiconductors:
D1 = Dual LED with 3 pins (Conrad Electronics # 187496)
IC1,IC2 = CNY17-2
T1,T2 = BC547B

Miscellaneous:
K1 = 4-way SIL connector
Small disk drive connector for PCB mounting, or solder pins (see text)
PCB, order code 030117-1 from the PCBShop

096 RC Switch

Paul Goossens



It is sometimes necessary for an RC (remote control) model to contain some kind of switching functionality. Some things that come to mind are lights on a model boat, or the folding away of the undercarriage of an aeroplane, etc. A standard solution employs a servo, which then actually operates the switch. Separate modules are also available, which may or may not contain a relay.

A device with such functionality is eminently suitable for building yourself. The schematic shows that it can be easily realised with a few standard components.

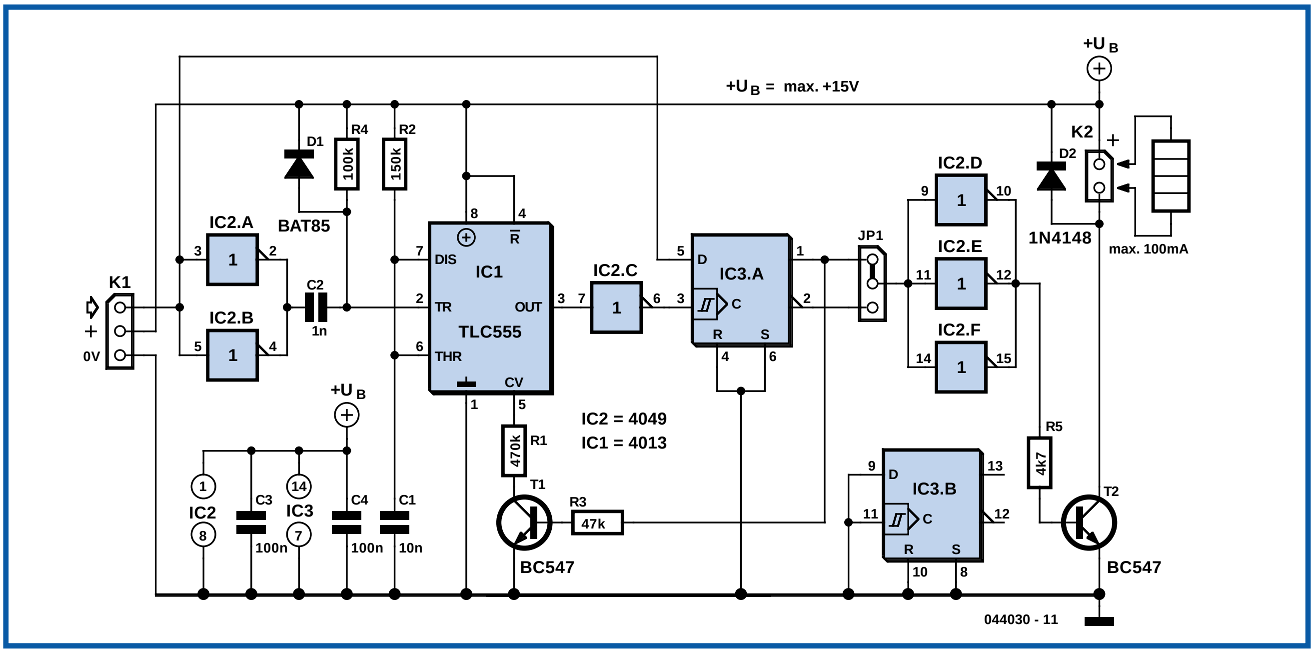
The servo signal, which consists of pulses from 1 to 2 ms duration, depending on the desired position, enters the circuit via pin 1 of connector K1. Two buffers from IC2 provide the necessary buffering after which the signal is differentiated by C2. This has the effect that at each rising edge a negative start signal is presented to pin 2 of IC1. D1 and R4 make sure that at the falling edge the voltage at pin 2 of IC2 does not become too high.

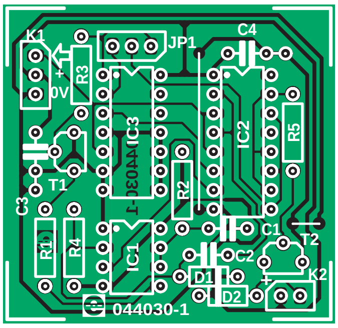
IC1 (TLC555) is an old faithful in a CMOS version. A standard version (such as the NE555) works just as well, but this IC draws an unnecessarily high current, while we strive to keep the current consumption as low as possible in the model.

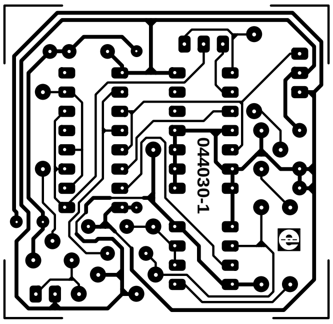
The aforementioned 555 is configured as a one-shot. The pulse-duration depends on the combination of R2/C1. Lowering the voltage on pin 5 also affects the time. This results in reducing the length of the pulse. In this circuit the pulse at the output of IC will last just over 1.5 ms when T1 does not conduct. When T1 does conduct, the duration will be a little shorter than 1.5 ms. We will explain the purpose of this a little later on.

Via IC2.C, the fixed-length pulse is, presented to the clock input of a D-flip-flop. As a consequence, the flip-flip will remember the state of the input (servo signal). The result is that when the servo-pulse is longer than the pulse form the 555, output Q will be high, otherwise the output will be low.

It is possible, in practice, that the servo







COMPONENTS LIST

Resistors:
R1 = 470kΩ
R2 = 150kΩ
R3 = 47kΩ
R4 = 100kΩ
R5 = 4kΩ7

Capacitors:
C1 = 10nF
C2 = 1nF
C3,C4 = 100nF

Semiconductors:
D1 = BAT85 or similar Schottky diode
D2 = 1N4148
IC1 = CMOS 555 (e.g., TLC555 or ICM7555)
IC2 = 4049
IC3 = 4013
T1,T2 = BC547B

Miscellaneous:
JP1 = jumper with 3-way pinheader
K1 = servo cable
K2 = 2-way pinheader or 2 solder pins
PCB, available from The PCBShop

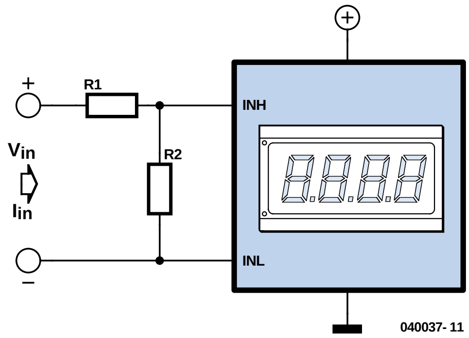
signal is nearly the same length as the output from the 555. A small amount of variation in the servo signal could therefore easily cause the output to 'chatter', that is, the output could be high at one time and low the next. To prevent this chatter there is feedback in the form of R1, R3 and T1. This circuit makes sure that when the flip-flip has decided that the servo-pulse is longer than the 555's pulse (and signals this by making output Q high), the pulse duration from the 555 is made a little shorter. The length of the servo-signal will now have to be reduced by a reasonable amount before the servo-pulse becomes shorter than the 555's pulse. The moment this happens, T1 will stop conducting and the mono-stable time will become a little longer. The servo-pulse will now have to be longer by a reasonable amount before the flip-flip changes back again. This principle is called hysteresis.

Jumper JP1 lets you choose between the normal or inverted output signals. Buffers IC2.D through to IC2.F together with R5 drive output transistor T2, which in turn drives the output. Note that the load may draw a maximum current of 100 mA. Diode D2 has been added so that inductive loads can be switched as well (for example, electrically operated pneumatic valves).

(044030-1)

Increased Range for DVM

097



	Range	R1	R2
V_{in}	2 V	910k	100k
	20 V	1M	10k
	200 V	1M	1k
	2000 V	1M	100 Ω
I_{in}	200 mA	0 Ω	1k
	2 mA	0 Ω	100 Ω
	20 mA	0 Ω	10 Ω
	200 mA	0 Ω	1 Ω

Voltmeter modules are readily available, both as LCD- and LED-versions. A disadvantage of these modules is the standard measuring range of 200 mV DC. So, with such a module you can only measure DC voltages up to 0.2 volts. Fortunately it is not difficult to increase the measuring range to higher voltages. In addition, it is also possible to measure current with these modules.

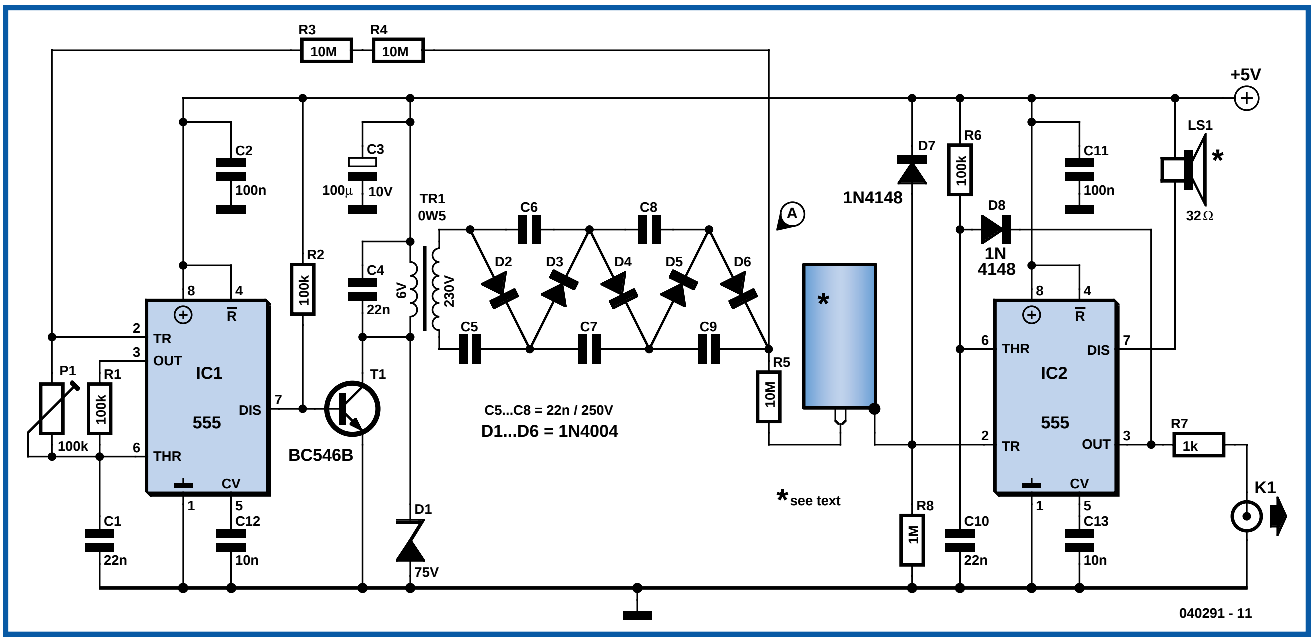
In order to measure higher voltages we have to reduce the voltage with a potential divider. For this purpose we add R1 and R2. R1 is connected in series with the + input of the module and R2 is connected in parallel with the inputs. In the table we can see the correct ratios of R1 and R2. These modules typically have an input impedance of more than 10 MΩ. With the attenuator in front of it the input impedance reduces to 1 MΩ, still high enough for most measurements.

To measure current with a voltmeter we first have to convert the current into an equivalent voltage. Resistor values for doing this are also shown in the table.

In contrast with the input impedance of a voltmeter, the input impedance of a current meter needs to be as low as possible. The input impedance of this circuit depends on the range and is practically identical to the value of R2. As a consequence, keep in mind that there is a voltage drop across the meter of up to 0.2 V. When making measurements you have to take into account that lethal voltages can be present in the circuit, particularly with the 200-V and 2000-V ranges. In addition, the specifications of your ordinary, common or garden resistor do not permit these kinds of voltages. When measuring these high voltages suitable resistors need to be used.

(040037-1)

098 Geiger Counter



Malte Fischer

April this year was the twentieth anniversary of the Chernobyl reactor accident. In the days following the incident winds deposited much of the reactor contents across central Europe, Scandinavia and the UK. A large area surrounding the reactor is still off limits but just how much of the fallout is still lying around on our gardens and farmlands? At the time of the release Iodine 131 was responsible for many cases of thyroid cancer but with a half life of 8.1 days this does not pose much of a threat in the long term. Strontium 90 is more of a problem; it has a half life of 28 years and more than 50 % of the fallout still remains. Radio caesium affects the food chain and can contaminate milk, meat and to a lesser extent crops.

Radioactivity is invisible so a detector is needed before we can start to make any measurements; the most common and simplest detector type is the Geiger counter. The design described here uses two NE555 type timer ICs, a small mains transformer and a few other standard components to make a low cost and simple to build Geiger counter. The only fly in the ointment is likely to be locating a Geiger-Mueller (GM) tube; this is not in any way a standard component. The on-line auction site eBay may provide a source of new or used counter tubes or alternatively Google will be useful in identify stockists. A brand new type ZP1300 tube can be purchased from ALRAD [1] at a cost of £55.00 plus VAT. The GM tubes are listed under nuclear products and nucleonics.

The counter tube requires a high voltage in the region of 700 V. IC1 is a NE555 timer configured as an astable multivibrator switching the BC547C transistor which in turn drives the secondary winding of a 6 V mains transformer. An alternating voltage of around 250 V is produced at the primary side which is then multiplied by the classic voltage multiplier configuration consisting of cascaded capacitors and diodes to produce around 700 V DC. The voltage is fed back to the timer input through resistors R3 and R4 to provide some stability of the output voltage.

The counter tube anode is connected to 700 V via a 10 MΩ protection resistor. In normal operation with no radiation detected there will be no current flowing through the tube and gas filling. When a radiation source is brought close to the tube, ionising radioactive rays pass through it and collide with some gas atoms knocking a few electrons out of their shell; this produces a current pulse from the tube terminal which in turn generates a voltage pulse across the 1 MΩ resistor high enough to trigger IC2. The NE555 effectively amplifies the pulse to produce the familiar tick-tick sound of a Geiger counter from the speaker LS1. An external pulse counter can be connected to K1. A copy of an original Philips Geiger tube data sheet is available at http://sbarth.dyndns.org/seiten/geigerzaehler/18550.pdf. Philips tubes are now made by Centronic [2] and their site contains a useful Geiger selection guide.

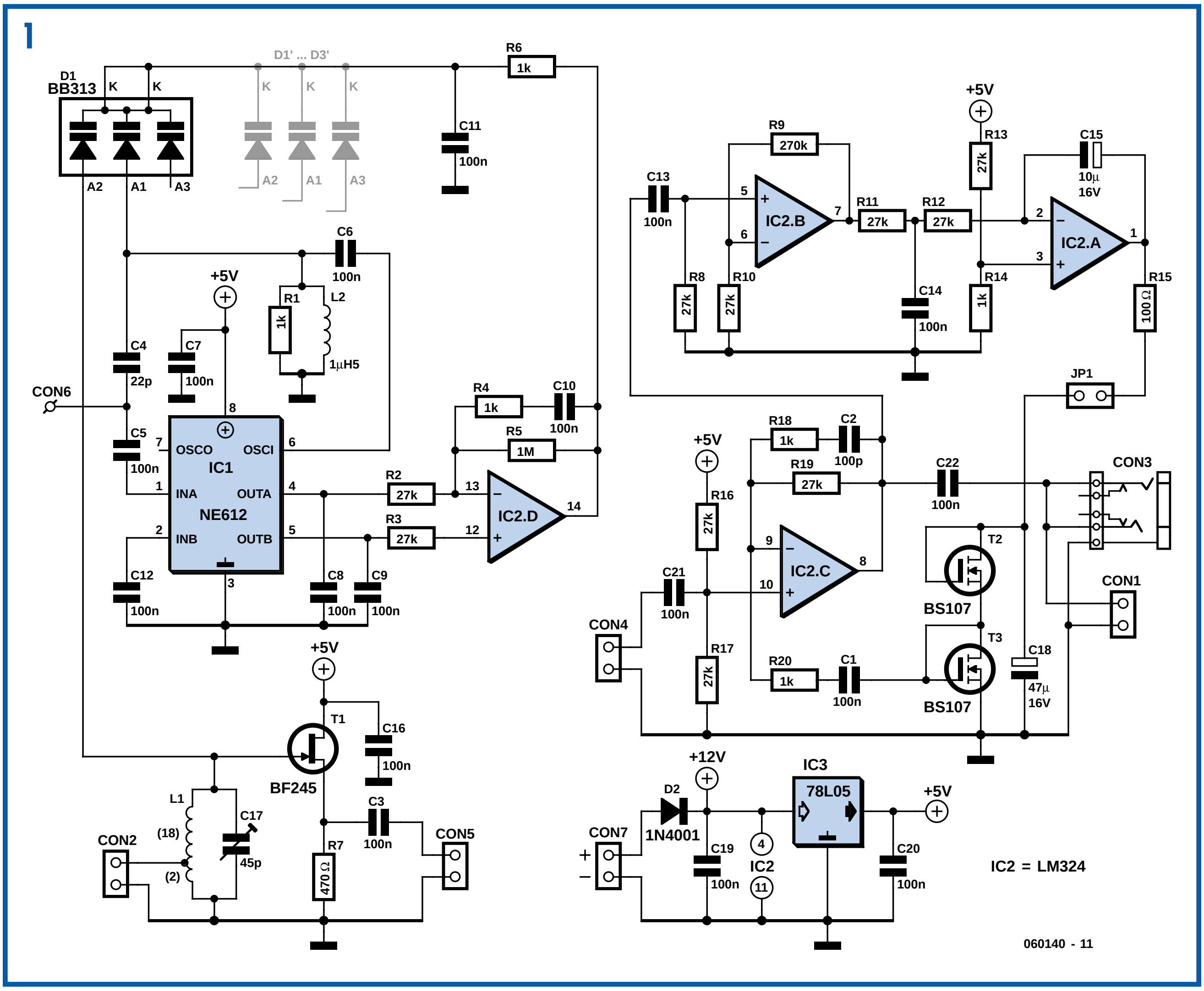
[1] www.alrad.co.uk
[2] www.centronic.co.uk

(040291-1)

DRM Receiver Upgrade

099

1

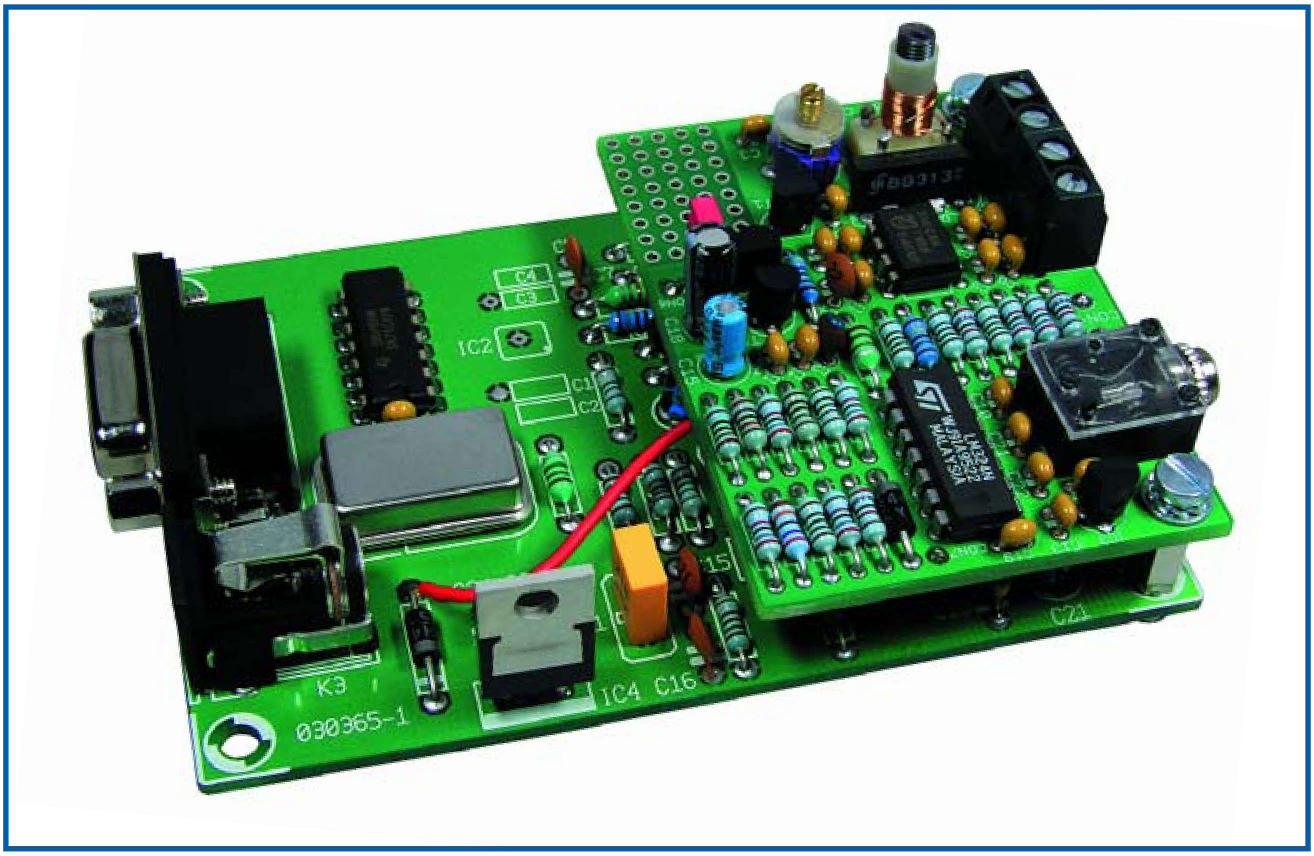


Burkhard Kainka

The DRM Receiver described in the March 2004 issue of *Elektor Electronics* has proved very popular and many thousand of the receivers are already in the field. Its excellent design is both simple and inexpensive. In the best tradition of homebrew construction we have supported the receiver by publishing two add-ons to the basic design; an automatic preselector (11/04) and an automatic gain control (2/06).

Both of these add-ons have been subject to continuous refinement by the author and the resulting combined circuit shown here can now be assembled on a ready-made PCB. This design equips the DRM receiver with an automatically tuned preselector for short wave signals in the frequency range from 3.5 MHz to around 16 MHz and an automatic gain control (AGC). The modifications improve the properties of the basic DRM receiver, in particular giving better image frequency rejection and higher receiver sensitivity so that more distant DRM, AM, SSB and CW broadcasts can be detected.

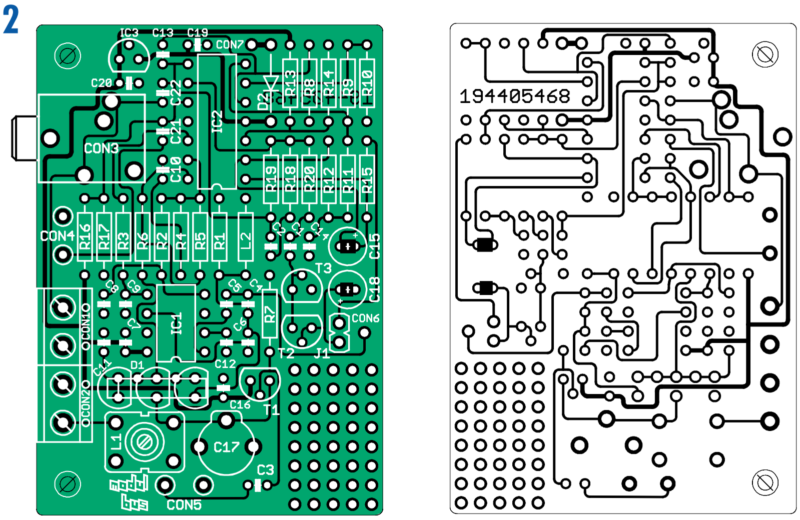
The RF input stage of the circuit in **Figure 1** is tuned by a varicap and passed through the source-follower formed by T1. A tuning voltage is generated by the passive PLL circuit and NE612 mixer. The DDS output signal from the receiver is connected to the input connector CON6.



The type of varicaps used in this design have a capacitance of 480 pF at 1 V. Triple packaged BB313 are shown on the diagram but individual BB112 varicaps can be substituted. An additional (unused) BB313 shown on the diagram facilitates future expansion of the design. The second part of the circuit is an automatic gain control stage built from an LM324 quad opamp which can provide up to 30 dB gain of the 12 kHz IF output signal to compensate for signal fading. Two VMOS transistors type BS107 are used as the controlling element where the drain-source current controls the internal resistance.

The finished PCB in **Figure 2** shows a neat circuit layout, coil L1 consists of 20

2



COMPONENTS LIST

Resistors
R1,R4,R6,R14,R18,R20 = 1kΩ
R2,R3,R8,R10-R13,R16,R17,R19 = 27kΩ
R5 = 1MΩ
R9 = 270kΩ
R7 = 470Ω
R15 = 100Ω

Capacitors
C1,C3,C5-C14,C16,C19-C22 = 100nF
C2 = 100pF
C4 = 22pF
C15 = 10µF 16V radial
C17 = 45pF trimmer
C18 = 47µF 16V radial

Semiconductors
D1 = BB313 or 3 off BB112
D2 = 1N4001
T1 = BF245
T2,T3 = BS107, BS170
IC1 = NE612
IC2 = LM324
IC3 = 78L05

Miscellaneous
J1 = Jumper
CON1,CON2 = 2-way PCB terminal block, lead pitch 5mm
CON3 = 3.5mm jack socket
CON4,CON5 = pinheader or wires
CON6,CON7 = 1mm dia. solder pin
L1 = inductor former with core (Conrad Electronics # 516651) and ECW 0.3mm
L2 = 2µH2 fixed inductor
PCB, ref. 060140-1

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turns of 0.3 mm enamelled copper wire (ECW) with a tap at the second turn up from the ground end of the coil, it is wound on a 5 mm diameter coil former fitted with a screw-in ferrite slug.

The regulated output signal is available at connector CON1 and the stereo jack socket CON3. This PCB is connected to the receiver PCB via connectors CON4 to CON7, jumper JP1 can be removed to disconnect the AGC signal.

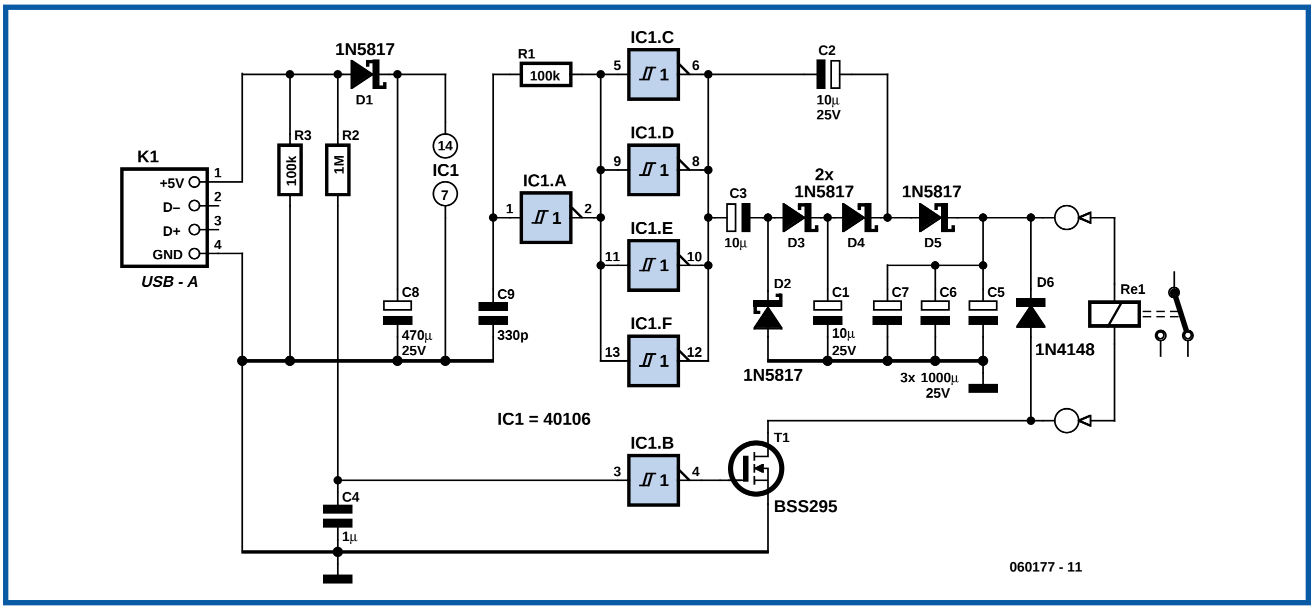
The automatic preselector requires a small amount of alignment to achieve optimum performance. Firstly tune the preselector to a station at the low frequency end of the scale and adjust the ferrite slug in L1 for maximum signal strength. Next tune in to a strong station at the upper end around 15 MHz and adjust trimmer C17 for maximum output signal. These two alignment points give a good synchronisation performance across the entire tuning range. The highest frequency which can be tuned depends on the voltage level on the varicaps so it is important to use a 12 V mains adapter to achieve the widest possible tuning range.

The receiver board uses a 9 V adapter and this limits the upper frequency range.

(060140-1)

Computer Off Switch

100



Uwe Kardel

How often does it happen that you close down Windows and then forget to turn off the computer? This circuit does that automatically. After Windows is shut down there is a 'click' a second later and the PC is disconnected from the mains. Up to now there were no mains switches available with a magnetic coil to turn off the power supply voltage, but now one is available from Conrad Electronics , with the article number 70061 for a price of 12.95 Euro (approx. £ 9.00). Surprisingly enough, this switch fits in some older computer cases. If the circuit doesn't fit then it will have to be housed in a separate enclosure. That is why a supply voltage of 5 V was selected. This voltage can be obtained from a USB port when the circuit has to be on the outside of the PC case.

A PCB design is available for the electronics part, but not for the high voltage part. It is best to solder the mains wires straight onto the switch and to insulate them with heat shrink sleeving.

C8 is charged via D1. This is how the power supply voltage for IC1 is obtained. A square wave oscillator is built around IC1a, R1 and C9, which drives inverters IC1c to f. The frequency is about 50 kHz. The four inverters in parallel power the voltage multiplier, which has a multiplication of 3, and is built from C1 to C3 and D2 to D5. This is used to charge C5 to C7 to a voltage of about 9 V. The generated voltage is clearly lower than the theoretical 3x4.8=14.4 V, because some voltage is lost across the PN-junctions of the diodes.

C5 to C7 form the buffer that powers the coil of the switch when switching off. The capacitors charge up in about two seconds after switching on. The circuit is now ready for use. When Windows is closed down, the 5-V power supply voltage disappears. C4 is discharged via R2 and this results in a '0' at the input of inverter IC1b. The output then becomes a '1', which causes T1 to turn on. A voltage is now applied to the coil in the mains switch and the power supply of the PC is turned off. T1 is a type BSS295 because the resistance of the coil is only 24 Ω.

When the PC is switched on, the circuit draws a peak current of about 200 mA, after which the current consumption drops to about 300 µA. The current when switching on could be higher because this is strongly dependent on the characteristics of the 5-V power supply and the supply rails in the PC.

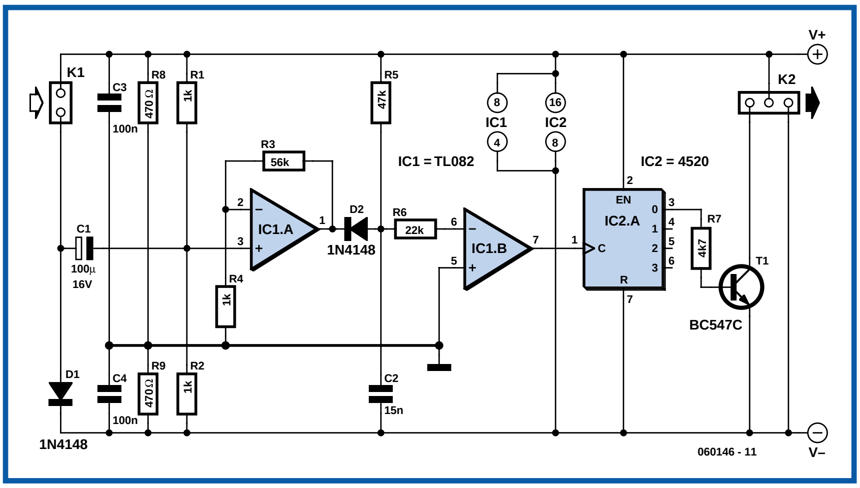
There isn't much to say about the construction of the circuit itself. The only things to take care with are the mains wires to the switch. The mains voltage may not appear at the connections to the coil. That is why there has to be a distance of at least 6 mm between the conductors that are connected to the mains and the conductors that are connected to the low-voltage part of the circuit. Also refer to the Electrical Safety page published from time to time In this magazine.

(060177-1)

101

Speed Pulse Generator for PC Fans

Stefan Schwarck



This circuit generates speed pulses from the speed-dependent voltage spikes generated by commonly used types of PC power supply fans, which are superimposed on the supply voltage. The pulse signal can be used by the motherboard to monitor the speed of the fan. For this purpose, the pulses are tapped off from a fan connected to K1 via capacitor C1 and amplified by opamp IC1a (one half of a TL082 dual opamp). The second opamp in the Tl082 (IC1b) transforms the resulting signal into a clean rectangular clock signal and passes it to a binary counter circuit in the form of IC2a (4520), which reduces the frequency by a factor of 2. A BC547C transistor (T1) connected to the counter output provides an open-collector output at K2 for connection to the motherboard.

K2 can be connected directly to a fan connector on the motherboard. The 12-V supply voltage for the circuit is also taken from the motherboard via this connector. Components C3, C4, R8 and R9 create an artificial ground potential at half the supply voltage (6 V), which serves as a reference voltage for the opamp. Diode D1 should have the lowest possible voltage drop to minimise the voltage loss to the fan.

The circuit is suitable for use with CPU fans and fans for graphics cards in addition to power-supply fans.

(060146-1)

102

Mains Slave Switcher II

Bart Trepak

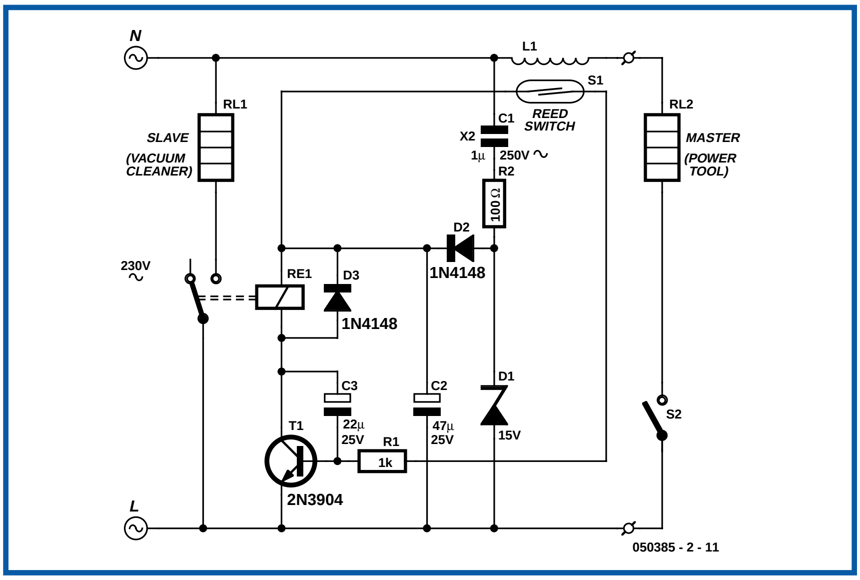
Many power woodworking tools such as saws and sanders have a provision for connecting a vacuum cleaner hose to suck up the dust and debris produced by their operation. The problem is of course that the vacuum cleaner must be switched on when the tool is switched on and as the operator's attention must be directed towards the work in hand especially when a blade with large teeth is spinning only inches from his fingers, there is often little incentive to look away to locate the vacuum cleaner switch. This unit was designed to fulfil this function by automatically switching on the vacuum cleaner when the power tool is switched on.

In this circuit, current flow is sensed using a reed relay which is not only cheap but provides a positive indication that current is flowing and dissipates very little power. Reed switches are often used in burglar alarms where they sense the magnetic field from a small magnet but it is also possible to produce a magnetic field by winding a coil around the reed switch and passing a current through this.

The circuit diagram shows a simple mains slave switch based on this idea. The coil may be wound directly onto the reed switch using insulated single core hook-up wire or enamelled copper wire of sufficient gauge to carry the current drawn by the power tool (or master appliance). In practice this should be as thick as possible to cater for any power appliance while still enabling a sufficient number of turns to be accommodated to produce the required magnetic field which will depend on the reed switch and is therefore best determined by

Warning

The circuit is by its nature connected directly to the mains supply. Great care should therefore be taken in its construction and the circuit should be enclosed in a plastic or earthed metal box with mains sockets fitted for the master and slave appliances.



experiment. As a guide, a one-inch reed switch with 40 turns reliably switched on with the current flowing through a 150-watt lamp (approx. 625 mA) but larger reeds may require more turns. If the master appliance draws less current (which is unlikely with power tools) more turns will be required.

The reed switch is used to switch on transistor T1 which in turn switches the relay RE1 and powers the slave appliance. Since reed switches have a low mechanical inertia, they have little difficulty in following the fluctuations of the magnetic field due to the alternating current in the coil and this means that they will switch on and off at 100 Hz. C3 is therefore fitted to slow down the transistor response and keep the relay energised during the mains zero crossings when the current drawn by the appliance falls to zero and the reed switch opens. C1 drops the mains voltage to about 15 V (determined by zener diode D1) and this is rectified and smoothed by D2 and C2 to provide a d.c. supply for the circuit.

The relay contacts should be rated to switch the intended appliance (vacuum cleaner) and the coil should have a minimum coil resistance of 400 Ω as the simple d.c. supply can only provide a limited current. C1 drops virtually the full mains voltage and should therefore be an X2-class component with a voltage rating of at least 250V a.c.

(050385-2)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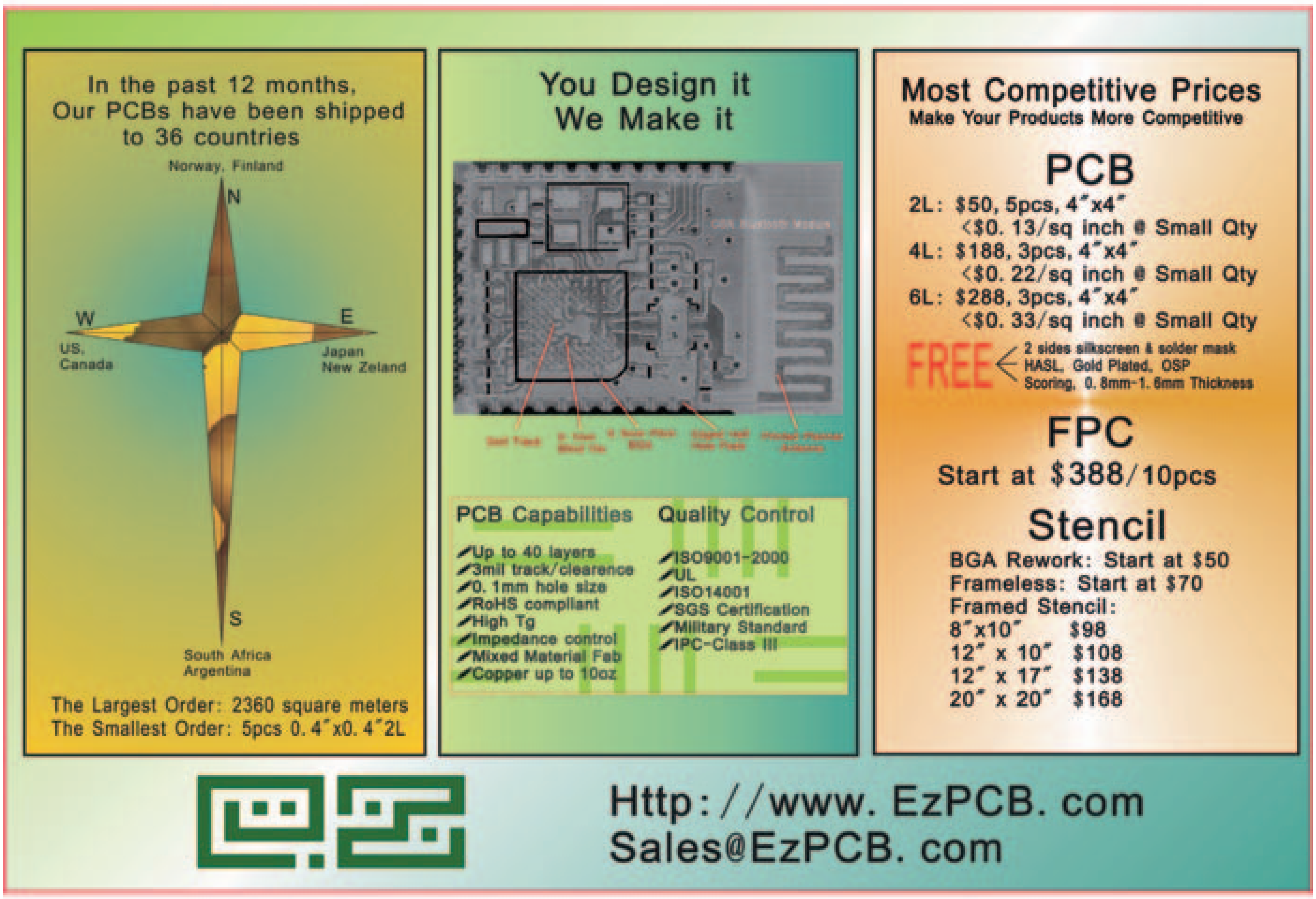
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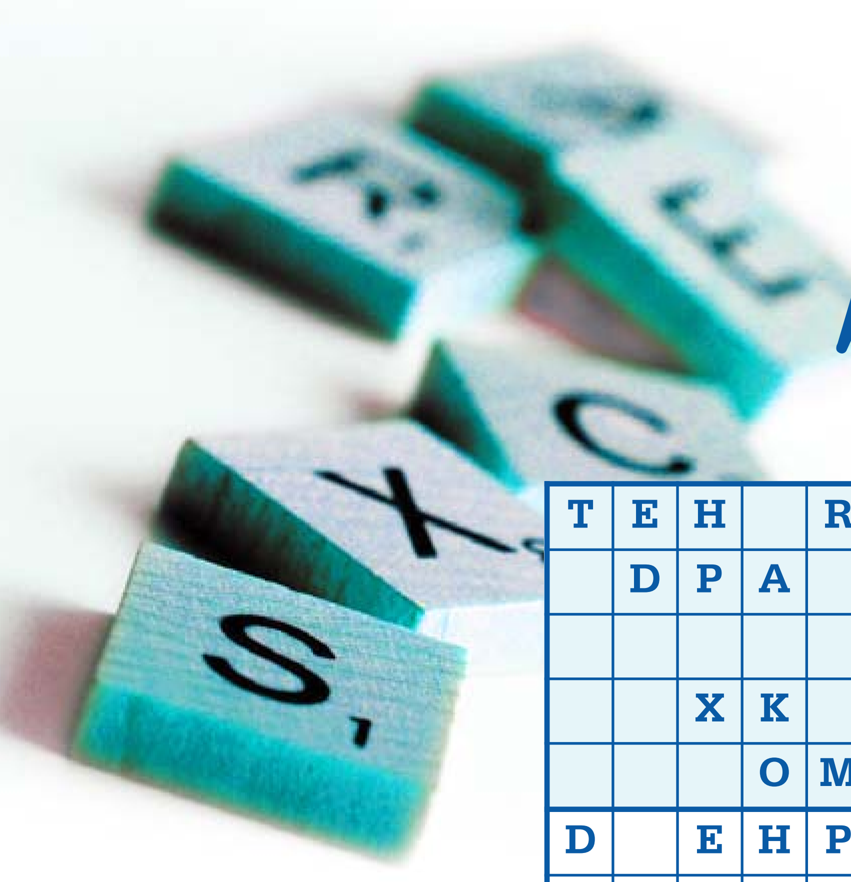

ALPHA

T	E	H		R					X				I		
	D	P	A					W	S						
						V	Y	T		O			B	Q	M
		X	K		B					S	H	F		E	
			O	M	G	A		F			R		V	T	
D		E	H	P					K		B			N	L
		L						X	T		S				Y
	V		B						A		J	K	L		U
	S		F		I	O			G		M	A			R
	K			X	C		R		U	D	O			G	
						T	S	Y				X	F	C	
			S			W		O	P	M				J	K
F		T		G	J	C	A					S	U		
B						Q					L	N	D		
E	H	K	L	A	X							P			S
	P	S			E	L					Y		G		C
		M			V	U	B			I			C		D
	C		I	T		R		Q	O	W					
H	X			L			N			F	K	R	T		
				J			C	I					N	D	A
V	J	Y				S	F				N	G		H	
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L					W		M	P		Y		E			H
R							O	B	H						J

So you thought our Hexadoku puzzles were hard to solve? "You ain't seen nothing yet"! For this year's Summer Circuits issue we've designed *Alphadoku,* a super version of Hexadoku you'll find so complex we're pretty sure it will take you every spare hour or even the better part of your summer holidays to solve.

Lots of *Elektor Electronics* readers have taken a great liking of the Hexadoku puzzle printed for the first time in our January 2006 issue. Feedback from you all indicated that the electronics-oriented Hexadoku was a welcome change from the well established Sudoku puzzle. Despite the varying degree of difficulty of the puzzles we get hundreds of correct solutions every month, a clear sign that lots of *Elektor Electronics* readers (and their family members) like to exert their brain to the maximum.
In this double Summer Circuits issue we step up the complexity of the puzzle by presenting a giant *Alphadoku* with a

DOKU

The ultimate brain rack for the summer holidays

V	G	J				L	Y	
U	O		H		I		F	
C		S			U			
I				O		M	R	
L						B	H	
A				I				
F	N	G	E		Q	U		A
				D	T	Y		P
	C							
			T	L	B	E		
N	L					J		R
	U	F		Q			V	
		V	Y			P		
R		A			C		X	M
	M			N		W		
			B	W				K
	E	N	K	G				
	J			S	V		P	
S							E	I
		W	G		O	R		T
	R	T						E
B		I	S					
X			N		W		U	J
			A				O	N
			C	K	D	T		S

whopping 25 times 25 boxes (thanks are due to our reader Mr. S. Jobse).
The instructions for the puzzle are really just as straightforward as for the Hexadoku variant, only the series of characters to be used is a bit longer. *Alphadoku* employs all letters of the alphabet except *Z*.
In the diagram composed of 25x25 boxes, enter letters in such a way that **all** letters *A* through *Y* occur once in every row, once in every column, and in every one of the 5x5 boxes (marked by the thicker black lines). A number of clues are given in the puzzle and these determine the start situation.
Your solution may win a prize and requires only the letters in the red boxes to be sent to us (see below). The puzzle is also available as a **free download** from our website (Magazine → 2006 → July/August).

Solve Alphadoku and win!

Correct solutions enter a prize draw for an

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Entering the competition

Please send the letters in the red boxes by email, fax or post to

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Fax (+44) (0)208 2614447.
Email editor@elektor-electronics.co.uk
Subject: alphadoku 07-2006.

The closing date is **1 September 2006**.

Competition not open to employees of Segment b.v., its business partners and/or associated publishing houses.

Prize winners

The solution of the May 2006 Hexadoku is: **02675**.

The **E-blocks Starter Kit Professional** goes to:
Rob Quin (Caste Douglas).

An Elektor SHOP Voucher worth £35.00 goes to:
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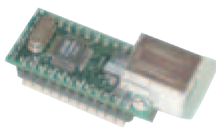

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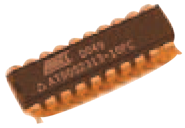

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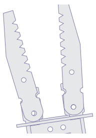
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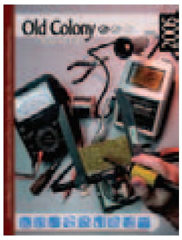

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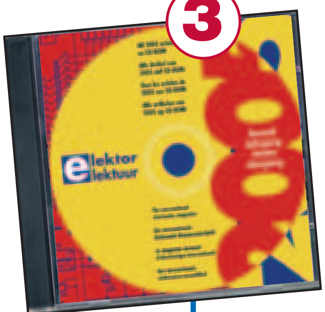

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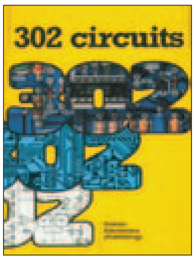

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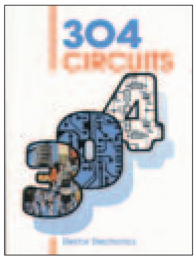

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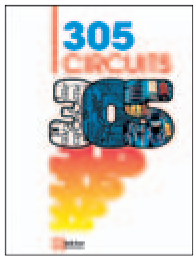

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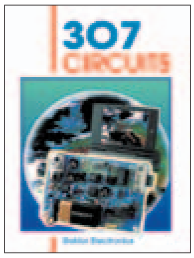

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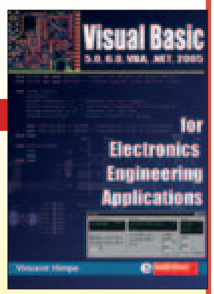

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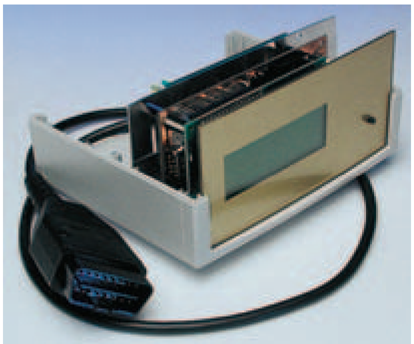

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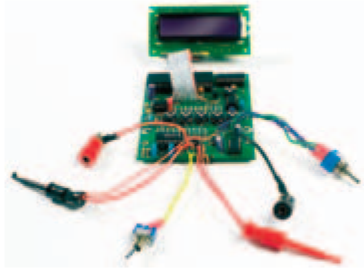

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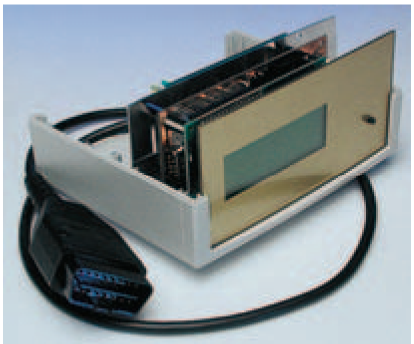

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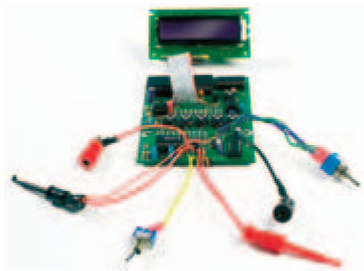

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If you build the USB version you get PC connectivity which enables additional information to be retrieved from the RFID card. The circuit is built around a Philips 89LPC935 microcontroller.

Free!

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Theme Plan for 2006

January	Recycling / Reverse Engineering
February	Motors / Propulsion
March	Development / Microcontrollers
April	Power Supplies / Safety
May	Soldering / Etching
June	Test & Measurement
July/August	Summer Circuits
September	**RFID / Satellites**
October	E-Simulation
November	Chipcards / Security
December	Electromechanical / Enclosures

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