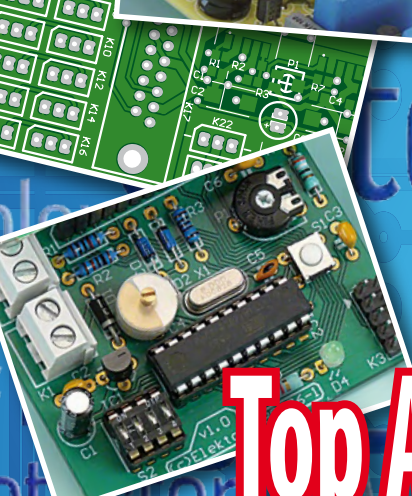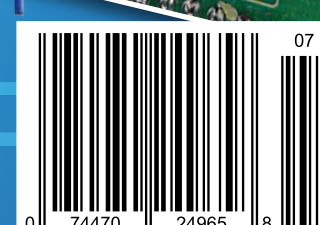# elektor

electronics & microcontrollers

SUMMER CIRCUITS CIRCUS
more than 100 circuits, ideas & tips

Top Act
ElektorWheelie

elektor
electronics & microcontrollers

Summer Circuits — made for you, by you

As the days shorten and the first fall winds howl and buffet the castle walls, the initial plans are drawn up. Seasons pass, fall and winter make way for spring, and when everyone looks like they could do with a bit more sunshine on as well as in their faces, it's finished and ready for printing: Elektor's Summer Circuits edition! To mark the real start of 'SC', however, we must go back even further in time — to the beginning of the summer of 2008, when many of you were thinking up exciting new ideas for the edition and eventually got round to sending them by email — and some even by snail mail.

Summer Circuits has been a collective effort since it was first produced for the British English market, now over 30 years ago. Every year we receive over 500 entries and ideas for publication! The projects come from all over the world, and we happily evaluate each item because the effort confirms the creativity and ingenuity of you, our readers.

All circuits in this edition have been tried and tested by Elektor Labs so repeatability should not be an issue if you read and work carefully – and know your way into our online forums because help and comfort is available there.

ElektorWheelie

While ElektorWheelie was literally 'under cover' in the June 2009 edition, this month we are unveiling the electronics starting on page 66 . Our DIY 'self-balancing two-wheeler' will take you further, both in distance and knowledge. In distance, because it is designed to take you from A to B in spectacular fashion. In knowledge, because ElektorWheelie is an 'Open Development'. Open for students and companies to redesign or modify, to make it even faster, or to make it run more miles on a battery charge. Who knows, some day we might even stage an Elektor-Wheelie Competition.

Have fun exploring this electrifying collection of more than 100 circuits, tips and ideas. None of our competitors has ever managed to publish anything remotely resembling our Summer Circuits edition. And don't forget, after a long day spent reading, soldering or measuring, comes well deserved recreation.

On behalf of the Elektor Team,
Wisse Hettinga
International Coordinating Editor

SUMMER CIRCUITS 2009

(Color of title indicates category, **bold type** = PCB design included)

CONTENTS

elektor international media

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

English
German
Dutch
French
Chinese

Italian
Spanish
Swedish
Finnish

Experimenting with the MSP430

Low-cost development system with a USB interface

NEW!

All the big electronics manufacturers supply micro-controllers offering a wide range of functions. Texas Instruments supplies handy USB evaluation sticks with related software for its low-cost MSP430 controllers. Unfortunately the I/O facilities are somewhat limited. These can be substantially enhanced with the help of the Elektor MSP430 board!

Together with Rotterdam's Technical College Elektor developed a low-cost development system that should appeal to those of you just starting out into microcontroller land. The basis of the system is the MSP-eZ430 USB-stick from Texas Instruments, a chip graced by a free develop-ment platform and a programming language (C). The associated experimenter's board easily accommo-dates the hardware for the project examples like a buzzer, a 7-segment display, some LEDs and pushbuttons.

Specifications

- Experimenter's board with several I/O possibilities
- Powerful 16-bit MSP430F2012 controller running at 16 MHz, 2 KB Flash and 128 bytes RAM
- 4 indicator LEDs
- 7-segment display
- Piezo buzzer
- 3 pushbuttons
- I2C/SPI connector
- Powered via the USB stick or an external adapter

Order in the Elektor Shop

PCB, populated and tested

Art. # 080558-91 • $55.00

TI eZ430-F2013 Evaluation Kit

Art. # 080558-92 • $35.00

elektor SHOP

Further information and ordering at www.elektor-usa.com/080558

Luxeon Logic

Brightness control for LED flashlights

Oliver Micic (Germany)

The small super-bright Luxeon LEDs from Philips are suitable for many applications, including small but handy (that is, bright) pocket torches. However, you don't always need maximum brightness, so it would be nice to have a simple brightness control. After giving this question a bit of thought, the author designed the circuit described here. An ATtiny microcontroller enables convenient one-button operation. Three brightness levels can be selected by pressing the button one to three times in succession, and pressing it yet again switches the LED off. In this state the ATtiny enters sleep mode with a current consumption of around 1.2 µA. The current consumption rises to around 12 mA in normal operation, plus the current through the LEDs. At 4.5 V, the currents measured by the author at the three brightness settings were 50 mA, 97 mA, and 244 mA. The LED current can be set to other levels by adjusting the value of R1 in the circuit, although the maximum operating current of the LED should not exceed 350 mA. If you want to use more than one LED, you will have to use a different transistor

type, since the maximum rated current of the 2N2222 is 600 mA.

With regard to the quite simple circuit, we can mention that it lacks a crystal because the clock is provided by the internal 8-MHz oscillator of the ATtiny microcontroller. The firmware [1] is written in BASCOM and works with PWM control using the internal clock divider (1:8). If any changes are made, this should be maintained to ensure that the firmware runs at 1 MHz, which reduces the current consumption.

A suitable small PCB is available via the Elektor website, and as usual the layout can be downloaded free of charge [1]. The author [2] designed a round PCB that fits nicely in a pocket flashlight with three AA batteries.

(081159-I)

Features
- Three selectable brightness levels
- One-button operation
- Microcontroller control circuit
- Current consumption in sleep mode only 1.2 µA
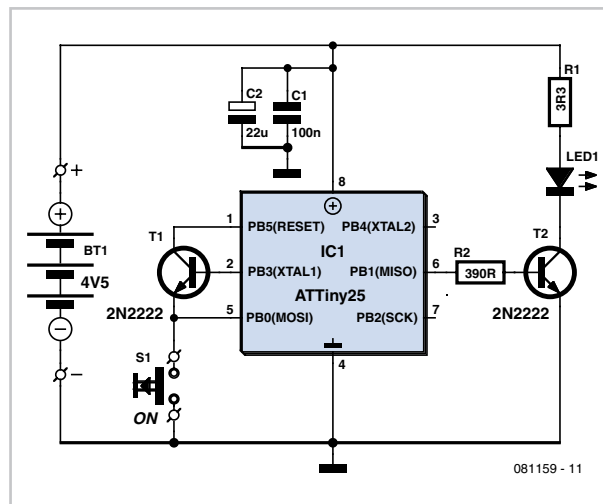
Internet Links
[1] www.elektor-usa.com/081159
[2] www.dg7xo.de

Downloads
081159-1: PCB design (.pdf), from [1]
081159-11: Source code and hex files, from [1]

Product
081159-41: ATtiny25 microcontroller, ready programmed

081159 - 11

COMPONENT LIST
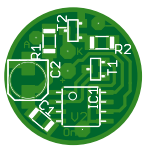
Resistors
R1 = 3Ω3 (1206)
R2 = 390Ω (1206)

Capacitors
C1 = 100nF (1206)
C2 = 22µF 10V (SMD)

Semiconductors
T1,T2 = 2N2222 (SOT-23)
IC1 = ATtiny25-20SU (SOT-8)
LED1 = Luxeon LED, 1W (SMD), white

Miscellaneous
Pushbutton
PCB # 081159-1 [1]

Preamplifier for RF Sweep Generator

Gert Baars (The Netherlands)

The RF sweep frequency generator ('wobbulator') published in the October 2008 issue of Elektor has a receiver option that allows the instrument to be used as a direct-conversion receiver. This receiver does however have a noise floor of only –80 dBm, which really should have been –-107 dBm to obtain a sen-

sitivity of 1 µV. So, for a good receiver some more gain is required. A wideband amplifier, however, generates a lot of additional noise as well and as a consequence will not result in much of an improvement.

As an experiment, the author developed a selective receiver with a bandwidth of about 4 MHz. Because a gain of at least 35 dB is

required, the preamplifier consists of two amplifying elements.

The input amplifier is designed around a dual-gate MOSFET, type BF982. This component produces relatively little noise but provides a lot of gain. The output stage uses a BFR91A for some additional gain.

Preamplifiers where both the gate and the drain are tuned often struggle with feedback via their internal capacitance. Here, the drain circuit has a relatively low impedance, which prevents this from happening. In the prototype that was tested, the input and output are located at right angles with respect to each other to prevent inductive coupling (see photo). Despite the high gain, the amplifier was perfectly stable even without any shielding.

The two air-cored coils in the circuit both consist of 4 turns and have an internal diameter of 6 mm, made from AWG #18 (1-mm) diameter silvered copper wire and with a tap after 1 turn.

The amplifier is mainly intended for the 144 MHz amateur band, but with other coils can also be used for the FM broadcast band, for example. FM detection is achieved by tuning near the edge of the IF filter. At an offset of 15 kHz this is only a few dB lower than at the centre of the pass-band, so that damping is not noticeable. The measured sensitivity in the 2 m band was about 1 μV (6 dB).

A good antenna always contributes to the reception, of course. A wideband (scanner) outdoor antenna will give good results. Adding this wobbulator/receiver option results in a nice monitor receiver. By setting the scan frequencies of the spectrum analyzer to 144 and 148 MHz (or 146 MHz where applicable), any signal within this range is directly vis-ible. When a signal is detected it is merely a case of clicking the scan stop button and then clicking on the signal in the display window using the right mouse button. After this, the receiver switches directly to this frequency and you can listen to the signal. You can subsequently resume the scanning so that you can continue to look for other signals.
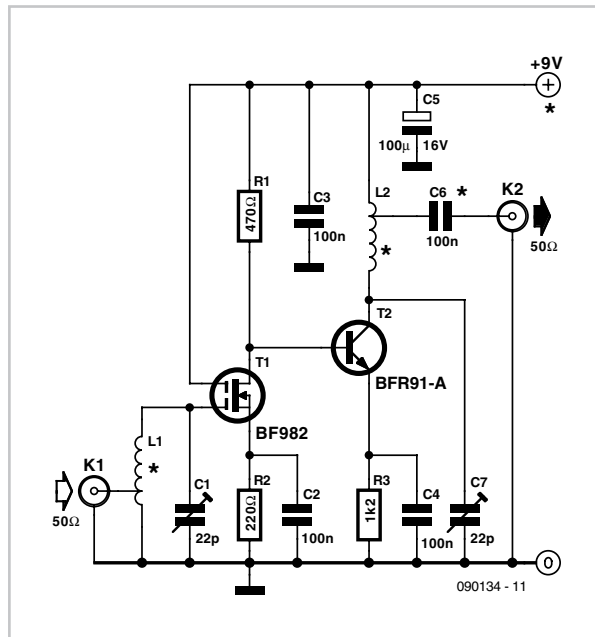
For narrowband FM detection you need to select the FMN button in the window for the receiver and this then provides the required offset for the edge detection at 25 kHz bandwidth. This value is adjustable via the 'setting' menu (default is 12,500 Hz) and can be changed experimentally for best results.

To power the circuit you can use a 9-V battery. It is also possible to power the amplifier directly from the RF sweep generator, if output capacitor C6 is replaced with a link; in the 'options' menu you will then have to select the option 'use probe'.

(090134-I)

Cheap Serial Port for the Mac

Gerrit Polder (The Netherlands)

Many people would agree that the Apple Macintosh is a fantastic computer. Even so, it's been less popular for a good while amongst electronics engineers and enthusiasts. Of course there was a good reason for this: Apple was one of the first companies that left out the ever so useful RS232 port. And not only on their notebooks (sorry, MacBooks!), they also left them out from their desktop computers. It's been a good 10 years since Apple started delivering those beautiful, futuristic iMacs in a range of colors, but unfortunately without an RS232 port. However, times change and Apple has steadily increased its market share, also amongst electronics enthusiasts. And as far as 'the other brands' are concerned, there is virtually no laptop made nowadays that does come with an RS232 port.

The RS232 port is still considered very useful by many electronics-minded people though. These days microcontroller circuits that employ ersatz-RS232 often work at 3 V rather than 5 V. The ±12 volt swing originally specified for RS232 isn't found or indeed useful anymore. For that reason a checklist was created to help you add a 3 or 5 volt RS232 port to your Macintosh (or other computer) at very little cost.
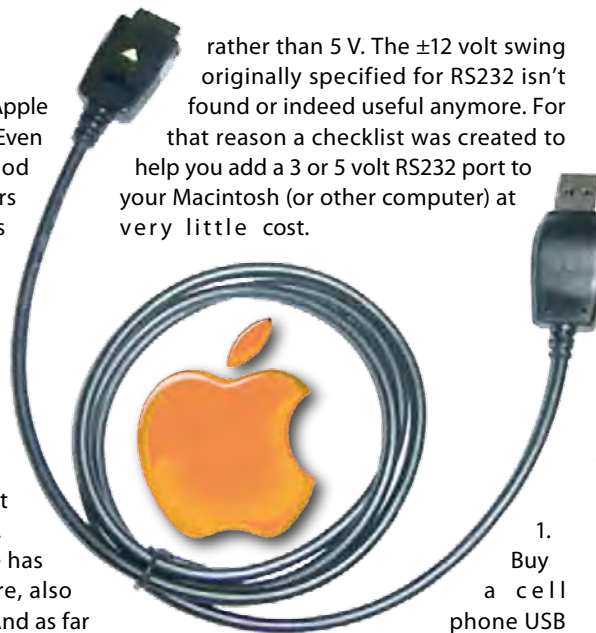
1. Buy a cell phone USB cable from a shop or via the Internet from Hong Kong; it shouldn't cost a lot.

2. Look at [2] for the pinout of the plug. It will tell you what connections are used by RS232 and what the operating voltage is. This will be 3 volts for most modern cell phones; for older models it is usually 5 volts.

3. You will usually get some software for Windows with the cable — if you can use it you're done. Congratulations!

4. Mac users have to do a bit more work though. Connect the cable to the computer and have a look in the System Profiler (Applications/Utilities) under Hardware/USB to see what type of interface it is.

As an example, you could see the following:

usb data cable:

Version:	1.00
Bus Power (mA):	500
Speed:	Up to 12 Mb/sec
Manufacturer:	Silicon Labs
Product ID:	0x10c5
Serial Number:	0001
Vendor ID:	0x10ab

5. You can see from this that you have a 'Silicon Labs' interface. From the website of this company [1] you download the CP210x USB to UART Bridge Virtual COM Port (VCP) driver for Mac OS X.

6. The driver is installed by double-clicking on the SLAB_USBtoUART Installer.
7. Unfortunately, the standard Product and Vendor ID of this driver do not correspond with those of the GSM cable, but that is easily rectified. The Product and Vendor ID that discovered in step 4 can be included in the file: */System/Library/Extensions/SLAB_USBtoUART.kext/Contents/Info.plist.* All that's left to do is

to type a few instructions to load the driver.
8. Open a terminal session and type:
$ sudo kextload /System/Library/Extensions/SLAB_USBtoUART.kext
$ touch /System/Library/Extensions
$ ls -al /dev/tty.SLAB*

If all went well you should see something like this:

crw-rw-rw- 1 root wheel 9, 8 Oct 18 08:32 /dev/tty.SLAB_USBtoUART

as proof that the new COM port is available.

(090092-I)

Internet Links
[1] www.silabs.com
[2] http://pinouts.ru

0–18 MHz Receiver

090082 - 11
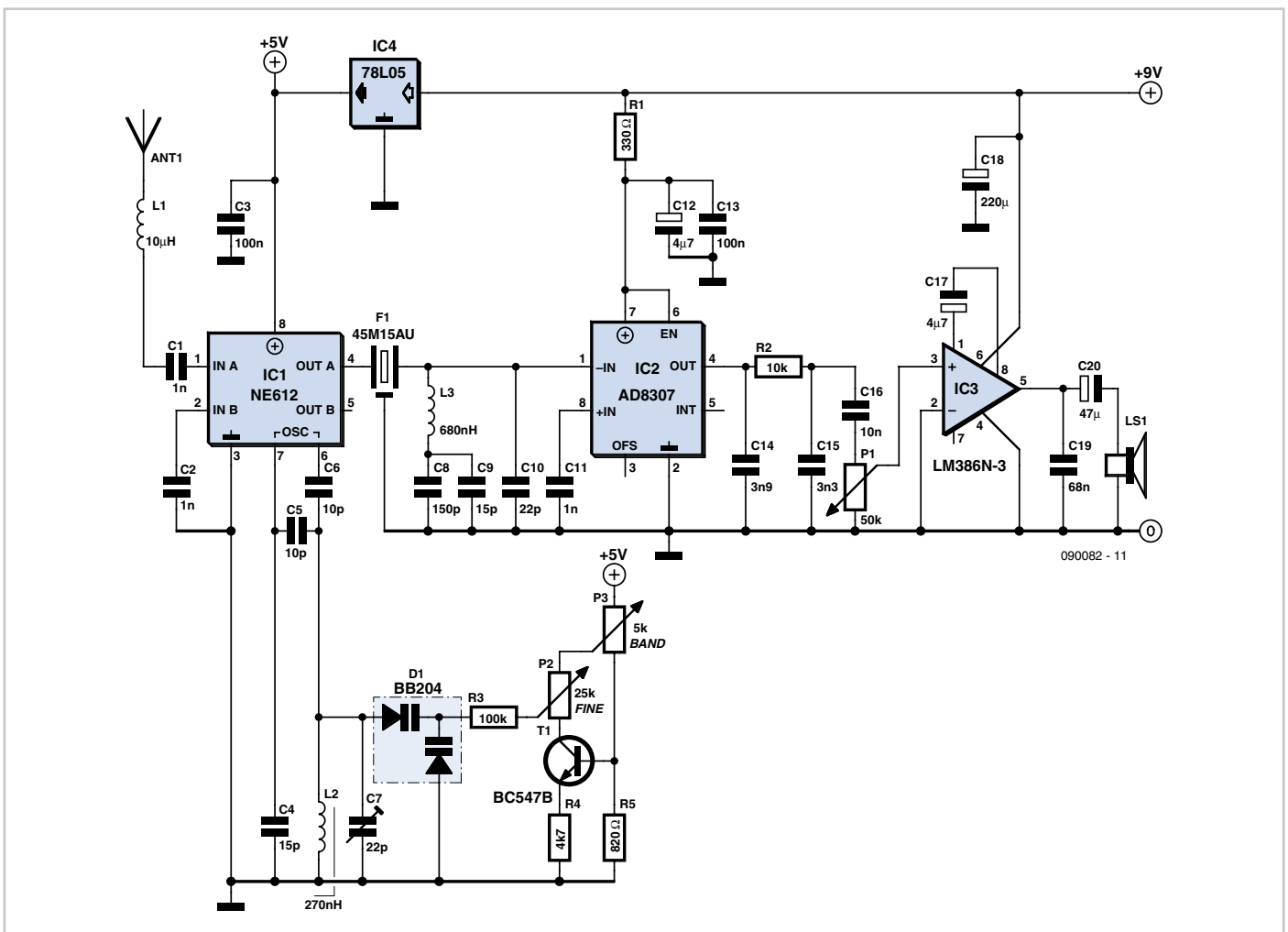
Gert Baars (The Netherlands)

The receiver shown in the schematic has some characteristics not unlike those of the so-called 'world band receivers' from the old days, which could usually receive LW, MW and SW up to about 20 MHz in AM and which were crammed with transistors. Because of the 'low-budget' character of this circuit it forgoes a tuning scale/indicator and the design has been kept as simple as possible. Nevertheless, the name 'Mini World Receiver' would not be inappropriate for this design.

In the RF bands up to 30 MHz, the majority of stations can actually be found below 18 MHz. It is possible to make a receiver for this with a relatively simple circuit. The simplicity of the circuit is therefore its primary strength, but that does not mean that the results are poor. The receiver is a single superheterodyne with the salient characteristic that the receiving range from DC to 18 MHz can be tuned in a singe range.

The circuit uses a high intermediate fre-

quency (IF). This makes the image frequency large, so that its suppression is very easy, which contributes to the simplicity of the circuit. This also means that the ratio between the highest and lowest required VFO frequencies remains small as well.

The circuit starts with a NE612 mixer IC (IC1), which also contains an oscillator. The oscillator is a Colpitts type and is tuned here using a dual-varicap diode (D1). The Mixer is followed by a crystal filter which has a center

frequency of 45 MHz and a bandwidth of 15 kHz. This bandwidth is a little large for AM, but the advantage of the filter type 45M15AU that is used here, is that it is reasonably if not favorably priced.

With an IF of 45 MHz and a receiving range from DC to 18 MHz, the VCO frequency therefore has to be IF+F0 = 45 to 63 MHz. The image frequency is now 90 MHz higher than the desired receiver frequency, at 90–108 MHz. A single coil in series with the antenna provides sufficient suppression at these frequencies. It really cannot be any simpler.
After the IF filter follows an LC combination which suppresses the fundamental frequency of the IF filter (45M15AU is a 3rd overtone type) and increases the damping. A logarithmic detector was chosen for the IF amplifier. The advantage is mainly the small number of external components that are required for this. The detector is an AD8307 (IC2) and has a sensitivity of about –75 dBm, which works out to about 40 µV. Together with the gain of the mixer (around 17 dB) the sensitivity of the receiver ends up at about 5 µV. Because of the logarithmic characters of the detector, an AGC (automatic gain control) is not necessary. A simple RC filter subsequently provides some additional fundamental frequency and

noise suppression.

The AF amplifier follows this filter and is configured for a gain of approximately 200. This is enough to drive a speaker so that it exceeds the ambient noise. If necessary the volume can be adjusted with P1.
To tune such a large frequency range it is certainly preferable to use a multiturn potentiometer. Because of the low-budget character of this design, a circuit around two potentiometers is used instead. A transistor configured as a current source provides a constant voltage of about 1 volt across the 'Fine' tuning potentiometer (P2). The 'Band' potentiometer (P3) has a negligible effect on the voltage across the 'Fine' potentiometer, but it does allow the voltage at both extremes to be changed. In this way the 'Band' control can be used to select a window within which the 'Fine' potentiometer is used for the actual tuning. The ratio is about 1 to 5. If you prefer a ratio of, say, 1 to 10, you can increase the emitter resistor R4 from 4.7 kohms to 10 kohms.
Because the VFO has to be stable, only the power supply to the mixer/VFO IC has been regulated. The power supply voltage to the AD8307 has been reduced with a resistor to a safe value, while the AF amplifier is pow-

ered directly from the battery. The current consumption of the circuit without a signal is less than 20 mA and with good audible audio about 50 mA. The circuit continues to work well with power supply voltages down to about 6.5 volts. This means that a 9 V battery will last extra long.

Calibration of the circuit is simple. The tuning potentiometers have to be set to the lowest frequency first. Use trimmer capacitor C7 to find a point where AC power line hum becomes audible. Here the receiver frequency is at 0 Hz. Optionally you can also tune to a strong longwave station as the lowest receiver frequency.

As a minimum a simple telescoping antenna with a length of about 2 feet is required, which makes the receiver eminently suitable for portable use. With such an antenna dozens of broadcast and amateur stations are audible, particularly during the evening when propagation becomes favorable. Although a wire antenna with a length of 20 to 60 feet does increase the signal strength, particularly during the day, you'll find that it is not strictly necessary.

(090082-I)

Start-up Aid for PCs

090128 - 11

090128 - 12
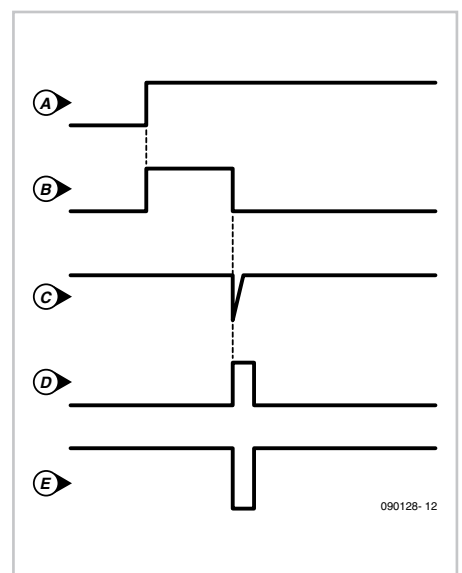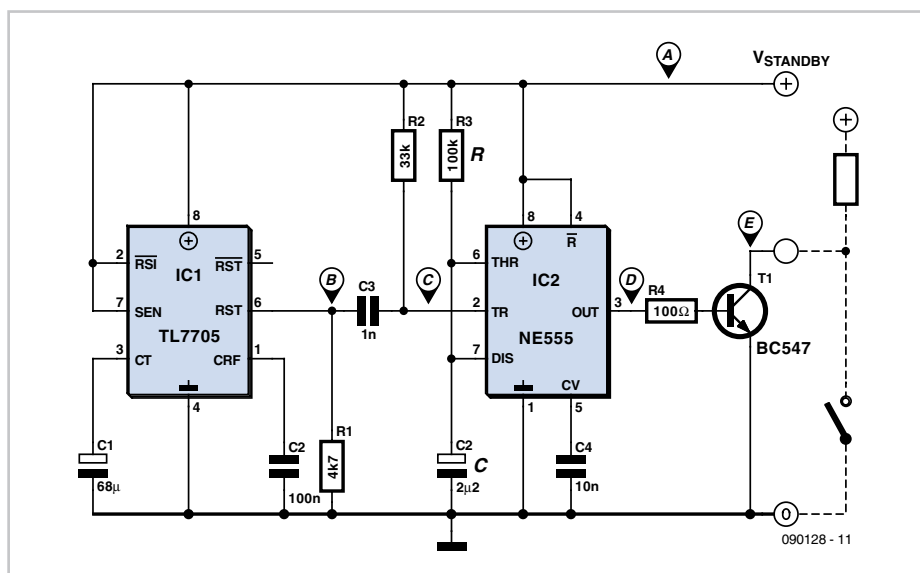
Egbert Jan van den Bussche (The Netherlands)

Since one of the servers owned by the author would not start up by itself after a power failure this little circuit was designed to perform that task.

The older PC that concerned did have a

standby state, but no matching BIOS setting that allows it to start up unattended. Although a +5 V standby supply voltage is available, you always have to push a button for a short time to start the computer up again. Modern PCs often do have the option in the BIOS which makes an automatic start

after a power outage possible. After building in the accompanying circuit, the PC starts after about a second. Incidentally, the pushbutton still functions as before.

The circuit is built around two golden oldies: a NE555 as single-shot pulse generator and a

TL7705 reset generator. The reset generator will generate a pulse of about 1 second after the supply voltage appears. The RC circuit between the TL7705 and the NE555 provides a small trigger pulse during the falling edge of the 1 second pulse. The NE555 reacts to this by generating a nice pulse of 1.1*RC*. During that time the output transistor bridges the above mentioned pushbutton switch of the PC, so it will start obediently.

Other applications that require a short duration contact after the power supply returns are of course also possible.

(090128-I)

Port Expander

Steffen Graf (Germany)

It can sometimes happen that even when using the largest version of a microcontroller for a particular design application there are just not enough I/O port pins to handle all the inputs and outputs. This can be the case when for example several LCDs are driven in parallel or when it is necessary to input values from aa large number of switches and pushbuttons.

The circuit shown here solves the problem using the I/O port expander IC type MAX7301 from Maxim [1]. This device can be powered from a supply between 2.5 V and 5 V which makes it suitable for use with both 3.3 V and 5 V controllers (the value of resistor shown as R2 is suitable operation from a 3.3 V supply).
The port expander uses the SPI interface so it only requires four microcontroller pins: Data In, Data Out, Clock and Slave Select. Many microcontrollers have an SPI interface already implemented on-chip but if not it should be relatively easy to implement the function in software. We have sacrificed four pins on the interface but this port expander now gives us 28 general purpose I/O pins (GPIOs) which can be configured as either inputs (with or without pull-ups) or outputs. Providing the microcontroller is fast enough the GPIOs can be switched at a
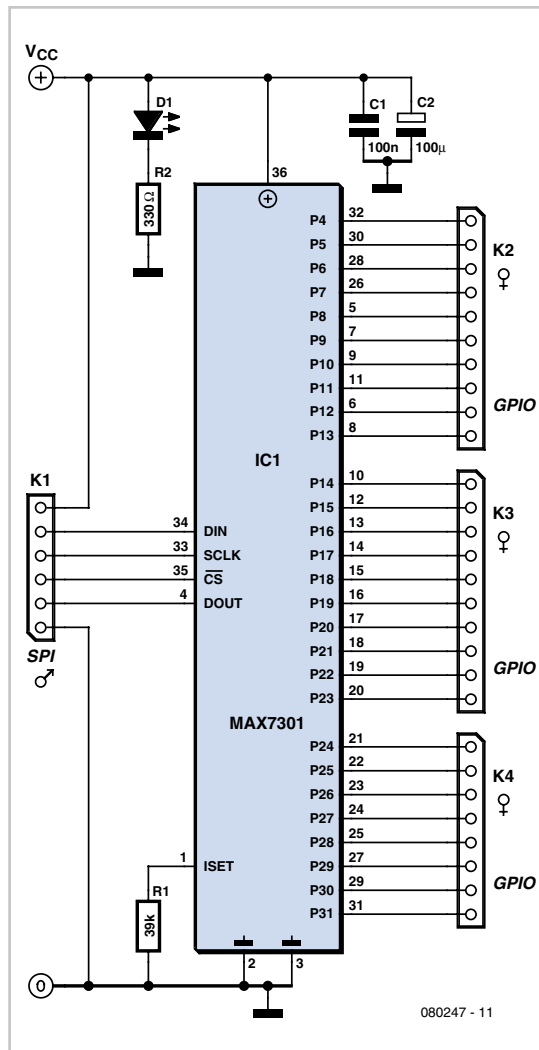
rate of 26 MHz.
The project page of this article [2] includes full listings (in the form of a small C library) of the author's software implementation. This allow the ports to be configured as inputs or outputs and the value of the input port pins to be read or output pins to be set.

The instruction
`io_max7301(0xF, Portpins);`
selects port pins used as outputs. A macro expression such as PCONF8_11 is used for Portpins to refer to port pins 8 to 11. The instruction
`io_max7301(0x0, Portpins);`
configures port pins as inputs. To output data from the port pins use
`set_max7301(data, Portpins);`
where *data* = binary data. And the instruction
`data = get_max7301(Portpins);`
reads the binary value of input data.

(080247-I)

Internet Links

[1] http://datasheets.maxim-ic.com/en/ds/MAX7301.pdf

[2] www.elektor-usa.com/080247

Download

Software
080247-11 source code, from [2]

080247 - 11

Slow Glow

Dirk Visser (The Netherlands)

There are many different ways in which a lamp can be made to light up gradually. This circuit presents one of them. What is special about this circuit is that it can be turned into a power potentiometer with only a small modification.

Slow Glow operates as follows: the instant the circuit is turned on, the inverting input

of the opamp is at the same voltage as the inverting input, which is equal to the supply voltage. However, C1 will slowly charge up, which causes the voltage on the inverting input to drop. This voltage therefore looks like an inverted RC charging curve. The reduction of this voltage causes the output voltage of IC1 to increase, and T1 is driven open harder. This in turn causes the voltage across the lamp to follow the

shape of an RC charging curve, and the use of a transistor means that a large current can be supplied.

When it comes to the choice of op amp you have to keep in mind its common mode range. In this circuit it needs to be equal to the full supply voltage. As a voltage follower the need is therefore for a rail-to-rail opamp. An LM8261 was picked mainly because it

combines an exceptionally small package (SOT23-5, 2.92 x 2.84 mm) with an equally exceptional supply voltage range of 2.7 V to 30 V. There are very few rail-to-rail opamps offering such a large supply voltage range. The opamp has been decoupled with C3 because of its speed (GBWP: 21 MHz). The speed isn't critical in this case though. R3 is connected in series with the MOSFET to prevent spurious oscillations from occurring.

It stands to reason that this circuit is best built using SMD components. C1 can be obtained in an 0805 package (ceramic multilayer) and all other parts are also available in SMD packages. For the MOSFET we found an SOT-223 variant made by ST, the STN4NF03L. It can switch more than 6 A, which is impressive considering its dimensions (7 x 6.5 mm). If more power is needed than the maximum dissipation of 3.3 W (at 25 °C) permits, there is no problem if a bigger FET is used (for example, one in a larger

D2PAK package). There is a large number of FETs available in this type of package that can cope with significantly higher currents and power.

The circuit can also be used with normal 12 V halogen lighting if a bit of cooling and a TO-220 package is used. With the values used for R1 and C1 the transistor needs to dissi-

pate the maximum power for only just over a tenth of a second. This power is obviously dependent on the type of lamp connected up. The gate-source voltage of the MOSFET determines the permissible supply voltage range. The absolute maximum value here is 16 V, and there is also a minimum voltage required to obtain a low channel resistance (<0.05 Ω at U_{GS} = 5 V). Hence the supply voltage range for this circuit is 6 to 15 V and a 16 V rated type for C1 is sufficient.

When C1 and R1 are replaced with a potentiometer (with the slider connected to R2), the whole circuit behaves much like a potentiometer, but one with very large output power. The MOSFET is driven by IC1 such that a balance exists between the inputs of the op amp. The voltage at the drain therefore becomes equal to the voltage at the wiper of the potentiometer.

(090029-I)

SRPP Headphone Amplifier

Martin Louw Kristoffersen (Denmark)

Mention tube amplifiers and many designers go depressive instantly over the thought of a suitable output transformer. The part will be in the history books forever as esoteric, bulky and expensive because, it says, it is designed and manufactured for a specific tube constellation and output power. There

exist thick books on tube output transformers, as well as gurus lecturing on them and winding them by hand. However, with some concessions to distortion (but keeping a lot of money in your pocket) a circuit configuration known as SRPP (series regulated push-pull) allows a low-power tube amplifier to be built that does not require the infamous output transformer. SRPP is normally used for pre-

amplifier stages only, employing two triodes in what looks like a cascade arrangement.

Here we propose the use of two EL84 (6BQ5) power pentodes in triode SRPP configuration. The reasons for using the EL84 (6CA5) are mainly that it's cheap, widely available and forgiving of the odd overload condition. Here, two of these tubes are SRPP'd

into an amplifier that's sure to reproduce that 'warm thermionic sound' so much in demand these days.

Before describing the circuit operation, it must be mentioned that construction of this circuit must not be attempted unless you have experience in working with tubes at high voltages, or can rely on the advice and assistance of an 'old hand'. As a safety measure, two anti-series connected zener diodes are fitted at the amplifier output. These devices protect the output (i.e. your headphones and ears) against possibly danger-

ous voltages at switch-on, or when output capacitor C3 breaks down.

The power supply is dimensioned for two channels, i.e. a stereo version of the amplifier. The values in brackets are for Elektor readers on 120 V AC networks. Note the doubled values of fuses F1 and F3 in the AC primary circuits. The PSU is a conventional design, possibly with the exception of the 6.3 V heater voltage being raised to a level of about +80 V through voltage divider R7-R8. This is done to prevent exceeding the maximum cathode-heater voltage specified for the EL84 (6CA5). R6 is a bleeder resistor emptying the reser-

voir capacitors C8 and C9 in a quick but controlled manner when the amplifier is switched off. Rectifier diodes D3–D6 each have an anti-rattle capacitor across them.

In the amplifier, assuming the tubes used have roughly the same emission, the half-voltage level of about +145 V exists at the junction of the anode of V1 and the control grid of V2. The SRPP is no exception to the rule that high quality, (preferably) new capacitors are essential not just for reproducibility and sound fidelity, but also for safety.

(081151-I)

Easy LEGO Robotics Set Up

Tilo Gockel (Germany)

At the beginning of 2006 the Danish company LEGO introduced the NXT programmable brick into their 'Robotics Invention System'. Many schools and universities all over the world have since recognized this as an ideal tool to introduce the concepts of software and hardware design. Spare parts or additional components for the system can be purchased from on-line auction sites or ordered from the LEGO web shop [1].
If you are planning to invest in the system for a child, teenager or even for your own personal use you should be aware that you may encounter some issues when first installing the software. The problems can occur on machines running Windows XP or Vista because the software is not officially supported. The following tips will be helpful and should solve the main problems you are likely to come across.

First off, try installing the software on the supplied CD as suggested in the manual. With any luck it will be successful. Choose 'complete installation' option and then tick Quicktime 2.1 option and not the Quicktime 3.0 and DirectX 6.1. It is likely that there is a more up to date version of DirectX already installed on your machine. It is important to specify Quicktime 2.1; more recent versions are not recognized!
In some cases the computer may now 'hang' when it tries to execute probe.exe, if this is the case then it is necessary to make a few changes to the installation:

1. Uninstall the LEGO software (Program files / LEGO MINDSTORMS / ... / uninstall)
2. Uninstall all versions of Quicktime (Start / Control Panel / Add or Remove Programs / right click on Quicktime)

3. Re-install the LEGO software selecting Quicktime 2.1.
4. Start / Control Panel / System / click 'Advanced' tab / Performance click 'Settings' / click 'Advanced' tab / Now on 'Virtual memory' reduce the size to 384 MB.

Step 4 is important, otherwise Quicktime reports that there is too little memory available and does not even start — a somewhat curious bug.

Now a change is necessary to the start icon for Mindstorms; right click on the LEGO Mindstorms desktop icon and select 'Properties', now click the Shortcut tab and change the 'Start in' path from 'C:\Program\LEGO MINDSTORMS\probe.exe' to 'C:\Program\LEGO MINDSTORMS'. Occasionally a problem will occur with the Windows installer service (error 1281) which causes the computer to hang. To get round this you can either reboot before each new installation or you can manually stop the installer by going to Start / Control panel / Administrative tools / Services / right click Windows Installer and click on the service status box 'Stop'. Now run the software by clicking on the desktop LEGO icon (make sure that the CD is in the computer's CD drive). Installing the older LEGO Robotics Invention Version 1.0 can sometimes generate a problem with the

screen Display Properties; a solution to the problem can be found at [2].

Some practical tips for newcomers to the LEGO system: communications between the brick and the IR transmitter can be disrupted by strong external light sources such as table lamps and fluorescent lighting. A green LED on the IR transmitter indicates that the communication was successful. When it is anticipated that the system will not be used for a period of time don't forget to remove the battery from the IR transmitter station.
The IR tower needs a serial port but newer computers do not usually have this type of port, in this case try a USB — infrared transmitter dongle these can be found on Internet auction sites and retail at relatively low prices. Alternatively an even cheaper solution is a USB to RS232 interface (e.g. the USB2 Serial USB 1.1 from Reichelt in Germany).
Several alternative programming environments have been developed for the LEGO system and for more adventurous projects like those described in [3] it is better to use a high-level compiled language rather than the LEGO graphic programming environment which comes bundled with the controller. A good choice is the free NQC (Not Quite C) cross compiler [4] which uses a C-like syntax.

(081129-I)

Internet Links

[1] http://shop.lego.com/ByCatalog

http://www.lego.com/education/school

[2] www.crynwr.com/cgi-bin/ezmlm-cgi/7/21888

[3] www.tik.ee.ethz.
ch/tik/education/lectures/PPS/mindstorms/#finished

www.informatik.uni-kiel.
de/rtsys/lego-mindstorms/projekte/#c1798

www.youtube.com/results?search_type=&search_qu
ery=lego+mindstorms&aq=f

[4] http://bricxcc.sourceforge.net/nqc/

Pseudo Fan

Dr. Thomas Scherer (Germany)

The aim of this circuit is to trick a so-called 'intelligent' fan controller that a fan is connected to it when it is not. This may sound like madness, yet there is method in it.

The author was so pleased with his small private server (a network attached storage, or NAS, device) that he recommended it to a friend. The friend had found a good source of low-cost SSDs (solid state disks) and replaced the spinning hard disks with semiconductor memory, with the aim of saving power. With the drives replaced, it became apparent that there was an opportunity to make the unit quieter still. Since the SSDs only dissipated a

Characteristics

● simulates a fan of any size(!)

● pseudo-rotation frequency adjustable from 15 Hz to 150 Hz

● current consumption less than 5 mA

● operating voltage from 4 V to 15 V

● low noise!

total of 5 W, surely it would be possible to disconnect the noisy internal 60 mm fan? Unfortunately it was never going to be that easy. The moment the fan was disconnected an annoying buzzer started to sound continuously: the electronics in the NAS box does not just control the fan speed to maintain a reasonable temperature inside the unit, it also checks that the fan is indeed spinning. If the controller thinks the fan has stopped, it sounds the alarm. The author was called in to see if he could solve the problem.

It immediately became clear that the fan had a standard three-pin connector. The cable carried a voltage of between +5 V to +12 V on the red wire and ground on the black wire; on the yellow wire the fan produced a square-wave signal with a frequency of about 35 Hz. To fool the controller into thinking that the fan is turning we simply needed to generate a square wave!

090445 - 11

Old hands will no doubt be able to guess what comes next: the 555 timer, one of the best-selling ICs ever, is ideal for this task. It can cope with the range of supply voltages,

COMPONENT LIST

Resistors
R1 = 47kΩ
P1 = 470kΩ, small, upright

Capacitors
C1 = 100nF
C2 = 10nF
C3 = 47μF 16V

Semiconductors
D1 = SB140 (Schottky diode)
IC1 = NE555

Miscellaneous
Branched cable with 3-way plug
PCB # 090445-1

and conveniently features a traditional open-collector output.

The circuit diagram contains no great surprises. Rather than using the standard astable configuration of the device, the frequency-determining resistance (comprising the series connection of R1 and P1) is wired to pin 3, which is normally used as the output. This has the twin advantages of leaving pin 7 free to use as an open-collector output and of giving a 50 % duty cycle. With the component values suggested the output frequency can be adjusted from approximately 15 Hz to approximately 150 Hz, which should be more than enough for any application.

It is of course possible to build a simple circuit like this on a small piece of prototyping board. However, a much more professional look can be achieved using the printed circuit board we have designed for the job. The layout file can, as usual, be found on the Elektor website on the pages accompanying this article [1].

The pseudo-fan is of course not limited to being used in small servers. It is becoming more and more popular to build PCs that are quiet, especially if they are to be used as media centers. This means using passive cooling wherever possible. Unfortunately in some cases the BIOS throws its spanner in the works by not allowing the fan rotation sensors on the motherboard to be disabled individually. The pseudo-fan provides a simple and quick solution to this problem and avoids complicated BIOS patches. Some fans use a four-wire cable, and these too can be 'virtualized' using this circuit by ignoring the fourth wire and connecting the remaining three in the way described above.

If it will not be necessary to adjust the pseudo-fan speed P1 can be replaced by a wire link and R1 chosen appropriately. The frequency is then given by $f = 1.44 / (2 \times R1 \times C1)$.

(090445-I)

Internet Link

[1] www.elektor.com/090445

Download

090445-1: PCB design (.pdf), from [1]

Programmable Nokia RTTTL Player

Sajjad Moosavi (Iran)

This circuit is an easy way to play monophonic music as you may remember it (fondly or not) sounding from those good old Nokia 3310 cell phones. The circuit can be used in applications like doorbells, phone ringers, bike horns or any other alarm circuit — waves of recognition and cell phone wistfulness in the audience guaranteed!

Monophonic music is made of some notes in a specific order with a given duration for each note. These notes are selected from a range specified in the **table** shown here. Nokia developed a programming language to transfer monophonic music to its cellphones and called it RTTTL, for Ringing Tone Text Transfer Language.

Looking at the table, each note has a different frequency according to selected octave. An octave is the interval between two points where the frequency at the second point is twice the frequency of the first. So to select a specific note in this table, you specify its column and row like A4 (220 Hz) or A#7 (1864.7 Hz). Two successive notes in the table differ by a factor of exactly the 12th root of 2 (approximately 1.059). For example: E6 (1318.8) = D#6 (1244.8) × 1.059 Hz.

After selecting the note, the next issue is its duration, i.e. how long it should sound. In contemporary music you will typically observe see the following basic note durations 1/1, 1/2, 1/4, 1/8th, 1/16th. A *Whole Note*, a.k.a. '1/1' or *semibreve*, is typically equal to four beats in 4/4 time. A *Beat* is the basic time unit of a piece of music. The real duration of a beat is related to *Tempo. Tempo* or *BPM* (beats per minute) is the speed of a given piece and specifies how many beats should be played in a minute.

The RTTTL format is a string divided into three sections: name, default value, and data. The name section consists of a string describing the name of the ringtone. The default value section is a set of values separated by commas. It describes certain defaults which should be adhered to during the execution of the ringtone. Possible names are: d (duration), b (tempo), o (octave).
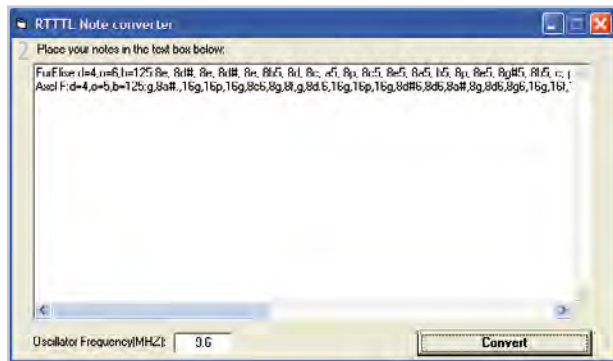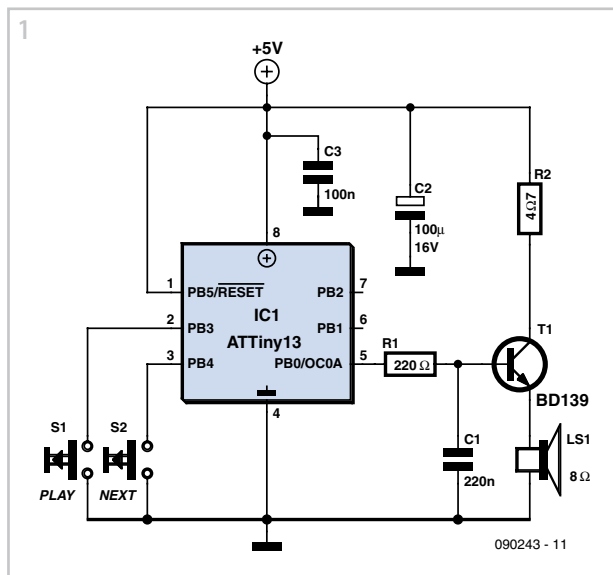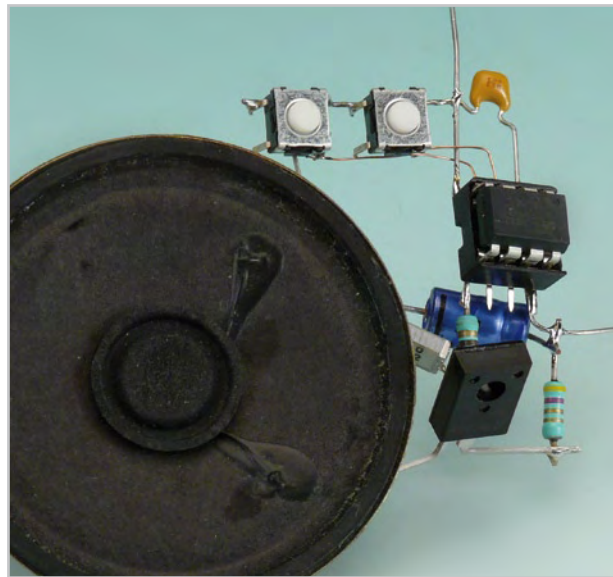
The data section consists of a set of character strings separated by commas, where each string contains a duration, note, octave and optional dotting (which increases the duration of the note by one half). For example here is RTTTL ringtone for the famous *Für Elise* piece:

FurElise:d=4,o=6,b=125:8e, 8d#, 8e, 8d#, 8e, 8b5, 8d, 8c, a5, 8p, 8c5, 8e5, 8a5, b5, 8p, 8e5, 8g#5, 8b5, c, p, 8e5, 8e, 8d#, 8e, 8d#, 8e, 8b5, 8d, 8c, a5, 8p, 8c5, 8e5, 8a5, b5, 8p, 8e5, 8c, 8b5, 2a5

The string consists of three parts separated by colons. The first part is the song name, 'FurElise' (apologies from Mr ASCII to the Beethoven Heritage for the non-umlauted *u*). The second part contains the defaults, with 'd=4' meaning that each note without a duration specification is by default a quarter note, 'o=6' setting the default octave, and 'b=125' defining the tempo. The third part comprises the notes proper. Each note is separated by a comma and includes, in sequence: a duration specification, a standard music note (as shown in first column of the table) and an octave specification. If no duration or octave specification is present, the default applies.

The circuit shown in **Figure 1** contains an ATtiny13 microcontroller programmed to read the RTTTL format (with some modification), store strings in its program memory and generate notes in the form of square waves. The note frequencies are read from a table stored in memory and durations will be calculated in the program. The commonly used octaves 3 through 7 (110 Hz – 3323.7 Hz) can be played by this circuit.

The microcontroller is an 8-pin ATtiny13 Atmel microcontroller employing its internal oscillator. The music signal generated at the PB0 pin applied to a simple emitter follower circuit that's open to your improvements in terms of filtering and amplification. Also, because the program puts a low demand on CPU use and resources, you can make the free microcontroller I/O ports do other jobs. The microcontroller's 1 KB program memory is good for storing about 20 songs. Other microcontrollers with larger memories may be used to be able to store more songs. As a minimum hardware requirement, the micro should have an 8-bit timer with compare/match capability. The microcontroller must first be programmed with the firmware for the proj-

Note	Octave								
	1	2	3	4	5	6	7	8	9
A	27.5	55.0	110.0	220.0	440.0	880.0	1760.0	3520.0	7040.0
A#/Bb	29.1	58.3	116.5	233.1	466.2	932.4	1864.7	3729.4	7458.9
B	30.9	61.7	123.5	247.0	493.9	987.8	1975.7	3951.3	7902.7
C	32.7	65.4	130.8	261.6	523.3	1046.6	2093.2	4186.5	8372.9
C#/Db	34.6	69.3	138.6	277.2	554.4	1108.8	2217.7	4435.5	8871.1
D	36.7	73.4	146.8	293.7	587.4	1174.8	2349.7	4699.5	9398.9
D#/Eb	38.9	77.8	155.6	311.2	622.4	1244.8	2489.5	4979.1	9958.1
E	41.2	82.4	164.9	329.7	659.4	1318.8	2637.7	5275.3	10550.6
F	43.7	87.3	174.7	349.3	698.7	1397.3	2794.6	5589.2	11178.4
F#/Gb	46.2	92.5	185.1	370.1	740.2	1480.4	2960.8	5921.8	11843.5
G	49.0	98.0	196.1	392.1	784.3	1568.2	3137.1	6274.1	12548.2
G#/Ab	51.9	103.9	207.7	415.5	830.9	1661.9	3323.7	6647.4	13294.8

ect. The programming procedure comprises these steps:

1. Convert your favorite RTTTL format songs using the 'Converter' utility.
2. Compile the ASM file using an AVR assembler like the one provided with Atmel AVRStudio.
3. Write the HEX file to the microcontroller using a suitable device programmer.

In the first step, use the 'Converter' software shown in **Figure 2**. This utility was developed using Visual Basic which runs under Windows operating systems. Paste or type the song data and specify the clock frequency of the microcontroller in Megahertz, then press the 'Convert' button. Note that the ATtiny13 micro uses its 9.6 MHz internal oscillator. The software converts the songs and copies them to a file called 'ringtones.inc'. Next, Assemble the 'rtttl.asm' file with 'ringtones.inc' using an AVR assembler. The assembler outputs are two main files, 'rtttl.hex' and 'rtttl.eep'. These files should be written to the micro-

controller's program memory (or EEPROM) using a serial or parallel programmer.

(090243-I)

Downloads & Product

Programmed Controller
Order code: 090243-41 (plays 'Popcorn' song only).
Software
File: 090243-11.zip (free download). Content: ATtiny13 source & hex files; 'Converter' utility; location: www.elektor-usa.com/090305

Switching Delay

Thorsten Steurich (Germany)

The circuit described here was designed as an addition to a remotely-controlled garage door opener. The problem was that a brief burst of interference, arising from a thunderstorm or an AC line spike, was enough to trigger the mechanism, and the author found this a nuisance. The effect of the circuit is to enable the output from the receiver module only when a relatively long pulse (more than about 0.5 s) is received. The circuit can of course also be used in other similar situations, such as electrically-powered shutters, alarms and the like.

081086 - 11

At the heart of the circuit is NAND gate IC1.C. The output of the circuit (after inverter IC1.D) only goes high when both inputs to IC1.C are at a high level. When the circuit is triggered T1 conducts, and the output of inverter IC1.A, and hence also pin 8 of IC1.C, go high. If we now arrange things so that for a preset time the other input to IC1.C remains low, the trigger signal will not be propagated to the output until this period has elapsed. In the case of the author's garage door opener, this will only happen if the button on the transmitter is held down.
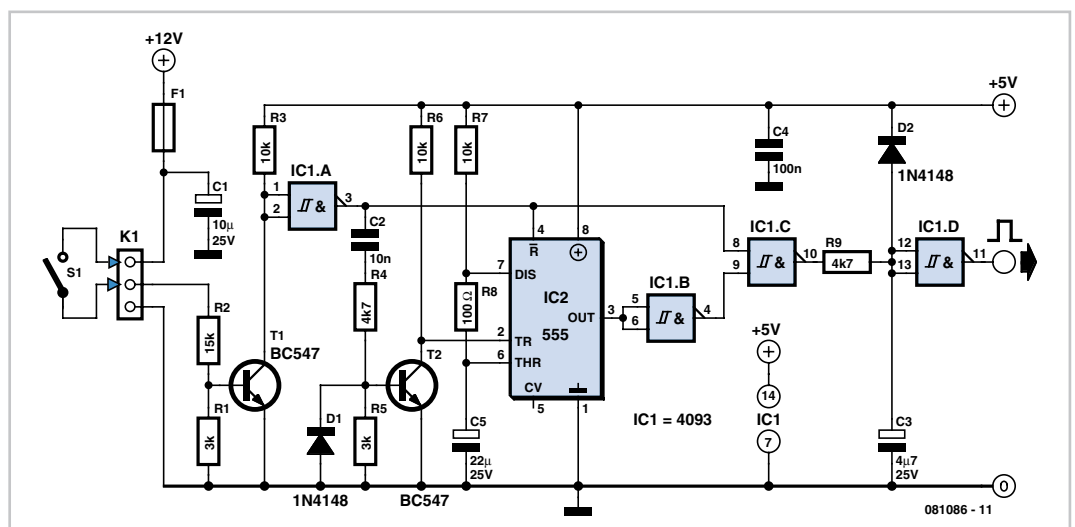
The 555 timer is used to generate the delayed gating signal for IC1.C. It is wired as a monostable multivibrator in a similar

fashion to the arrangement in the 'Economy Timer' circuit elsewhere in this issue. When the circuit is triggered T2 will briefly conduct as a result of the positive edge at the output of IC1.A. This triggers the 555 timer: its output will go high, and thus pin 9 of IC1.C will go low. Because of the propagation delays through the components a very short low pulse will appear at the output of IC1.C when

the circuit is triggered. The RC combination at the input to IC1.D ensures that this does not affect the output.

When the period of timer IC2, as determined by R7 and C5, expires its output returns low. This allows the input signal to pass through IC1.C. If the button on the remote control has been released before the timer expires, no signal will pass to the output.

When the trigger signal is removed the output of IC1.A goes low, which resets the timer: the 555's reset input, like its trigger input, is active low. The circuit is now again in its quiescent state.

(081086-I)

Six-digit Display with SPI Port

081154 - 11
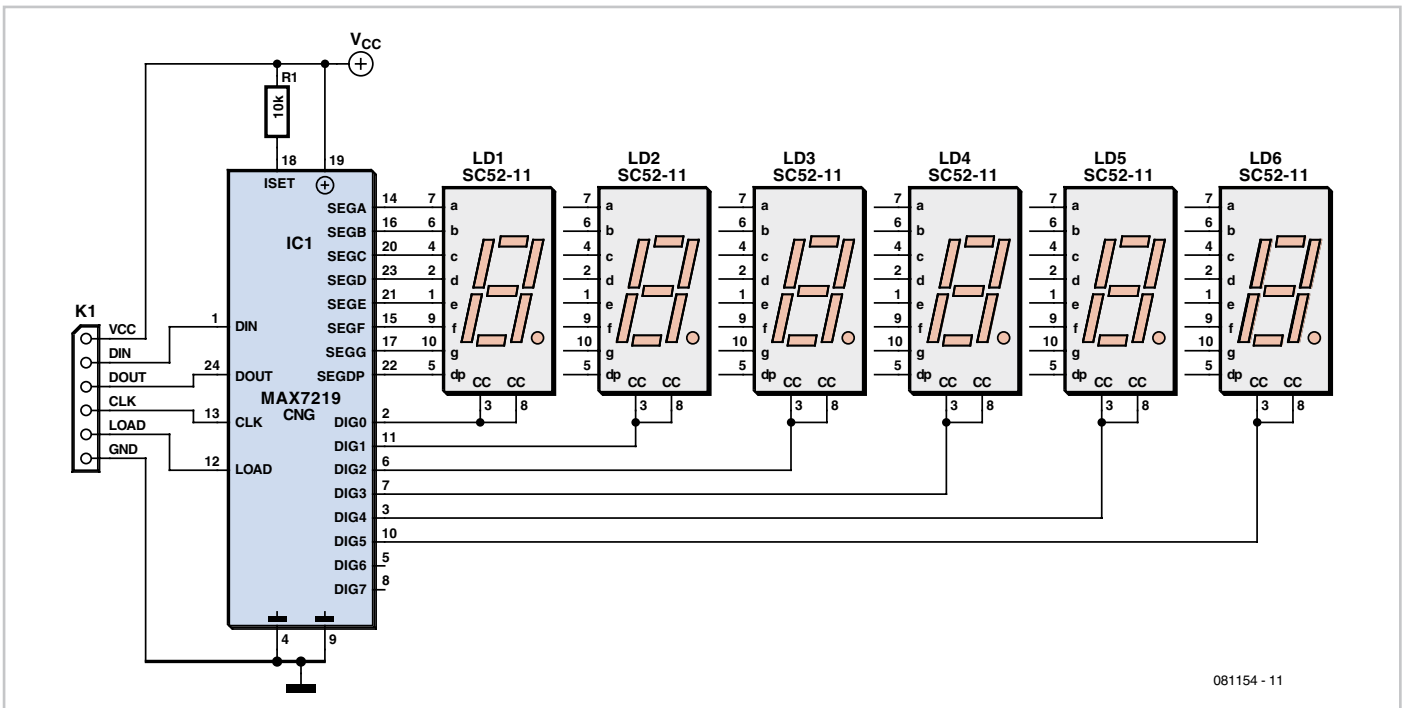
Characteristics
- six-digit seven-segment display
- just two components, plus display modules
- driven using software SPI emulation
- C driver routines easily adapted to any type of microcontroller

Uwe Altenburg (Germany)

There is no essential difference between a seven-segment display and seven individual LEDs with either their cathodes or their anodes connected together. Often the display will be driven by a microcontroller, and when several digits are wanted, they are usually driven in a multiplexed fashion. This involves connecting together each segment in a given position across the digits, with each of the seven common segment lines (plus decimal point) being driven by an output port pin of the microcontroller via

a series resistor. Each digit also requires a transistor, which again needs an output port pin to drive it. For a six-digit display, this means a total of fourteen output port pins: almost two whole ports on an 8-bit microcontroller.

Maxim offers a solution to this problem in the MAX7219. The device is controlled over an SPI port, requiring just four I/O pins on the microcontroller. It can drive up to eight individual seven-segment displays. Contrary to popular belief, multiplexing the displays does not reduce overall power consumption: although each digit is only driven briefly the LED current must be correspondingly increased in order to achieve the same average brightness. According to the device's datasheet the MAX7219 can deliver up to 500 mA per digit. The rapidly changing current draw can cause interference to the microcontroller's power supply if adequate decoupling is not provided.

An advantage of the MAX7219 is that neither series resistors nor drive transistors are required. Only one external resistor is needed, which is used to set the segment current for all the digits. Since it is also possible to adjust the segment current over the SPI port, a fixed 10 kΩ resistor is suitable.

The small printed circuit board is designed to accept Kingbright SC52-11 common cathode display modules, which have a digit height of 13.2 mm. The display is available in a range of colors. If you wish to modify the board layout to suit a different display, the Eagle file is available for download from the web pages for this article [1].

A special feature of the MAX7219 is the ability to cascade multiple devices, allowing several display boards to be driven from a single microcontroller. No extra I/O pins are required on the microcontroller as the data bits are shifted through the chain of

devices: the output DOUT of one module is connected to the DIN input of the next, and the LOAD and CLK signals are wired in parallel.

How do we program the device? The MAX7219 contains 16 internal registers that can be serially addressed and written to. Each seven-segment display is configured using a separate 16 bit message, where bits 0 to 7 carry the data to be displayed and bits 8 to 11 carry the register address. Bits 12 to 15 are not used.

Each bit is clocked into the device on the rising edge of the CLK signal. While the data bits are being transmitted the LOAD signal must remain low; when it goes high the message is written to the addressed register. It is not necessary for the microcontroller to have dedicated SPI hardware: a low data rate is adequate in almost all cases and so the necessary

waveforms can be generated in software. The author has written suitable routines in C [1], which are easily adapted for any type of microcontroller. The routine SendCmd() is responsible for 'bit banging' the I/O ports to generate the SPI signals.

A couple of the MAX7219's registers require initialization. The mode register determines whether the internal BCD-to-seven-segment decoder is used or whether the data stored in the registers correspond directly to segment patterns. The latter option is more general but requires the use of a look-up table in the driver: in the author's source code this array is called Segments. A further register sets the total number of digits to be driven; and finally the segment current must be set and the display enabled. Once everything is initialized the digit registers can be written to using the function UpdateDisplay().

The display module is also supported by the M16C TinyBrick [2] described in the March 2009 issue of Elektor. A simple example program can be downloaded from the project website, showing how easy it is to control the display using the built-in BASIC interpreter.

(081154-I)

Internet Links
[1] www.elektor-usa.com/081154
[2] www.elektor-usa.com/080719

Downloads
081154-1: PCB layout (.pdf), from [1].
081154-11: source code, from [1].
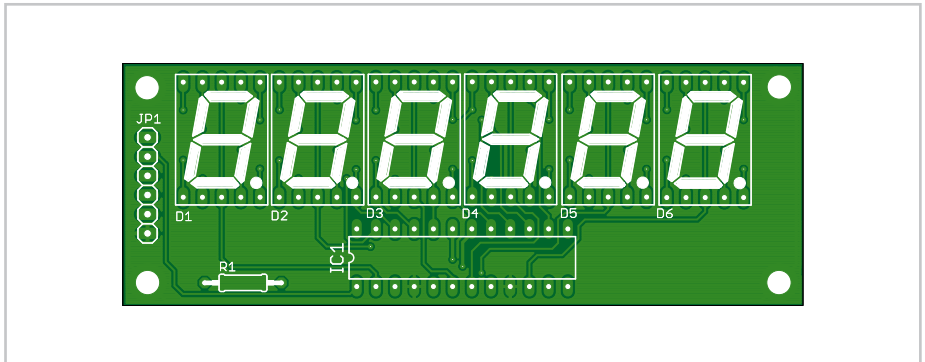CAD files, from [1].

COMPONENT LIST

Resistors
R1 = 10kΩ

Semiconductors
D1–D6 = SC52-11 (Kingbright)
IC1 = MAX7219CNG

Miscellaneous
JP1 = 6-way pinheader
PCB # 081154-1 [1]

LiPo Monitor

Werner Ludwig (Germany)

The LiPo Monitor simplifies voltage monitoring of Lithium Polymer (LiPo) batteries during use. You clearly want to avoid discharging them too far and another thing on your wish list should be a warning when the permitted limit of safe discharge is approaching. A green LED remains on for all the time that the battery voltage remains adequate. If the volts drop as far as the terminal voltage level, a red LED lights to signal that further use (and discharge) of the battery will be harmful and not allowed. Before this happens, in the lower but still OK voltage range, both LEDs illuminate to warn that the end is nigh. The circuit is particularly suitable for
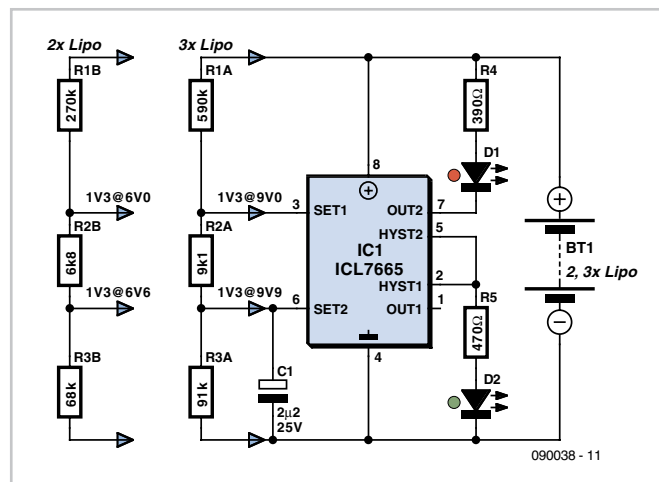
monitoring the LiPo propulsion batteries of radio control models that are used primarily in short range operation, such as indoor model helicopters.

The ICL7665 device used in this circuit

contains two comparators plus an internal 1.3 V voltage reference. Each comparator has two outputs, OUT and HYST. This enables you to monitor each of the two inputs SET1 and SET2 for over and under-voltage.

OUT1 is an inverting output, whereas the other three are non-inverting. The maximum current is 25 mA per output. OUT1 and OUT2 are current sinks (open-drain outputs of N-channel MOSFETS, source to ground). HYST1 and HYST2 are current sources (open-drain outputs of P-channel MOSFETS, source to $+U_B$). The truth table shown below provides information on the switching behaviour of the ICL7665.

The two comparators in the LiPo Monitor form a window discriminator (voltage

range sensor). The battery voltage under observation is applied, via a voltage divider, to both of the inputs. The voltage dividers in this circuit are designed for situations using two or three LiPo cells and are arranged so that the warning range, in which

ICL7665 Truth Table		
SET1/SET2	OUT1/OUT2	HYST1/HYST2
USET1 > 1.3 V	OUT1 = ON = LOW	HYST1 = ON = HIGH
USET1 < 1.3 V	OUT1 = OFF = high-impedance	HYST1 = OFF = high-impedance
USET2 > 1.3 V	OUT2 = OFF = high-impedance	HYST2 = ON = HIGH
USET2 < 1.3 V	OUT2 = ON = LOW	HYST2 = OFF = high-impedance

both LEDs light together, lies between 3.0 and 3.3 volts per cell. This makes for timely charging and avoids deep discharge of propulsion batteries.

Low-drop Series Regulator using a TL431

Lars Krüger (Germany)

Like the author you may keep some 12 V lead-acid batteries (such as the sealed gel cell type) in stock until you come to need them. A simple way of charging them is to hook up a small unregulated 15 V 'wall wart' power supply. This can easily lead to overcharging, though, because the off-load voltage is really too high. The remedy is a small but precise series regulator using just six components, which is connected directly between the power pack and the battery (see schematic) and doesn't need any heatsink.

The circuit is adequatele proof against short

090014 - 11
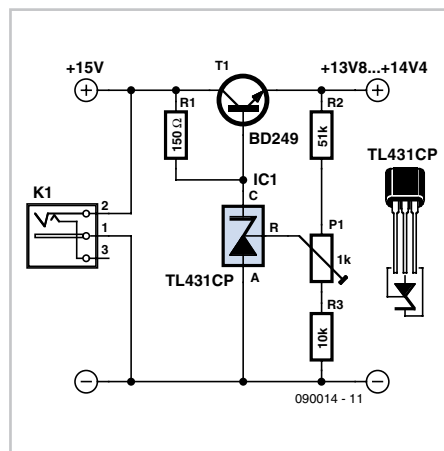
circuits (min. 10 seconds), with a voltage drop of typically no more than 1 V across the collector-emitter path of the transistor.

For the voltage source you can use any transformer power supply from around 12 V to 15 V delivering a maximum of 0.5 A. By providing a heatsink for T1 and reducing the value of R1 you can also redesign the circuit for higher currents.

VGA Background Lighting

090080 - 11
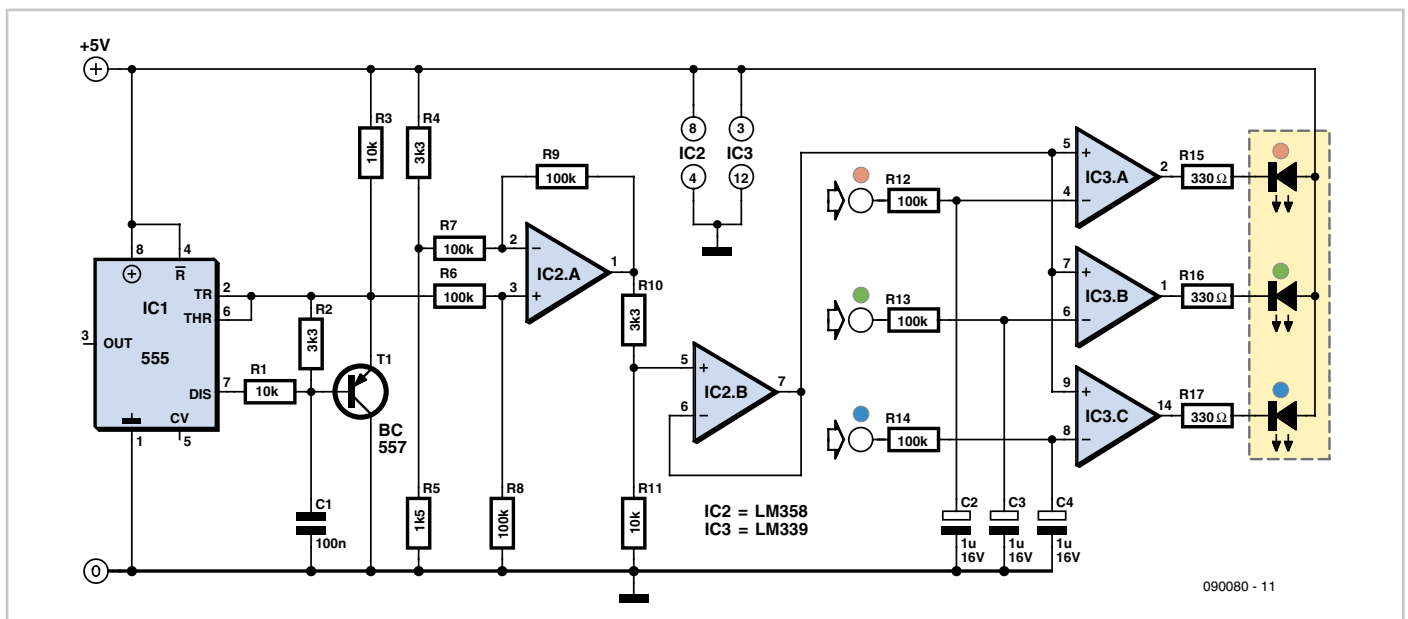
Heino Peters (The Netherlands)

More and more people are using a PC (conventional or notebook) to view films. The VGA output can be used to provide a matching 'Ambilight' effect for this. If you restrict your-

self to a single RGB LED, you can also draw the power for this circuit from the VGA connector, along with the RGB signals.

The following pins of the 15-way VGA connector (three rows of five pins) are used for this circuit:

Pin 1:   Red video signal
Pin 2:   Green video signal
Pin 3:   Blue video signal
Pin 5:   GND
Pin 9:   +5 V

The video signals for the red, green and blue channels are available at the RGB outputs. These signals have an amplitude of 1 to 1.35 V, and they output the screen imagery at the rate of dozens of frames per second. This produces the visible image on the screen. The circuit described here drives an RGB LED according to the average values of each of these three signals. Of course, this is not a full-fledged 'Ambilight' system, but the RGB LED will produce a nice green light during a rugby match or an orange hue if a sunset is shown on the screen.
A sawtooth generator is built around IC1 and T1. It supplies a nice sawtooth signal

to opamp IC2a via R6. The frequency of the sawtooth signal is approximately 850 Hz, and its amplitude ranges from 1.6 to 3.4 V. IC2A subtracts approximately 1.6 V from this due to voltage divider R4/R5. After this, voltage divider R10/R11 reduces the peak value of the sawtooth to around 1.35 V. The resulting sawtooth signal is buffered by IC2b and used to drive the three comparators in IC3. The level of the red video signal is averaged by the R12/C2 network. IC3a constantly compares the previously generated sawtooth signal with the average value of the red video signal. If the image has a high red content, the output of IC3a will be logic Low a good deal of the time, while with a low red content it will be Low less often. This comparator circuit thus implements a PWM driver for the red LED. The same arrangement is used for the green and blue channels.

Note that with a notebook computer you always have to enable the VGA first, usually by pressing Fn-F5. If you use a desktop or tower PC, you can tap off the video signals from an adapter connected between the video cable and the monitor.
You can also use several LEDs or a LED strip (available from Ikea and other sources) in

place of a single RGB LED. In this case you will need an external power supply for the LEDs, but the control circuit can still be powered from the PC. If you use multiple LEDs or a LED strip, connect the cathodes (negative leads) of the LEDs to the comparator outputs of IC3 as shown on the schematic diagram, and connect all the anodes (positive leads) to the external power supply. Resistors R15–R17 are often already integrated in the LED strip. There's no harm in using an external supply with a higher working voltage, such as 12 V. Remember to connect the ground terminal of the external supply to the ground of the control circuit.

IC3 can handle a current of 15 mA on each output. If this is not enough, swap the connections to the inverting and non-inverting inputs of the three comparators in IC3 and connect their outputs to the bases of three BC547 transistors. Connect a 10-kΩ resistor between each base and the positive supply line (+5 V). Connect the emitter of each transistor to ground, and connect the collector to the LED strip. A BC547 can switch up to 100 mA with this arrangement, and a BC517 can handle up to 500 mA.

(090080-I)
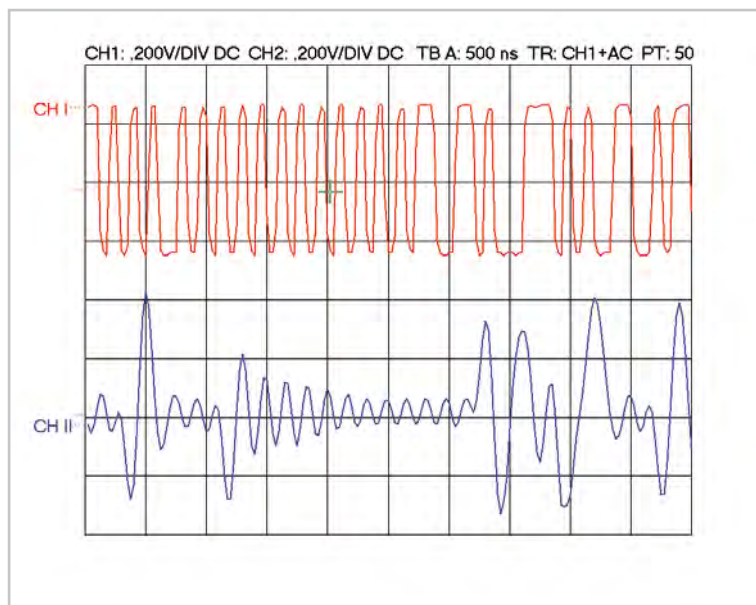
Wireless S/PDIF Connection

Ton Giesberts (Elektor Labs)

A question came to mind after the 'Hi-fi Wireless Headset' article was published in the December 2008 issue of Elektor: why don't we design a wireless S/PDIF connection? This would of course have been a very useful option (the modules in question digitise an analogue signal in the transmitter, which is then converted back to analogue by the receiver).

The idea is therefore to create a digital (in other words, lossless) connection between two devices. As a compromise we could have added

CH1: .200V/DIV DC   CH2: .200V/DIV DC   TB A: 500 ns   TR: CH1+AC   PT: 50

an S/PDIF input to the transmitter mentioned above. However, in that case the D/A converter in the receiver would mainly determine the quality of the analog signal, and that was something we didn't want.

Amongst lots of other things, a possible

solution was found on the Internet, which we wanted to try out in practice. It concerns the use of wireless audio/video modules to transfer the signal. However, no use is made of the audio section of the modules! The S/PDIF signal is connected directly to the video input of the transmitter, without modification

or any extra circuitry! At the video output of the receiver you then have a copy of the S/PDIF signal — well, that is the theory.

The bandwidth of the modules we used is just enough to transfer the digital signal from a CD. We tested this with a Gigavideo 30 made by Marmitek. This is a somewhat older version, and equivalent devices shouldn't cost much more than a few tens of dollars.
To reliably transfer an S/PDIF signal from a CD player you need a bandwidth of at least 6 MHz. The minimum pulse width of an S/PDIF signal of 44.1 kHz is 177 ns. The video bandwidth of 5.5 MHz (this depends very much on the quality of the modules used) seems to be sufficient to create a usable link.

The shape of the signal at the output of the receiver no longer consists of a tidy square

wave, but looks more like a sine wave. This is of course the result of the limited bandwidth available. Everything will be fine as long as the zero crossing points (or original pulse edges) haven't shifted with respect to each other. This is because an S/PDIF receiver retrieves the clock signal from the input signal with the help of a PLL circuit.

Because the edges are less steep, the receiver will be more susceptible to noise and some jitter could occur. If the edges start shifting with respect to each other it is likely that the PLL can no longer cope with the signal. The quality of the connection is therefore not as good as that provided by a coaxial cable, but for those of you who don't want to lay a cable, between two floors for example, this is obvi-

ously a cheap alternative!

Something that should also be taken into account is that walls can significantly reduce the maximum distance between the transmitter and receiver. In our lab are two areas that are partially divided by a 1-metre (3 feet) thick brick wall. When this wall was between the transmitter and receiver the maximum range was reduced to barely two metres (6.5 ft).

We decided to test the circuit with an S/PDIF signal with a sample frequency of 96 kHz (DVD with 24-bit audio). The minimum pulse width for this signal is only 81 ns. This would seem to be too short to be transferred reliably by the modules. The oscillogram shows

the signal at the input of the transmitter (top waveform) and the output from the receiver. This shows clearly how the shorter pulses are attenuated (the bottom waveform has been delayed by about 440 ns compared with the top one).

We tried adding a frequency dependent amplifier to compensate for the restricted bandwidth, but the amplitude of the attenuated pulses could not be increased enough without affecting the phase of the pulses. We found out that the S/PDIF receiver just couldn't cope with this 'improved' signal at all.

(081034-I)

One Wire RS-232 Half Duplex

Andreas Grün (Germany)

Traditional RS-232 communication needs one transmit line (TXD or TX) and one receive line (RXD or RX) and a Ground return line. The setup allows a full-duplex communication; however many applications are using only half-duplex transmissions, as protocols often rely on a transmit/acknowledge scheme.

With a simple circuit as shown in **Figure 1** this is achieved using only two wires (including Ground). This circuit is designed to work with a 'real' RS-232 interface (i.e. using positive voltage for logic 0s and negative voltage for logic 1s), but by reversing the diodes it also works on TTL based serial interfaces often used in microcontroller designs (where 0 V = logic 0; 5 V = logic 1). The circuit needs no additional voltage supply, no external power and no auxiliary voltages from other RS-232 pins (RTS/CTS or DTR/DSR).

Although not obvious at a first glance, the diodes and resistors form a logic AND gate equivalent to the one in **Figure 2** with the output connected to both receiver inputs. The default (idle) output is logic 1 (negative voltage) so the gate's output follows the level of the active transmitter. The idle transmitter also provides the negative auxiliary voltage –U in Figure 2. Because both receivers are connected to one line, this circuit

080705 - 11

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080705 - 13
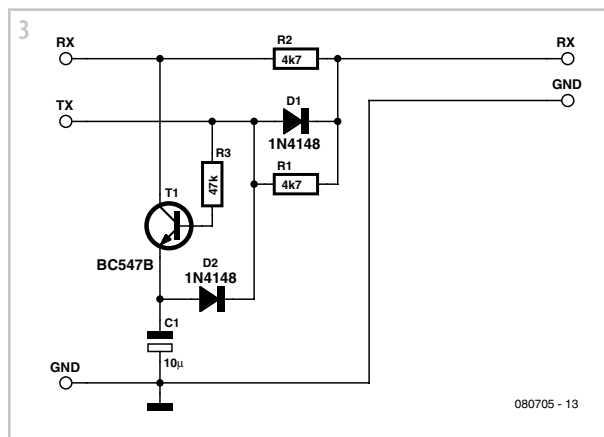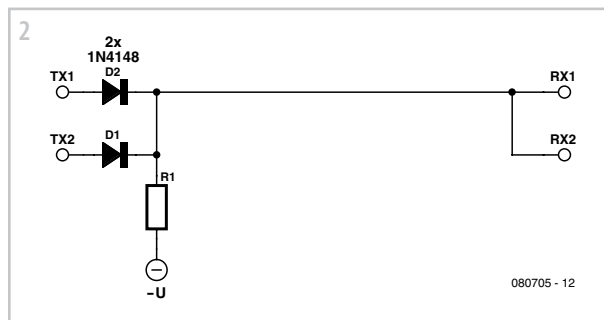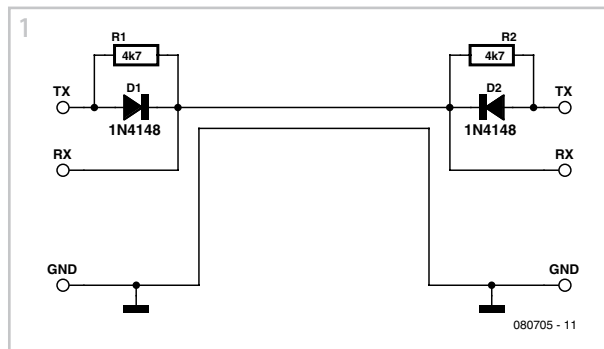
generates a local echo of the transmitted characters into the sender's receiver section. If this is not acceptable, a more complex circuit like the one shown in **Figure 3** is needed (only one side shown). This circuit needs no additional voltage supply either. In this circuit the transmitter pulls its associated receiver to logic 1 (i.e. negative voltage) by a transistor (any standard NPN type) when actively sending a logic 0 (i.e. positive voltage) but keeps the receiver 'open' for the other transmitter when idle (logic 1). Here a negative auxiliary voltage is necessary which is generated by D2 and C1. Due to the start bit of serial transmissions, the transmission line is at logic 1 for at least one bit period per character. The output impedance of most common RS-232 drivers is sufficient to keep the voltage at C1 at the necessary level.

Note: Some RS-232 converters have quite low input impedance; the values shown for the resistors should work in the majority of cases, but adjustments may be necessary. In case of extremely low input impedance the receiving input of the sender may show large voltage variations between 1s and 0s. As long as the voltage is below –3V at any time these variations may be ignored.

(080705-I)

Breadboard/Perfboard Combo

©Elektor
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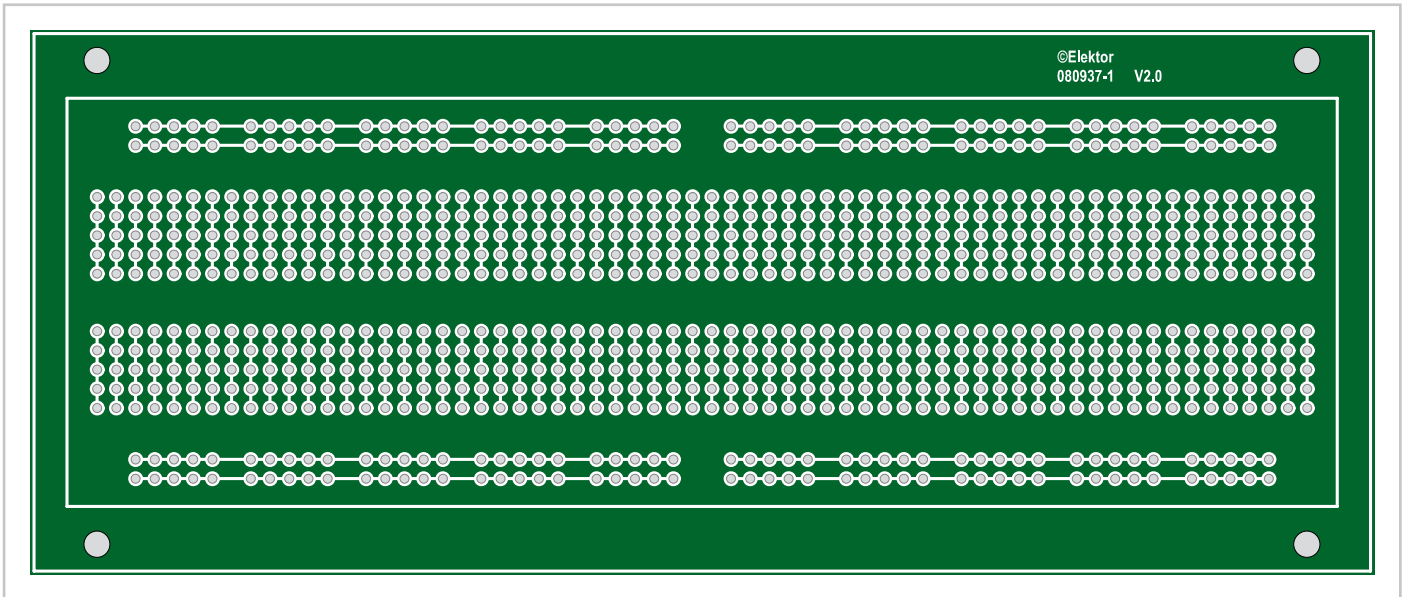
Based on an idea from Luc Heylen (Belgium)

Electronic hobbyists and engineers often use breadboards to experiment with small circuits. A breadboard consists of a thick strip of plastic with an array of holes and embedded metal contact strips that interconnect individual rows of holes. A few long rows extending over the entire length are located along the sides; they can be used for supply voltages. With this arrangement of holes and strips, you can plug all sorts of electronic components (including ICs) into the breadboard and build a circuit by interconnecting them as desired with short lengths of wire. Of course, we don't have to explain this to most of our readers, since they have probably used a breadboard occasionally.

The advantage of a breadboard is that you can try out different ideas to your heart's content without having to use a soldering iron every time you make a change. It's also a lot easier to see what you're doing than when you build a circuit on a piece of perfboard, where the wiring on the copper side can quickly turn into a rat's nest that isn't so easy to sort out when you want to make changes.

Of course, breadboards also have their disadvantages. They can't be used for RF circuitry, which is something you always have to consider. The spring contacts also tend to wear or weaken over time, which can lead to poor connections. Despite these disadvantages, breadboards are especially convenient and affordable tools for electronic designers.

If you do a lot of work with a breadboard, you are often faced with the problem that after you have managed to build and test a circuit that works the way it should, you have

to take it all apart and rebuild it on a piece of perfboard because the circuit has to be used somewhere right away. In such cases, leaving the circuit in its breadboard form is not a long-term option.

The person who thought up the idea described here, who is a fervent breadboard user, encountered this problem regularly and came up with the following solution. Make a printed circuit board with the same layout, hole spacing and interconnections as a standard breadboard. Secure this PCB on top of the breadboard, and then plug the components and interconnecting wires through the holes in the PCB, mounting them the same way as you would normally do with the breadboard (**Photo 1**). Use slightly longer component leads and wire ends than usual, due to the extra thickness of the PCB. Fit ICs in sockets with extra-long pins (wire-wrap
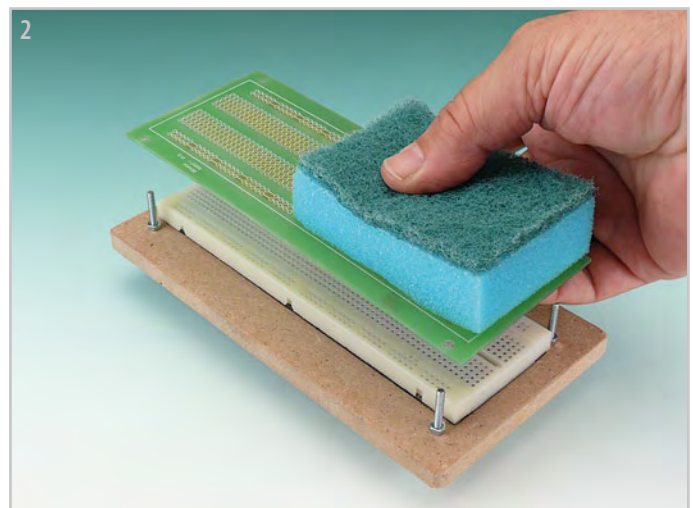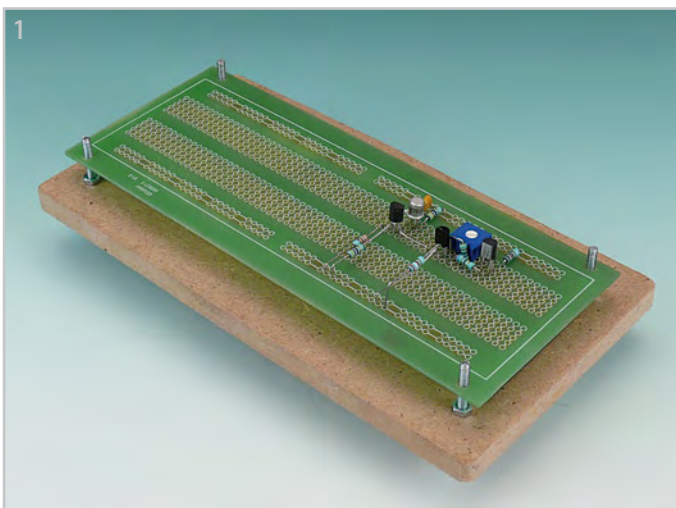
pins). In a circuit built using this arrangement, the contact strips in the breadboard provide the interconnections, so there's no need for soldering.

Once the circuit is finished and works the way it should, you don't have to rebuild it before you can use it somewhere else. Press a sponge or a bag filled with styrofoam particles on top of the circuit (**Photo 2**) and clamp it securely in place (**Photo 3**). After this, you can pull the PCB with the components free from the breadboard, turn it over, and then trim all the leads protruding from the copper

side and solder them in place (**Photo 4**). The interconnections are exactly the same as on the breadboard.

To make it easy to work with this combination of a breadboard and a PCB, it's a good idea to mount the breadboard on a piece of wood with four long M3 screws arranged to fit exactly through the corner holes of the printed circuit board. This way you can mount the PCB precisely and securely on top of the breadboard.
For the breadboard, we used a type SD12N from Velleman [1], which is carried by a num-

ber of electronics retailers. Note that other types of breadboards may have different dimensions or contact arrangements, which means that they cannot be used with the PCB layout shown here.

(080937-I)

Internet Link
[1] www.velleman.be/nl/en/product/view/?id=40573

Download
080937-1: PCB layout (.pdf), from www.elektor-usa.com/080937
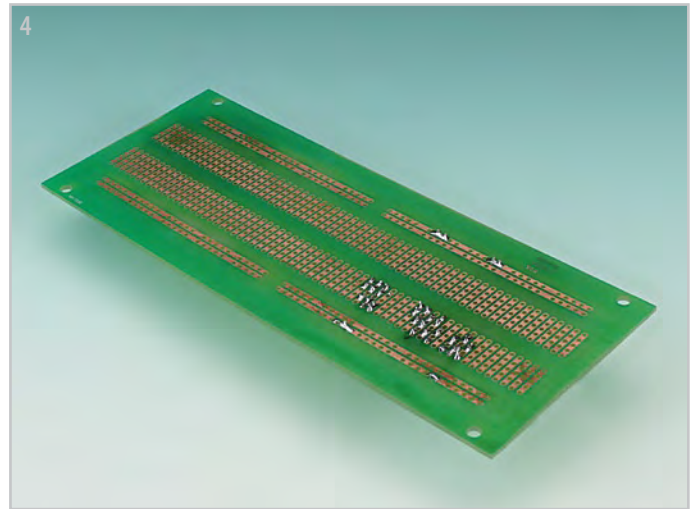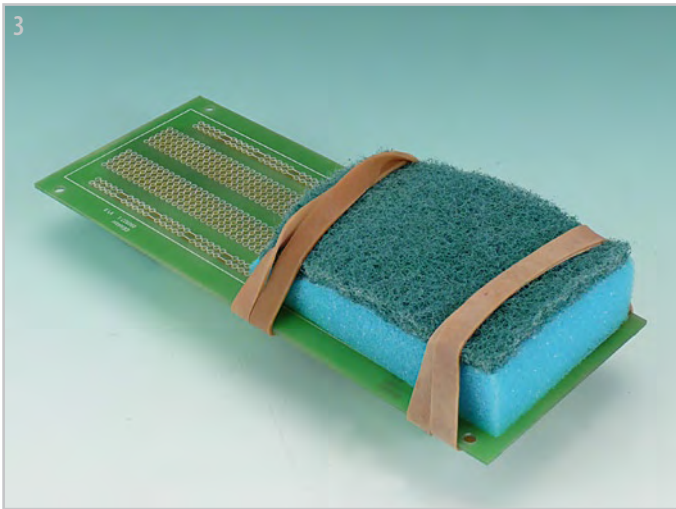
Momentary Action with a Wireless Switch

Matthias Haselberger (Germany)

Many different types of wireless switch modules with a relay for switching AC power loads are commercially available. However, some applications require a short On or Off pulse, such as is provided by a momentary-action (pushbutton) switch. Here we describe a solution that simulates a pushbutton switch with a standard wireless switch. A supplementary circuit converts the switch module into a remotely controllable momentary-action switch.
In the supplementary circuit, S1 is the switching contact of the relay in the wireless switch module. This contact energises a 24-V power supply connected directly to the AC power outlet, consisting of a bridge rectifier (D1–D4) with a series resistor (R1), a series capacitor (C1), and a charging capacitor (C2). The two Zener diodes in the bridge rectifier (D1 and D2) limit the DC voltage on C2 to approximately 24 V.
When the wireless switch module closes contact S1, 24 VDC is applied to the coil of relay

RE1, which closes. At the same time, capacitor C3 charges via D5. When the contact of RE1 switches, capacitor C4 provides the charging current for C3. The charging current flows through the coil of RE2, which remains

actuated as long as the current is sufficiently large. The current decreases as the voltage on C4 rises, with the result that RE2 drops out and the contact of RE2 (the 'momentary' contact) opens again.

080912 - 11
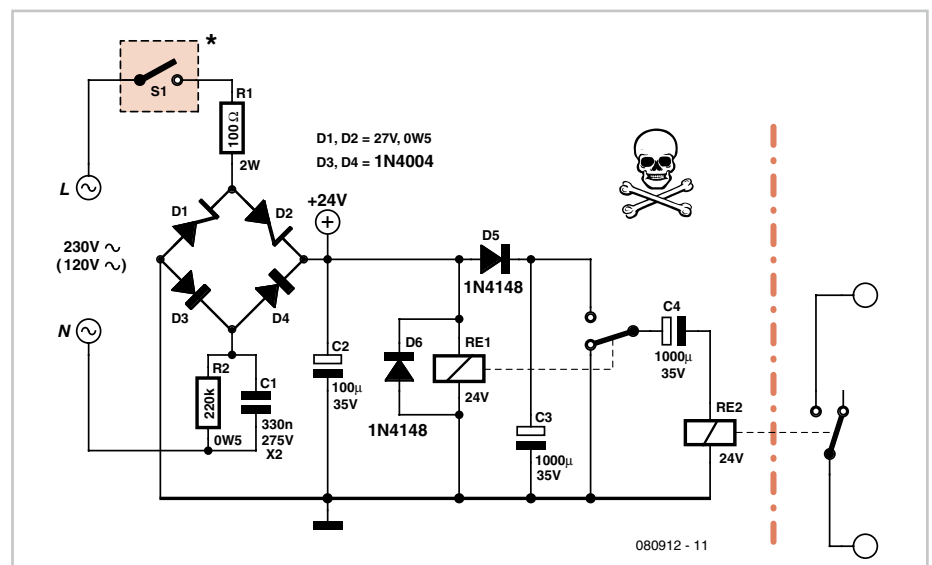
S1 opens when the relay in the wireless switch module is de-energized, which causes RE1 to drop out shortly afterward and connect capacitor C4 to ground. The capacitor discharges through the coil of RE2, causing its 'momentary' contact to be actuated again. The timing diagram shows the switch-on and switch-off sequences of the wireless switch (S1 contact).

The duration of the 'button press' (engagement time of RE2) depends on the capacitance of C3 and C4. The equation $Q = C \times U = I \times t$ can be used to calculate suitable capacitor values for a specific hold time (t_1 in the timing diagram) with a given relay current. The value shown in the circuit diagram (1000 µF) corresponds to a hold time of 1 second with a relay current (holding current I_H) of 10 mA: $C = I_H \times t_1 / U = (0.01\ \text{A}) \times (1\ \text{s}) / 10\ \text{V} = 1000\ \text{µF}$. A reed relay cannot be used for RE2 because the voltage across the coil reverses. This also
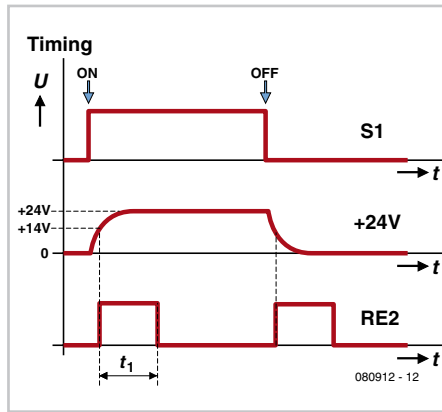
means that a free-wheeling diode cannot be used, but it is anyhow not necessary due to the slow discharge of C4. RE2 should be a 'Class II' relay (such as the Omron G6D-1A-ASI 24DC) to provide adequate insulation of the switch contact. RE1 does not have to be a

Class II relay. Due to the presence of AC power line voltage, R1 and R2 must have a rated working voltage of 250 V (150 V), although they can also be formed from two resistors with half this rated working voltage connected in series, each with half of the specified power rating. In this case, R1 consists of two 47 Ω / 1 W resistors and R2 of two 100 kΩ / 0.25 W resistors. Readers on 120 VAC 60 Hz AC networks should change C1 into 680 nF. The circuit can be fitted in a plastic enclosure with an integrated AC power plug, which can easily be plugged into the wireless switch module. The contact of RE2 can then be fed out to a terminal strip as a floating contact. For adequate AC isolation, a safety clearance of at least 6 mm (air and creepage paths) to other conductors must be maintained, in addition to using a Class II relay.

(080912_1)

Servo Scales
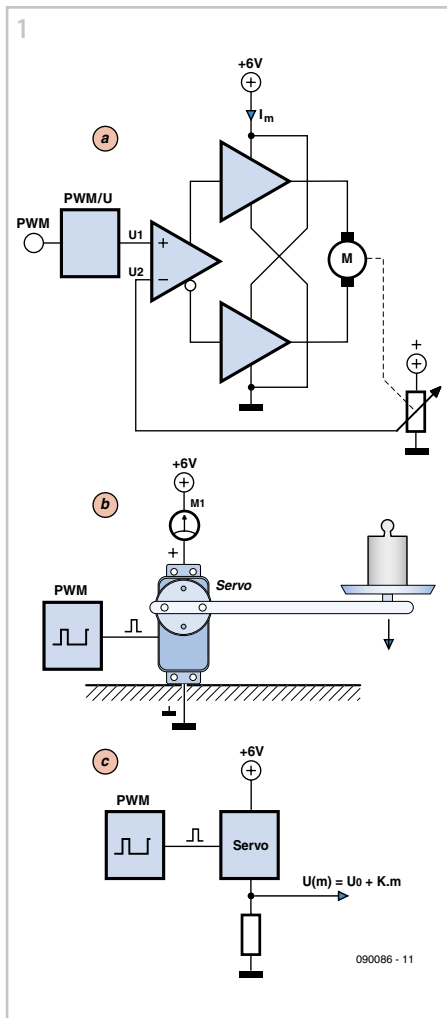
Gert Baars (The Netherlands)
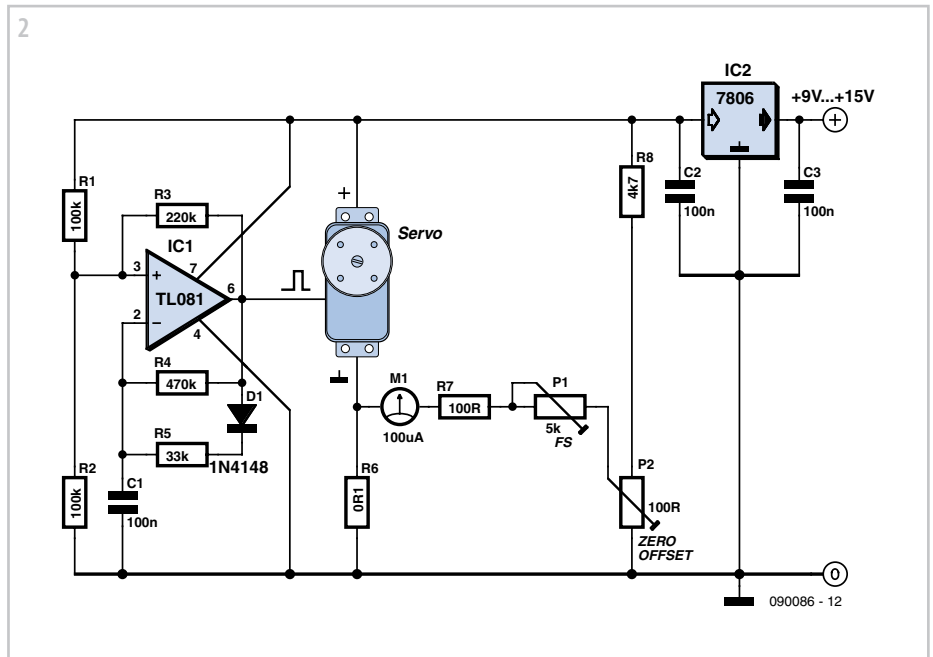
With a bit of adeptness, you can build an electronic scales based on a servo motor. Depending on the type of servo you use, it can measure weights of up to around 10 pounds (just under 5 kilograms) with reasonable accuracy.

If you examine the operating principle of a servo motor in more detail (**Figure 1a**), you can see that in simple terms, it consists of a control loop that uses a potentiometer to convert the motor position to a voltage that is compared to the voltage from a PWM con-

verter. Based in this information, the motor is rotated so that its measured position corresponds to the desired position (U2 = U1).

As can be seen from **Figure 1**, all you need for a scales based on a servo motor is a square-wave oscillator that supplies a signal at a constant frequency of around 50 Hz with a fixed duty cycle of approximately 10%. This defines a fixed setting for the position of the motor axle. If a mechanical force tries to rotate the motor axle in this situation, the servo control loop adjusts the drive signal to the motor to counteract the rota-

tional force. The motor thus has to supply an opposing force, and that costs power, with the result that the current through the motor increases. With a type RS-2 servo, this current can rise to as much as 1 A, while the quiescent current is no more than a few dozen milliampères. If you attach an arm to the motor axle and fit it with a weighing pan, and then connect an ammeter in the servo supply line, you have a sort of simple electronic scales. The scales can be calibrated using a reference weight, with the length of the arm set to produce a certain amount of current with a certain weight,

such as 0.25 A with 1 lb. Two pounds would then draw 0.5 A, and so on.

The scales can also generate a voltage output if you measure the voltage across a sense resistor in series with the ground lead of the servo (**Figure 1c**). Due to the quiescent current consumption of the servo motor with no load, this voltage is not zero with no weight on the scales, but it is low compared with the value with a certain amount of weight. Naturally, this offset can be compensated by using an instrumentation amplifier. This increases the accuracy, and you could even consider equipping the scales with a digital readout.

Figure 2 shows a simple finished version with a PWM oscillator and analog readout. The two potentiometers can be used to adjust the offset and weighing range. The length of the scale arm multiplies the torsion on the servo motor due to the weight. Doubling the arm length reduces the weighing range by half and thus doubles the accuracy, but it also increases the zero offset due to the weight of the arm. In practice, an arm length of around 10 cm (4 inches) proved to be a good compromise.

(090086-I)

Driver Free USB

Richard Hoptroff (United Kingdom)

USB (universal serial bus) was supposed to solve a lot of problems when connecting devices to PCs, but in many ways it's still a bit of a pain in the plughole. Typically, each new device needs a new driver to be installed. Often, a COM port then gets assigned, and you have to find out from the operating sys-

tem what the COM port number is. And with some products, that COM port number can change if you plug it into a different socket! A sneaky way round the driver problem is to use the Human Interface Device (HID), as used by mice and keyboards, or the Mass Storage Device (MSD) interface, as used by flash drives. This is because just about all the flavors of Windows, Mac and Linux operating systems available today have HID and MSD drivers pre-loaded. HexWax Ltd. have adopted this approach for their driver-free USB chip sets. Their USB to UART, SPI and I2C bridges use the HID interface and their embedded file system and data logger chips
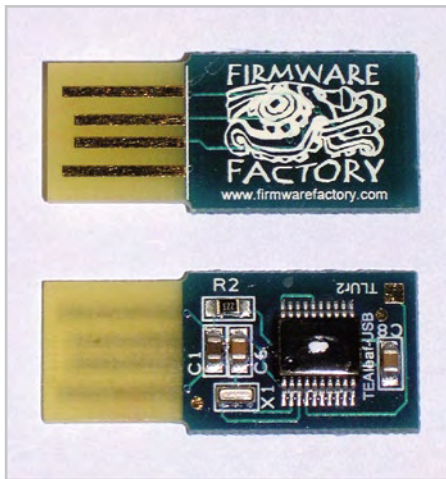
use the MSD interface.

A particularly flexible friend is called 'expandIO-USB'. As its name suggests, it is an I/O expander with a USB interface. But that's a modest description, considering its analog-to-digital inputs, interrupts, PWM, comparators,
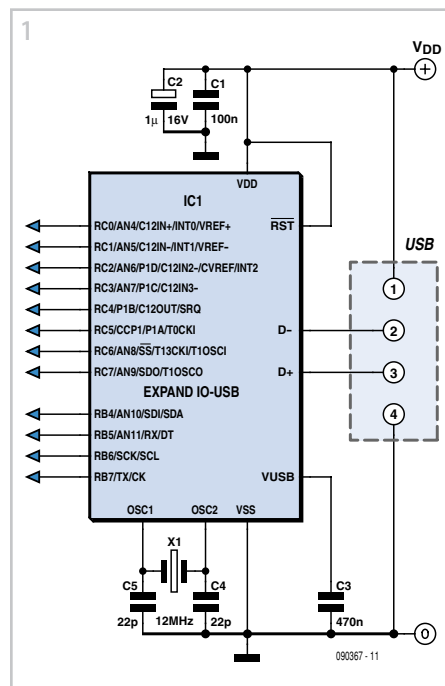
counters, timers, SPI, I2C, UNI/O, etc. The USB interface is designed so that all the programming is done on the PC rather than on the chip, which saves a lot of development time.

For example, to measure the analog voltage on AN6, you send the following 4-byte command from the PC (*0x* prefix denotes hexadecimal):

0x96 0x06 0x00 0x00

The chip takes the measurement and reports the result as a 4-byte response: *0x96 0x06 0x02 0x36*.

In this example, the voltage measured is 5 V $\times$ 0x0236 $\div$ 0x03FF = 2.76 volts. Similarly, the following command exchanges three bytes with a slave SPI device:

0xAF 0x03 0x45 0x67 0x00. Command: Send
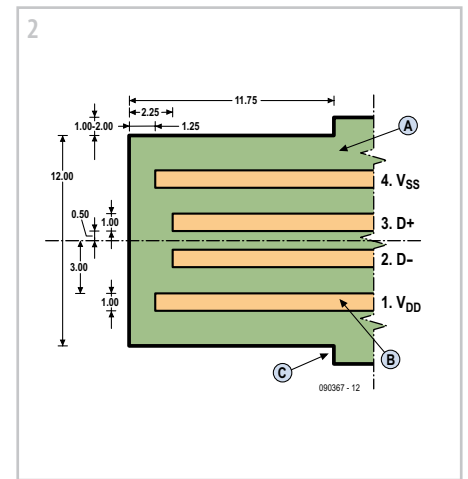
0x45 0x67 0x00 to slave.
0xAF 0x03 0x00 0x00 0x89. Response: Slave sent *0x00 0x00 0x89*.

The commands are sent using the operating system's HID interface, which is very similar to reading and writing to a file. Example source code is provided at [1].

In the basic circuit of the driver, **Figure 1**, only a crystal and filter capacitors are required in addition to the 'expandIO-USB' chip also described in some detail at [1]. Although it is available as a through-hole device, the surface mount version has the advantage that

it is small enough for 'dongle'-style applications as shown in **Figure 2**. Surface mount USB plugs can be quite difficult to source, but an elegant, zero-cost solution exists. You can design one into the printed circuit board itself, so long as you don't mind a PCB 2.0–2.20 mm thick including tracks (arrow 'A' in Figure 2) for the dimensions. For best reliability, the PCB contacts ('B') should be plated with hard gold flash (0.25-1.27 µm) over nickel (2.6-5.0 µm). Finally, shoulders ('C') are required to prevent over-insertion force.

The overall PCB width should be 16.00 mm or less.

(090367-I)

Lighting Up Model Aircraft

Werner Ludwig (Germany)

This circuit provides aircraft modellers with extremely realistic beacon and marker lights at minimum outlay. The project's Strobe output (A) provides four brief pulses repeated periodically for the wing (white strobe) lights. In addition the Beacon output (B) gives a double pulse to drive a red LED for indicating the aircraft's active operational status. On the prototype this is usually a red rotating beacon known as an Anti-Collision Light (ACL). The circuit is equally useful for road vehicle modelers, who can use it to flash headlights and blue emergency lights.
All signals are generated by a 4060

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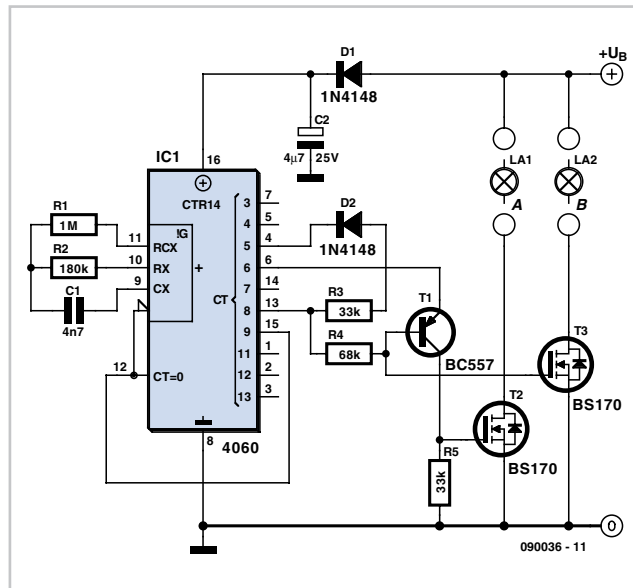
14-stage binary counter and some minimal output selection logic. Cycle time is determined by the way the internal oscillator is configured (resistor and capacitor on pins 9/10) and can be varied within quite broad limits. High-efficiency LEDs are your first choice for the indicators connected to the Beacon and Strobe outputs (remember to fit series resistors appropriate to the operating voltage Ub and the current specified for the LED used).

The sample circuit is for operating voltages between 5 and 12 V. Current flow through the two BS170 FET devices must not exceed 500 mA.

(090036-I)

LED Bicycle Lights

Ian Field (United Kingdom)

Before getting started an acknowledgement is due, the circuit presented here uses an ingenious method of controlling a flyback converter by the voltage developed on a current sensing resistor; this was published by Andrew Armstrong in the July 1992 issue of ETI magazine.
The reworked circuit is quite simple. At the instant that power is applied only a small current flows to charge C4 so insufficient voltage is developed on R3 to switch T2 on. Also, D1 allows C2 to charge from the 6 V battery, so R1 feeds enough voltage to switch on T1 — this shunts the voltage across L1 and the current in it starts to rise. At a certain point the current which returns via R3 will develop sufficient voltage to switch on T2 which shunts the gate voltage to T1 causing it to switch off, initiating the flyback voltage from L1. The flyback pulse forces a current around the circuit, charging C4 and feeding the LEDs. As the return current is via the current sensing resis-

080702 - 11

tor R3, this keeps T2 turned on and T1 turned off, so the flyback phase is not clamped until it has given up all its energy. Capacitor C3 provides positive feedback to ensure reliable oscillation and sharpen up the switching edges. Components D1, D2 & C2 form a bootstrap boost circuit for the MOSFET gate, although it is logic level it only guarantees the stated $R_{D-S(on)}$ at a V_g level of about 8 V — by happy coincidence the combined V_f of
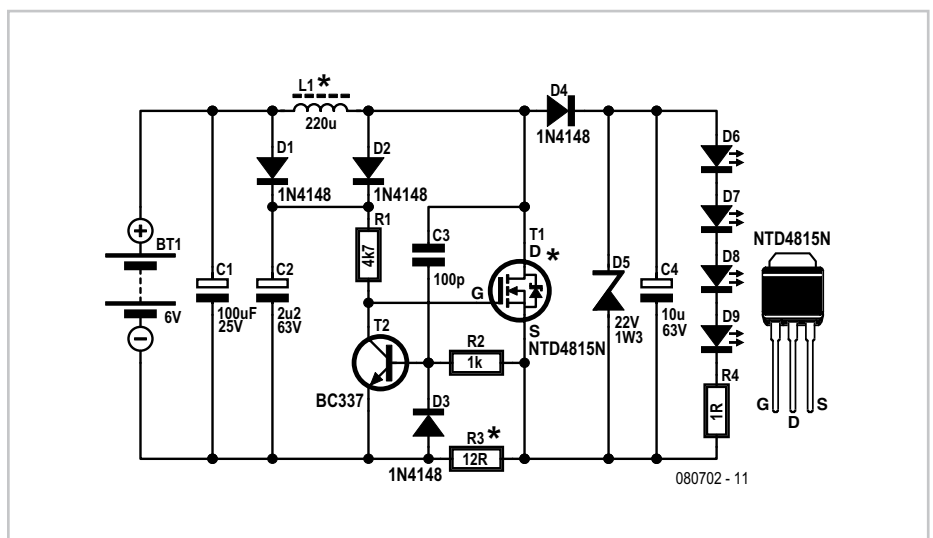
four ultrabright red LEDs is about 8.8 V and this is the value that the output is normally clamped to.

There are some notes on the components specified. For position T1 an n-channel MOS-FET with a very low $R_{D-S(on)}$ of 15 mΩ (at 10 V) Is suggested, although its high I_D rating (35 A) is not strictly necessary. Purists may wish to use Schottky barrier diodes for D2 and D4, but a quick look at the data sheet for the popular BAT85 shows that with a T_{rr} of 4 ns it is not actually any faster than the 1N4148. It is doubtful whether the lower V_f would make any noticeable difference.

Zener diode D5 has been included as a safety measure in case the output should ever find itself open circuit. The flyback converter can develop a quite impressive voltage when run without load and would have no difficulty damaging the MOSFET. If a higher voltage MOSFET is used then C4 could easily fall prey to excessive voltage if the lead to the LED breaks. In the final working prototype D5 was a 1.3-watt 22-volt zener, but any value between 18 and 24 V is fine. Bear in mind that with four white LEDs on the output the voltage will be somewhere in the region of 13 V. L1 is a 9 mm diameter 0.56 A 220 µH inductor with a low DC resistance (Farnell # 8094837); don't even think about using those small axial lead inductors disguised as resistors — even the fat ones last only a few seconds before failing with shorted turns.

On R3, this resistor is selected depending on the configuration of LEDs. A value of 20 mA is fairly typical for 5 mm LEDs, on this basis four red LEDs will need about 12 Ω; five red LEDs about 10 Ω, and four white LEDs about 6.8 Ω. Resistor R4 (1 Ω 1%) is provided to use as a temporary connection for the LEDs' negative lead so the volt drop can be measured to indicate the current flowing during setting the correct LED current by adjusting R3. The efficiency of the circuit depends on the LED current, which also determines to some extent the switching frequency. At 10 mA (4 white LEDs) 170 kHz was measured on the prototype — and that's about the maximum normal electrolytic capacitors are able to withstand. If more current is drawn (e.g. three white LEDs at 30 mA) then the switching frequency drops to about 130 kHz and the efficiency rises to around 75%.

The circuit is simple enough to construct on stripboard, which can be built as a single or double unit to suit whatever lamp housings are ready to hand. The double unit should fit comfortably in a 2x D cell compartment and the single board is only a whisker bigger than a single C cell.

Suggested lamp housings are the Ever Ready and the Ultralight but there should be many others that can be modified to house the stripboard. In many cases the hole for the bulb will need 4 notches cut with a round file so that the LEDs can be pushed far enough through. These can be secured in place with a spot of hot melt glue.

The battery and switch box can be surprisingly challenging, the unit built for a family member went on a bicycle with a wire basket so it was easy to bolt a Maplin ABS project box to that. With only the tubular frame to fix things onto, it's not so easy. The author's battery box for the present project is an old Halfords lamp — the one that drops into a U shaped plastic clip that does nothing to deter thieves, but it's far more secure when cut down to make a battery box and clamped to the handlebar with a jubilee clip. It easily holds a 6 V 1.3 Ah SLA battery from Maplin but any nominal 6 V type can be used as per individual preference. Deep discharging should be prevented.

Please Note. Bicycle lighting is subject to legal restrictions, traffic laws and, additionally in some countries, type approval.

(080702-I)

Remote Washing Machine Alert

Götz Ringmann (Germany)

It is often the case these days that the washing machine and tumble dryer are installed in an outbuilding or corner of a garage. This not only makes the kitchen a much quieter place but also leaves room for a dish washer and gives additional cupboard space. The problem now is how to tell when the wash cycle is finished. In bad weather you don't want to make too many fruitless trips down the garden path just to check if the wash cycle is finished. The author was faced with this problem when he remembered a spare wireless door chime he had. With a few additional components and a phototransistor to passively detect when the washing machine's 'end' LED comes on, the problem was solved.

C1 smoothes out any fluctuations in the LED

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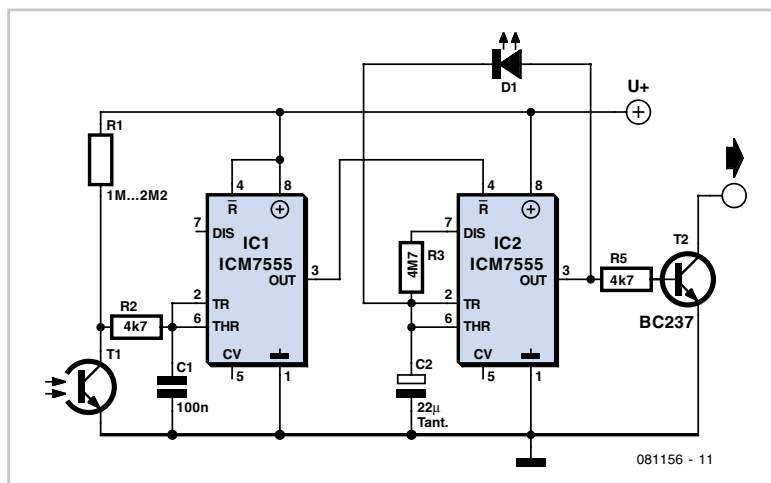
light output (they are often driven by a multiplex signal) producing a more stable DC voltage to inputs 2 and 6 of IC1. The circuit is battery powered so the CMOS version of the familiar 555 timer is used for IC1 and IC2. The output of IC1 (pin 3) keeps IC2 reset (pin 4) held Low while there is no light falling on T1. When the wash cycle is finished the LED lights, causing T1 to conduct and the voltage

on C1 starts to fall. Changing the value of R1 will increase sensitivity if the LED is not bright enough.

When the voltage on C1 falls below 1/3 of the supply voltage IC1 switches its output (pin 3) High, removing the reset from IC2. T2 conducts and LED D1 is now lit, supplying current to charge C2. When the voltage across C2 reaches 2/3 supply IC2 switches its output Low and C2 is now discharged by pin 7 via R3. The discharge time is roughly one minute before the transistor is again switched on. The process repeats as long as light is falling on T1.

Transistor T2 is a general-purpose small signal NPN type. The open collector output is wired directly in parallel with the bell push (which still functions if the transistor is not switched on). Ensure that transistor output is wired to the correct bell push terminal (not

the side connected to the negative battery terminal).

Each timer consumes about 60 μA quiescent and the circuit can be powered from the transmitter battery. Alternatively a 9 V battery can be substituted; it has much greater capacity than the original mini 12 V battery fitted in the bell push.

Before you start construction, check the range of the wireless doorbell to make sure the signal reaches from the washing machine to wherever the bell will be fitted.

(081156)

Freezer Trick

Reuben Posthuma (New Zealand)

There are a number of explanations to why putting devices in the freezer often repairs them. Firstly, cooling PCBs down to freezer-level temperatures can often repair dry joints, because of the effects of expansion/contraction due to temperature change. Although the wholesome effect of a night in the freezer may be temporary, it may help you track down rare or otherwise elusive errors in circuits.

Secondly, with rechargeable batteries on boards, the cold temperatures basically cause the cell(s) to do a complete discharge cycle,

which effectively resets corrupted memory by causing a complete 'factory' reset to be performed.

Thirdly, the low temperatures can (sort of) rejuvenate the chemicals in the battery, which results in a 'good as new' battery!

Although any or all of the above explanations may be refuted scientifically, the 'he who dares, wins' approach prevails. In other words, no harm in giving it a try.

Be sure to use good quality plastic bags to securely package circuit boards, components or batteries before putting them into the freezer. This will eliminate any risk of contaminating foodstuffs.

(090205)

LEDify It!

Mobile 3-watt LED Lamp

Jürgen Stannieder (Germany)

A traditional hand-held flashlight could hardly be described as a cutting-edge piece of technology; in fact it's probably the exact opposite, circuits don't come much simpler! Text books have for years used a battery, light bulb and switch to describe just what a circuit is. We are also aware of the shortcomings of the filament lamp; the light dims as the battery discharges and occasionally you need to replace a burned-out bulb. Why not treat an old flashlight to a 21st century make-over? Replace the bulb with more efficient LEDs, the 5 mm 70 mW types will not be very illuminating but 1-watt white LEDs are now reasonably priced.

It's not quite as simple as removing the bulb and replacing it with an LED. Unlike a

Features

- Three 1 W LEDs powered from 4.8 V
- Efficiency > 80 %
- Light output independent of battery voltage
- Battery deep-discharge protection

filament bulb an LED exhibits differential resistance i.e. its resistance depends on the applied voltage. It is necessary to supply it with a constant current. This can be achieved (approximately) by using a series resistor but power loss in the resistor reduces efficiency. Also, light output will decrease as the battery voltage sinks. The LEDify design solves both these problems: firstly, a switching regulator reduces losses and maintains a constant light output as the battery voltage falls. Secondly, an adjustable constant current source maintains stable operating conditions for the LEDs.

The LM2577T-ADJ step-up voltage regulator [1] forms the centre point of the design. Together with coil L1 and the flywheel diode D1 it boosts the input voltage from 4.8 V up to 10 to 12 V. The 4.8 V input is provided by four NiMH rechargeable batteries connected in series while the 10 to 12 V output is used to power three series connected white

080585 - 11

LEDs. One half of the dual op amp IC2 forms an adjustable current source while the other half switches the light off when the supply voltage sinks too low to avoid discharging the cells too much.

IC2A is configured to generate a constant current. Zener D2 supplies a reference 2.7 V at its cathode which is divided by the R9/P3 network to supply an adjustable voltage of 0 to 128 mV to the non-inverting input of IC2A. IC2A controls T1 so that the voltage at its inverting input, produced by the voltage drop across the resistors R12 to R15, is the same as at its non-inverting input. The adjustment range of P3 produces a current of between 0 and almost 0.5 A through the 0.25 Ω resistor formed by the four parallel 1 Ω resistors. The typical operating current of a 1-watt LED is around 350 mA, this produces a

voltage of 88 mV across the four parallel resistors. With the LM358 even with the input at zero there will be an output voltage of 0.6 V so with P3 at a minimum a few milliamps will still be flowing through the LEDs.

The LEDs are turned off when the battery voltage falls too low, IC2B comparing a proportion of the battery voltage via P2 with the reference voltage on D2. If the battery voltage is below the reference voltage the output of IC2B will go high and the current source IC2A will be switched off. The circuit still draws a few milliamps when under-voltage is triggered so a good lower threshold to set is around 1 V per cell. With four cells P2 should be adjusted so that the LEDs switch off when the battery voltage falls below 4 V.

The adjustment range on P2 produces a voltage of around 3 V to over 10 V. Although four cells are shown in the diagram the circuit can accommodate anything from three to six cells. Do not use more than six cells when driving three LEDs in series, the input voltage would produce excessive dissipation in IC1 which can result in the battery voltage being applied directly to L1 and D1. The voltage step-up function of IC1 ensures that the cathode of D1 is at a higher voltage than the anode so D1 is not conducting. When the IC output switches, energy stored in L1 is converted into a higher voltage but lower current passing through D1 and then stored on capacitors C5 and C6. The 52 kHz switching frequency gives a stable output voltage with very little ripple.

IC1 reads the feedback voltage measured

COMPONENT LIST

Resistors
R1,R3 = 2kΩ2
R2 = 22kΩ
R4,R5,R6 = 1kΩ
R7,R9 = 100kΩ
R8 = 3MΩ9
R10 = 4kΩ7
R11 = 560Ω
R12,R13,R14,R15 = 1Ω
P1,P2 = 10kΩ preset, miniature, horizontal
P3 = 5kΩ preset, miniature, horizontal

Capacitors
C1 = 330nF MKT lead pitch 5mm or 7.5mm
C2 = 47µF 25V radial, lead pitch 2.5mm, ø max. 8.5mm
C3,C4,C9 = 100nF ceramic, lead pitch 5mm
C5,C6 = 470µF 16V radial, lead pitch 2.5mm, ø max. 8.5 mm
C7 = 10µF 63V radial, lead pitch 2.5mm, ø max. 6.5 mm
C8 = 100pF ceramic, lead pitch 5mm

Inductor
L1 = 100µH axial, upright mounting, suggested types: 5800-101 (Bourns) rated 0.63A/0.2Ω (Digi-Key # M8290-ND), B82111EC25 (Epcos) rated at 1A/0.65Ω (Farnell # 9752102) or MESC-101 (Fastron) rated at 1A/0.65 Ω (Reichelt # MESC 100µ)

Semiconductors
D1 = 1N5822
D2 = 2V7 0W5 zener diode
D3 = 1N4148
T1 = BD139
IC1 = LM2577T-ADJ (TO-220-5 case, straight pins)
IC2 = LM358 (DIP-8)

Miscellaneous
K1,S1,BT1 = 2-way PCB terminal block, lead pitch 5mm
S1 = single-pole on/off switch
BT1 = holder for 4 NiMH batteries*
3 pcs 1-watt power LED
PCB # 080585-1

* see text

at pin 2 and compares it with a reference of 1.23 V. It adjusts the peak switch current accordingly to maintain a constant output voltage. The divider chain formed by R2, R3 and P1 allow the output voltage to be varied between 3.5 V and 19 V. A typical 1 W LED has a forward voltage drop of around 3.25 V. Three LEDs in series gives 9.75 V, when the voltage drop across T1 and R12 to R15 are added to this we get 10 V. The adjustment range of P1 is sufficient to cater for LEDs with a forward voltage drop of up to 4.0 V.

In the Elektor lab we measured a supply current of 0.87 A from the 4.8 V battery pack giving a current through the LEDs of 0.35 A. Using 2000 mAh rechargeables you can expect a full battery pack to last for more than two hours. The circuit efficiency is over 82 % with a 4.8 V battery pack and around 89 % with a 5.6 V battery.

The set up procedure for the completed circuit is simple. Using an adjustable power supply set the output voltage to 4.8 V. Connect three LEDs in series to the anode and cathode (A, K) contacts of K1 and adjust P1 so that the voltage measured between the A connection of K1 and ground is 12 V. Now set the current by adjusting P3 until 88 mV is measured across resistors R12 to R15. To operate the circuit at optimum efficiency reduce the 12 V supply by adjusting P1, check that a constant 88 mV is maintained across R12 to R15, if it starts to fall then you have set P1 too low. Lastly adjust P2 so that the LEDs turn off when the supply drops below 4 V. Should the LEDs not light at all check that P2 has not been set too high.

(080585-I)

Internet Links

[1] www.national.com/mpf/LM/LM2577.html
[2] www.elektor-usa.com/080585

Download

**PCB**
080585-1 PCB layout (.pdf), from [2]

Annoy-a-Tron

Tolunay Gül (The Netherlands)

The idea for this circuit came from the website www.thinkgeek.com [1]. The author thought that it could be made better and simpler. A search on the Internet didn't get any results so the next logical step was to design something himself. With the help of a small AVR microcontroller from the spares box and a buzzer the experimenting could begin.
The circuit consists of little more than the AVR micro, a buzzer and an ISP header to program the code into the microcontroller. Apart from two resistors, a jumper to select the mode and an on/off switch, the circuit just needs a battery. The author used an old battery from a Nokia mobile phone because it had a large capacity, but was still fairly small. In principle a small button cell and a holder will suffice as well, and possibly even some solar cells from an old calculator could work.

The mode switch is used to choose between normal mode and a test mode. In the latter mode the Annoy-a-Tron will beep constantly. In normal mode the tone generator creates irritating beeps with a random pause of 10 to 500 seconds between successive beeps.

090084 - 11
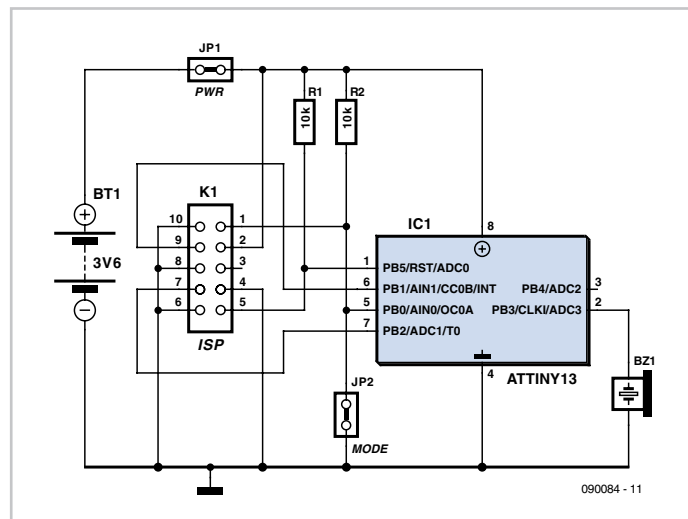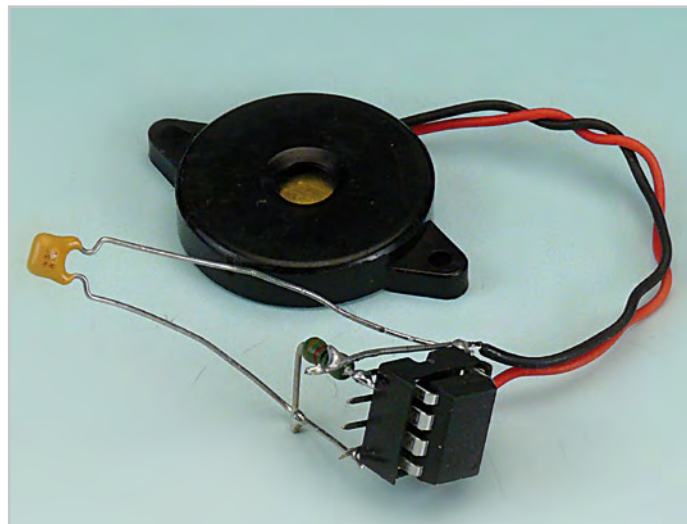
The controller obviously needs a program written for it. As is usual for BASCOM-AVR the code starts with a regfile that states which AVR is used. This is followed by the Xtal/internal oscillator choice. Next come the software and hardware stack, the frame size and the configuration settings. First portb.3 is configured as an output and given the name 'speaker'. Then the variable 'seconds' is defined as a 'word' type.

When the AVR is turned on it first comes to an endless loop. In this it checks if the mode jumper is in place or not. If it's not in place (a logic '1' caused by the pull-up resistor) the micro jumps to sub1. Here it comes to an endless loop again. Within this loop it creates a constant beeping noise.

When the mode jumper is put in place and the power is removed from the circuit and then reapplied (a reset), the controller once more comes to an endless loop. However, this time it sees a '0' because the jumper pulls the I/O pin to a low level. This causes the program to jump to sub2. This is again an endless loop, which immediately generates a beep. It then generates a random number from 0 to 50, adds one to it and stores it in the variable 'seconds'. The number in 'seconds' is then multiplied by 10 to obtain a longer pause before the next beep. The pro-

gram then waits for the required number of seconds before jumping back to the beginning of the loop.

The circuit can be easily built on a piece of stripboard. Alternatively, an SMD board could be designed, which means that the resulting circuit could be made very small. The software can be downloaded from the Elektor website [2].

(090084)

Simple Wireless and Wired Emergency Stop System

Jacquelin K. Stroble (USA)

This circuit allows a cheap or discarded wireless doorbell set (i.e. transmitter and receiver unit) to be used as a remote emergency stop on a high-power electrical motor or motor controller system.

When the button on the wireless doorbell unit is pressed, the resulting 0 V signal from the receiver unit ('motor E-Stop') causes pnp transistor T1 to be turned on. Via transistor T2, latching relay Re1 then changes state. The same is achieved when the wired Motor E-Stop button, S1, is pressed. The reset button, S2, must be pressed to reverse the state of the latching relay.

The choice of T1 and T2 is not critical — they are general purpose, low voltage pnp and npn switching transistors respectively, for which many equivalents exist.
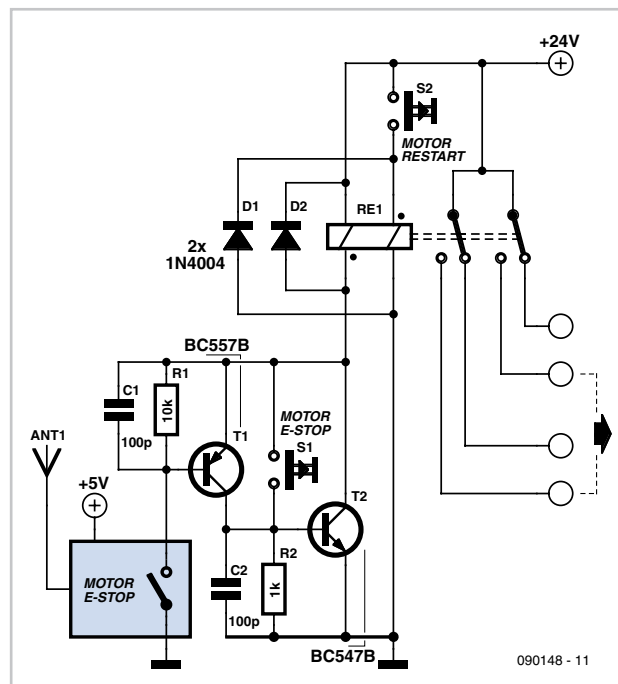
As an EMC precaution, small capacitors (100 pF) are fitted across base resistors R1 and R2, preventing the motor from being shut down by external electrical noise and interference. The set and reset coils of the latching relay each have a flyback diode to prevent back-emf peaks damaging T1 and T2. The contacts of the latching relay can be used to switch a more powerful relay, or a motor driver.

(090148-I)

090148 - 11

# Desulphater for Car Batteries

Christian Tavernier (France)

Even if you take great care of your car or motorbike battery, you're bound to have noticed that its life is considerably shorter than the high purchase price and sales pitch probably led you to expect. Of course there are several reasons for this, and high on the list is the phenomenon of slow but inevitable sulphating of the plates. To understand properly what this involves, we need to look at a bit of chemistry.

A lead/acid battery exploits a chemical reaction which is written as follows, when discharging:

$Pb + 2H2SO4 + PbO2 \longrightarrow PbSO4 + 2H2O +$ PbSO4
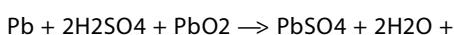
This indicates that, in contact with sulphuric acid, the porous lead of one plate and the porous lead dioxide of the other are both converted into lead sulphate and water. During charging, the following reverse chemical reaction occurs:

$PbSO_4 + 2H_2O + PbSO_4 \longrightarrow Pb + 2H_2SO_4 + PbO_2$
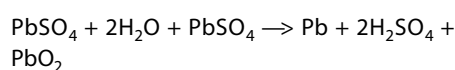
This time, the electric current being passed converts the lead sulphate and water into lead, lead dioxide, and sulphuric acid. In theory, the reaction is totally reversible, which is why a battery can be charged and discharged a great many times.

Unfortunately, with the passing of time and successive charge/discharge cycles, the second reaction, i.e. the one that converts the lead sulphate back into lead, becomes incomplete, and leaves some lead sulphate on the surface of the battery plates. As this is a poor conductor, it tends to get thicker in places where it has started to collect, and unfortunately this phenomenon of sulphating, for that's what it's called, is cumulative and gets worse and worse as time goes by.

Once a battery has got badly sulphated beyond a certain point, no standard charging process is able to recover it. What happens is that, because the lead sulphate Is a poor conductor, the battery's Internal resistance Increases, which In turn reduces the charging current, and thereby the effectiveness of the

charging chemical reaction; this in turn leaves even more lead sulphate on the plates… and so it goes on, in a vicious circle. There is a chemical process that makes it possible to eliminate the lead sulphate from a battery before it's too late, but it's a tricky operation and uses highly corrosive chemicals that are dangerous to handle. What's more, many of the batteries sold these days are sealed and so it's impossible to gain access to their electrolyte without damaging them.

The project we're suggesting here lets you desulphate your battery electronically — and the sooner you start doing it, the more effective the process will be. It is based on research carried out in the United States, which showed conclusively that if you apply short, high-amplitude pulses to the battery, the resulting ionic agitation produced at the battery electrodes gradually breaks up the lead sulphate crystals. Even if you're a bit sceptical about the effectiveness of this process, you can try it out for yourself without any great financial risk, as the circuit required is simple and cheap. Nothing ventured, nothing gained!

The circuit used is very similar to the one currently to be found in the United States, where this type of desulphating process is popular as well as widespread. Apart from a few details, it's pretty much like a 'boost' type switch-mode power supply unit (SMPSU) — i.e. one that steps up the input voltage. IC1 is wired as an astable multivibrator running at a frequency of the order of a kilohertz and generates very short mark/space (on/off) ratio pulses at its output.

When T1 is turned off by the level of these pulses, capacitor C5 is able to charge up to the battery voltage through inductor L2. When T1 turns back on again, which happens for only a very short time, given the mark/space ratio of the pulses, capacitor C5 discharges abruptly via T1 and L1. When T1 then turns off again, the inductor L1 means that the discharge current can't stop instantly. So it is obliged to pass through the battery via diode D2.

With a high-quality capacitor for C5 (meaning a device with a low ESR) and a short connection in heavy-gauge wire from the circuit, we can push a peak current of some 5 to 10 A through the battery. Despite this, the power consumption of the circuit is still fairly low, of the order of 40 mA, because of the very low
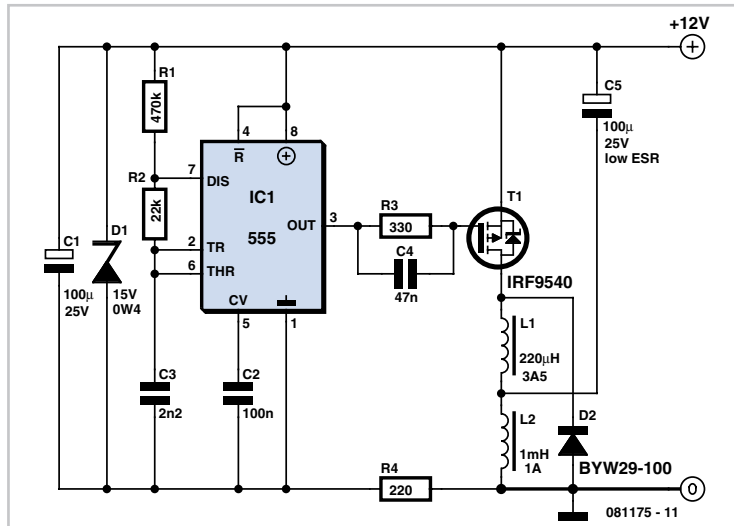
mark/space ratio of the signals produced.

Construction shouldn't be any problem, especially if you use the printed circuit board design suggested [1], but for optimum per-

formance, you do need to pay careful attention in choosing the components.
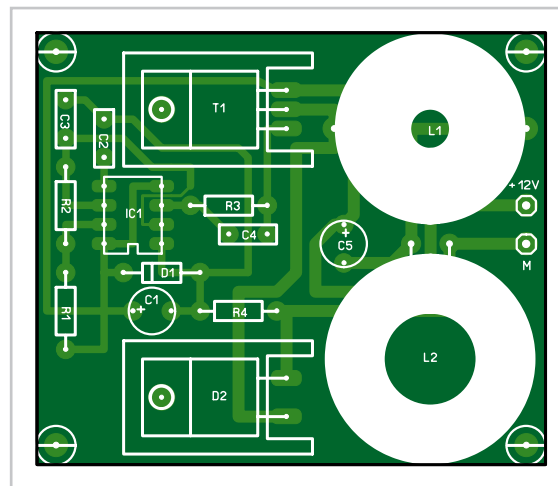
The inductors used must not be changed. They are available, for example, from Radiospares (RS Components) as part numbers 228-422 (L1) and 334-9207 (L2). Diode D2 is a readily-available type and should only be replaced if this is unavoidable, and then only by an ultra-fast device. Capacitor C5 must be a low series resistance type, such as those intended for switch-mode power supplies. As can be seen from the component overlay of the PCB designed by Elektor Labs, T1 and D2 are fitted with small U-shaped heatsinks designed to take TO-220 packages.

It is advisable to install the circuit into an earthed metal case, as it generates quite severe electromagnetic interference that it's best not to allow to radiate out as it is likely to upset the operation of other equipment. EMC regulations and recommendations apply here.

The battery connection must be made using short wires, of at least 2.5-3.0 mm² gauge (AWG # 12-13), securely connected to the battery terminals, since for the process to be effective, it's important to minimize any series resistance between the circuit and the battery. If necessary, it can be left permanently connected.

Some writers and pundits advise connecting a charger (even a low output one) to the battery at the same time, to avoid the circuit's discharging the battery in the long term. But we would not recommend doing so, since the charger's relatively low output impedance distorts the pulses produced by the circuit and hence diminishes its effectiveness.

Caution / Safety Notice

If you use this desulphater directly on your vehicle battery, remember to disconnect at least one of the connections to the battery, as the parallel impedance of the many devices that stay permanently powered in modern cars once again diminish the effectiveness of the system.

Internet Link

[1] www.elektor-usa.com/081175

Download

081175-1: PCB layout (.pdf), from [1]

COMPONENT LIST

Resistors
R1 = 470kΩ
R2 = 22kΩ
R3 = 330Ω
R4 = 220Ω

Capacitors
C1 = 100µF 25 V
C2 = 100nF
C3 = 2nF2
C4 = 47nF
C5 = 100µF 25 V, low ESR

Semiconductors
D1 = 15 V 0.4 W zener diode
D2 = BYW29-100
IC1 = NE555
T1 = IRF9540

Inductors
L1 = 220µF 3.5A
L1 = 1mH 1A

Stereo Widening

Huub Smits (The Netherlands)

Although the principle is quite old, 'widening' of the sound image is still done these days in many portable devices, ghettoblasters and PC loudspeakers, even though it is usually called something else in these applications. To generate the stereo image, the left channel also contains part of the sound from the right channel, shifted a little in phase compared to the right channel. The same is true for the right channel, where the signal from the left

IC1...IC6 = TL071

090174 - 11
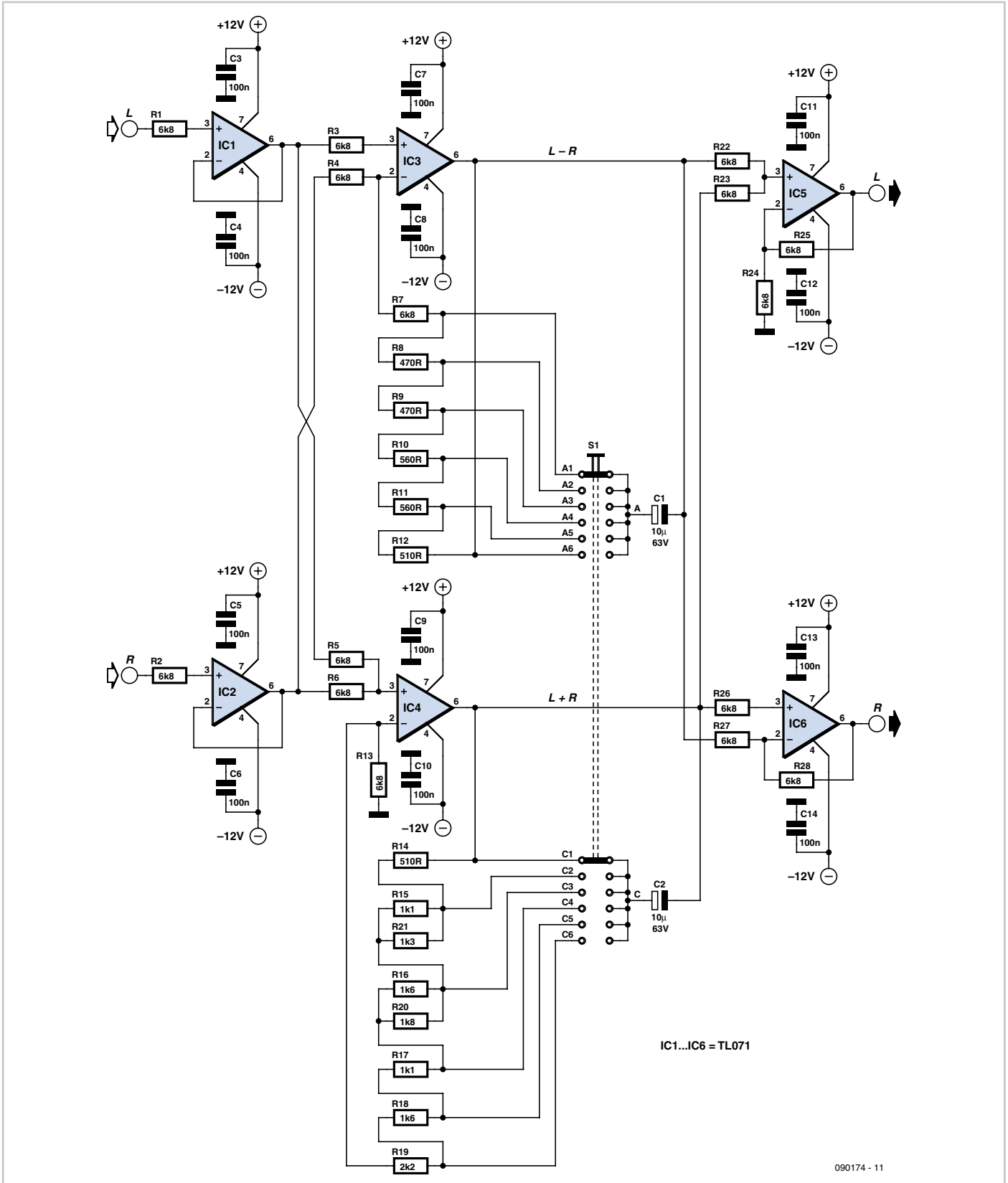
channel is slightly shifted in phase. To make the stereo image 'wider', you can amplify the difference signals of both channels.

To do this you generate a sum- and a difference signal from the left and right channels. With a couple of opamps you can realise a 'left+right' signal and a 'left-right' signal. So the (left–right) signal needs to be made stronger with respect to the (left+right) signal. Expressed as a formula:

$$(L+R) + (L-R) = 2L \text{ and } (L+R) - (L-R) = 2R$$

With a suitable circuit, the left signal in the left channel is increased and the right signal is decreased. Similarly, in the right channel

the right signal is increased if the left signal reduces. To maintain a constant volume, we also have to make sure that the total signal strength remains the same.

From the schematic you can see how this problem was solved. IC1 and IC2 are the input buffers. After the buffer, the left and right signals are combined with the other channel respectively. IC3 generates the (L–R) signal and IC4 the (L+R) signal. With two times six resistors and a multi-position switch, the amount of the effect can be adjusted. The values of resistors R7–R12 and R14–R21 are selected such that the total volume remains about the same when changing the switch. IC5 and IC6 generate

the final left and right signal from the (L+R) and (L–R) signals.

For additional protection, electrolytic coupling capacitors of 10 µF 16 V can be added to the inputs and outputs. Each of the inputs of IC1 and IC2 will then also need a 10 kΩ resistor to ground, otherwise the opamp outputs will run up against power supply rail.

The power supply requires a symmetrical voltage of ±12 V. This voltage can usually be found in an existing amplifier, so normally there is no need to build a special power supply.

(090174-I)

SMD Transistor Tester

Ludwig Libertin (Austria)

The article 'SMD Soldering Aid' by Gert Baars in the December 2005 issue of *Elektor* [1] was the original inspiration for a truly 'electromechanical' version of this design for a transistor tester for SMD transistors in SOT23 case outline. However, Gert's strip metal construction method was not chosen and instead an alternative design was created out of strips of soldered PCB material. Glassfiber epoxy resin PCB material cannot compare with strip metal for springiness so the spring from a discarded ballpoint pen was used, which provides adequate clamping pressure. The key advantage of this choice of materials is that the TUT (transistor under test) is pressed hard onto three PCB tracks that lead directly to sockets into which a conventional transistor tester can be plugged. It really is this simple (without any soldering) to check whether the TUT is flaky or worth keeping for reuse.

The actual procedure for using this SMD transistor tester is no different from checking out transistors that have wire leads. In most cases all you are interested in is whether the TUT is dead or alive and also if it is of the NPN or PNP variety. This much you can discover with-

out the need to hook up an external transistor (and the extra bother).

No sooner said than done. The result is a project that's equally useful as a simple 'test connector' hook-up for the TUT and as a simple transistor tester. The very minimalist circuit consists of a CD4049 (CMOS HEX inverter/buffer) and a few additional components — naturally all in SMD form factor. IC1.D and IC1.C together with R1 and C1 form a squarewave generator with a frequency of around 2 Hz. This drives inverters IC1.A and IC1.F (connected in parallel for higher output current),

Features

- Standalone SMD transistor tester
- Identifies defective transistors
- Distinguishes NPN from PNP

which in turn feed IC1.B and IC1.E. If no transistor under test is connected, LEDs D1 and D2 will both flash together in anti-phase and half the operating voltage will be present at base connection B.
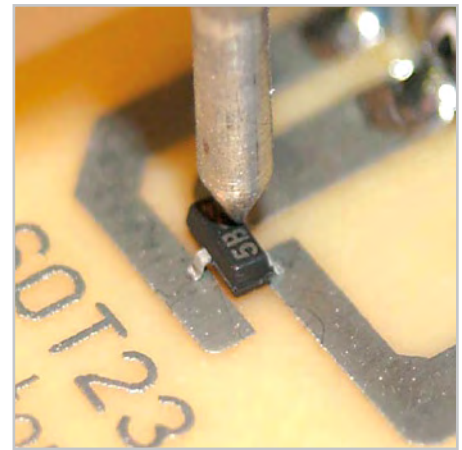
Now insert a transistor in the test device: both LEDs flashing indicate an open circuit,
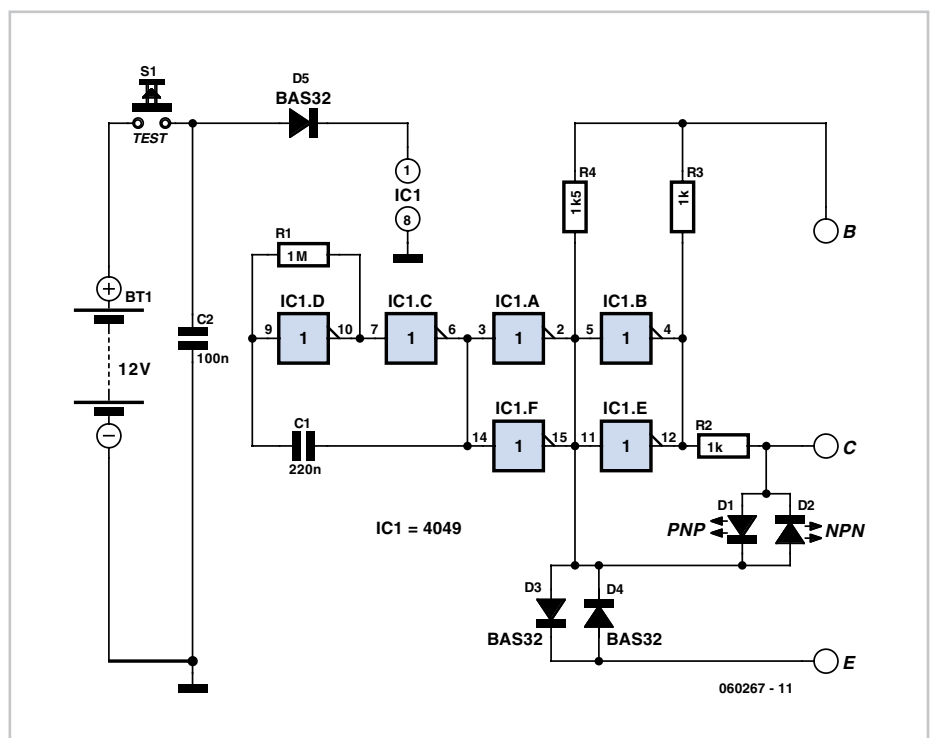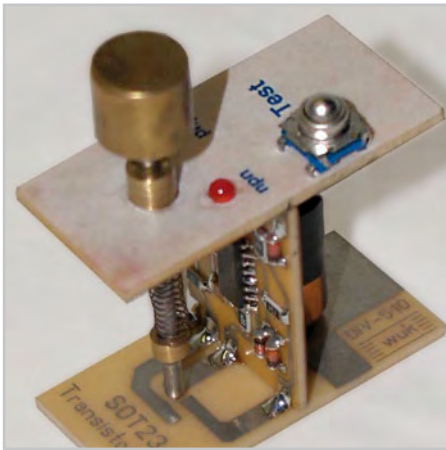
a PNP device. The circuit draws only 10 mA or so and using pushbutton S1 for operation means that the battery will have a very long life.

The type GP23A 12 V battery is an integral part of the mechanical structure and is clamped between the upper and lower printed circuit boards. A small section sawn from a piece of plastic pipe is used as a *de facto* battery clip glues to the vertical printed circuit board improves stability (**2**). The nail-like metal pin is passed through a small ring of brass soldered to the upper PCB.

To simplify the task of replicating the PCBs the author has made the layout files of the three small PCBs available on the article's web page [2]. To use these you will not need the full version of the Sprint Layout software, as you can open the files just as well with the free Viewer programme [3].

(060267)

in other words the transistor is defective. An internal short circuit (connection between C and E) is indicated by the two LEDs glowing dimly. A functional NPN transistor conducts only when the voltage on C is higher than on E. LED D1 Is now short-circuited and only D2 flashes. In similar fashion only D1 flashes for

Internet Links

[1] www.elektor.com/magazines/2005/december/smd-soldering-aid.57995.lynkx

[2] www.elektor-usa.com/060267

[3] www.abacom-online.de/html/dateien/demos/splan-viewer60.exe

COMPONENT LIST

Resistors
R1 = 1MΩ
R2 = 1kΩ
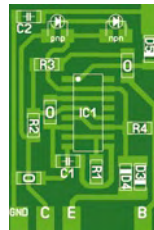R3, R4 = 10kΩ

Capacitors
C1 = 220nF
C2 = 100nF

Semiconductors
D1, D2 = LED, 3 mm
D3, D4 = BAS32
IC1 = 4049 (SO16)

Miscellaneous
S1 = pushbutton, push to make
12 V battery GP23A
Mechanical parts as described
PCBs (see text)

TL431 Multivibrator

Gilles Clément (France)

Oscillators have a certain appeal to electronics enthusiasts. They're rather 'alive' because there's something 'beating' inside them, isn't there?

Here the TL431 'super zener', an easily-sourced standard device, is made to oscillate. It's a 3-pin IC: cathode, anode, and ref. input. An op amp compares V_{ref} with an internal 2.5 V reference and drives a bipolar transistor that 'shorts' the cathode to the anode. So

the cathode voltage V_k has two stable states: $V_k = V_{supply}$ if $V_{ref} < 2.5$ V and $V_k = 2$ V (the V_{ce} of the transistor) if $V_{ref} > 2.5$ V. A bit like a transistor that works with voltage instead of current, so with a little effort it should be possible to force it to oscillate between

081167 - 11
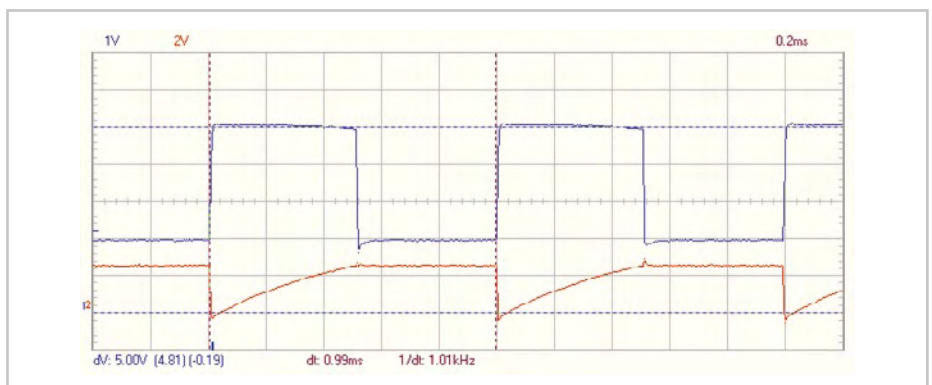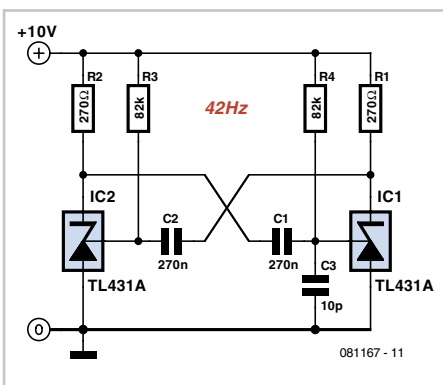
these two states.

If two TL431s are wired as an astable multivibrator you'll find that it works! But actually, it ought not to, since the op amp's V+ input is unable to sink the capacitor charging current! So, how does it work then?

In fact, the current passes via a stray internal diode between V_{ref} and the cathode (which is certainly noted on some data sheets like [1], but not on all of them).

This was checked using the excellent (and free) LTspice simulator [2]. The frequency is defined by R and C (and of course the supply voltage). It gives a very good square-wave (see scope trace) up to around 50 kHz. The signal is much better than using bipolar transistors. However, the low voltage stays at 2 V, but this can be solved by using a FET on the output, or by using similar ICs with lower reference voltages like for example the TLV431 (threshold 1.24 V) or the ZXRE060 (threshold 0.6 V).

The 10 pF capacitor C3 is only there to make the LTspice simulation start up correctly; it's not needed in the real circuit, which makes use of natural asymmetries.

The author's LTspice model is available for free download from [3].

(081167-I)

Internet Links

[1] www.datasheetcatalog.org/datasheet/calogic/TL431.PDF

[2] www.linear.com/designtools/software/#Spice

[3] www.elektor-usa.com/081167

S-video Converter

Christian Tavernier (France)

With the astonishingly rapid growth in the market for flat-screen TVs and high-definition TV, many CRT television sets have been consigned to the attic, even though many of them were still working perfectly and could have been used as spare sets in a bedroom or

S-video signal into a composite signal and so will perhaps enable you to give a new lease of life to your old CRT television.

The principle of S-video is very simple, as it merely consists of carrying the chrominance and luminance information, which form the basis of all color video signals, over

that our CRT television is expecting to see. In order for this recombination to be correct, there is just one constraining factor to be taken into account, concerning the respective levels of the components, as the chrominance one is only half the amplitude of the luminance one.

081179 - 11
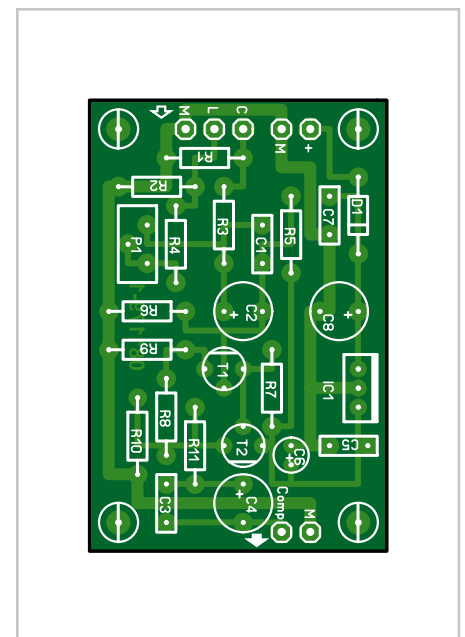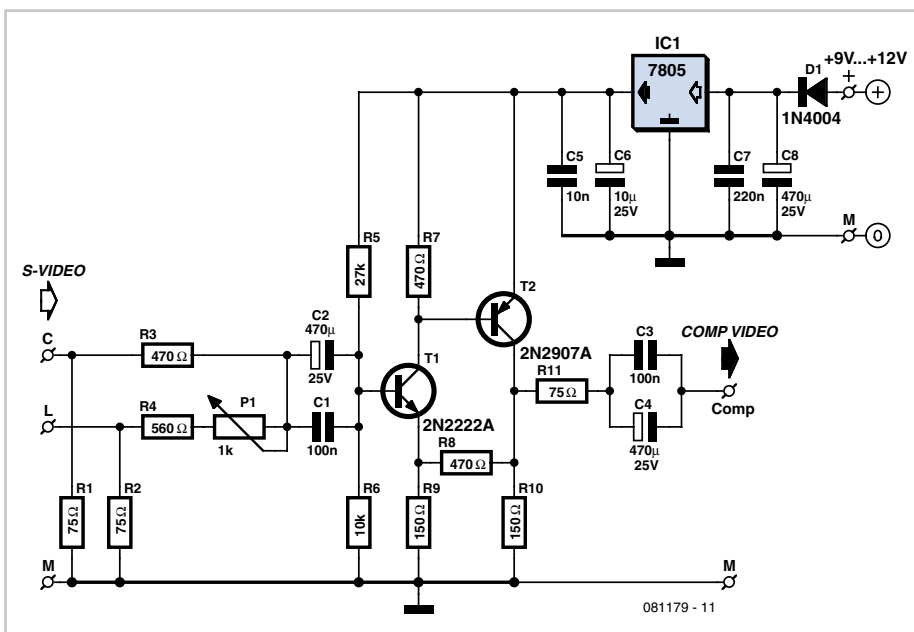
another room, for example. Although all current flat-screen receivers have very comprehensive facilities and include digital inputs via DVI or HDMI connectors and analog inputs in S-video format, this was unfortunately not the case with the CRT televisions that were being sold only a few short years ago, which were more often than not fitted with only composite video inputs, either directly or via their SCART socket. The converter we are suggesting building, very simple since it only uses two transistor, lets you convert any

separate channels. In composite video, by contrast, both these signals are combined over a single path, and the resulting inevitable interferences between them degrade the appearance of the image being reproduced. Fortunately, the components of an S-video signal, whether in the SECAM, PAL, or even NTSC standards, are almost the same as the ones found in a composite signal of the same standard. So it's going to be relatively simple to combine them in order to reconstitute the composite video signal

Our circuit picks up the component signals on the two standardized pins of the 4-pin mini-DIN socket normally used for S-video (also known as an Ushiden socket), taking care to maintain the 75 Ω impedance via R1 and R2. The mixing of the two signals is then taken care of by R3, R4, and P1; the latter lets you adjust the respective levels of the two component signals exactly.

The two transistors that come next are wired in such a way as to create a wideband ampli-

fier, the gain of which is set to 3 by the ratio between R8 and R9. Combining the input components has had the effect of dividing the overall amplitude of the video signal by a factor of 1.5, and the output impedance matching resistor is going to divide the signal in half again (once the signal is terminated at the input of the destination equipment), all of which adds up to a total attenuation of 2×1.5, corresponding to the make-up gain we have designed into our amplifier. In this way, inserting our converter into a video chain will have no effect on the level of the signals passing through it.

The composite video output passes via 75 Ω resistor R11 in order to match the circuit's output impedance to the input impedance of the composite video input on the device to which it is connected. At both input and output, note the parallel combinations of C1 / C2 and C3 / C4, so that the video signals, with a frequency range extending from a few tens of Hz to several MHz, can pass through these capacitors under the best possible conditions.

If we want to avoid unwanted color or brightness variations, it is vital to power the circuit from a stabilized supply, achieved here by using a standard 3-pin regulator IC to provide a 5 V rail for the circuit. So the project can be powered from a 'plug-top' AC adaptor

that gives 9 to 12 V at 100 mA or so. Diode D1 is there just to protect against any accidental inversion of the PSU polarity that might possibly occur.

The circuit itself is very easy and construction shouldn't present any difficulties. It can be built on the PCB we suggest [1] or on a piece of prototyping board, but in either case, we recommend using fiberglass board, because of the high frequencies involved in the video signals.

If you want your converter to follow the proper standard in terms of connectors, you'll want to use a female 4-pin mini DIN S-video socket for the input and a female phono socket (a yellow one, for the purists!) for the output. As for the power supply, all you'll need is a simple jack to suit the AC adaptor unit you've chosen.

The circuit should work right away, and all that you then have to do is to adjust the preset P1 so as to obtain a composite video signal that gives correct contrast and saturation on the TV receiver you are using.

(081179-I)

Internet Link

[1] www.elektor-usa.com/081179

Download

081179-1: PCB layout (.pdf), from [1].

COMPONENT LIST

Resistors
R1,R2,R11 = 75Ω
R3,R7,R8 = 470Ω
R4 = 560Ω
R5 = 27kΩ
R6 = 10kΩ
R9,R10 = 150Ω

Capacitors
C1, C3 = 100nF
C2, C4, C8 = 470µF 25V
C5 = 10nF
C6 = 10µF 25V
C7 = 220nF

Semiconductors
D1 = 1N4004
T1 = 2N2222A
T2 = 2N2907A
IC1 = 7805

Miscellaneous
4-pin mini DIN connector
Cinch connector (yellow)
DC supply connector

SSR 2.0

OptoMOS semiconductor relays

Fredi Krüger **(Germany)**

OptoMOS or PhotoMOS relays are something of a special category. Looking at a block diagram the device falls somewhere between an optocoupler and a conventional SSR (Solid State Relay).

To compare technologies the input signal to a standard analog optocoupler modulates the light of an LED. The light induces a current in an isolated phototransistor or Darlington. The output current from this type of device is relatively small (a few milliamps) and is approximately proportional to the input signal.

Solid state relays by comparison have a similar input LED but this time the light is used to trigger a built-in triac or thyristor. They are used to switch

AC loads and some variants include circuitry to ensure switching occurs as the AC passes through zero. This reduces switching EMI but also makes them unsuitable for phase control applications.

Conventional mechanical relays have been around for years. They switch both AC and DC supplies and can be designed to handle high current and voltage. Standard semiconductor relays can switch high current and high voltage loads but are not suitable for DC supplies and cannot be switched at high frequency.

Taking a closer look at the block diagram of a typical modern optoMOS relay shows an LED at the input as in the a normal optocoupler, but this time the light is used to switch two complementary photo MOSFETs which form a bidirectional switch. This bidirectional configuration is capable of switching both AC and DC supplies at speeds of around 1 ms. Most of the major IC manufacturers produce their own versions and amongst those stocked by one supplier include NEC (PS7141-2B), International Rectifier (PVN012APbF), Clare (LBB110) and Vishay Semiconductors (LH1502BB). The characteristics of these devices

range from a maximum load current from 50 mA to 10 A with a voltage range from 20 V up to 2 kV. The switch resistance can be as low as a few mΩ to 100 Ω and the input control current ranges from around 2 mA to 10 mA depending on the type of relay. Some other manufacturers are Toshiba, Fairchild, Aromat (NAiS), Panasonic, Sharp, Cosmo and Avago. Some of the advantages of OptoMOS relays are:
• Small package outline — also in SMD!
• Long service life
• No contact wear
• No contact bounce
• No generation of EMI
• High switching speed
• Insensitivity to vibration
• Insensitivity to magnetic fields
• No magnetic field emission
• Low control power requirements

There are several different package outlines including one with eight relays in the same

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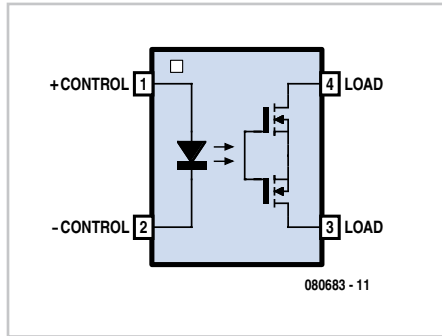
package. When choosing a relay for a particular application the description will include the specification 'X form Y'. X is a number indicating how many switches are in the package and Y indicates the type of contact: 'B' = normally closed while 'A' = normally open. Some of these relays have both normally open and normally closed in the same package, useful for making a changeover switch.

In the Elektor labs we took a look at the TLP4227G-2 from Toshiba. This 8-pin version is described as '2 form B', i.e. two normally closed relays. The contacts are capable of switching 350 V at 150 mA. Without any current flowing in the LED the device is on and we measured an output resistance of 15 Ω. With an LED current of 0.5 mA the resistance starts increasing and at around 0.9 mA it rises sharply giving an off resistance of around 300 MΩ.

The FOD3180 is another variant from Fairchild; it is a high speed MOSFET gate driver optocoupler which has additional load supply voltage connections. It is capable of switching 2 A at 250 KHz. At this speed it is necessary to take precautions to suppress EMI generation generated in the load.

(080683-I)

Internet link
www.toshiba.com/taec/components2/Datasheet_Sync//214/4495.pdf
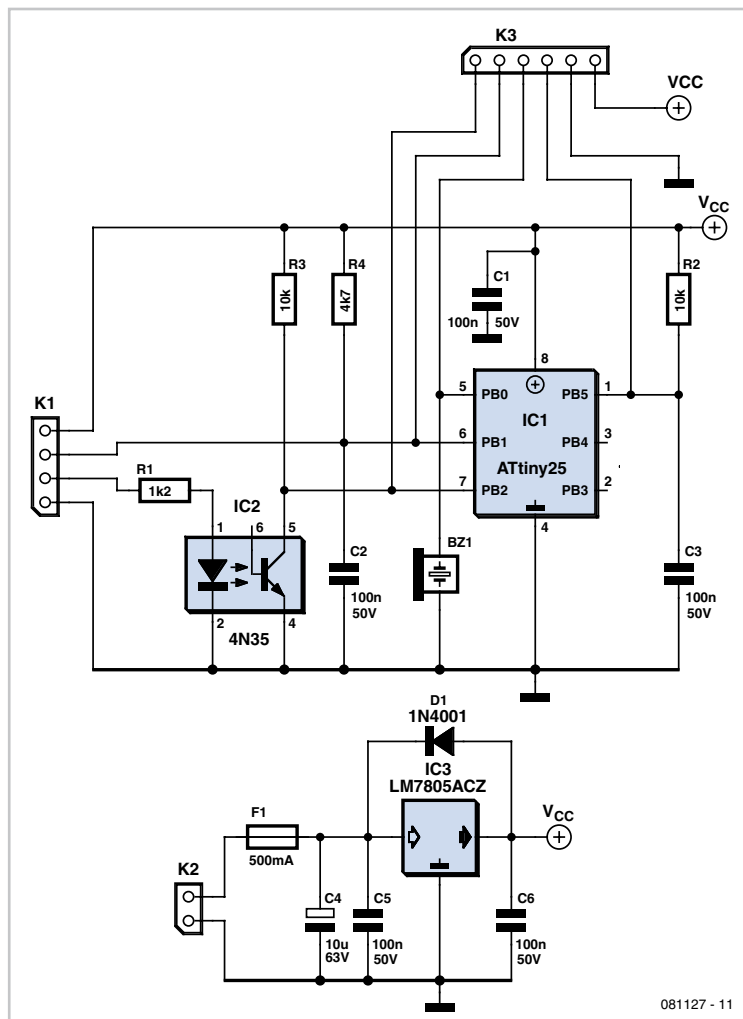
Speed Control

Mark Donners (The Netherlands)

The author went for a ride in a rental Citroen a while ago. This car had a nice gadget onboard that the author was unable to find available as a separate accessory. In such cases, there's only one option for an electronics enthusiast: do it yourself!
The device in question monitors how fast you are driving. An alarm sounds if you go faster than the preset speed. This gives the driver good control over how fast he actually drives. You can regard it as a pseudo cruise control.
This circuit is built around an Atmel ATtiny25 microcontroller, which has all the features necessary for achieving the desired objective. The microcontroller operates at 1 MHz using a clock signal generated by an internal oscillator. The desired speed is set by a pushbutton switch connected between pins 3 and 1 of connector K1, which is connected to input PB1 of the microcontroller.
The idea is that the driver should push the button when the car reaches the desired speed detec-

081127 - 11

tion limit. After this speed has been 'stored' via input PB1, the microcontroller will generate an acoustic alarm if the set speed is exceeded. It produces two short beeps if the speed is slightly higher than the set value, or a long, loud beep if the speed is significantly higher.
The speed is measured via pin 2 of connector K1. Optical isolation with IC2 protects the PB2 input of the microcontroller against excessively high voltages. You can tap off the speed input signal of the car speedometer for this purpose, or you can fit a magnet and reed relay to the driveshaft or an axle.
The firmware is written in C and assembled using Codevision. All the firmware does is to monitor the speed input signal using an interrupt-driven routine. The signal is monitored by measuring the interval between two successive pulses: the shorter this interval, the higher the speed. If the set speed level is exceeded, an

alarm signal is generated. You can use connector K3 to program the microcontroller (1 = SCK; 2 = MISO; 3 = MOSI, 4 = $\overline{\text{RESET}}$). Information about available speed signals in different makes of cars is found on the Internet, for example, at [2].

Caution. Tapping off or altering the speed signal generated by a vehicle for use on public roads may be illegal and/or void manufacturer's warranties.

(081127-I)

Internet Links
[1] www.elektor-usa.com/081127
[2] http://koti.mbnet.fi/jylhami/trip/speedsignal.pdf

Download
081127-11: source code and hex code, from [1].

Four-component Missing-pulse Detector

Lars Näs (Sweden)

A missing-pulse detector is a 'one-shot' triggered device that is continuously retriggered by incoming pulses before a predefined timing cycle is completed. At room temperature, the positive-going threshold voltage (V_{th+}) for the CD40106BC hex Schmitt trigger IC falls in the range of 60% to 86% of its supply voltage (V_{cc}: 5 V–15 V). If we also take into account that capacitor C1 takes a time constant defined as R1×C1 [seconds] to reach 63% of its full charge voltage, the constant is roughly the time C1 takes to charge up to the level V_{th+}, thus changing the logic state of pin 6 on IC1.C.

Based on the above assumption, if a pulse train with a High-level period shorter than

$$T = R1C1 \text{ [s]}$$

is present on the base of T1, this pnp transistor will remain in the cutoff state. This allows

080137 - 11
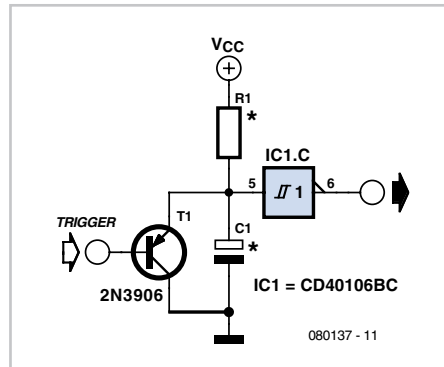
R1 to charge up capacitor C1, but not sufficiently to reach the positive voltage threshold set at input pin 5 of the gate. Consequently Schmitt trigger output pin 6 will remain High. For a retriggered pulse period of 3 seconds (or 0.3Hz) you'd use R1 = 330 kΩ and C1 = 10 µF.

Now, if the High-level pulse duration on the base of transistor T1 is longer than *T*, the transistor will remain cut off, but the capacitor will

charge until V_{th+} is reached and the output pin 6 of the Schmitt trigger gate will change to logic Low.

When no pulse (i.e. a logic Low state) is present on the base of T1, the transistor is driven into saturation. This allows C1 to instantly discharge, setting up the initial conditions for the next pulse.

The trigger signal can for instance be supplied by a Hall-Effect switch set up to measure if a wheel with a magnet is rotating or not.

This circuit uses one gate in the CD40106BC, leaving the other gates free for use for other purposes. Do take into account that CD40106 devices from different manufacturers or production batches may have slightly different threshold voltages, which requires the calculated value of T to be adapted carefully to match the specifications of the gate used.

(080137-I)

Hassle-free Placement of SMD Components

Leo Szumylowycz (Germany)

Gadgets can be very useful to assist the task of placing components in printed circuit boards. Some people clamp the PCB in a small vice, either the vacuum-fixing variety (with a sucker) or the type that clamps to the edge of the workbench, or else they use one of those 'third hand' devices with several crocodile clips. But none of these is much help when you are dealing with surface mount (SMD) components. Even the steadiest hand is of little use if just the smallest slip causes the PCB to jump out of the croc clips. In this kind of operation you cannot steady your hands on the work surface and they soon get tired.

The author has discovered a better, albeit unconventional, solution: a substance like modeling clay that is sold for cleaning the
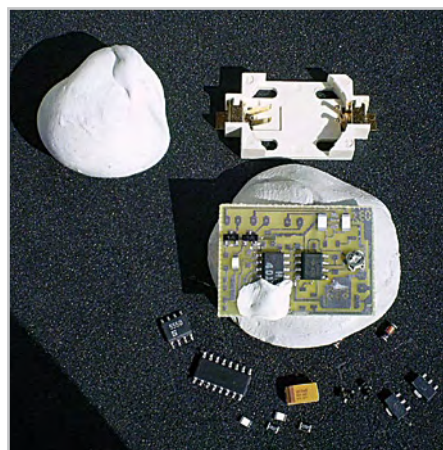
gummy mess out of the metal type letters on traditional typewriters (yes, some people do still use these good old machines). This substance is sold in specialist stationery shops

but if you can't find it, a good substitute is Blu-Tack adhesive putty (or one of the several similar products), which you can buy in strips, square or small pads. You'll need to knead it in your hands a while for this kind of assembly work.

Once you have softened a lump to a suitably elastic consistency, you can press it onto the actual work preparation area and place the printed circuit board on top (see photo). The underlay should be rectangular or circular, about 20 to 25 cm (8 to 10 inches) across. This approach enables you to maneuver the SMD printed circuit board into the best position at any time during the parts placement process and fix it firmly in place with both hands. Using a conductive material for this underlay enables it to be earthed for discharging any static electricity charge. Many mousepads are

suitable for this purpose, used with the conducting surface uppermost.

Instead of Blu-Tack you could use other materials such as Plasticine or even chewing gum, although the author has not tested these personally. Here practitioners will state that SMD printed circuits boards can also be populated using double sided sticky tape. Blu-Tack has the advantage, however, that you can use it to fix individual components onto the PCB tidily and 'squarely' before soldering, leaving both hands free for the actual soldering.

(090368-I)

Daylight Switch

Mickael Bulet (France)

This project was originally designed for lighting up an illuminated sign for a wine-grower. The sign was originally controlled by a simple time-switch, which had to be reprogrammed every day to avoid the sign's lighting up while it was still daylight. This is time-consuming, and can lead to wastage of electricity and other resources. A better solution would be an automatic switch capable of detecting the transition between daylight and night-time. In addition to that fundamental requirement, the specifications also demanded a very compact unit that would be easy to install and not require major modifications to the existing electrical installation.
The project described here is compact

enough, fitting into an 80×80 mm (inter-

090049 - 11
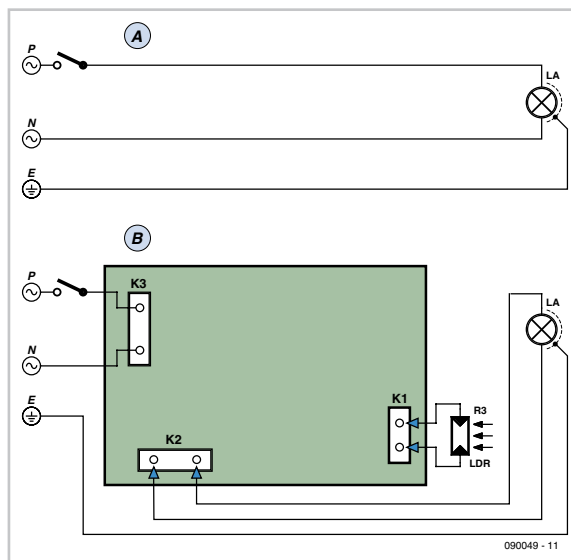
nal dimensions) IP55 junction box, for example, the Plexo® range from Legrand. It is easy to install; all you have to do is cut into the cable leading to the light and wire it in series.
The circuit is AC powered, without using a transformer. The impedance of a capacitor is used to drop the 230 VAC (or 120 VAC) power voltage and limit the current. Resistor R1 protects the capacitor (C1) against surge currents when power is applied at lighting-up time, and R2 ensures that it is discharged at turn-off. Readers on 120 VAC, 60 Hz networks should change component values as follows: R1 = 2x 100 Ω in parallel (stacked) or 1x 47 Ω, 2 watts; C1 = 2.2 µF. Also note P = phase, N= neutral, P (PE) = protective earth.
Rectification is achieved using a bridge rectifier, which makes it possible to double

090049 - 12
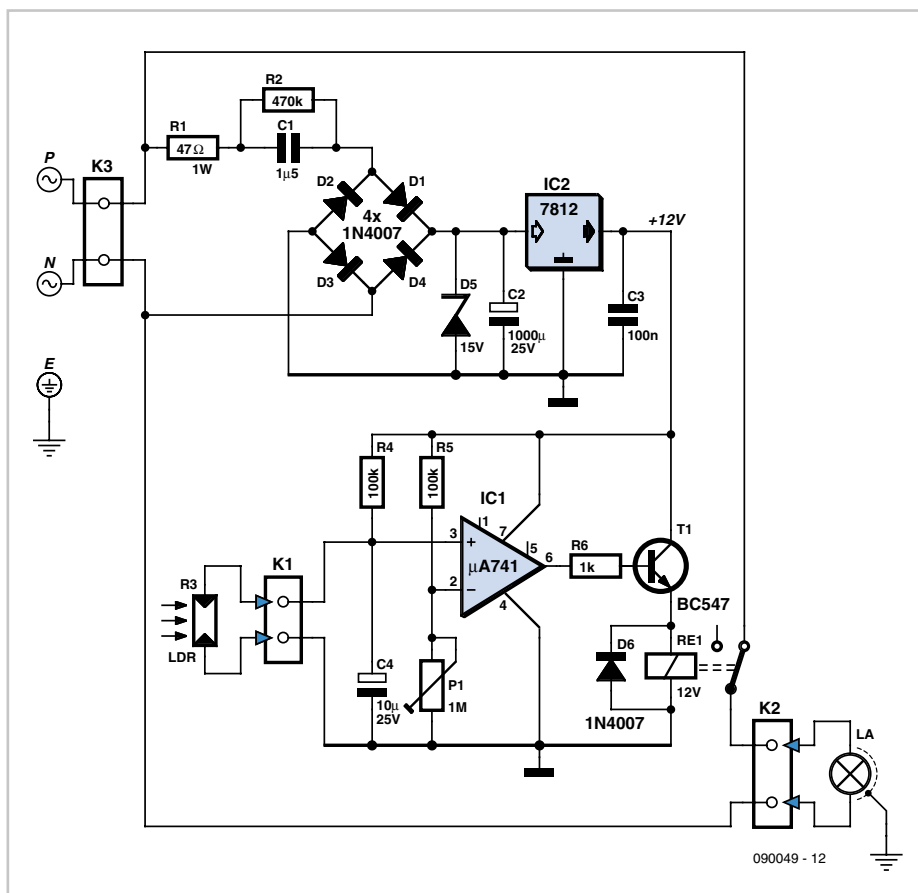
COMPONENT LIST

Resistors
R1 = 47Ω 1W
R2 = 470kΩ
R3 = LDR
R4, R5 = 100kΩ
R6 =1kΩ
P1 = 1MΩ multiturn preset, vertical

Capacitors
C1 = 1µF5 400V MKT
C2 = 1000µF 25V axial
C3 = 100nF LCC 63V
C4 = 10µF 25V radial

Semiconductors
D1–D4, 6 = 1N4007
D5 = 15V 1.3W zener diode
T1 = BC547 or equivalent
IC1 = µA741 or equivalent
IC2 = 7812, or low-drop equivalent

Miscellaneous
RE1 = relay, 12V coil, 1x 10A, 250V c/o contact
K1,K2,K3 = 2-way PCB terminal block, 5mm (0.2")
   lead pitch
Type IP55 electricity junction box, internal
   dimensions 80 x 80 mm (3.15" x 3.15") e.g. plexo
   LEGRAND # 922-06
20 mm length of electricity conduit, diam. 20 mm
   (0.8")

the usable current compared with the conventional rectification often encountered in this sort of power supply. A zener diode of around 15 V (minimum, as the 12 V regulator needs to be allowed enough headroom to do its job properly) limits the voltage in the first instance; it is then smoothed by C2, then more accurately regulated by IC2 and finally decoupled by C3. The stable 12 V supply is required above all for the voltage divider that acts as a reference for the comparator.

The darkness is detected by an LDR, which in conjunction with R4 forms a voltage divider, the output voltage of which is inversely proportional to the intensity of the light falling on the LDR. Capacitor C4 absorbs rapid changes in this voltage, in order to avoid unwanted triggering. R5 and P1 form a voltage divider for the comparator (IC1) reference voltage — this is what determines the threshold for the light to be turned on. When the voltage on pin 3 of IC2 is higher than the voltage on pin 2, the comparator activates the relay via T1, and the sign is lit up.
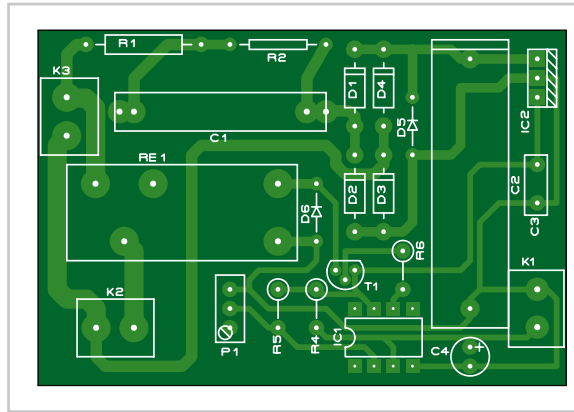
A printed circuit board has been designed (the design is available free from [1]) to make building the switch easier. Don't forget to tin the tracks switched by relay RE1 so they can carry as much current as possible to the light to be controlled. In some cases, it may be necessary to beef up the tracks with pieces of solid copper wire.

The circuit fits into a sealed IP55 box, like an electricity junction box, for example. Drill a hole in the lid of the box to allow the leads to pass through from the LDR, which you will need to glue to the lid. In front of the LDR, fit a piece of 20 mm diameter plastic conduit about 20 mm long as a shield, so that the LDR won't be affected by the light coming from the light you are trying to control. Install the switch as far away as possible from the light it is operating, to avoid ending up with a flasher!

Last of all, adjust P1 for the light level at which you want the relay to switch on.

Caution / Notice

When you're handling the circuit for testing etc., be really careful to avoid getting a shock, as there is live AC voltage present over most of the PCB. Never connect the circuit's internal ground rail to the protective earth (E/PE) line.

Internet link

[1] www.elektor-usa.com/090049

Control Interface via PC Keyboard

Jacob Gestman Geradts
(France)

One of the more difficult aspects when making a control or security system that uses a PC (a burglar alarm using a PC, for example), is the connection of the sensors to the computer. In addition to typically requiring specialist interface expansion boards, the writing of the program that includes interrupts is often also an insurmountable obstacle. But when only a simple system is concerned consisting of, for example, four light barriers or, if need be, trip wires giving a digital on/off signal when uninvited guests enter, then a much cheaper but nevertheless effective interface is possible.

For this interface we use an (old) computer keyboard. This contains as many switches as there are keys.

090379 - 11
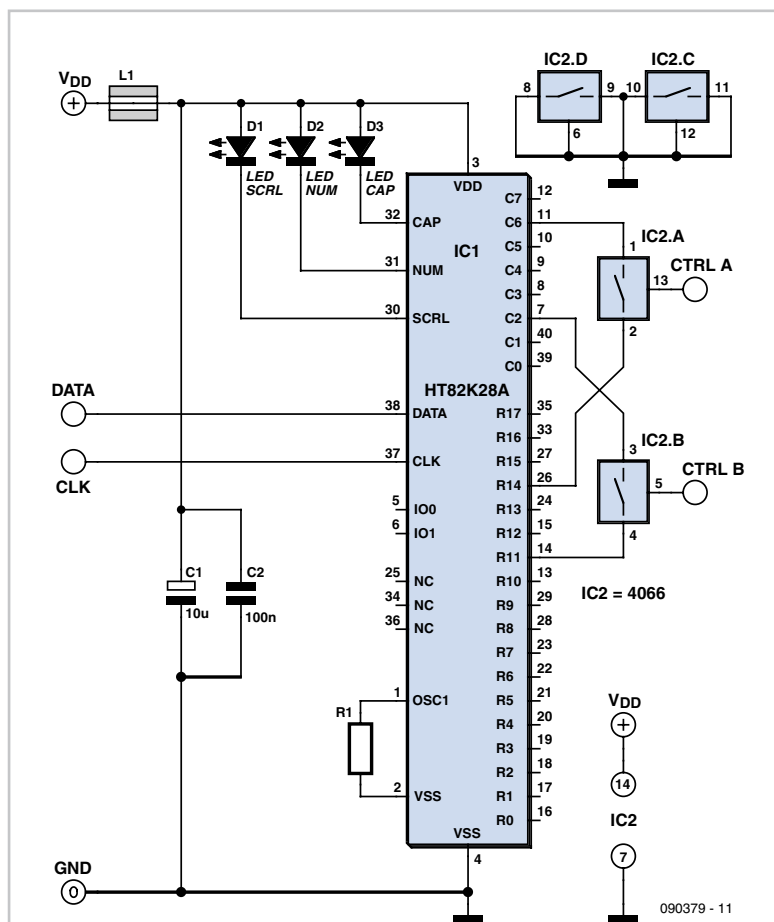
These switches are scanned many times per second in a matrix in order to detect the potential press of a key. The number of columns is usually eight (C0–C7 in the schematic); the number of rows varies for each type of keyboard and can range from 14 to 18 (R0–R17 with the HT82K28A keyboard encoder mentioned in the example). To each switch there is a single column- and a single row connection.

The intention of the circuit is that sensor A will 'push' the letter A, when it senses something. This requires tracing the keyboard wiring to figure out which column and which row is connected to the A key. One of the four analog switches from the familiar CD4066 CMOS IC is then connected between these two connections; that is, in parallel with the mechanical A key on the keyboard. When the Control-A input of the

CD4066 is activated by sensor A, the letter A will be sent to the computer by the keyboard. The PC can then act appropriately, for example by entering the alarm phase.

The system is not limited to (burglar) detection using a PC. The remote control of a TV set or other electronic devices can also be operated with a 4066 in the same way; for example to scan through a number of TV channels in a c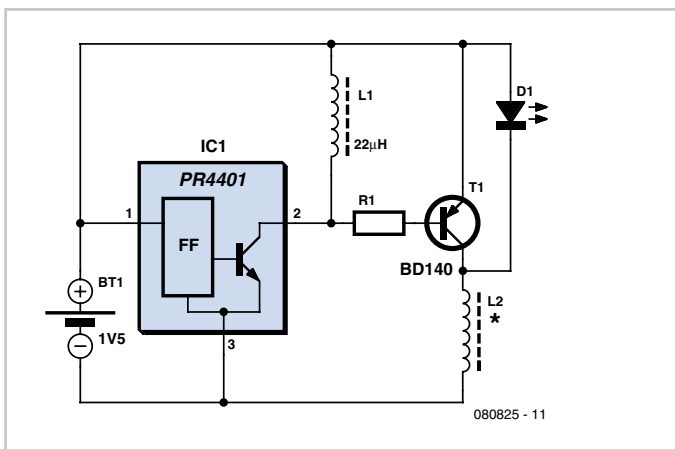yclical fashion. To do this, you could, for example, shunt the 'next channel' button using one of the 4066 switches, which itself is activated by a 1-Hz square wave generator.

In the schematic only switches A and B of the CD4066 are connected to the keyboard. You can, of course, use all four of the switches and if you need more than four you can use multiple CD4066 ICs. The indicated wiring between the keyboard IC and the 4066 is an example only, and each 'typed' letter has to be determined by the user for the specific keyboard that is used. It is important that each CD4066 switch is always connected between a row- and a column connection. The output signal from the sensors has to be suitable for the CD4066 and the power supply voltage of 5 volts used by the keyboard. The power supply for the CD4066 may be obtained from the keyboard.

(090379-I)

PR4401 1-Watt LED Driver

080825 - 11

T.A. Babu (India)

The PR4401 chip from Prema can be used to drive an LED directly, but not a high-power LED like one of the popular 1-watt types currently available on the market. The circuit shows that the drive signal at the V_{out} terminal of the PR4401 chip (pin 2) turns a medium-power PNP switching transistor (T1) on and off. When T1 is switched into conduction, inductor L1 is charged. When T1 is switched off, the inductor discharges its stored energy through the LED during flyback with enough current to allow a one-watt LED to light up at nominal brightness. During the 'on' time of transistor T1, the current through inductor L2 ramps up linearly to a peak value as expressed by.

$$I_{L2(pk)} = [(V_{batt} - V_{CEsat(T1)}) \times T_{on}] / L2$$

where $V_{CEsat(T1)}$ is the collector-to-emitter saturation voltage of T1 (here, a type BD140 is suggested).

During T1's 'off' time, the inductor voltage reverses, forward-biasing the LED and discharging through it at a constant voltage roughly equal to the forward voltage of the LED, while its current ramps down to zero. Because this cycle repeats at a high rate, the LED appears to be always on, its brightness depending on the device's average current, which is proportional to the peak value. The LED current is roughly a triangular pulse with a peak current approximately equal to the inductor's current because of the finite turn-off time of T1. The estimated average current may be calculated from

$$I_{LED(avg)} = 1/2 \times I_{L2peak} \times [T_{dis} / (T_{on} + T_{off})]$$

Where T_{dis} is the discharge time of inductor L2 through the LED. The LED's brightness can be increased or decreased by varying the inductance of L2. In practice, any value between 10 and 56 µH will work just fine. The inductor current increases on each cycle until T1 goes out of saturation, hence a small resistance (R1) is required at the base of T1. Without the 'stopper resistor', the final current goes out of control due to the DC gain of T1. A transistor with a high DC current gain and low collector-to-emitter saturation voltage is the best choice if you want to tweak the circuit for efficiency. Regarding L2, make sure the peak current through it is below the saturation level.

(080825-I)

TurboGrafx-16 (PC-Engine) RGB Amplifier

Marco Bettiol (France)

The PC-Engine, also marketed under the name TurboGrafx-16 [1] is an 8-bit games console made by NEC/Hudson Soft which appeared in Japan in 1987. In terms of units sold, for some time it exceeded Nintendo and its famous Famicom (NES in Europe). Despite this success, it was never officially distributed in Europe. Sodipeng was the only company to market it, but it remained a pretty well kept secret.

Nowadays, people who want to play again with this excellent machine are faced with a problem of incompatibility of the video

loscope, and calculator!

The principle of this circuit is very simple and is based around a single IC, the LT6551 from Linear Technology. The package contains four independent video amplifiers with a fixed gain of 6 dB. This IC is available in MSOP format, which means the overall size of the circuit can be kept down. The RGB + sync signals are picked up directly from the expansion port.

The input impedance of the circuit is set at 10 kΩ so as not to overload the HUC6260. R9 for the sync circuit, R10, 11, and 12 for the RGB. Next, we need to eliminate the 3.6 V DC component and set the RGB signals at a more suit-

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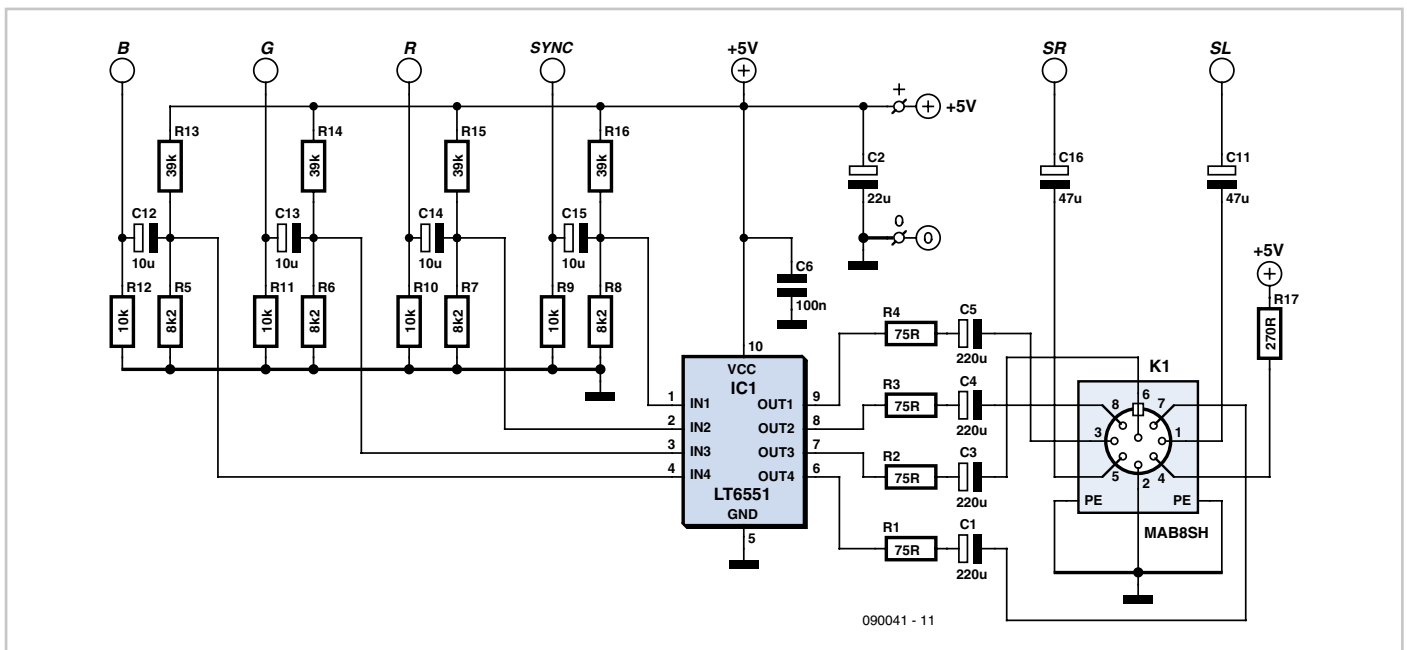
signals, as the PC-Engine's NTSC video output may not be compatible with some PAL/SECAM television sets. The only way to be able to use this console and obtain a color picture is to connect directly to the HUC6260 video processor which provides the red, green, and blue primary signals plus sync. As luck would have it, these signals are directly

available on the machine's rear expansion port. This port also provides the left and right audio signals, along with a 5 Vdc power rail. Even though the RGB signals are at the standard level of 0.7 V p-p, they still can't be fed to the TV set directly, as the HUC6260 is not capable of driving into a 75 Ω load. This is where you get out our soldering iron, oscil-

able level. If the signal were to be amplified as is, the amplifier would be bound to saturate. So the choice of a proper level is vital in order not to distort the reproduction of the image being amplified. Capacitors C12–C16 provide coupling, and only the wanted AC component of the signal passes on to the next stage.

SCART socket wiring [2]

Ground	4, 5, 9, 13, 17, 18, 21, (14)
R	15
G	11
B	7
Video/Sync	20
Audio Left	6
Audio Right	2
RGB switching	16

PC-Engine expansion port (resembles DIN 41612) [3]

A1	Audio Left
C1	Audio Right
C2, 20	ground
A2, 21	+5 V dc
A23	Red
B23	Green
C23	Blue
C22	sync

This AC signal needs to be fixed or 'clamped' to an optimum level. The specifications of the LT6551 offer an input range from 0 to 2.5 V maximum with a 5 V supply (see data sheet). R5/R13 and the three other identical pairs of resistors create voltage dividers. By choosing the values of 8.2 kΩ and 39 kΩ, you obtain an operating point around 0.86 V. A little calculation just to check: 0.7 V plus 0.86 V gives a maximum input signal of 1.56 V.

It's important to choose the coupling capacitor value correctly, according to the value of these resistors. Together, they form a high-pass filter that attenuates the lower frequencies of the wanted signal. As a rule-of-thumb, you need to calculate this filter in such a way as to set the cut-off frequency at one tenth of the lowest frequency to be passed, which in this case is 30 Hz, the NTSC frame rate (25 Hz

for PAL/SECAM). So let's take 30 Hz as the cut-off frequency. The formula for the cut-off frequency of a first-order filter $f_c = 1/(2\pi RC)$ gives C = 3.9 µF (with R = R5//R13 = 6,775 Ω and f_c = 3 Hz) and so you'll choose the slightly higher value close to this: 4.7 µF for example.

The LT6551 amplifies the video signal by a factor of two (+6 dB) and so we find at its output terminals a signal of 1.4 V, together with a DC component. A capacitor (C1, C3, C4, C5) removes this unwanted DC component and the output impedance is set to the standard value of 75 Ω by a resistor (R1–R4). This 75 Ω output impedance is effectively in series with the 75 Ω impedance of the TV set's input stage, which divides the voltage by two, bringing the video signal back down to its standard value of 0.7 V. And that's why

we need to use an amplifier with a gain of 6 dB.

An 8-pin DIN socket carries the RGB + sync signals. The sound signals are filtered of any DC component and the RGB switching signal needed by the SCART input is also provided. All that remains is to make up the cable with the correct pin-outs.

This little project helps us remember that video games can generate very serious activities, and that in electronics nothing is ever chosen by chance. Enjoy your gaming!

(090041-I)

Internet links
[1] http://en.wikipedia.org/wiki/PC-Engine
[2] http://en.wikipedia.org/wiki/SCART
[3] http://www.gamesx.com/misctech/pcebp.php

Fan Speed Controller

Andreas Vogel (Germany)

Anyone who uses a computer for long periods will appreciate the benefits of a silent PC. Quite a few websites now sell computer accessories specifically designed to make your desktop run more quietly. The CPU fan is often the main culprit in a noisy PC; in many cases it can be replaced by a large passive heat sink to dissipate the heat more efficiently. The heat sink fins are arranged to make optimum use of air blown through the case by the power supply fan.

The specification of Intel's ATX type PC form factor even suggests that the cooling air should be used in this way but to be successful on modern machines it is necessary to pay careful attention to a number of factors. Firstly it is important to use a processor which has the lowest possible power consumption (especially in idle mode), the lower cost 45 nm technology chips are a good place to start here. Secondly it is important to pay attention to the air flow in the case to ensure that it is ducted efficiently from the PSU through the passive CPU heat sink. The main drawback with this setup is that fan speed is only controlled by the temperature of the PSU, not the processor.

The solution of course is to install a new fan speed controller and fit a temperature sensor to the CPU heat sink. The controller senses the air temperature in the PSU as well as the processor heat sink and adjusts the fan speed according to the warmest read-

070579 - 11
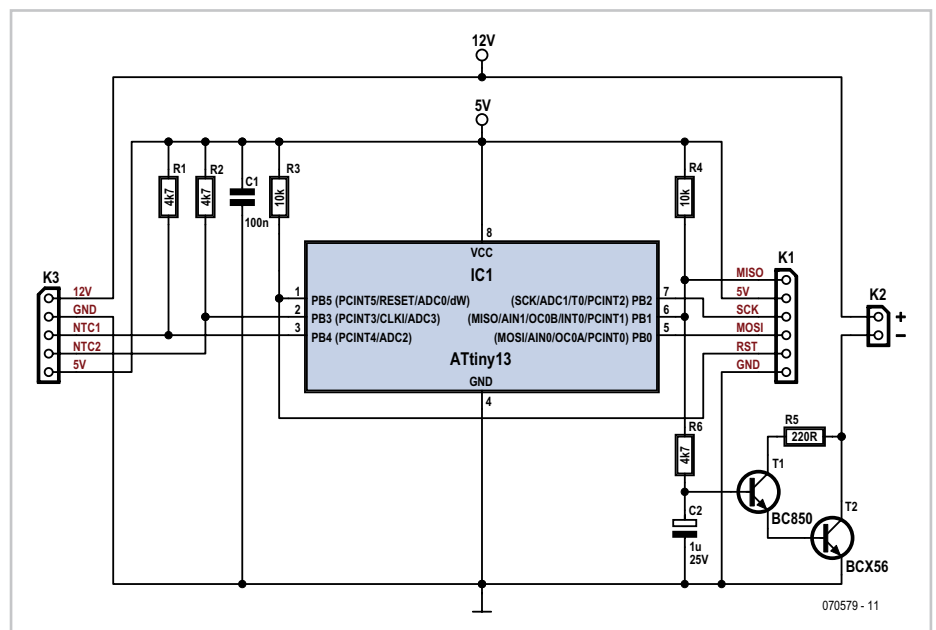
ing. This approach ensures that everything remains cool.

With this in mind the author built this versatile fan speed controller using little more than a small microcontroller, a few transistors and two NTC thermistors. The main circuit element IC1 is an 8-pin 8-bit ATtiny13 microcontroller from Atmel. This controller has more than enough 10-bit resolution analog inputs for the job.

The circuit diagram is not so complicated: Two thermistors are connected between NTC1 and NTC2 of K3 and ground. Together with R1 and R2 they form two voltage divider networks. The voltages produced at NTC1

and NTC2 are proportional to the measured temperatures. These are sampled by the analog inputs ADC2 and ADC3 of the microcontroller. The controller will select one of ten fan speed settings depending on the measured values of temperature. The higher of the two temperature readings will always be used. The output from pin 6 is a pulse modulated waveform to control fan speed. The output Darlington configuration of T1/T2 drives the fan from the PWM waveform integrated by R6/C2. This low pass network filters out the 15 Hz fundamental of the PWM output signal to reduce any PWM noise generated in the fan windings.

The power connections to 12 V and 5 V on K3 can be supplied from an unused floppy disk drive or spare hard disk power cable. K1 provides the connection for the in-circuit programming cable for the microcontroller. R4 should ensure that the fan is switched on if the microcontroller hangs or a fault occurs. The circuit is so simple that it can comfortably fit on a square of perforated stripboard and housed in a small plastic enclosure. Fix one of the thermistors onto the heat sink (doesn't matter which one but make sure it is electrically insulated from the heat sink). The other thermistor can be positioned in the air flow from the PSU so that air can pass freely around it. The PSU fan can now be connected to the new fan speed controller. Some fans have a built-in thermistor which regulates the fan speed autonomously. In this case remove the thermistor and replace it with a fixed resistor to make sure it runs at full speed (try 1 kΩ).

The firmware for IC1 is written in assembly language and would also run in principle on other variants of the ATtiny microcontroller family.

Download & Product

Programmed controller
070579-41 Controller ATtiny13

Software
070579-11: source code and hex files, from www.elektor-USA.com/070579

Power-up/down Sequencer

Christian Tavernier (France)

Whether you're talking about a home cinema or a computer system, it's very often the case that the various elements of the system have to be turned on or off in a quite specific order, or at least, automatically. Constructing this sort of automation system is well within the capability of any electronics enthusiast worthy of the name, but in this 'all-digital' age, most of the circuits of this type to be found in amateur electronics magazines or websites use a microcontroller. Even though that is indeed a logical solution (in more ways than one!), and you might even say the easiest one, it does pose problems for all those people who don't (yet) have the facilities for programming these types of IC. So we decided to offer you now an approach that's very different, as it only uses a simple, cheap, commonly-available analog integrated circuit, which of course doesn't have to be programmed. Our project in fact uses as it's 'brain' an LM3914, a familiar IC from National Semiconductors, usually used for driving LED VU (volume unit) meters.

Before taking a look at the circuit for our project, let's just remind ourselves that the IC has one analog input and ten outputs intended for driving LEDs. It can operate in 'point' mode, where the LEDs light up in turn, from first to last, depending on the input voltage, but only one LED is lit at any given time. Alternatively it can operate in 'bar' mode (this is the mode normally used for VU meters), and in this case, the LEDs light up one after the other, in such a way as to create a strip of light (bar) that is longer or shorter according to the input voltage. This is the mode selected for the LM3914 in the circuit described in some detail below.

So as to be able to control the AC powered equipment our sequencer is intended to manage, we are using solid-state relays — four, in our example, though you can reduce or increase this number, up to a maximum of ten. Since the input devices in solid-state relays are LEDs, they can be driven directly by the LM3914 outputs, since that's exactly what they're designed for. As only four relays are available, these are spread across outputs L2, L4, L6, and L8, but you can choose any arrangement you like to suit the number of relays you want to use.

Resistor R7 connected to pin 7 of the LM3914 sets the current fed to the LEDs by the LM3914 outputs. Here, it's been set to 20 mA, since that is the value expected by the solid-state relays chosen. The input voltage applied to pin 5 of the LM3914 is none other than the voltage present across capacitor C1 — and this is where the circuit is ingenious. When the switch is set to 'on', C1 charges slowly through R5, and the LEDs of the solid-state relays on the outputs light one after another as this voltage increases; in this way, the units being controlled are powered up in the order you've chosen. To power-down, all you have to do is flip the switch so that C1 discharges through R5, and the LEDs go out in the reverse order to that in which they were lit, in turn powering down the units connected

081180 - 11

to the solid-state relays. Easy, isn't it?

If you're not happy with the sequence speed, all you need do is increase or reduce the value of R5 in order to alter the speed one way or the other.

The circuit needs to be powered from a voltage of around 9 to 12 V, which doesn't even need to be stabilized. A simple 'plug-top', 'wall wart' or 'battery eliminator' unit will be perfect, just as long as it is capable of supplying enough current to power all the LEDs. As the LED current is set by R7 to 20 mA per LED, it'll be easy for you to work out the current required, according to the number of solid-state relays you're using.

In our prototype the type S216S02 relays from Sharp were used, mainly because they proved readily available by mail order. They also have the advantage of being compact, and their switching capacity of 16 A means you can dispense with a heatsink if you're using them for a computer or home cinema system, where the current drawn by the various units can be expected to remain under 1 A. These solid-state relays must be protected by a fuse, the rating of which needs to be selected according to the current drawn by the devices being powered.

Also note the presence across the relay terminals of a VDR, also known as a GeMOV or SiOV, intended to protect them from any spurious voltage spikes. You can use any type that's intended for operation on 250 VAC without any problem. The values of fuses F1 to F4 are of course going to depend on the load being protected.

Construction of the circuit shouldn't present any particular difficulty, but as the solid-state relays are connected directly to AC power, it is essential to install it in a fully-insulated case; the case can also be used to mount the power outlet sockets controlled by the circuit. Note that sockets are female components.

Let's just end this description with the sole restriction imposed by our circuit — but it's very easy to comply with, given the intended use. In order to remain triggered, the solid-state relays must carry a minimum holding current, which is 50 mA in the case of the devices we've selected. In practical terms, this just means that each of the devices powered by our sequencer must draw at least 50 mA, or in other words roughly 12 VA at 230 VAC, or 25 VA at 120 VAC.

(081180-I)

Floating Message
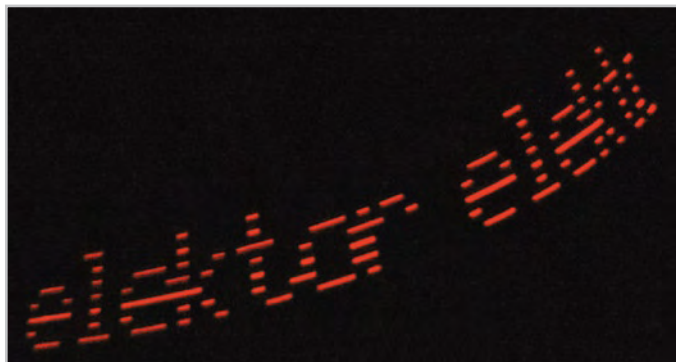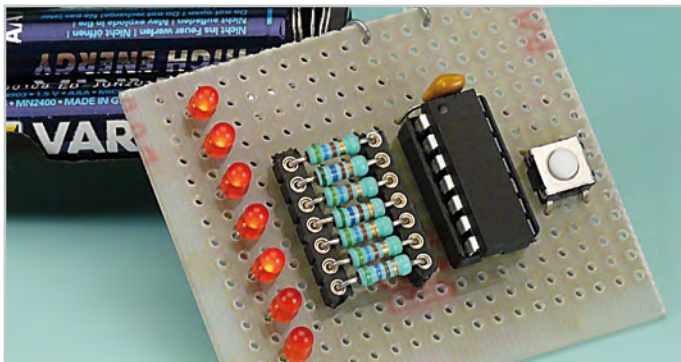
Ludovic Voltz (France)

This project lets you display a message floating in the air using just seven LEDs, a microcontroller, and the movement of your arm. How can that be possible?
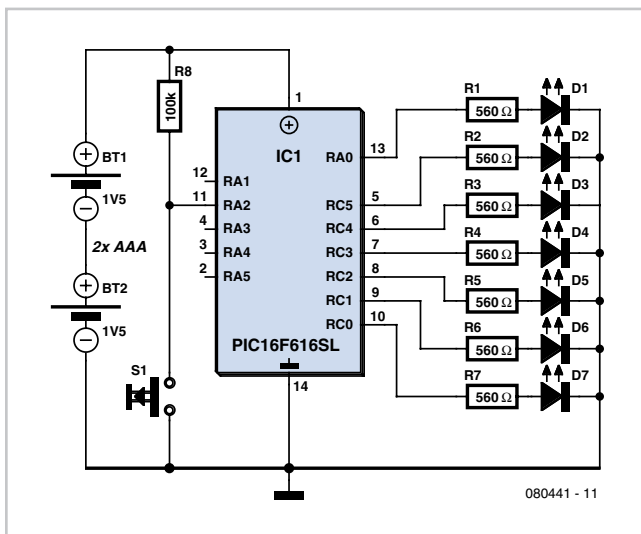
The human eye and brain can't resolve a moving object, and the same applies to anything that changes rapidly. It is by exploiting this shortcoming (or capacity, depending on which way you look at it!) that we are able to see videos and all types of footage, clips, visual effects and so on, on the many screens around us. When the images on the screen appear at a rate of at least 24 per second, humans can no longer make them out as individual images and perceive the result as a moving object.

080441 - 11

It's this 'persistence of vision' that the author has exploited in creating this project.

The characters of the message to be displayed use a very common 7 line × 5 column character style. The columns are displayed sequentially by the seven LEDs arranged in a column: first column 1, then 2, and so on up to 5. If the LEDs are moved on slightly before displaying the next column, the eye thinks it is seeing the whole character. The LEDs flash at a frequency of the order of 200 Hz, and so all you have to do is move the circuit around to see the message appear as if it were floating in mid air. Here's a little gadget that will amuse young and old alike on summer evenings.

For simplicity and compactness, this project uses a PIC16F616 microcontroller from Microchip, capable of working off no more than 2 V. This allows the circuit to be powered from two AAA rechargeable batteries (2 × 1.2 V), a good compromise between battery life and the space taken up. What's more, this solu-

tion is environmentally-friendly, as the batteries can be recharged, unlike CR2035 button cells, for example.

The messages are created with the help of an Excel file, where all you have to do is fill in the cells with 0's or 1's according to the character you want to display. This file then directly gives the hex code for the corresponding constant. Naturally, this file is available in the download accompanying this article [1]. Using the circuit is as simple as its operating principle. A brief press of the button starts the sequence for displaying the word. Then all you have to do is synchronize your movements with pressing the button. In order to be able to read the word properly, it's best to repeat the operation more than once. You can store several words in the PIC's Flash memory (up to the limit of its capacity, of course). To move on to the next word, you must press the button for at least 0.6 s. The reproduction will be clearer if the background lighting is low.

(080441-I)

Internet Link
[1] www.elektor-usa.com/080441

Micropower Crystal Oscillator

Rainer Reusch (Germany)

Crystal oscillators for digital circuits are normally built as Pierce oscillators with an inverter. The inverter operates as a linear amplifier and thus requires extra current. But you can also build a crystal oscillator using an operational amplifier (op amp for short)! If a very low frequency is involved, for instance 32.768 kHz (commonly used for clocks), you can get away with a comparatively 'slow' micro power op amp.

In the sample circuit shown a widely available TLC271 is used. On pin 8 we have the opportunity to set the 'bias mode', with three choices ranging between fast operation with higher current consumption and slower operation at low current. For our clock crystal the

$I_{CC} = 85\mu A @ +3V3$
$I_{CC} = 100\mu A @ +5V0$

090320 - 11
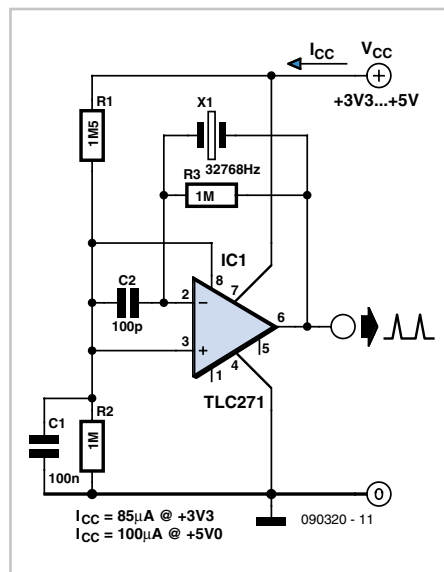
middle setting will suit us fine. Pin 8 is therefore connected to the voltage divider R1/R2. The current consumption of the entire circuit is impressively modest and at 5 V this is just 56 µA! The oscillator also functions astoundingly well at 3.3 V. At the same time the current drops to a more battery-friendly 41 µA. A prototype built in the Elektor Labs produced the slightly higher values indicated in the circuit diagram.

The output signal delivered by this circuit has admittedly scant similarity to a square wave. Nevertheless some cosmetic surgery will tidy this up, with treatment in the Schmitt trigger following. To save current (naturally) we use a CMOS device such as the 74HC14.

(090320-I)

Automatic TV Lighting Switch

Piet Germing (The Netherlands)

The author is the happy owner of a television set with built-in Ambilight lighting in the living room. Unfortunately, the television set in the bedroom lacks this feature. To make up for this, the author attached a small lamp to the wall to provide background lighting, This makes watching television a good deal more enjoyable, but it's not the ideal solution. Although the TV set can be switched off with the remote control, you still have to get out of bed to switch off the lamp.
Consequently, the author devised this auto-

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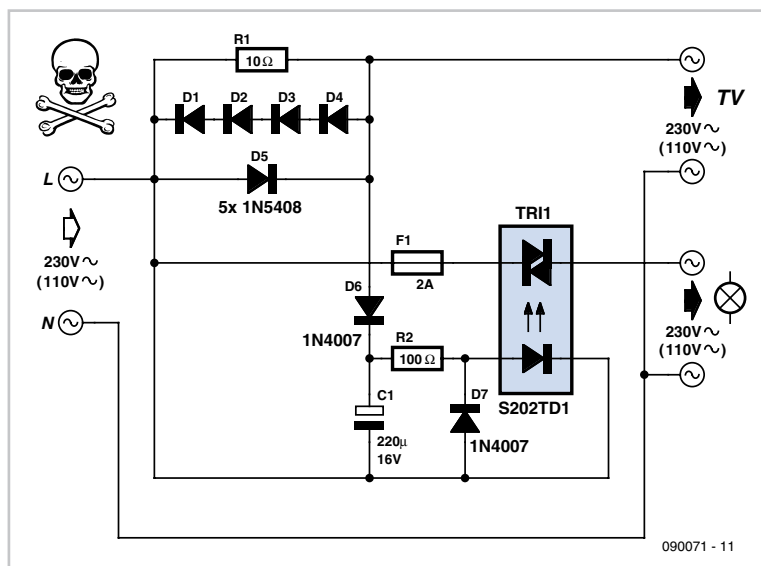
matic lighting switch that switches the background light on and off along with the TV set. The entire circuit is fitted in series with the AC power cable of the TV set, so there's no need to tinker with the set.
It works as follows: R1 senses the current drawn by the TV set. It has a maximum value of 50 mA in standby mode, rising to around 500 mA when the set is operating. The voltage across R1 is limited by D5 during negative half-cycles and by D1–D4 during positive half-cycles. The voltage across these four diodes charges capacitor C1 via D6 during positive half-cycles. This voltage drives the internal

LED of solid-state switch TRI1 via R2, which causes the internal triac to conduct and pass the mains voltage to the lamp.

Diode D7 is not absolutely necessary, but it is recommended because the LED in the solid-state switch is not especially robust and cannot handle reverse polarization. Fuse F1 protects the solid-state switch against overloads.

The value of used here (10 Ω) for resistor R1 works nicely with an 82-cm (32 inch) LCD screen. With smaller sets having lower power consumption, the value of R1 can be increased to 22 or 33 Ω, in which case you should use a 3-watt type. Avoid using an excessively high resistance, as otherwise TRI1 will switch on when the TV set is in standby mode.

Some TV sets have a half-wave rectifier in the power supply, which places an unbalanced load on the AC power outlet. If the set only draws current on negative half-cycles, the circuit won't work properly. In countries with reversible AC power plugs you can correct the problem by simply reversing the plug. Compared with normal triacs, optically coupled solid-state relays have poor resistance to high switch-on currents (inrush currents). For this reason, you should be careful with older-model TV sets with picture tubes (due to demagnetization circuits). If the relay fails, it usually fails shorted, with the result that the TV background light remains on all the time. If you build this circuit on a piece of perfboard, you must remove all the copper next to conductors and components carrying mains voltage. Use PCB terminal blocks with a spacing of 7.5 mm. This way the separation between the connections on the solder side will also be 3 mm. If you fit the entire arrangement as a Class II device, all parts of the circuit at AC line potential must have a separation of at least 6 mm from any metal enclosure or electrically conductive exterior parts that can be touched. Local/national electrical safety regulations may dominate however.

(090071-I)

Phone Ring Repeater

Christian Tavernier (France)

Even though cordless phones have invaded our homes and offices, you don't always have them at hand, and as their ringtones are usually very much quieter than the old rotary-dial-type analog phones, it can happen that you miss a call you've been waiting for while you've been going about your daily business. Until quite recently, you could still find remote ringers that could be plugged into any standard phone socket in order to have an additional ringer, but it seems as if these accessories are currently being phased out as everyone is 'going cordless'. So we decided to suggest something better, with this phone ring repeater that makes it possible to control any device connected to the AC power outlet using the ringtone available on any subscriber line, and naturally, with all the guarantees of safety and isolation that are of course rightly expected. So it's capable of driving a ringer, or indeed even a high-powered sounder to alert you when you are in the garden, for example; but it is equally able to light a lamp for a 'silent ring' so as to avoid waking a sleeping baby or elderly person. This circuit has been designed to be compatible with all phone systems the author is aware of and also to be totally stand-alone. What's more, the circuit can be connected to the phone system without any danger — though in some countries, it is prohibited to connect non-approved devices to the public switched telephone network (PSTN). Check local regulations in this respect.
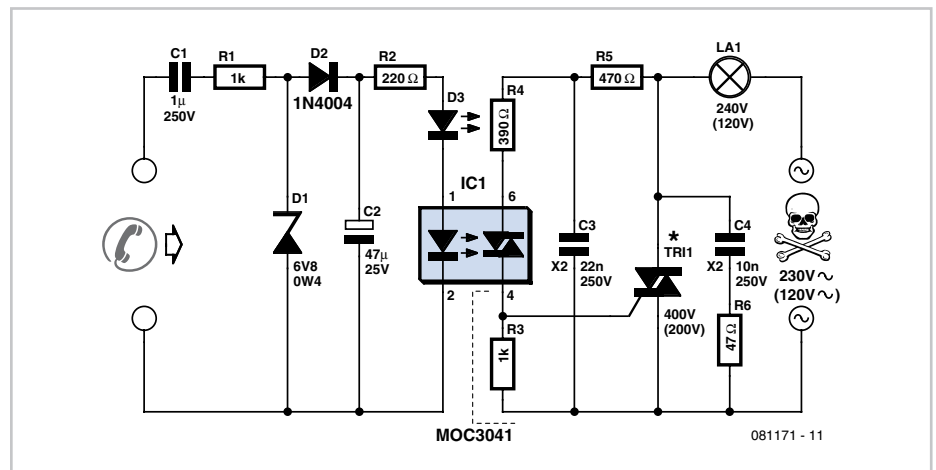
In order to understand the principle of it, we just need to remember that the ringtone present on a phone installation is an alternating voltage, whose amplitude and frequency vary somewhat between countries, but always with comparable orders of magnitude except in the case of exchange systems used in large companies. However, when the line is quiescent or a call is in progress, it carries only a direct voltage. Capacitor C1 makes it possible to pick off just the AC ringing voltage, which is then rectified by D2 and amplitude-limited by D1. The resulting DC voltage

081171 - 11

charges capacitor C2, which makes it possible to light LED D3 as well as the LED in the optocoupler IC1. This is no ordinary optocoupler, but is in fact an AC power zero-crossing detecting opto-triac, which allows us to control the chosen load while generating no, or less, interference, which would not be the case using a standard opto-triac.

The output triac it contains is not powerful enough to drive a load directly connected to the mains, so it is used to drive the trigger of triac TRI1, which is a totally standard 400 V device, rated at x amps, where x is chosen to suit the maximum power of the load you want to control using this circuit. Resistors and capacitors R5 and C3 on the one hand, and R6 and C4 on the other help, serve to suppress the switching transients, which are already inherently low because of the AC zero-crossing switching provided by IC1. Construction is not at all difficult, but does require a few precautions in choosing some of the components. First of all, capacitor C1 must be an MKT type, mylar or equivalent, with a 250 V operating voltage because of the relatively high amplitude of the ringing voltage. For safety reasons, it is essential that capacitors C3 and C4 are self-healing types intended for AC power use at 250 VAC. These capacitors are generally known as Class X or X2 capacitors.

As for the triac, it should have a 400 V operating voltage (but see below for users on 120 VAC power) and maximum current slightly greater than the maximum current drawn by

the load being driven. As this will usually be a sounder or a common lamp, a 2 A type will usually be more than adequate in most situations. As the circuit can be expected to operate for short periods only, there is no need to mount the triac on a heatsink.

One final important point: as the right-hand part of the circuit is connected directly to AC power, it is vital to fit this inside a fully-insulated housing, for obvious safety reasons. Make sure you cannot touch any part when the circuit is in use.

The circuit should work at once and without any problems, but if you notice that D3 doesn't light up fully, and hence incorrect or erratic triggering of the triac, because of too low a ringing voltage, all you need to put things to rights is reduce the value of resistor R1.

The circuit as shown was dimensioned for operation from 230 VAC power. Readers on 120 V AC power should modify the following component values: R4 = 180 Ω; R5 = 220 Ω; TRI = 200 V model; IC1 = MOC3031. Optionally, C3 and C4 may be rated at 120 VAC.

(081171-I)

Pulse Clock Driver with DCF Synchronization ◀

Hans Oostwal (The Netherlands)

Sometimes you can pick up a nice office clock or station clock at a bargain price. To ensure that these clocks all show the same time inside an organization such as the railway system and avoid hassles with changing between winter time and summer time or replacing empty batteries, these clocks are normally connected to a clock pulse network that is driven by a master clock or radio signal. The master clock generates a pulse every minute, with successive pulses having opposite polarity.

If you want to use a clock of this sort, you naturally want it to keep good time. This is handled by the circuit described here, which offers the following features:

- it is synchronised to the DCF77 time reference signal at 77.5 kHz (from Mainflingen, Germany) so the time is always correct;
- it is inexpensive – by using a microcontroller (in this case a PIC16F648A), the circuit requires only a few components, and it can easily be assembled on a piece of perfboard;
- it generates pulses at one-minute intervals with alternating polarity;
- it also shows the time and date on an alphanumeric LCD module;
- automatic switching between winter and summer time;
- time data is backed up in case of power failure (stored in PIC EEPROM).

When using a clock of this sort, note that some models have jumpers that can be fitted or removed to configure the clock for different working voltages. If you have this type of clock, select the lowest voltage (usually 24 V). Based on the author's experience, clocks from the Dutch PTT (former postal and telecommunication authority) also work OK at 12 V.

Figure 1 shows the schematic diagram of

090035 - 11
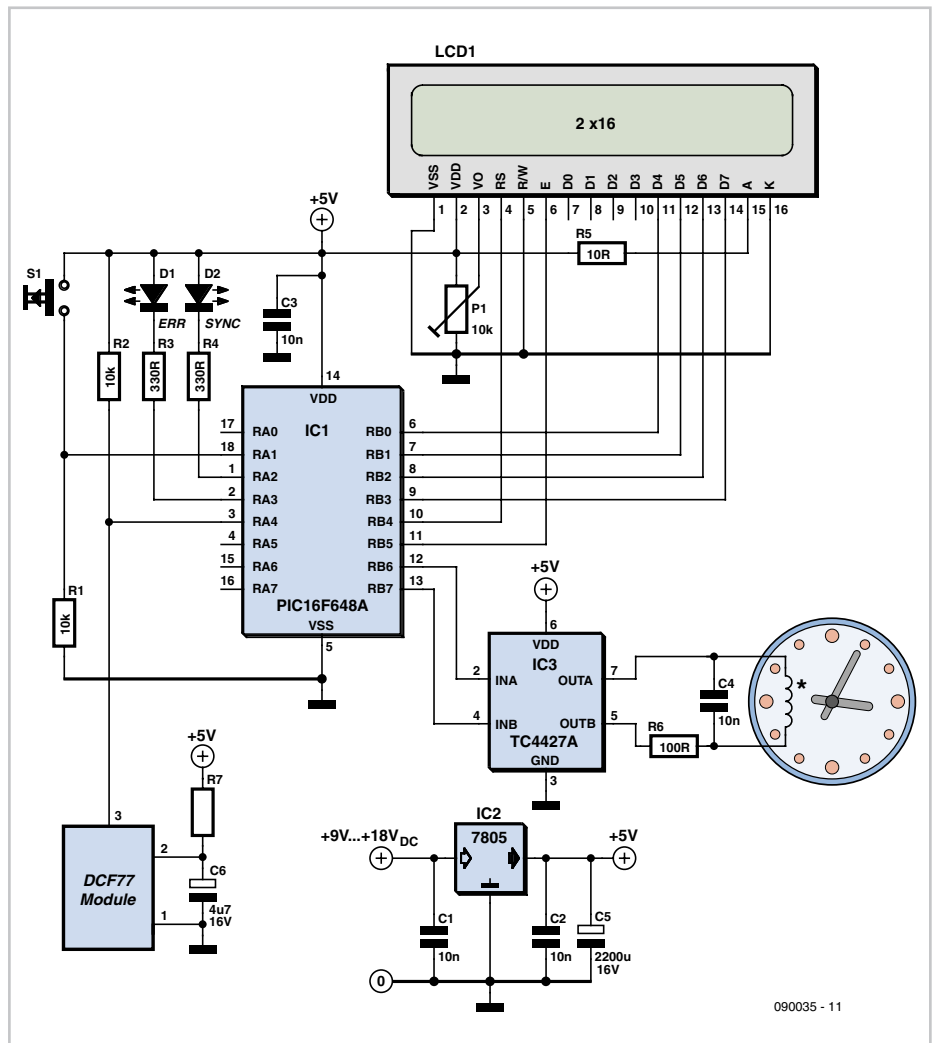
the hardware. The circuit is built around a PIC16F648A clocked by its internal 4-MHz oscillator. A standard two-row LCD (HD44780 compatible) is connected to the microcontroller to display operating instructions or the date and time.

The circuit can be powered from an AC mains adapter that supplies a DC voltage in the range of 9 to 18 V. A voltage regulator (IC2) generates a stable 5-V supply voltage for the electronics from this. The supply voltage from the adapter is connected directly to

the TI4427A MOSFET driver IC that drives the clock coil. This driver IC has a operating voltage range of 4.5 to 18 V and a maximum rated output current of 500 mA (1.5 A peak). This is adequate for most clocks. If you need more current, you can add a transistor or relay to the output stage. The clock coil has a fairly high inductance, so the supply voltage has extensive decoupling in the form of several ceramic capacitors (C1–C4) and an electrolytic capacitor (C5).

A DCF77 receiver/decoder module from Con-

rad Electronics (p/n 641138) provides the time reference signal. It is also powered by the 7805 voltage regulator. The non-inverted output of this module is connected to port RA4 of the microcontroller. As reception of the long-wave signal from the DCF transmitter may not be good in some locations, especially if you fit the circuit in a metal enclosure, it is advisable to fit the DCF module in a separate plastic box that can be placed a certain distance away from the clock.

The source code of the software is written in Flowcode 3 Pro and is available free on the Elektor website for downloading (item number 090035-11). It is based on the software for the E-Blocks DCF clock published in the December 2007 issue (075094-11). The original software has been adapted to this application and extended with code that generates a pulse signal on ports B6 and B7 with a period of 1 minute and alternating pulse polarity.

Pushbutton switch S1 is used for most of the operator functions. This button is connected to port A1 and has several functions:

- if S1 is not pressed when the power is switched on, the microcontroller executes a warm start. This is the normal situation. In the event of a power failure, the analog time and the polarity are saved in EEPROM, and they are restored after the next warm start;

- if S1 is pressed when the power is switched on, a cold start is executed. This must be done the first time the circuit is used (see below for more information);

- if S1 is pressed during normal operation, the variables 'a_hrXX' and 'a_minuteXX' are shown on the display, which enables the user to set the analog clock.

In order to synchronize the analog clock to the digital clock, the analog clock must first be set to exactly 12 o'clock. If you have a clock that can only be operated electrically, which means it does not have any mechanism (such as a knob) to set the time manually, you can hold S1 pressed after the cold start to cause the circuit to generate a continuous series of clock pulses. Release S1 when the clock reaches exactly 12 o'clock. If you have a clock that can be set manually, first set it to 12 o'clock and then switch on power to the circuit with S1 held pressed. Release S1 when the message 'cold start… done' appears on the LCD. If the DCF signal is being received properly, the date and time will be shown on the display after a few minutes and the analog clock will be set to the right time.

If the time shown by the analog clock differs from the time shown on the LCD by one minute, the polarity of the pulses does not match the state of the stepper motor in the clock. This can be corrected by first setting the clock to the right time and then swapping the two leads. This action must be completed within one minute.

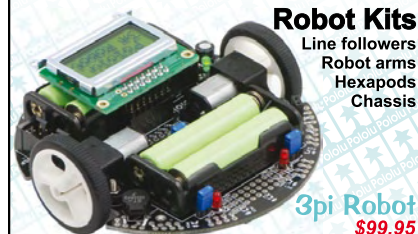(090035-I)

Internet Link

[1] www.elektor-usa.com/090035

Product

090035-41: Programmed PIC

Download

090035-11: Flowcode (.fcf) and hex files, from [1]
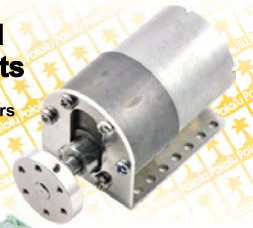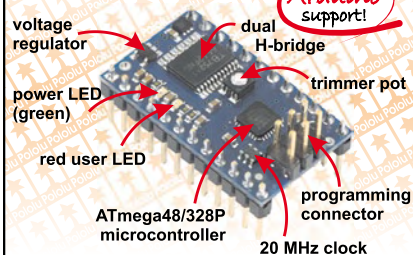
Frequency and Time Reference with ATtiny2313

Vladimir Mitrovic (Croatia)

In this project an AVR microcontroller type ATtiny2313 acts as a variable frequency divider, giving a sequence of very stable reference frequencies with a 50% duty cycle and covering a frequency range of 0.1 Hz – 4 MHz in 1, 2, 4 or 8 steps. The circuit is very simple because everything is done inside the microcontroller. In the program 31 different frequencies are predefined and may be selected by switches S1–S5 according to **Table 1**.

The ATtiny2313 has two timers/counters: 16-bit Timer/Counter1 and 8-bit Timer/Counter0, both offering various modes of operation. The 'Clear Timer on Compare Match' (CTC) mode is the most appropriate for generating a waveform output. In CTC mode Timer/Counter1 counts the system clock or external pulses up to the value given in the OCR1A (Compare1A) register. When the counter value matches the OCR1A value the counter is cleared to zero and the OC1A pin (PB3) toggles. In CTC mode Timer/Counter0 counts the system clock or external pulses up to the value given in the OCR0A register. When the counter value matches the OCR0A value, the counter is cleared to zero and the OC0A pin (PB2) toggles. Division factors up to 2 x 65536 (for Timer1) or 2 x 256 (for Timer0) can be obtained by setting appropriate values in the OCR1A and OCR0A registers. Besides by the timer division factor, an output frequency is also determined by the system clock, the system clock prescaler (1-2-4-8-16-32-64-128-256) and the timer prescaler (1-8-64-256-1024). In this design, an 8 MHz or a 20 MHz crystal may be used in position X1 (20 MHz shown in circuit diagram) but not indiscriminately because matching firmware should reside in the ATtiny.
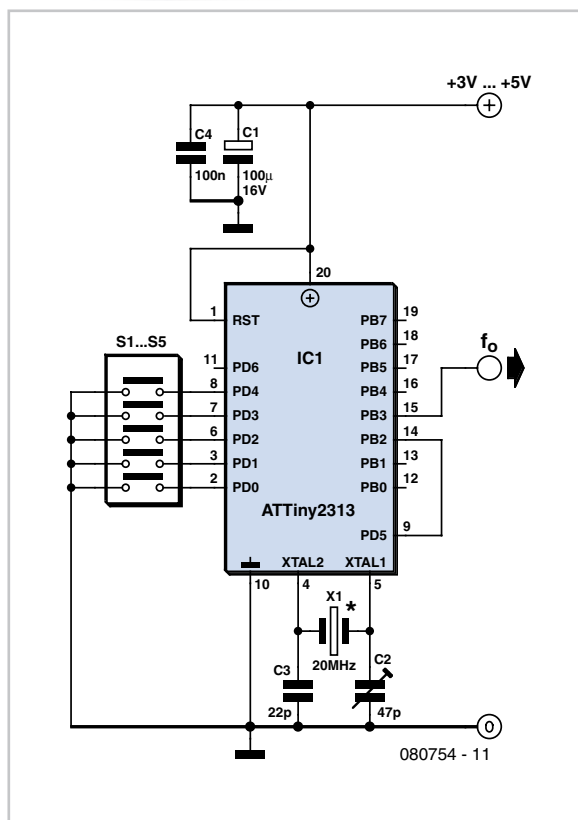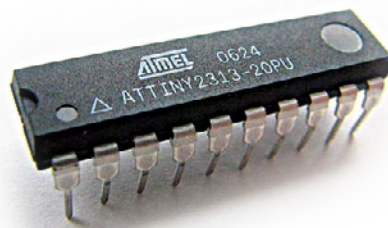
There are obviously several appropriate settings for producing a given frequency. As the system clock and the system clock prescaler setting determine the overall current consumption as well (lower frequency = lower consumption), we will always choose the lowest possible CPU clock. Assuming X1 = 8 MHz, for the 1 Hz to 4 MHz frequency range, only Timer/Counter1 is used. It counts the (prescaled) system clock pulses and the output frequency may be calculated from:

$$f = 8{,}000{,}000 / [2 \times system\_clock\_prescale \times (1 + OCR1A\_value)]$$

For the lower frequencies, 8-bit Timer/Counter0 is used as an additional prescaler (division factor: 10) between the prescaled system clock and Timer/Counter1. The latter is set in the counter mode and now counts pulses at the Timer/Counter0 output pin OC0A (PB2); hence, the OC0A pin (PB2) and the external input pin T1 (PD5) are interconnected. The output frequency can be calculated as:

$$f = 8{,}000{,}000 / [2 \times system\_clock\_prescale \times (1 + OCR1A\_value \times 2 \times (1 + OCR0A\_value)]$$

The program, which was written in BascomAVR, constantly monitors switches S1–S5. It is available as a free download [1]. If any change in the switch settings occurs, the 'Set_f' subroutine is called to set a new frequency. The subroutine will stop timers, reconfigure them, set proper values in various registers to obtain the proper division factor and restart the timers. The values for the registers are written in three tables.

1. 'Clock_prescale_table' contains the values in the range of 1 to 256 (only values 2^n are allowed) which will be used to calculate the proper value for the Clock Prescale Register, CLKPR.

2. 'Ocr1a_table' contains the values in the range of 1 to 65535 which will be used to calculate the proper value for the Timer/Counter1 Output Compare Register OCR1A. Only values 5^n (1, 5, 25, 125, 625, 3125 and 15625) are used in this design. A zero (0) entry denotes that Timer/Counter1 is stopped for this frequency. Note that the value in the table is decremented by 1 before being written into the OCR1A.

3. 'Ocr0a_table' contains the values in the range of 1 to 255 that will be used to calculate the proper value for the Timer/Counter0 Output Compare Register OCR0A. Only values 0 and 5 are used in this design: a '0' entry denotes that the Timer/Counter0 is stopped for this frequency, while '5' produces division of the system clock by 10. If even lower frequencies are needed, other type-5^n values (25 and 125) can be used to produce division factors of 100 and 1000. Note that the value in the table is decremented by 1 before being written into the OCR0A.

The *Fref_ATtiny2313_Elektor_8MHz.bas* program should be compiled and the resulting hex code programmed into the ATtiny2313 microcontroller before first use. Be sure to set the Flash Fuse bits to the proper value for an external crystal resonator (CKSEL3...0 = 1111) because the internal RC Oscillator is selected by default. The hex file for 8 MHz is also available straight away in the download at [1]. A variable capacitor C2 is provided to tune a crystal frequency to exactly 8.000 MHz, if

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possible. If you are satisfied with the crystal's accuracy, replace C2 with a fixed capacitor. Set the configuration switches according to Table 1 to obtain the wanted frequency. Powered at 3 V, the 8-MHz version of the frequency reference may still be used with most logical families running at 5 V: CMOS, LSTTL, HC, HCT and so on. However, be careful and do not allow any current to flow from 5 V powered circuits back into the micro-controller through the PB3 pin. This could cause battery charging through the micro-controller's clamping diodes with unpredictable results for both the battery and the microcontroller. If such a risk exists, connect a 3 V zener diode between PB3 and GND to effectively limit the voltage to a safe value. Caution: ready-programmed device **080754-41** from the Elektor Shop is programmed for the 20-MHz configuration and does not work down to 3 V.

Raising the supply voltage to 5 V will approximately double the supply current to 15 mA (max.), but it will also allow you to raise the clock frequency to 20 MHz and obtain some higher frequencies from the circuit. If current consumption is not an issue, you may contemplate the use of a precision quartz oscillator to drive the microcontroller.

The program *Fref_ATtiny2313_Elektor_20MHz. bas* will produce reference frequencies in the 0.001 Hz – 10 MHz frequency range in steps of 1, 2 or 5. The main difference with the 8 MHz program is that the timer prescaler for Timer/Counter0 is used here in order to produce frequencies under 0.01 Hz. A table called "Timer0_prescale_table" is added to the program. It contains values '0' (if Timer/Counter0 is not used), '1' (if it is used but not prescaled) or '8' (if it is used and prescaled by the factor of 8).

The frequencies supplied by the 20 MHz version are given in **Table 2**. The two lowest frequencies, marked by an asterisk (*) in the table, could not be obtained exactly, but the division error is well under the crystal tolerance and therefore may be totally neglected.

(080754-I)

Internet Link

[1] www.elektor-usa.com/080754

Downloads & Products

Programmed Controller
080754-41 ATtiny2313, ready programmed, 20 MHz configuration

Software
080754-11 Source and hex files for 8 MHz and 20 MHz, from [1]

Table 1. DIP switch settings for X1 = 8 MHz							
S5	S4	S3	S2	S1	PD4…PD0	Output freq.	
on	on	on	on	on	00000	4	MHz
on	on	on	on	off	00001	2	MHz
on	on	on	off	on	00010	1	MHz
on	on	on	off	off	00011	800	kHz
on	on	off	on	on	00100	400	kHz
on	on	off	on	off	00101	200	kHz
on	on	off	off	on	00110	100	kHz
on	on	off	off	off	00111	80	kHz
on	off	on	on	on	01000	40	kHz
on	off	on	on	off	01001	20	kHz
on	off	on	off	on	01010	10	kHz
on	off	on	off	off	01011	8	kHz
on	off	off	on	on	01100	4	kHz
on	off	off	on	off	01101	2	kHz
on	off	off	off	on	01110	1	kHz
on	off	off	off	off	01111	800	Hz
off	on	on	on	on	10000	400	Hz
off	on	on	on	off	10001	200	Hz
off	on	on	off	on	10010	100	Hz
off	on	on	off	off	10011	80	Hz
off	on	off	on	on	10100	40	Hz
off	on	off	on	off	10101	20	Hz
off	on	off	off	on	10110	10	Hz
off	on	off	off	off	10111	8	Hz
off	off	on	on	on	11000	4	Hz
off	off	on	on	off	11001	2	Hz
off	off	on	off	on	11010	1	Hz
off	off	on	off	off	11011	0.8	Hz
off	off	off	on	on	11100	0.4	Hz
off	off	off	on	off	11101	0.2	Hz
off	off	off	off	on	11110	0.1	Hz
off	off	off	off	off	11111	standby	

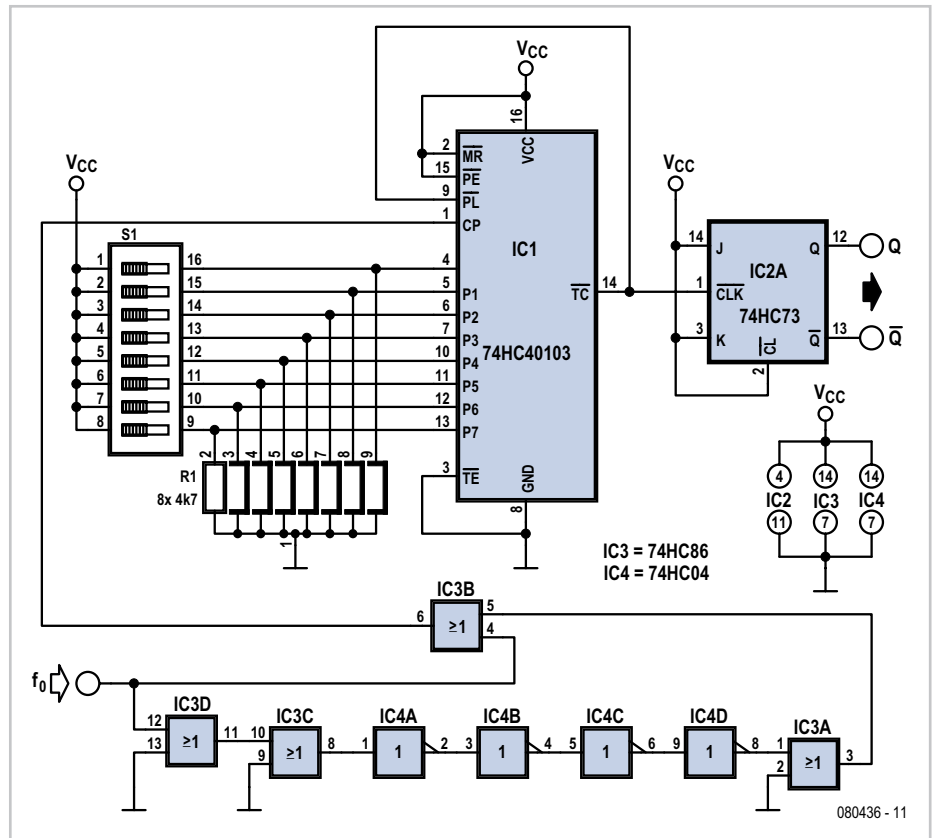| Table 2. DIP switch settings for X1 = 20 MHz							
S5	S4	S3	S2	S1	PD4…PD0	Output freq.	
on	on	on	on	on	00000	10	MHz
on	on	on	on	off	00001	5	MHz
on	on	on	off	on	00010	2	MHz
on	on	on	off	off	00011	1	MHz
on	on	off	on	on	00100	500	kHz
on	on	off	on	off	00101	200	kHz
on	on	off	off	on	00110	100	kHz
on	on	off	off	off	00111	50	kHz
on	off	on	on	on	01000	20	kHz
on	off	on	on	off	01001	10	kHz
on	off	on	off	on	01010	5	kHz
on	off	on	off	off	01011	2	kHz
on	off	off	on	on	01100	1	kHz
on	off	off	on	off	01101	500	Hz
on	off	off	off	on	01110	200	Hz
on	off	off	off	off	01111	100	Hz
off	on	on	on	on	10000	50	Hz
off	on	on	on	off	10001	20	Hz
off	on	on	off	on	10010	10	Hz
off	on	on	off	off	10011	5	Hz
off	on	off	on	on	10100	2	Hz
off	on	off	on	off	10101	1	Hz
off	on	off	off	on	10110	0.5	Hz
off	on	off	off	off	10111	0.2	Hz
off	off	on	on	on	11000	0.1	Hz
off	off	on	on	off	11001	0.05	Hz
off	off	on	off	on	11010	0.02	Hz
off	off	on	off	off	11011	0.01	Hz
off	off	off	on	on	11100	0.005	Hz
off	off	off	on	off	11101	0.002	Hz*
off	off	off	off	on	11110	0.001	Hz*
off	off	off	off	off	11111	standby	

Frequency Divider with 50% Duty Cycle

Roland Heimann (Germany)

In digital circuit design, especially in microprocessor or measuring applications, it is often necessary to produce a clock signal by dividing down a master clock. The 4-chip solution suggested here is very versatile; it takes a 50% duty cycle input clock and outputs a 50% duty cycle clock selectable (via an 8-way DIP switch) for every divisor from 1 to 255.

The most complex chip in this design is IC1, an 8-bit down-counter which is 'programmed' by the binary value set up on the eight DIP switches. An edge detector circuit made up of IC3 and IC4 produces a pulse at every rising and falling edge of the input clock f_0. Each time the counter reaches zero a flip flop is toggled to produce a 50:50 mark/space ratio output signal.

It does not matter if the gates used in the edge detector circuit are inverting or non-inverting; the only important points are that the correct number of gates are used and the delay time produced by each gate. The total propagation delay through seven HC type gates will be enough to generate a pulse of sufficient width to reliably clock the counter. Propagation delay is the time taken for a signal at a gate's input pin to affect the output, and this is given in the data sheet. The edge detector produces a pulse on both the positive and negative edges of the input clock signal.

The down-counter decrements its value each time it receives a clock impulse on CP. Whenever the counter reaches zero the terminal count pin ($\overline{TC}$) generates a negative pulse, reloading the counter (via parallel load $\overline{PL}$) with the binary switch setting. The counter continues counting down from this value.

The JK flip flop IC3 is configured as a toggle type flip flop (both inputs J and K wired to a '1') the outputs Q and $\overline{Q}$ change state (toggle) on each rising edge of the $\overline{TC}$ output of IC1. The DIP switches are used to set up the division ratio, to divide the clock by 23 for example, set the DIP switches to the binary value of 23 i.e. 00010111 (setting P4, P2, P1 and P0 to High).

(080436-I)

PIC Detects Rotation Direction

Lionel Grassin (France)
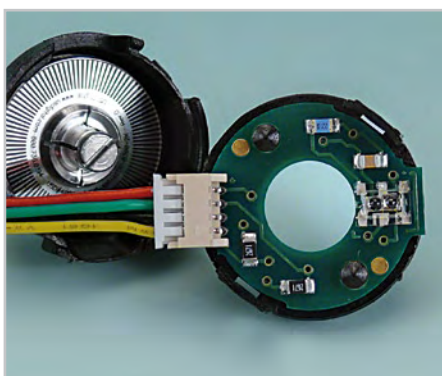
In the field of robotics, along with many other applications involving a motor (printers, for example), it is often necessary to measure a motor's speed and acceleration or direction of rotation. One simple technique is to fit a quadrature encoder to the shaft of the motor to be monitored. A quadrature encoder (see photo) is a device that produces two square-wave signals 90° apart as it turns. The direction in which the encoder rotates determines which of these two signals is in advance (compared with the other), thereby making it possible to detect the rotation direction. An algorithm for detecting the rotation direction doesn't need to be complicated, but it does need to be fast enough to be able to follow high speeds and speed variations. This can be achieved using program-

mable logic (FPGA, GAL, PAL, etc.), but the author wanted to use a small, cheap microcontroller. He opted for the PIC12C509A from Microchip, an 8-pin microcontroller with six I/Os. Two inputs and one output are all the rotation direction sensor needs, so the little PIC is able to handle two quadrature encoders at the same time.

The algorithm developed by the author operates asynchronously, which ensures a very wide operating range, dependent on the capabilities of the microcontroller. The algorithm loop time is 20 µs for a PIC12C50X using the internal 4 MHz clock, so it is theoretically possible to follow a pulse signal of up to 50 kHz. This corresponds to a speed of 3,000 rpm for a motor fitted with a quadrature encoder giving 1024 pulses per rotation.
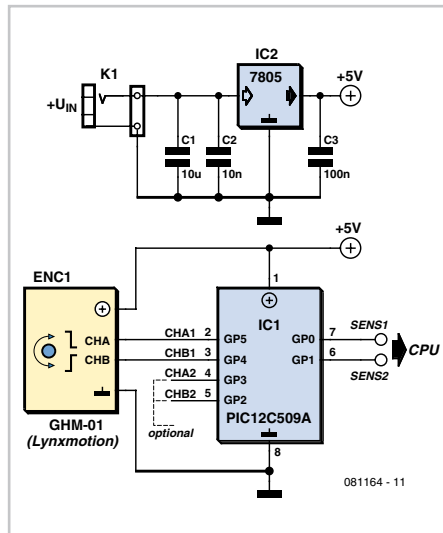
And all this for two motors/encoders at the same time! You can find all the details of the algorithm — and more — on the (French) website of the Fribotte team to which the author belongs [1].

The program (source code and hexadecimal file) is available on free download from the web page for this article [2].

(081164-I)

Internet Links

[1] http://fribotte.free.fr/bdtech/detectsens/detect-sens.html

[2] www.elektor-usa.com/081164

Download

081164-11: source code and hex file, from [2]

Vocal Adaptor for Bass Guitar Amp

Jérémie Hinterreiter (France)

These days, music is a major hobby for the young — and not-so-young. Lots of people enjoy making music, and more and more dream of showing off their talents on stage. But one of the major problems often encountered is the cost of musical equipment. How many amateur music groups sing through an amp borrowed from a guitarist or bass player?

This is where the technical problems arise — not in terms of the .25" (6.3 mm) jack, but in terms of the sound quality (the words are barely understandable) and volume (the amp seems to produce fewer decibels than for a guitar). What's more, unpredictable feedback may cause damage to the speakers and is very unpleasant on the ear. This cheap little easy-to-build project can help solve these technical problems.

A guitar (or bass guitar) amplifier is designed first and foremost to reproduce the sound of the guitar or bass as faithfully as possible. The frequency response of the amp doesn't need to be as wide or as flat as in hi-fi (particularly at the high end), and so this sort of amplifier won't permit faithful reproduction of the voice. If you build an adaptor to compensate for the amp's limited frequency response by amplifying in advance the frequencies that are then attenuated by the amp, it's possible to improve the quality of the vocal sound. That's just what this circuit attempts to do.

The adaptor is built around the TL072CN low-noise dual FET op amp, which offers good value for money. The NE5532 can be used with almost the same sound quality, but at (slightly) higher cost. The circuit breaks down into two stages. The first stage is used to match the input impedance and amplify the microphone signal. For a small 15 W guitar or bass amplifier, the achievable gain is about 100 (gain = P1/R1). For more powerful amplifiers, the gain can be reduced to around 50 by adjusting P1. The second stage amplifies the band of frequencies (adjustable using P2 and P3) that are attenuated by the guitar amp, so as to be able to reproduce the (lead) singer's voice as clearly, distinctly, and accurately as possible. To refine the adaptor and tailor it to your amplifier and speaker, don't be afraid to experiment with the component values and the type of capacitors.

The circuit can readily be powered using a 9 V battery, thanks to the voltage divider R4/R5 which converts it into a symmetrical ±4.5 V supply.

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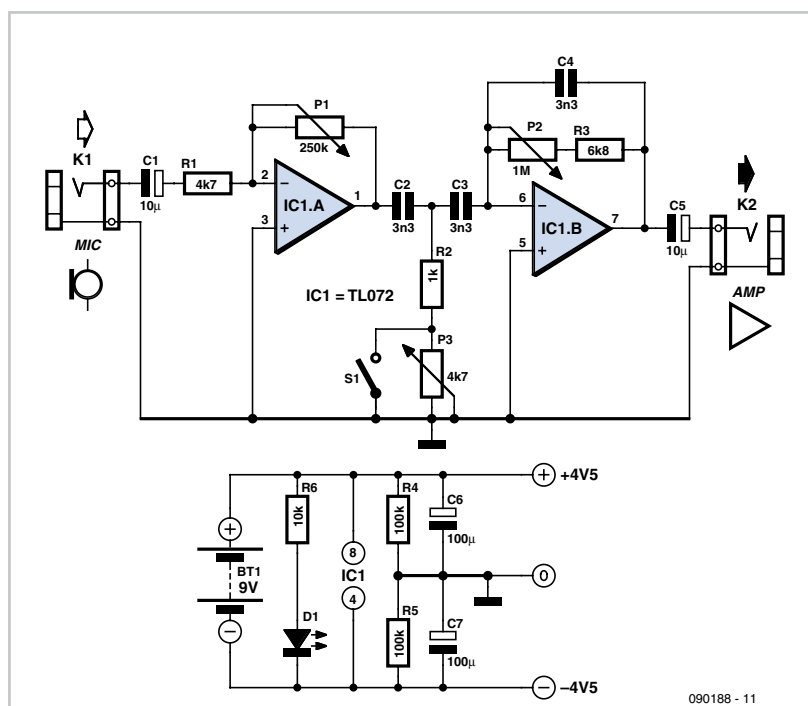
Guitar Pick-up Tone Extender

David Clark (United Kingdom)

This design extends the basic sonic possibilities of an electric guitar without the use of any electronic 'effects'. The expanded number of tone possibilities is brought about by mixing continuously-variable amounts of the output from each of the guitar's pick-ups, along with switching the phase of each pick-up. This effectively gives an infinite range of tones as opposed to the five available for a normally switched set-up. This is not a project for the faint-hearted, however; it involves modifying the wiring to the guitar's pick-up coils and switches, and possibly the scratchplate itself, depending on the chosen location for the replacement for the standard 0.25-inch (6.3-mm) jack connector. Use of a cheap 'copy'-style guitar is recommended!

The standard 'Stratocaster'-style guitar features three pick-ups and a five-way switch that allows the player to select one of the following combinations:

- neck pick-up
- neck and middle pick-up in parallel
- middle pick-up
- middle and bridge pick-up in parallel
- bridge pick-up

Guitarists eager to find new sounds from their instrument sometimes alter the wiring and add other switches to this arrangement, but this is of course not a flexible arrangement, and certainly not something that could be altered mid-performance playing for a crowd, no matter if a dozen or so in a downtown bar or 40 k at Woodstock v. 2.1.1!

This project allows up to four pick-ups to be employed, since the bridge pick-up on a 'Stratocaster' is often a so-called 'humbucker' type, which can be split into two independent pick-ups, shown here as Bridge 1 (L3) and Bridge 2 (L4).

The really intrepid among you may decide to build the circuitry in SMD and incorporate a tiny board into the guitar. However, having four switches and four pots on the guitar may be too much of a good thing.

The alternative is to wire the guitar pick-ups individually to
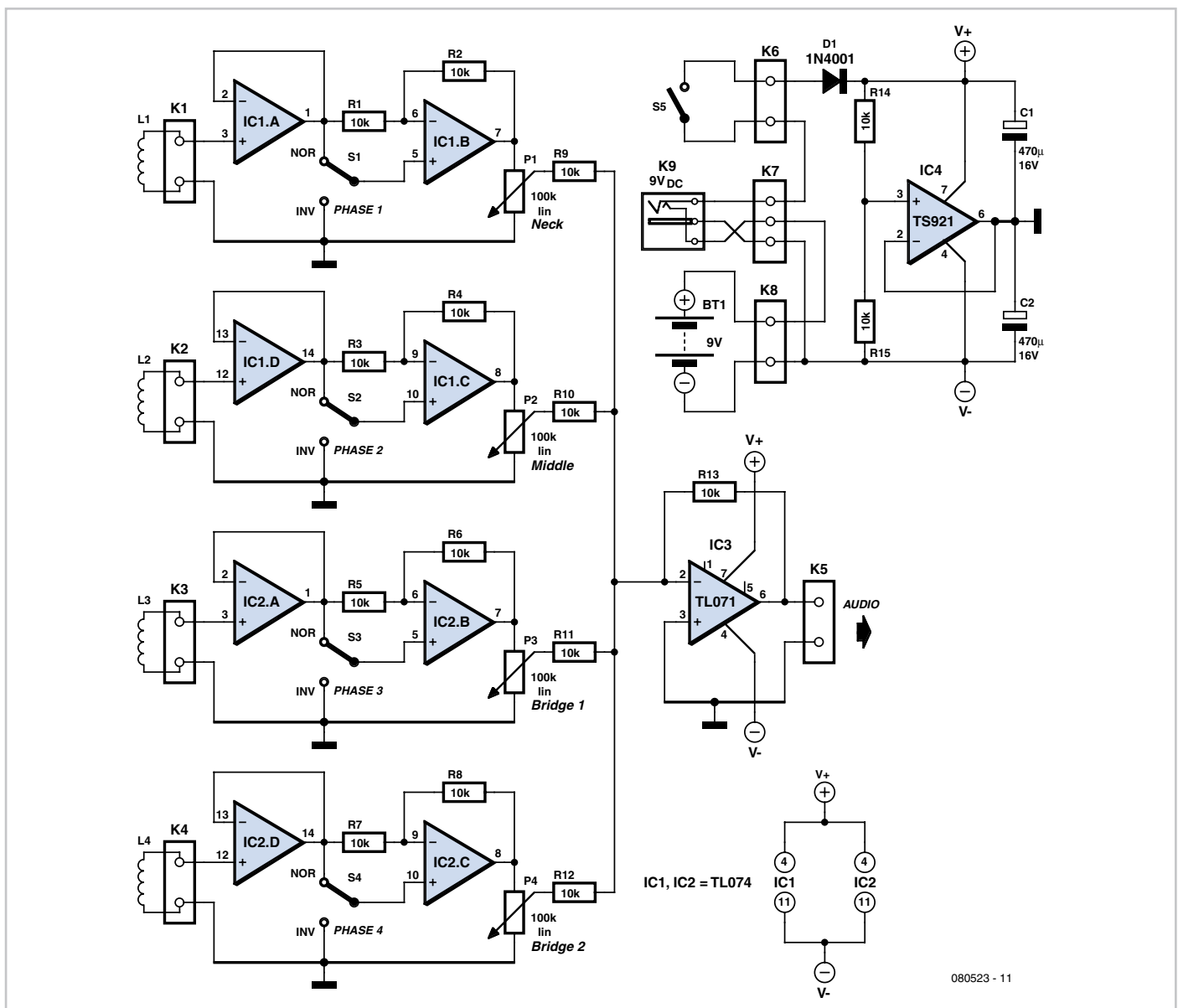
a 9-pin sub-D type connector that is added either to the guitar body or its scratchplate. The connector is linked to the input sub-D connector on the control unit via a long 'straight-through' serial interface computer cable. The Tone Extender circuitry may be built in a Vero style box, of which an example is shown in the photograph. Connection from the unit to an unmodified guitar amplifier is via a standard guitar lead.

Each pick-up section consists of two opamps from a TL074 package, one inverter (e.g. IC1.A) and one buffer (e.g. IC1.B). Each has a normal/invert switch (NOR/INV, e.g. S1) to select the phase of the signal component, and a 100-kΩ linear law potentiometer at its output to set the desired level. The output signals of all four opamp sections are summed by IC3 (a TL071) which provides a suitably low output impedance to drive the guitar amplifier.

Opamp IC4 splits the supply voltage obtained from 9 V (6LR22) battery BT1 into symmetrical rails V+ and V−. Alternatively, a battery eliminator with a regulated output voltage of 9 V DC may be connected to K9, when the battery is automatically disconnected.

Whatever method of construction is chosen, the unit effectively provides the guitarist interested in experimenting with unusual pick-up configurations a flexible way of quickly setting up and trying probably all possible variations, without having to get out the soldering iron and hard-wire each new idea. As such it should be an invaluable aid to allowing all manner of sonic possibilities to be realized.

(080523-I)

Lithium Battery Charger using BQ24103

Steffen Graf (Germany)

The BQ24013 is a simple-to-use charge controller suitable for use with lithium-ion and lithium-polymer batteries. A major advantage it has is that it includes integrated power MOSFETs capable of working with charge currents of up to 2 A. Its switching frequency is high, at 1.1 MHz, and so only a small external coil is needed. In comparison to linear charging circuits the switching topology offers a much higher degree of efficiency.

A further benefit is that it is capable of charging battery packs consisting of either a single cell or of two cells wired in series. Two LEDs indicate when the battery is being charged (D1 lights) and when the battery is fully charged (D2 lights). The charge current is set by the choice of external resistors [1]. There are three currents to set: the initial (precharge) current, the charge current and the charge termination current. With the component values given the precharge current is 67 mA, the charge current is 667 mA and the termination current is also 67 mA.

The IC of course ensures that the charging process is carried out correctly and in particular that the maximum permissible cell voltage is never exceeded: this is extremely important for lithium chemistry cells. Even more

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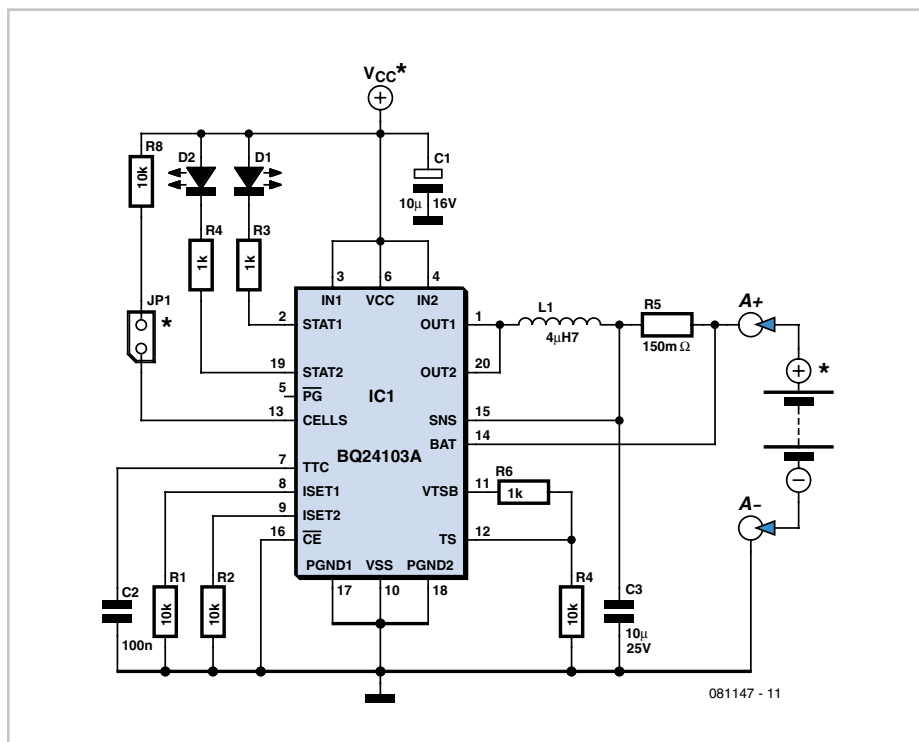
important is to note that jumper JP1 should be fitted **only in the case where two cells are being charged**. When charging a single cell the jumper must **not** be fitted, or there is a risk of **explosion** or **fire** as the charging voltage will be too high.

The minimum supply voltage for charging a single cell is 5 V; for charging two cells it is 9 V. According to its datasheet, the IC is specified for supply voltages of up to 16 V. Unfortunately the IC is only available in a QFN20 package, which is rather tricky to

solder. In compensation, the tiny package does make it possible to build a complete 2 A charging circuit on less than 2.5 cm² of printed circuit board.

For the prototype, with a charging current of 670 mA, we selected for L1 a 4.7 µH inductor with a DC resistance (DCR) of 0.082 Ω (82 mΩ) rated for a current (DCI) of 1.72 A. If a charge current of up to 2 A is wanted, an inductor with a DCR of less than 0.025 Ω (25 mΩ) and a current rating of 4 A or more should be chosen. For R5 we used a Vishay 150 mΩ SMD resistor in an 0805 package (available, for example, from Farnell), and for C3 a ceramic barrier-layer capacitor with a working voltage of 25 V. If an electrolytic capacitor is used it must have a very low ESR.

An overview of the various versions of the IC that are available can be found at [2]. For our prototype we used a type BQ24103A.

Internet Links

[1] www.ti.com/lit/gpn/bq24103a
[2] http://focus.ti.com/docs/prod/folders/print/bq24103a.html

12 V AC Dimmer

Peter Jansen (The Netherlands)

The circuit described here is derived from a conventional design for a simple lamp dimmer, as you can see if you imagine a diac connected between points A and B. The difference between this circuit and a normal diac circuit is that a diac circuit won't work at 12 V. This is the fault of the diac. Most diacs have a trigger voltage in the range of 30 to 40V, so they can't work at 12 V, which means the dimmer also can't work.

The portion of the circuit between points A and B acts like a diac with a trigger voltage of approximately 5.5 V. The network formed by R1, P1 and C1 generates a phase shift relative to the supply voltage. The 'diac equivalent' circuit outputs a phase-shifted trigger pulse to the triac on each positive and negative half-cycle of the sinusoidal AC voltage.
This works as follows. First consider the posi-

090370 - 11

tive half of the sine wave. C1 charges when the voltage starts to rise, with a time constant determined by C1, R1 and P1. T1 does not start conducting right away. It waits until the voltage across D2 reaches 4.7 V and the Zener
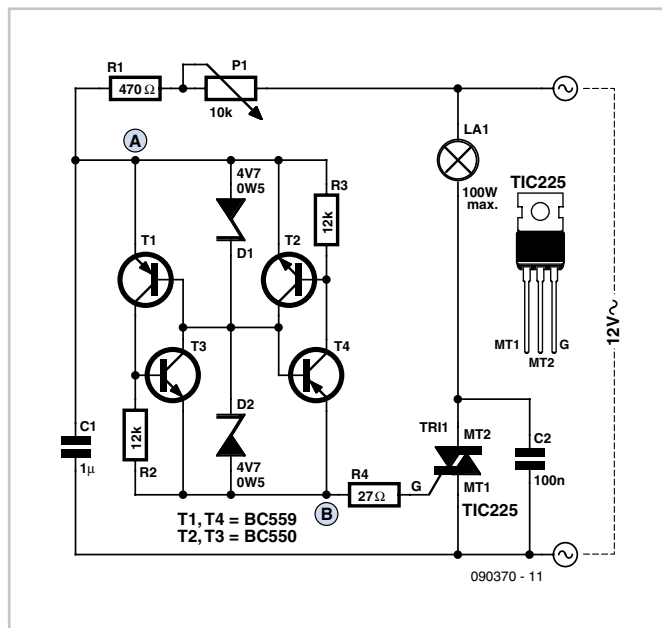
diode starts to conduct. Then current starts to flow, driving T1 and T3 into conduction. This produces a pulse at point B. The same principle applies to the negative half of the sine wave, in this case with D1, T2 and T4 as the key players. The trigger angle can be adjusted with P1 over a range of approximately 15 degrees to 90 degrees. C2 provides a certain amount of noise decoupling. Depending on the load, the triac may need a heat sink. You can use practically any desired transistors; the types indicated here are only examples. If the circuit does not dim far enough, you can change the value of P1 to 25 kΩ. This allows the trigger angle to be increased to 135 degrees.

Note: this circuit works fine with normal transformers, but **not** with 'electronic' transformers.

Simple Temperature Measurement and Control

Jochen Brüning (Germany)

The circuit described here and its accompanying BASCOM software arose from the need to control the temperature in a laminator. The laminator does include its own temperature controller, but it was not suitable for the author's purposes (making printed circuit boards using a thermal transfer method [1]). The result (see circuit diagram) is based around an ATmega48 microcontroller with a 2-by-16 LCD panel and a rotary encoder. The base-emitter junction of an ordinary NPN power transistor in a TO220 package is used as the temperature sensor. Although this technique is not often seen, it is far from new: decades ago Elektor published a digital thermometer design with an NPN transistor pressed into service as the sensor. The approach has the advantage of a wide linear temperature range from −50 °C to +150 °C and the TO220 package is particularly convenient because it has a handy fixing hole and heatsink to allow good thermal contact. Note that the heatsink is electrically connected to the collector of the transistor, so it may be necessary to use an insulating washer.

The BD243C is wired as a diode by connecting

LCD1

2 x 16

VSS VDD VO RS R/W E D0 D1 D2 D3 D4 D5 D6 D7
1 2 3 4 5 6 7 8 9 10 11 12 13 14

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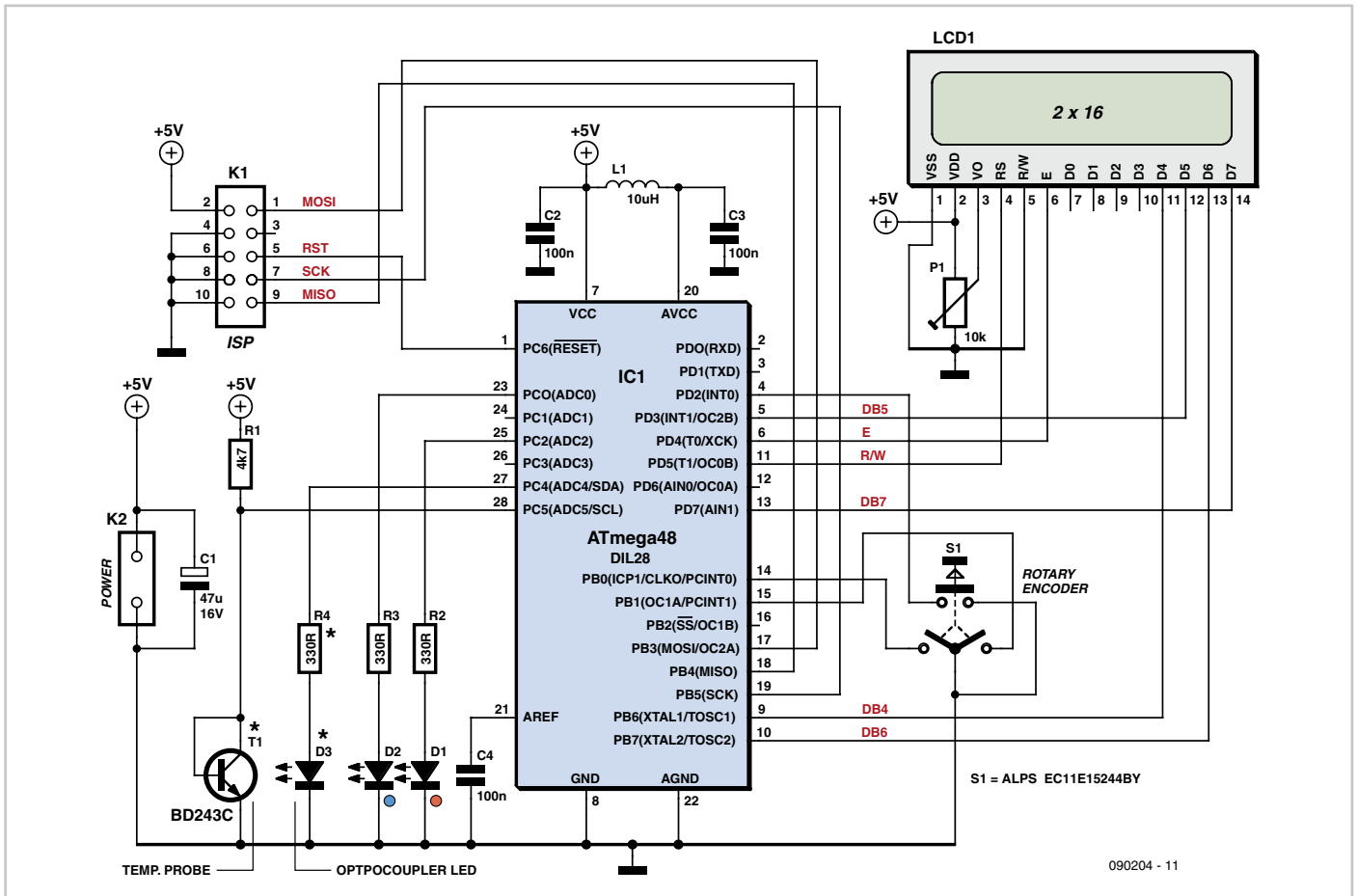
its collector and base together and powered from the 5 V rail via a 4.7 kΩ resistor. A current of approximately 1 mA therefore flows through the diode. The voltage across the diode has a reasonably constant negative temperature coefficient of around –2 mV/K, and so the plot of voltage against temperature is reasonably straight. The voltage is measured using the ATmega48's internal A/D converter using input ADC5 on pin 28. A point to note is that we can use the 1.1 V internal reference voltage to obtain good precision when converting the diode voltage drop, which is around 0.6 V. Not all AVR-series microcontrollers have the 1.1 V internal reference for the A/D converter, which should be borne in mind if modifying the design to use a different microcontroller.

The set point for temperature control is entered using the rotary encoder in one degree steps. Turn the encoder to the right to increase the set point, to the left to decrease it. It is possible to set upper and lower thresholds for switching. If the rotary encoder has a pushbutton function, this can be used to select between setting the upper and lower thresholds; if not, a separate button must be fitted.

The display consists of the LCD panel and two LEDs. The upper line of the LCD shows the measured temperature and the lower line shows the current set point (upper and lower temperature switching thresholds). P1 adjusts the contrast of the LCD.

The two LEDs show the state of the controller at a glance. If the blue LED (D2) is lit, the temperature is too low (below the lower switching threshold); if the red LED (D1) is lit, the temperature is too high (above the upper switching threshold); and if both LEDs are lit the temperature is just right (between the lower and upper switching thresholds).

Since at least one LED is always lit there is no need for a power indicator LED.

The output of the controller is the logic level on pin 27 (PC4). The author used this to drive a solid state relay (SSR) in his application which in turn controlled the heating element in the laminator. The circuit diagram shows this as LED D3, which is intended to represent the LED in the optocoupler in the SSR.

ISP connector K1 is optional and can be dispensed with if a ready-programmed microcontroller is used (see 'Downloads and products'). It will then not be possible to calibrate the temperature reading, as this can only be done in the software using the ISP interface. However, for many one-off applications it will be sufficient to determine the upper and lower switching thresholds experimentally, including compensation for any error in the temperature measurement.

Details of the control process can be found by inspecting the BASCOM source code. Calibration of the temperature measurement, as mentioned above, is done by directly modifying the software. Remove the comment characters (') from lines 105 to 107 of the program, and comment out lines 108 to 110 by adding a single inverted comma at the start of each. The display will now show the conversion results from the A/D converter in the ATmega48. Immerse the sensor in a mixture of ice and water and wait until the reading stabilizes. Note down the conversion result (or take a number of results and average them for better accuracy). Now immerse the sensor in boiling water and repeat the procedure. Replace the number 546 in line 86 of the source code with the conversion result for the ice-water mixture. Now subtract the conversion result for boiling water from the ice-water result and divide by 100: substitute the answer for the value 2.460 in line 87 of the source code.

As indicated at the start, we assume in this calibration that the conversion result versus temperature relationship is linear. We can write this in the form $y = mx + c$, where c is the A/D conversion result at 0 °C (the intercept of the A/D conversion result axis) and m is the (negative) slope of the base-emit-

ter junction voltage-temperature character-istic, calculated by dividing the difference between the conversion results at 0 °C and 100 °C by 100. These two numbers allow you map any conversion result into a correspond-ing temperature.

(090204-I)

USB Switch

Rainer Reusch (Germany)

Anyone experimenting or developing USB ported peripheral hardware soon becomes irritated by the need to disconnect and connect the plug in order to re-establish communica-tion with the PC. This pro-cess is necessary for exam-ple each time the peripheral equipment is reset or a new version of the firmware is installed. As well as tiresome it eventually leads to exces-sive contact wear in the USB connector. The answer is to build this electronic isolator which disconnects the peripheral device at the touch of a button. This is guaranteed to reduce any physical wear and tear and restore calm once again to the workplace.
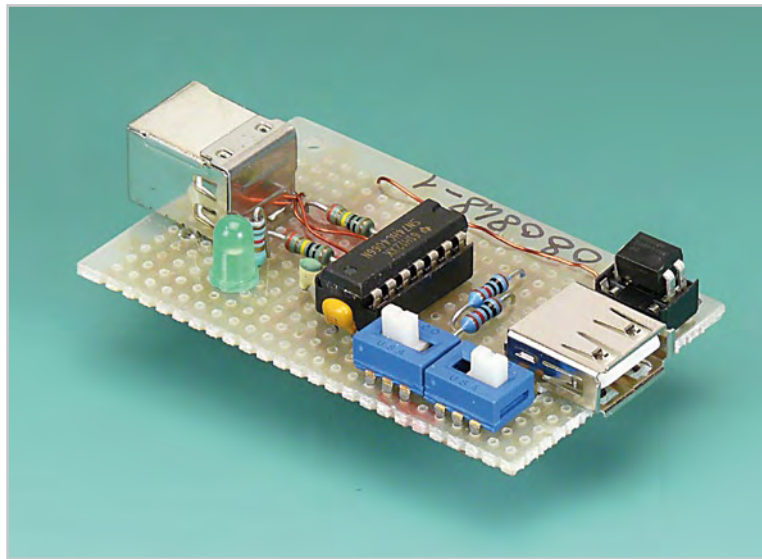
The circuit uses a quad analog switch type 74HC4066. Two of the switches in the pack-age are used to isolate the data path. The remaining two are used in a classic bistable flip-flop configuration which is normally built using transistors. A power MOSFET switches the power supply current to the USB device. Capacitor C2 ensures that the flip flop always powers-up in a defined state when plugged into the USB socket ('B' in the diagram). The peripheral device connected to USB socket 'A' will therefore always be 'not connected' until pushbutton S2 is pressed. This flips the bistable, turning on both analog gates in the

data lines and switching the MOSFET on. The PC now recognizes the USB device. Pressing S1 disconnects the device.

The circuit does not sequence the connec-tions as a physical USB connector does; the power supply connection strips are slightly longer than the two inner data carrying strips to ensure the peripheral receives power

before the data signals are connected. The electronic switch does not suffer from the same contact problems as the physical connector so these measures are not required in the circuit. The simple circuit can quite eas-ily be constructed on a small square of perforated strip-board. The design uses the 74HC(T)4066 type analog switch, these have better characteristics compared to the standard 4066 device. The USB switch is suitable for both low-speed (1.5 MBit/s) and full-speed (12 MBit/s) USB ports applications but the properties of the ana-log switches and perf-board construction will not support hi-speed (480 MBit/s) USB operation.

The IRFD9024 MOSFET can pass a current of up to 500 mA to the peripheral device with-out any problem.

(080848-I)

IRFD9024

IC1 = 74HC4066

080848 - 11

ElektorWheelie

The electronics behind a special kind of vehicle

Chris Krohne (Germany)

In this first article describing our DIY self-balancing single-axle vehicle we look at the electronics modules. An ATmega32 processes the controls and sensor data and drives the two electric motors via power driver stages. It keeps the vehicle balanced and can drive it in any desired direction at any desired speed from stationary to about 11 mph.

The electronics in the ElektorWheelie processes input signals from a control potentiometer, an acceleration sensor and an inclination sensor. It controls the magnitude and direction of the torque applied to the wheels via two motors using PWM signals and MOSFET drivers. The sensors provide enough information to allow the vehicle to maintain its balance over its full range of speeds, and it can even spin on the spot.

Characteristics

- Two 500 W DC drive motors
- Two 12 V lead-acid AGM batteries, 9 Ah
- Two fourteen-inch wheels with pneumatic tires
- H-bridge PWM motor control up to 25 A
- Automatic power off on dismount
- Fail-safe emergency cutout
- Battery charge status indicator
- Maximum speed approx. 11 mph (18 km/h)
- Range approximately 5 miles (8 km)
- Weight approximately 77 lbs (35 kg)

Sensors:
- Invensense IDG300 (or IDG500) gyroscope
- Analog Devices ADXL320 accelerometer
- Allegro ACS755SCB-100 current sensor

Microcontrollers:
- ATmega16 (motor control)
- ATtiny25 (current monitoring)

Compiler used:
- BASCOM-AVR Basic compiler

A delicate balance

For the vehicle to be able to balance successfully it is essential that the sensors provide reliable information about the inclination of the platform and its angular velocity. This is in addition, of course, to ensuring that the control system, motor drivers and motors themselves are properly designed.

Balancing itself is relatively straightforward. If the rider leans forwards the platform tilts and the motors are driven so as to bring the whole system (vehicle plus rider) back towards balance. That means that the rider's feet are pushed forwards under the centre of gravity of the whole system, opposing the rider's leaning and reducing the tilt angle.

The system therefore tilts as a whole, which requires both a strong mechanical construction and a carefully designed and experimentally tested filter function. The damping characteristic of the filter is set just short of the point where the system starts to become unstable.

Steering is performed by applying differential acceleration or braking to the two motors. Note that at higher speeds the tightness of the turning circle has to be limited. In the ElektorWheelie the limit is set so that the rider cannot overturn the vehicle by trying to change direction suddenly.

No motor has an infinite amount of power. In the case of the ElektorWheelie there is the potential for serious consequences for the rider if a motor does not have enough power headroom to allow for balance to be maintained. For this reason the motors are normally only driven up to approximately 70 % of their maximum power. This keeps a little in reserve so that, when top speed is reached, the wheels can be given a small extra acceleration. This throws the rider back slightly, which automatically leads to a reduction in speed. Leaning back slows the vehicle down, leaning forwards speeds it up.

The drive train is based on two 500 watt DC electric motors, with power being provided by two 12 V AGM (absorbed glass mat) lead-acid batteries. Most of the electronics is located on a control board, with a sensor board mounted on it.

The control system uses dynamic stabilization. The vehicle senses the attitude of its platform in an analogous way to the human sense of balance. If the platform starts to tilt forwards or backwards, the vehicle makes a proportional acceleration to oppose the tilt using both motors. By applying different amounts of drive to the two motors, the vehicle can turn.

Block diagram

Central in the block diagram of the attitude control and motor drive unit shown in **Figure 1** is an Atmel ATmega32 microcontroller. This has two PWM outputs that are used to drive the two 24 V DC motors via a pair of MOSFET H-bridges. A second microcontroller, an Atmel ATtiny25 this time, monitors the motor current using a Hall effect sensor. If an excessive current (over 80 A) should flow because of a short circuit in the system, the ATtiny25 interrupts the 15 V power supply to the H-bridge driver circuitry using the shutdown input of its regulator. In the event of a total failure of the control electronics the battery current can also be interrupted using a purely electromechanical emergency stop device, providing the ultimate protection against the vehicle running out of control.

In normal operation the ATtiny25 will also notify the ATmega32 when the motor current exceeds a preset value of around 25 A, which will cause the controller to attempt to reduce the current by limiting the range of the PWM control signals.

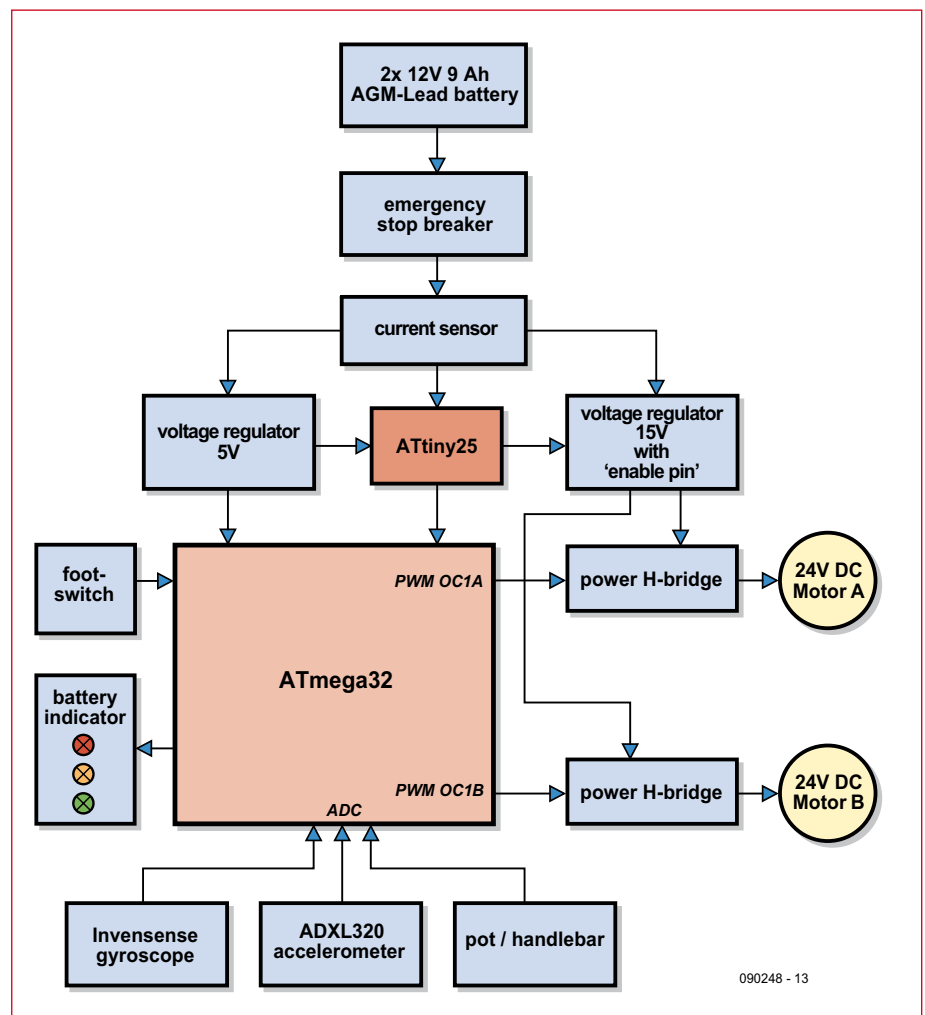The ATmega32 receives sensor inputs

Figure 1. Block diagram of the motor controller.

using its ADC (analogue-to-digital converter) from the gyroscope and the accelerometer on the sensor board and from the high-reliability potentiometer that is mechanically connected to the steering control of the ElektorWheelie. The ADC inputs are sampled around 100 times per second.

As a further safety feature a footswitch is connected to an input of the ATmega32. If this switch is not held down (because the rider has dismounted) the microcontroller will interrupt the motor current after two seconds. This also helps to prevent the vehicle from running away on its own.

The battery voltage is also monitored by the ATmega32 using its ADC, and used to drive three LEDs that indicate the remaining available running time to the rider.

Sensors and stabilization

The attitude sensors are mounted on their own small printed circuit board that plugs into the main control board. **Figure 2** shows the circuit of the sensor board, which includes an Invensense IDG300 [1] two-axis gyroscope and an Analog Devices ADXL320 [2] two-axis accelerometer. Voltage regulator IC3 provides the required 3 V supply for the sensors; this voltage also serves as the reference voltage for the ATmega32's A/D converter on the main board.

The output of the gyroscope is a voltage proportional to the rate at which it is turning (its angular velocity). If the platform is tipping rapidly there will be a large and rapid swing in the gyroscope's output voltage. When stationary the output voltage of the gyroscope is approximately half its supply voltage.

The accelerometer measures the component of the acceleration due to gravity in its own plane. If the sensor is tilted this will affect the angle at which gravity acts relative to the device, which therefore operates as an inclination sensor, delivering an output depending on the attitude of the platform.

To obtain the best possible stability it is important to determine the attitude
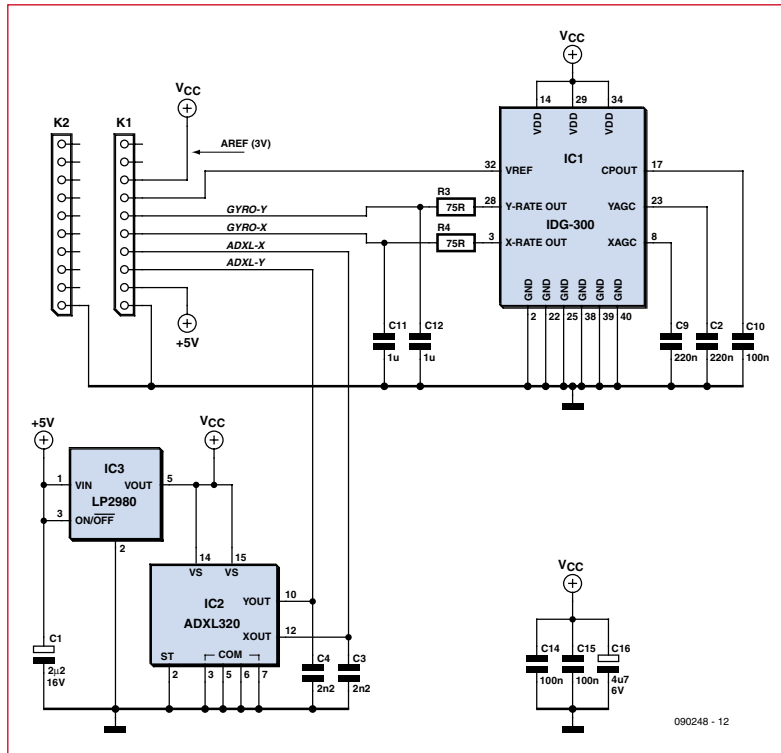
Figure 2. Circuit diagram of the sensor board with gyroscope and accelerometer.

of the platform as accurately as possible at each instant in time. The output of the accelerometer is therefore integrated over a relatively long time period to obtain a smoothed signal. To this smoothed result is added the output of the gyroscope, in proportions that have been empirically optimized. The acceleration signal delivered to the motor controller is calculated as a preset linear combination of the attitude error (the difference between the actual inclination angle and the target inclination angle) and the angular velocity with which the platform is tipping. In essence, the greater the attitude error and the greater the angular velocity, the greater the motor acceleration required for stabilization.

Motor control

The circuit diagram of the main printed circuit board in **Figure 3** contains all of the control circuitry of the ElektorWheelie, including the power driver stages. Only the attitude sensors, as mentioned above, are mounted on a separate board.

It is fairly easy to identify the components corresponding to the various parts of the block diagram. In the center is the ATmega32, clocked at 16 MHz. It is directly connected to 10-way in-system programming (ISP) connector K4 and to the three LEDs, LED1

to LED3, that show the battery status.

The sensor board is connected to K2 on the control board. The X-axis and Y-axis outputs of the sensors are connected to A/D converter inputs ADC2 to ADC5 on the ATmega32, and pin 32 (AREF) is fed with 3 V from the voltage regulator on the sensor board. The 3 V supply is also taken to K3 where it provides power to the steering potentiometer. The wiper of this potentiometer thus provides a voltage to analog input ADC6 on the ATmega32 that depends on the position of the steering control. Analog input ADC0 measures the battery voltage via the voltage divider comprising R10 and R11, and ADC7 monitors the position of the footswitch via K3. The fault detection signal (CURRFLAG) is taken to pin 16 (INT0) of the ATmega32 from the ATtiny25 current monitor IC10, which in turn is connected to current sensor IC5. IC5 is an integrated Hall effect sensor from Allegro Microsystems offering linear operation up to 100 A. CURRFLAG is set if the current reaches approximately 25 A and causes the motor current to be limited by bounding the range of the PWM drive signal.

We now turn to the output signals of the ATmega32. The result of processing the various inputs to the microcontroller appear as the signals on the four outputs PWM-L, PWM-R, CW/CCW-A and CW/CCW-B, on pins 18 to 21. CW/CCW-A and CW/CCW-B are logically combined with the PWM outputs PWM-L and PWM-R in IC8 and IC9 is such a way that they determine the direction of rotation of the motors, while the PWM signals control the current delivered to the motors via the H-bridges. Each motor thus has two control signals and a complete H-bridge driver, and each H-bridge is composed of two

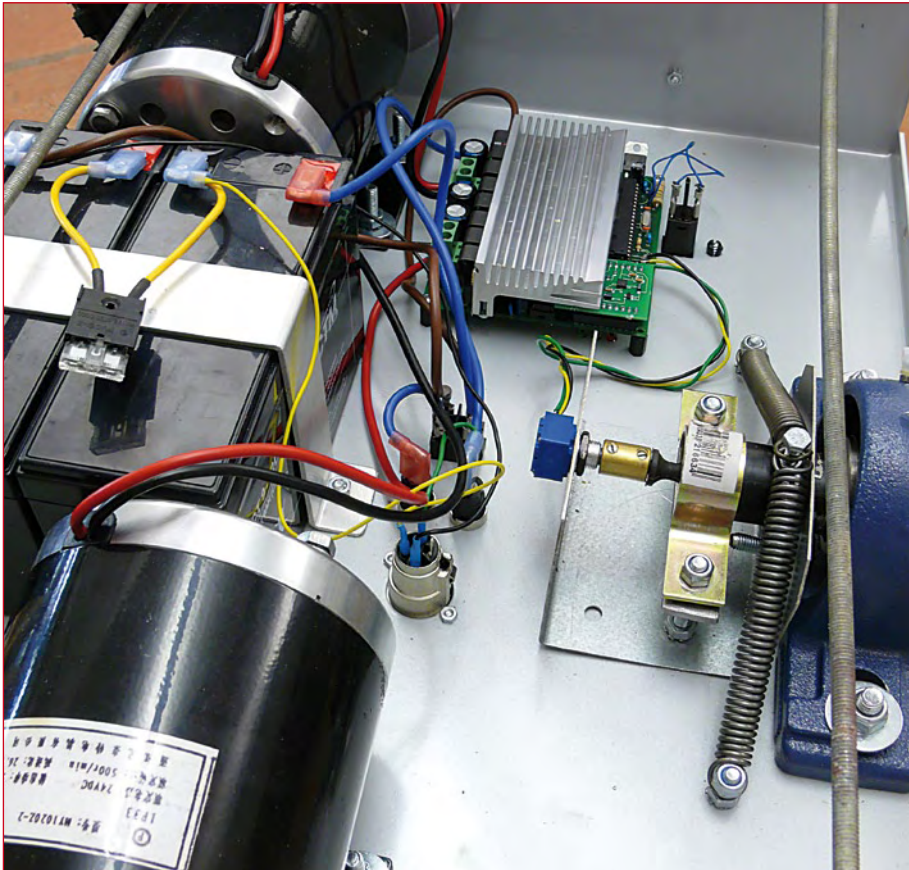Figure 3. Circuit diagram of the main board, including control and power electronics.

series via current sensor IC5.

The half-bridge driver ICs receive their own 15 V supply from the MIC2941 voltage regulator IC11. This IC has a shutdown input (pin 2) that is connected to the 'enable' output signal from the current monitoring circuit (pin 5 on IC10). When excess current is detected this signal shuts down the regulator and hence also the bridge driver ICs. The MOSFETs then block and the motor current is interrupted. All the other ICs are powered with 5 V from IC6, a standard regulator.

Figure 4. The batteries and electronics module are mounted on the underside of the metal chassis.

A compact module

Figure 4 shows the metal chassis of the vehicle. The electronics module (**Figure 5**), comprising the main board and the sensor daughter board is mounted on the underside of the platform.

The eight MOSFETs are positioned in a row on the reverse of the main board and are cooled using a specially-designed common heatsink. The heatsink is bolted to the printed circuit board and the MOSFETs are held on to the heatsink using spring clips. A self-adhesive thermally conductive sheet between the MOSFETs and the heatsink provides electrical isolation.

The main board contains only leaded devices, in contrast to the SMD-populated sensor board. The printed circuit board layouts are as usual available for free download from the project web pages [3] as PDFs, along with associated parts lists.

half-bridge driver ICs type IR2184 and four IRF4105 MOSFETs. The left wheel motor is driven by IC1, IC2 and T1 to T4, while the right wheel motor is driven by IC3, IC4 and T5 to T8.

The MOSFET bridge circuits are powered from the 24 V supply derived from the two lead-acid AGM batteries in

Software

The firmware for the two microcontrollers was written using BASCOM-AVR. **Figure 6** gives an overview of the main functions involved in controlling the motors, which will be described briefly below. If necessary, refer to the BASCOM-AVR source code files found at [3].

Function Init:
This function initializes and configures Timer0, Timer1 and the PWM outputs, initializes variables and calibrates the gyroscope, accelerometer and steering potentiometer.

Function Get_Angle:
This function reads values from the analog inputs (gyroscope, ADXL320, potentiometer, battery voltage and footswitch). The gyroscope, ADXL320 and battery voltage readings are integrated over a period of fifty samples.

Figure 5. The compact electronics module comprises the main board with heatsink and sensor daughter board.

Then the angular velocity (Angle_Rate) and absolute angle (Tilt_angle) are calculated.

Function Filter:
This function calculates the change in acceleration required of the motors (Balance_Diff) and the overall motor speed (Drive_Speed).

Function Process:
This function uses the current speed and the position of the steering control to calculate the necessary modification to the speed of the motors to turn the vehicle as requested. It checks to see if the ATtiny25 has reported an overcurrent condition and reduces the motor speed (Drive_speed) if needed. The overcurrent condition and footswitch alarm states are indicated by the LEDs flashing.
The function calls Get_speed_batt.

Function Get_speed_batt:
This function adds a value Angle_Correction in the case where the maximum speed is exceeded. It also sets the state of the three LEDs according to the battery voltage.

Function PWM_Out:
This function configures the PWM outputs according to the acceleration required for motors A and B, and sets the other outputs to reflect the desired rotation direction.
The function also imposes a limit on the maximum drive power (PWM_MAX).

Function interrupt:
This function is called 100 times per second. In turn it calls Get_Angle, Filter, Process and PWM_Out.

Mechanics

In the second and final part of this series we will look at the mechanics of the ElektorWheelie. We will describe the construction of the vehicle and outline how it is assembled and wired. Finally we will give a few tips on how to drive the vehicle and some further practical suggestions.

(090248-I)

Internet links

[1] http://www.invensense.com/shared/pdf/DS_IDG300.pdf

[2] http://www.analog.com/static/imported-files/data_sheets/ADXL320.pdf

[3] http://www.elektor-usa.com/090248

Figure 6. Control software functions.

Load Protection for Audio Amplifiers

Joseph Kreutz (Germany)

In order to be effective, any protection device connected between an audio amplifier output and the speakers needs to connect the load only after a few seconds' delay, disconnect it immediately the AC supply is turned off, and prevent any high-level DC component from being able to damage the loudspeakers. As the circuit suggested here can readily be 'grafted' onto any existing circuit, it merits the title 'universal'. The circuit diagrams in **Figure**s **1** and **2** relate to a prototype fitted to an amplifier producing 50 W into 8 Ω, with a ±35 V power supply. This circuit can be readily adapted to other supply voltages, and hence to other audio power outputs. The appropriate values for R1, R2, R8, R15, and R19, along with the operating voltages for C1 and C3 and the choice of semiconductors D9, D10, T1, T2, and T3 are given in **Table 1**.

Circuit operation is simple: when the amplifier is turned on, the voltage at the junction of bridge rectifier B1 and diode D1 quickly charges capacitor C7 via resistor R3. Capacitor C7 avoids mains zero crossings causing spurious triggering. When the upper threshold voltage of IC1a is reached, its output goes low. At this moment, C6 is gradually charged via R5, and once the voltage across it reaches the required value, IC1b output goes high and turns relays RE1 and RE2 on via transistors T2 and T3. This process produces a delay of around 5 s. In order for us to be certain that IC1b output starts off low, the initial voltage across C6 must be zero. So this capacitor is connected directly to the +5 V rail. This circuit works by determining voltage thresholds: this means that we need to choose an SN74HCT132 quad Schmitt NAND gate for IC1.

Gate IC1c inverts the relay control signal and feeds it to one input of IC1d, which then operates as an oscillator, making LED D8 flash at around 4 or 5 Hz during the delay period.
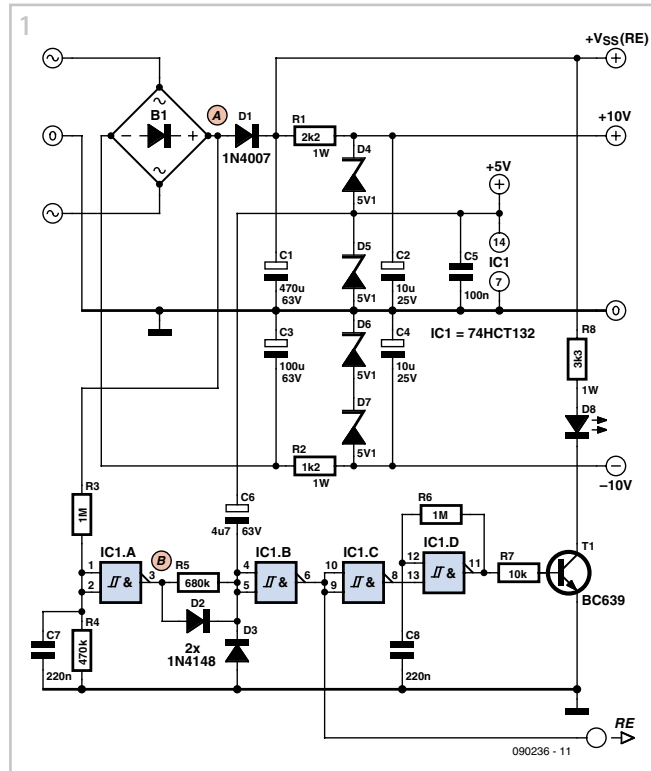
As soon as the relay control signal goes high and the relays turn on, the IC1d oscillator is disabled and LED remains constantly lit. The LED is powered directly from the HT rail across C1, and 3.3kΩ resistor R8 limits the current through it to 10 mA. As shown in **Table 1**, the value of R8 depends on the supply voltage and hence on the power of the amplifier to which the protection circuit is to be connected.

As soon as the AC power is turned off, IC1a output goes high and capacitor C6 discharges rapidly through D2, which then causes IC1b output to go low and the relays RE1 and RE2 to turn off almost immediately. So the amplifier load is isolated instantly and the circuit re-armed so as to produce the required delay next time AC line power is applied.

Detection of any DC component is performed by IC2, an LM339 quad comparator. The networks C9/R12 and C10/R16 act as low-pass filters: they attenuate the audio signal very heavily, but if any DC voltage is present on the amplifier output, it will be fed to IC2's comparator inputs. If it exceeds ± 3.75 V, at least one of the comparators will output a 'low' signal, and thus turn off the corresponding relay control transistor. The load will remain isolated as long as the fault condition continues. This signal will also cause current to flow in the LEDs D11 or D12, indicating that the protection has been activated. Zener diodes D13 to D16 provide over-voltage protection for the comparator inputs. It's wise to make sure that R12 and R16 are indeed correctly connected to the amplifier outputs and not to the relay contacts feeding the loudspeakers. The choice of relays is not really critical: any
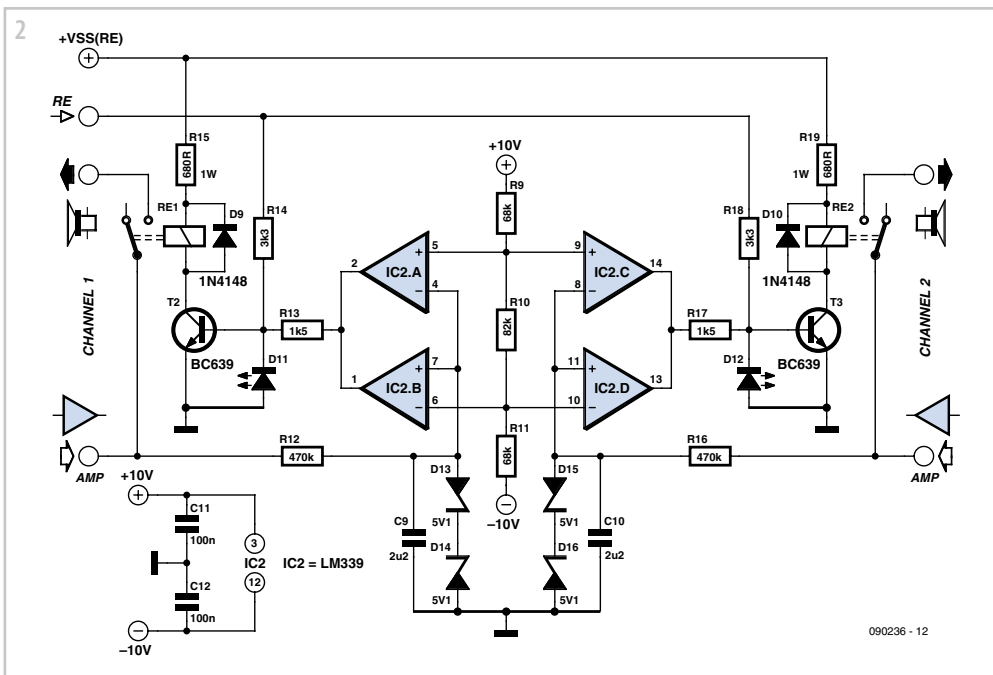

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Table 1. Stereo (2-channel) amplifier

Supply voltage [V]	27	35	47	56	64	70	76
Power into 4 Ω [W]	50	100	200	300	400	500	600
Power into 8 Ω [W]	25	50	100	150	200	250	300
Working voltage for C1 (470 µF) & C3 (100 µF) [V]	40	63	63	80	80	100	100
Value for R1	1k8, 0,25 W	2k2, 1 W	3k3, 1 W	4k7, 1 W	4k7, 1 W	5k6, 1 W	5k6, 1 W
Value for R2	820 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 2 W	2k7, 2 W	2k7, 2 W	3k3, 2 W
Value for R3	2k7, 0,25 W	3k3, 1 W	4k7, 1 W	5k6, 1 W	6k8, 1 W	8k2, 1 W	8k2, 1 W
Value for R15 & R19 (*)	-	680 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 1 W	2k7, 2 W	2k7, 2 W
D9 et D10	1N4148	1N4148	1N4148	1N4148	1N4148	BAV21	BAV21
T1, T2, T3	BC639	BC639	BC639	BC639	BC639	2N5551	2N5551
* for 24 V relays drawing a current in the region of 15 mA.							

type that has a high enough breaking capacity, works from 24 V, and only needs around 15–25 mA to drive it will do. The relays fitted to the prototype are RT 314024 ones made by the Austrian company Schrack [1]. They can switch 16 A, which is enough for amplifiers with pretty reasonable powers. The prototype is fitted to a 50 W per channel stereo amplifier, whose 35 V supply voltage is higher than the relays' rated operating voltage. So it was necessary to fit series resistors R15 and R19 in order to drop the excess 11 V. As the relay coil resistance is 1,450 Ω, these series resistors need to be 680 Ω and rated for a dissipation of 1 W. Naturally, the value of R15 and R19 depends on the type of relay chosen and the amplifier's supply voltage, as shown in **Table 1**. However, the value isn't critical, as the relays are pretty tolerant about their operating voltage. Besides, it's easy enough to find out the resistance of a relay coil: just measure it with an ohmmeter!

It's essential to pick up the power
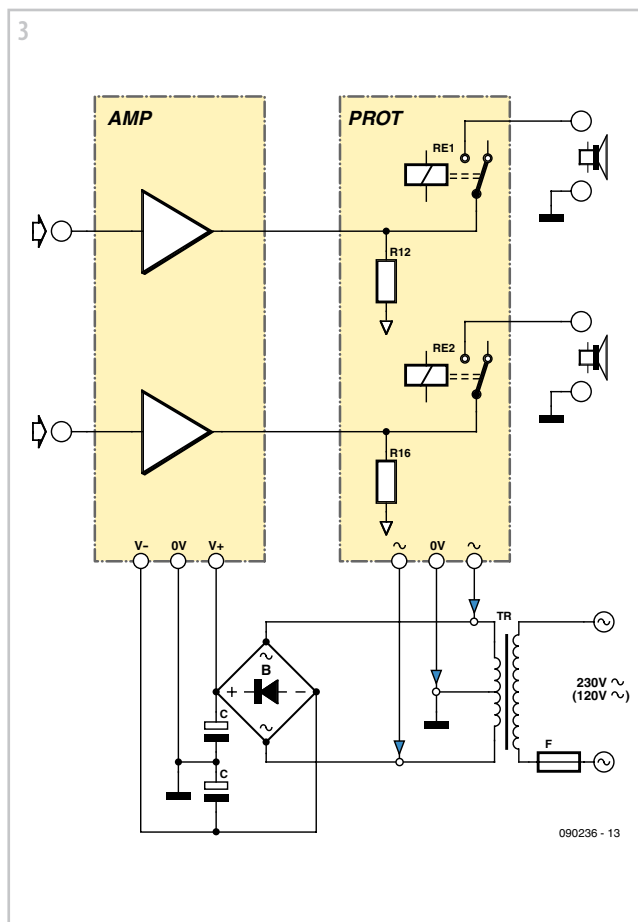
for the circuit directly from the amplifier's power transformer terminals, before the rectifier and smoothing capacitors, as shown in the connection diagram in **Figure 3**. This voltage is rectified by bridge rectifier B1 and applied via D1 to the 470 µF smoothing capacitor C1. The power for the relays and LED D8 is taken from directly across this capacitor. Diode D1 allows capacitor C1 to be isolated as soon as the AC line power goes off: so when the amplifier is turned off, there is zero voltage at IC1a input , and the relays are guaranteed to be off. The +10 V and +5 V rails are regulated by zeners D4 and D5, while D6 and D7 stabilize the −10 V rail feeding IC2. Using two zeners in series limits the power each of them has to dissipate.

It is perfectly simple to extend the circuit for 5+1 or 7+1 channel audio systems, as used on an increasing number of computers. And it's all the more advisable because the sound cards often produce erratic signals when the computer

Table 2. System with 5+1 or 7+1 channels

Supply voltage [V]	27	35	47	56	64	70	76
Power into 4 Ω [W]	50	100	200	300	400	500	600
Power into 8 Ω [W]	25	50	100	150	200	250	300
Working voltage for C1 (2200 µF) & C3 (470 µF) [V]	40	63	63	80	80	100	100
Value for R1	820 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 2 W	2k7, 2 W	2k7, 2 W	3k3, 2 W
Value for R2	270 Ω, 2 W	390 Ω, 2 W	560 Ω, 5 W	680 Ω, 5 W	820 Ω, 5 W	820 Ω, 10 W	1k, 10 W
Value for R3	2k7, 1 W	3k3, 1 W	4k7, 1 W	5k6, 1 W	6k8, 1 W	8k2, 2 W	8k2, 2 W
Value for R15 et R19 (*)	-	680 Ω, 1 W	1k2, 1 W	1k8, 1 W	2k2, 1 W	2k7, 2 W	2k7, 2 W
D4 - D7	BZV85C5V1 or 5V1 device capable of dissipating 1 W						
D9 & D10	1N4148	1N4148	1N4148	1N4148	1N4148	BAV21	BAV21
T1, T2, T3	BC639	BC639	BC639	BC639	BC639	2N5551	2N5551
* for 24 V relays drawing a current in the region of 15 mA.							

is powered up or down, which when amplified can be at best unpleasant, and at worst, damaging for the loudspeakers.

As shown in **Figure 4**, the +5 V supply rail present on the computer's USB bus is applied to one of the inputs of gate IC1a, the other input being used to check the presence of the amplifier supply voltage. So both the computer and the amplifier have to be running for the speakers to be connected after a 5-second delay. The 100 nF capacitor C13 avoids unwanted triggering. Turning off the computer or the amplifier disconnects the speakers immediately.

The **Figure 1** delay circuit, modified as per the circuit in **Figure 4**, is common to all channels, and provides the relay control signal for them all. But the DC component switching and protection unit shown in **Figure 2** has

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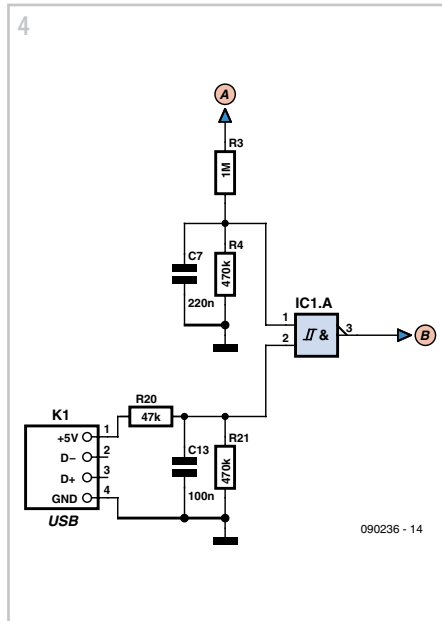
to be repeated 3 or 4 times, so as to be able to control the number of channels in the system. Refer to **Table 2** for the component values for a protection circuit for a 5+1 or 7+1 channel system. The modifications mainly affect the following points:
- The values of R1 and R2 are reduced, but their dissipation increased, as shown in **Table 2**;
- C1 and C3 are also increased to 2,200 µF and 470 µF respectively;
- Zener diodes D4 to D7 change to type BZV85C5V1 or equivalent, capable of dissipating 1 W.

(090236-I)

Internet Link
[1] www.schrack.com

Impact Clock

G. van Zeijts (The Netherlands)

The read/write heads of a hard disk drive are moved back and forth over the magnetic platters by a linear motor. This motor consists of a coil that moves in a strong magnetic field, combined with some sophisticated electronics that drives it such that the read/write heads are quickly positioned to the desired location.

By now enough hard disk drives have crashed that every enthusiast should have no trouble getting his or her hands on one and using it for other purposes.

As the head motor has a fairly long stroke and can supply considerable force, we used it in this project to build a special sort of clock.

If you simply apply a DC voltage to the coil, the arm jumps from one end to the other one with a bang. If you reverse the polarity of the voltage, the arm moves in the opposite direction. The voltage applied to the coil can be controlled by a PC with the aid of a Darlington circuit (**Figure 1**). We used one of the pins of the Centronics port on the computer (K1 in the schematic drawing) to drive the circuit. Here the control signal is provided by pin 2 of the Centronics connector, which cor-

090121 - 11
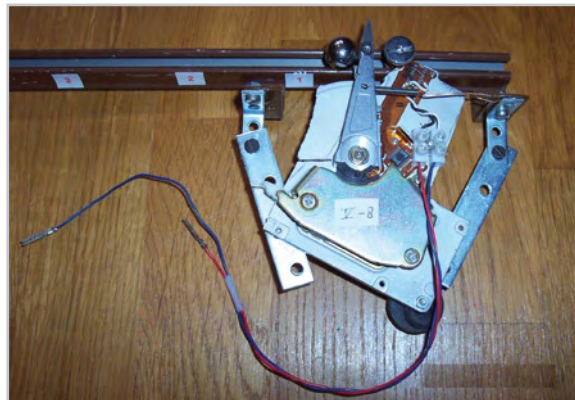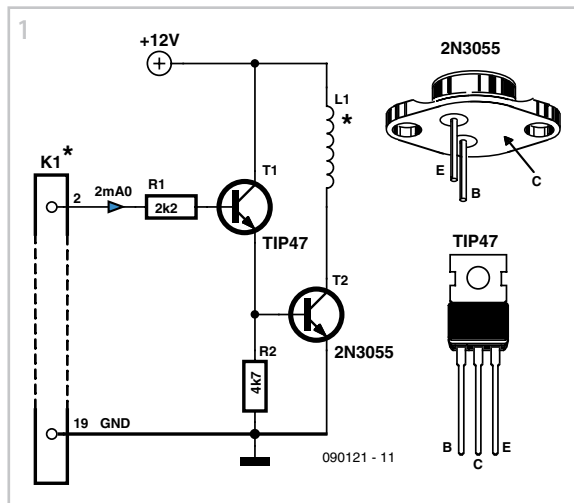
responds to bit 0 of port H378. Pin 19 (ground) is tied to the ground line of the control circuit. Use a hefty AC power adapter for the power supply; it must be able to deliver at least 2 A.

The mechanical design of the clock is rather unusual. It consists of a length of curtain rail arranged at an oblique angle, along which a steel ball from a ball bearing can be propelled upward and roll back down under its own weight. If the ball is struck by a blow whose strength depends on the time of day, it will travel for a certain distance along the curtain rail. By observing the motion of the ball, you can read the time (approximately) from an hours scale marked along the length of the rail. The previously mentioned head motor from a discarded hard disk drive is used to generate the impact on the ball. The ball rests against the arm of the motor when it is at its lowest point on the rail. The computer calculates the force of the impact and drives the motor for a certain length of time.

The program for the clock is written in Visual Basic and has a simple design. The software is extensively documented.

Now for some practical details on the clock:

- Rail length approx. 160 cm (5' 5")
- Height difference (top/bottom) approx. 10 cm (5")
- Ball diameter 17 mm (11/16")
- Head motor coil resistance 5–15 Ω (depending on hard disk model)

- Coil voltage 5–12 V (depending on coil resistance)

The hours scale on the rail must be determined experimentally after first adjusting the impact for 12.00 h so the ball nearly reaches

the highest point of the rail.

Download
090121-11: Visual Basic program, from www.elektor-

Lead Acid Battery Protector

Jürgen Stannieder (Germany)

The circuit described here can be used to ensure that a 12 V sealed lead acid (SLA) gel battery isn't discharged too deeply. The principal part of the circuit is a bistable relay, which is driven by the output of an op amp.

The battery voltage is first reduced via D1, R1, P1 and R2, and then continuously compared with a reference voltage set up by diode D2. When the battery discharges too much and its terminal voltage drops below the level set by P1, the output of the opamp becomes High, which causes the relay to toggle. This in turn isolates the load from the battery. The battery can be reconnected via S1 once the battery has been replaced or recharged.

The relay used in the prototype is a 5 V bistable type made by Omron (G6AK-234P-ST-US 5 VDC). The two windings of the relay each have a resistance of 139 Ω (for the RAL-D 5 W-K made by Fujitsu this is 167 Ω). When the battery voltage starts to become too low and the relay is being reset the current consumption of the circuit is about 45 mA. Shortly

080583 - 11
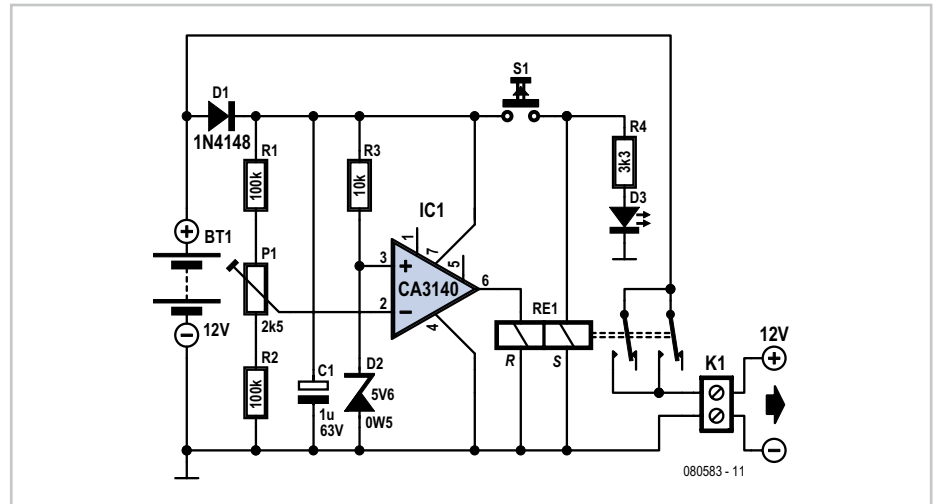
after the load has been disconnected, when the battery voltage rises above the reference voltage again, the reset coil will no longer be powered and the current consumption drops back to about 2.5 mA.

The range of P1 has intentionally been kept small. With a reference voltage of 5.6 V (D2) and a voltage drop of 0.64 V across D1, the circuit reacts within a voltage span of 11.5 V and

11.8 V. This range is obviously dependent on the zener diode used and the tolerance.

For a greater span you can use a larger value for P1 without any problems. With the potentiometer at its mid setting the circuit switches at about 11.6 V.

Automatic Curtain Opener

Ton Smits (The Netherlands)

This circuit can be used with a timer clock to open and close curtains or (vertical) Venetian blinds. The curtain or blind is driven by an electric motor with a reduction gearbox fitted to the control mechanism of the curtain or blind. This circuit is ideal for giving your home an occupied appearance while you are away on holiday or for some other reason. In the author's house, this arrangement has provided several years of trouble-free service on a number of windows fitted with Venetian blinds.
The original design was a simple relay circuit with pushbuttons for opening and closing

and reed switches acting as limit switches. The mechanical drive is provided by a small DC motor with a reduction gearbox and pulley (all from Conrad Electronics).
It was later modified to work automatically with a timer clock. The timer operates a small 230-VAC (or 120-VAC) relay with a change-over contact. Thanks to the two timers, the motor stops after a few seconds if one of the reed switches is missed due to a mechanical defect.
The circuit works as follows (see Figure 1).
In the quiescent state, relays RE1–RE3 are de-energized and the motor is stopped.
Open the blind:

When the timer clock applies power to the 230-V (120-V) relay RE3, the voltage at the junction of C1 and R1 goes high. IC1 (a 555) then receives a trigger pulse on pin 2, which causes its output (pin 3) to go High and energize RE1, which in turn causes the motor to start running. When the magnet reaches reed switch S1 ('Open'), the 555 is reset. If the reed switch does not operate for some reason, the relay is de-energized anyhow when the monostable times out (time delay = 1.1 RC; approximately 5 seconds).
Close the blind:
The timer clock removes power from RE3, which causes a trigger pulse to be applied to

the other 555 timer (IC2) via R5 and C4. Now the motor starts running in the other direction. The rest of the operation is the same as described above for opening the blind.

Diodes D2 and D5 prevent the outputs of the 555 ICs from being pulled negative when the relay is de-energized, which could otherwise cause the timer ICs to malfunction.

All components of the mechanical drive come from Conrad Electronics [2]: a motor with a reduction gearbox (type RB32, order number 221936) and a pulley (V-belt pulley, order number 238341) on the output shaft. An O-ring is fitted to the pulley to provide sufficient friction with the drive chain of the Venetian blind. The magnet for actuating the reed switches is a rod magnet with a hole in the middle (order number 503659), and the chain of the Venetian blind is fed through this hole.

(090150-I)

Internet Links

[1] www.elektor-usa.com/090150

[2] www1.conrad-uk.com

090150 - 11
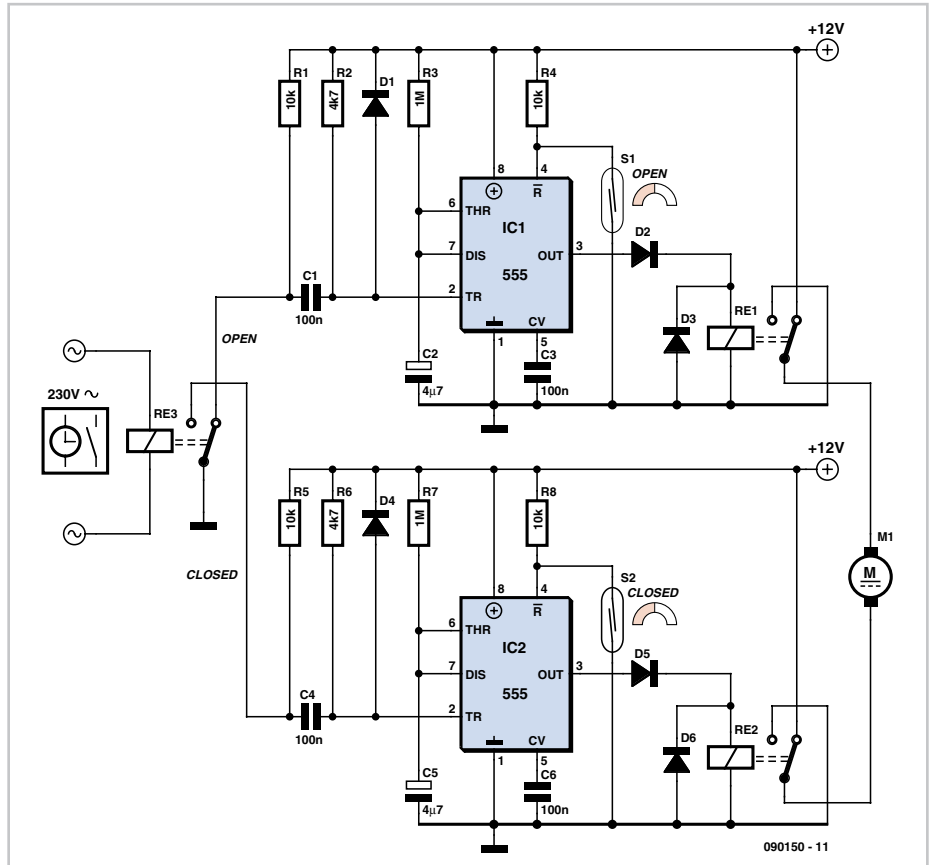
Stress-o-Meter

Markus Bindhammer (Germany)

The common meaning of the term 'stress' is distinctly different from what specialists understand by the term, and even they disagree with each other. The Wikipedia entry for this term [1] gives an impression of its complexity. Consequently, it's a good question whether it is even possible to measure stress. However, it is certainly possible to measure how our bodies respond to stress. No matter whether something is especially pleasant or instead triggers anxiety or aggression, if there is a strong stimulus, our bodies are prepared to act accordingly. Jumping for joy, fleeing, and attacking all cost a lot of energy. One the many consequences is thus an increase in the heart rate, which is probably the most easily measured response to stress.

The resting heart rate of a healthy person is around 50 to 100 beats per minute (bpm). A person's pulse can be measured either electrically with an ECG instrument or by sensing the periodic variation in blood flow through the body tissue. The first method requires electrical contact between electrodes and the skin, which is not especially advisable for
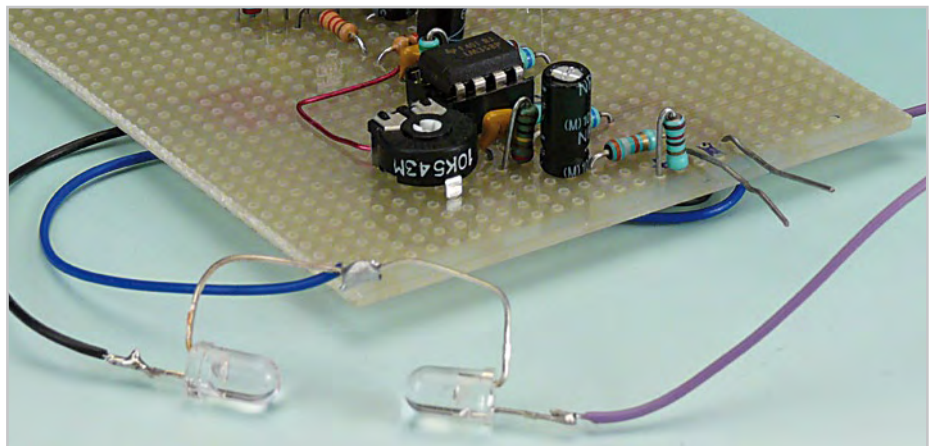
DIY electronics. By contrast, the variation in blood flow can easily be sensed using light transmission, since the absorption of the transmitted light depends on the blood flow. Ear lobes and fingertips are especially suitable for light transmission measurements.

The author converted an ordinary plastic clothespin into a finger or ear clip. To do so, he first drilled a 5-mm hole in each arm of the clip and then glued an IR LED (type SFH487) in one hole and a phototransistor (type SFH309FA) in the other hole (see drawing). A bright red LED or even a white LED can be used in place of the IR LED. It's even possible to use an LDR as the photosensor. Ready-made clips are also available commercially as medical accessories (expensive) or accessories for ergometers and similar sports equipment (inexpensive).

With a 5-V supply, the current through the IR LED is around 30 mA. The sensor signal (with its small voltage variations) passes through a high-pass filter (C1/R3), which removes slow drift, to the non-inverting input of opamp

IC1a. The combination of C2 and R5 forms a low-pass filter that decouples high-frequency noise. IC1a amplifies the signal in the passband, which is centred at 100 bpm, by a factor of 100. A similar combination of filter and amplifier is built around IC1b, in this case with a gain of 500. The LM348 dual opamp is especially suitable for this circuit because it can handle small-signal inputs close to 0 V, even when powered from a single-ended supply. The overall gain of the two stages can be adjusted with P1. The output of IC1b drives T2 and T3 in parallel, so D2 blinks at the same rate as the variation in blood flow through the ear or finger between D1 and T1.

The 'excess rate', or stress, is indicated by IC2, a conventional 555 timer IC. Transistor T3 shorts out capacitor C6 when D2 is on. This resets the internal flip-flop of the 555 and causes pin 3 to go High, which in turn causes D4 to light up. When D2 is off, C6 can charge via R12. If the charging interval is long enough for the voltage on C6 to rise to two-thirds of the supply voltage, the output of the 555 changes state, LED D4 goes dark, and D3 flashes briefly. This means that the user's pulse rate is low as long as D3 blinks periodically. C6 and R12 are dimensioned such that D3 remains dark at heart rates above 100 bpm.

For safety reasons, an AC power adaptor should not be used as the power source. The circuit works properly with a supply voltage of 4.5 to 7 V, so a set of four alkaline, NiCd or NiMH cells forms a perfectly adequate power source.

(080831-I)

Internet Link

[1] http://en.wikipedia.org/wiki/Stress
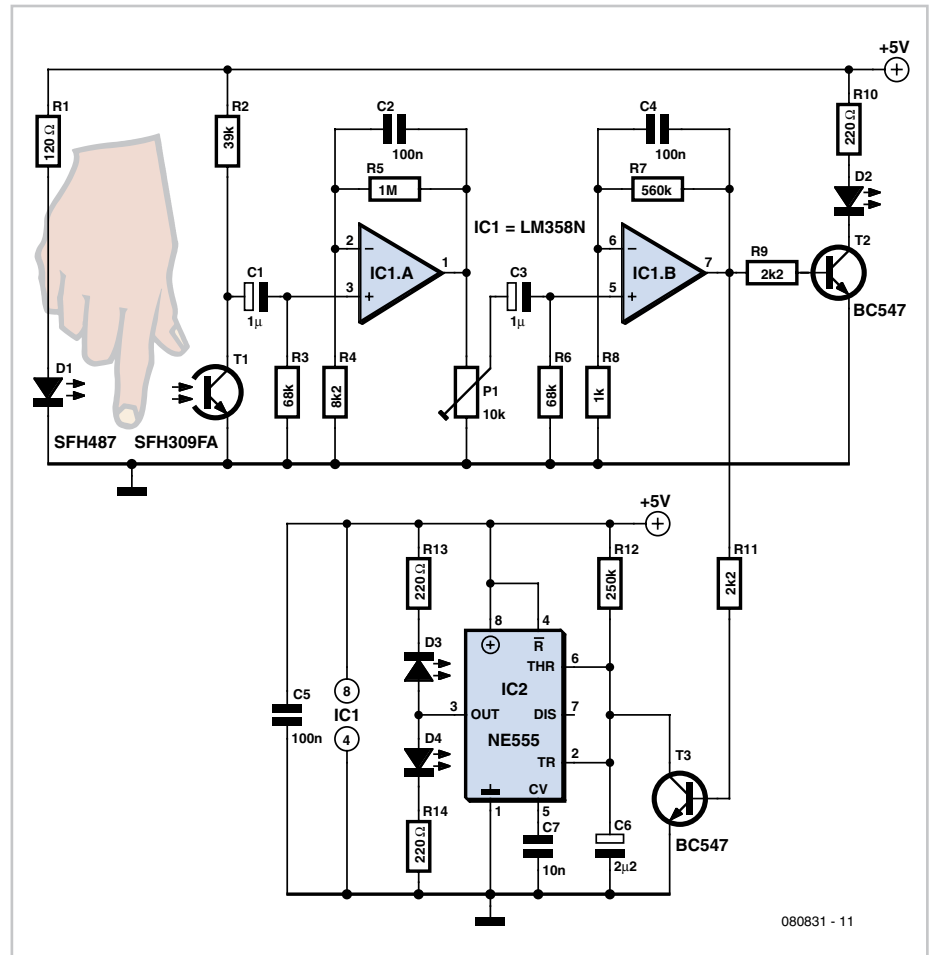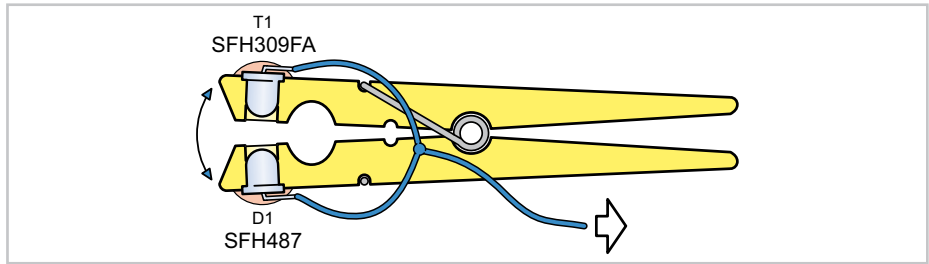
Powering a Second Hard Drive

Leo Szumylowycz (Germany)

Just about every hands-on computer builder knows the problem: you've acquired an extra hard drive or cooling fan but there are no spare cables or connectors to power these additional components inside the computer case. In situations like this splitter cables, also called Y-cables, can be a blessing. But what if you don't have one of these to hand and the local computer shop is closed? There's only one thing for it — DIY! As tasks go, splicing in an extra cable is not particularly difficult, as long as you have sharp eyesight. All you need is a second power cable and a choc block ter-

minal strip and the job's done. It works adequately (for a while) but it doesn't look particularly attractive, reliable or professional.

A more elegant solution would be to solder the new power cable direct to the corresponding connector of the existing device. Elegant, yes, but not particularly straightforward, since the power supply rails are seldom easy to get at, whilst the metal pins of individual power connectors are of course buried inside their plastic shell.

A little trick involving the sleeves that go on the ends of wires will enable you to extract the pins as far out of the retaining mount as

needed to solder onto the rear of these pins additional wires for the accessory device you wish to install.

We need two types of sleeves, 4 mm (0.16") for the plugs and 6 mm (0.24") for the sockets.

First of all the contact on the cable is pressed hard into the plastic retainer to ensure the restraint spring grips cleanly and fully.

Next we attach wire sleeves to the pin that we are extracting and push it carefully and slowly into the plastic retainer as far as the latch and end stop. Just before this point is reached you will feel some resistance, with a click sound heard after you have overcome
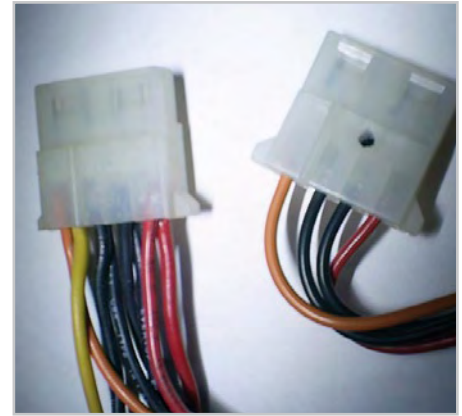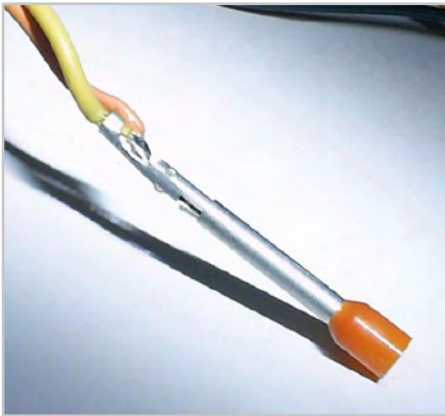
the pressure. Exactly as this click is heard you need to remove the wire in question, with its pin, from behind out of the plastic housing. If this doesn't work exactly as desired, it can help to twist the sleeve around while you are pulling. Normally you can release about four pins using one sleeve. For assured reliability, however, it is recommended to use several

sleeves.

The free ends of the additional cable should be soldered (using great care and as little solder as possible, as shown in the photo) to corresponding pins close up against the existing cable. Any unwanted solder blobs are best removed with desoldering braid (solder wick). Finally we need to bend the con-

tact springs gently outwards and press each pin back into its right position. You will find the longer sizes of sleeve are easier to handle, also that the individual parts of the connectors move around more easily if you spray them first with contact lubricant.

(090201-I)

Two-button Digital Lock

Francis Perrenoud (Thailand)

Now here's a digital lock unlike any other, as it has only two buttons instead of the usual numeric keypad. The way it works is as simple as its keypad. Button S1 is used to enter the digits of the secret code in a pulsed fashion — i.e. the number of times you press the button is determined by the digit to be entered. A dial telephone uses the same type of coding (now maybe there's an idea?). Press four times for a 4, nine times for a 9, etc. Pressing button S2 indicates the end of a digit. For example, to enter the code 4105, press S1 four times, then press S2, then S1 once, S2 once, then without pressing S1 at all, press S2 again, then finally S1 five times and S2 once to finish. If the code is correct, the green LED

D1 lights for 2 seconds and the relay is energized for 2 seconds. If the code is wrong, the red LED D2 lights for 2 seconds, and the relay is not energized.

To change the code, fit a jumper to J1 and enter the current code. When the green LED D1 has flashed twice, enter the new 4-digit code. D1 will flash three times and you will need to confirm the new code. If this confirmation is correct, D1 will flash four times. If the red LED D2 flashes four times, something's wrong and you'll need to start all over again. To finish the operation, remove the jumper and turn the power off and on again — the digital lock is now ready for use with the new code.

The software can be found on the web page for the project [1]. Don't forget to erase the

microcontroller's EEPROM memory before programming it, so you can be sure that the default code is 1234 and not something unknown that was left behind in the EEPROM.

A little exercise for our readers: convert this project into a single-button digital lock — for example, by using a long press on S1 instead of pressing S2 to detect the end of a digit.

(090127-I)

Internet Link

[1] www.elektor-usa.com/090127

Download

090127-11: source codes and hex file, from [1].

Wireless Baby Monitor

Wolfgang Papke (Germany)
Ton Giesberts (Elektor Labs)

Walkie-talkies (also known as handheld or PMR, Personal Mobile Radio) can be bought at low prices even from department stores, and they can be operated without a licence in many countries. Considering the low cost, such a set would be very suitable for use as a wireless baby monitor, with the addition of several external components. These are connected to the jack sockets for an external loudspeaker/microphone and an external PTT (Push-To-Talk) switch, which are often found on these devices.

The walkie-talkie with the extra electronics and microphone is placed in the baby's room. When the PTT switch on the other walkie-talkie is actuated for about a second the 'baby' walkie-talkie produces a series of tones, which the external electronics can detect. This then activates its own PTT switch for about 5 seconds, so it switches over to transmit. During this time the other device can hear what the external microphone picks up.

Figure 1 shows the circuit that the author designed for this. It has been designed specifically for a Tevion 3000 PMR sold some time ago by Aldi. This type of PMR has a combined jack socket that includes all the required connections.

The voltage present on the PTT connector is used to generate the supply voltage for the circuit via R3, D1 and C1/C2. When the loudspeaker output presents a series of tones (when the PTT switch on the other walkie-talkie is held down), it causes T1 to conduct. This also turns on T2 and T3, so that the external microphone is connected to ground. The resulting current that flows through the microphone should be sufficient to activate the PTT circuit in the walkie-talkie, causing it to transmit. If the external microphone doesn't draw sufficient current, a resistor (R8) should be connected in parallel. Some experimentation with the value of this resistor may be required. If you want to make use of the internal microphone then R8 should be replaced with a wire link.

When the walkie-talkie switches to transmit the built-in amplifier stops producing a signal and T1 turns off. However, since electrolytic capacitor C3 has been charged up in the mean time, transistors T2 and T3 will keep conducting for several seconds until C3 has been almost discharged via R4.

In the Elektor labs a simpler version with the same functionality (**Figure 2**) has been designed for use with a cheaper PMR set

that can be obtained from Conrad Electronics (PMR Pocket Comm Active Pair, order number 930444). These walkie-talkies have separate jack sockets for the LS/Mic and PTT connections.

When there is a call a series of tones is produced that is used to turn on T1 via R3. T1 then activates the PTT function and the microphone amplifier is turned on. However, it's not just the audio signal that is used, but also the DC offset produced when the internal output stage is turned on. Both the internal as well as external loudspeaker are driven via an output capacitor of 100 µF.

When there is a call it charges up via R3 and the base-emitter junction of T1. If the walkie-talkie is called often there would be a danger that the output capacitor would remain charged and the DC offset of the audio signal would no longer be sufficient to turn on T1. To prevent this, D1 is connected in reverse across the base-emitter junction of T1, providing a discharge path for the output capacitor. To keep the circuit active for a minimum amount of time the microphone voltage is used to provide an extra base current. This is done by charging C1 via R1. When the transmitter is turned off the microphone and R2/

1

080701 - 11
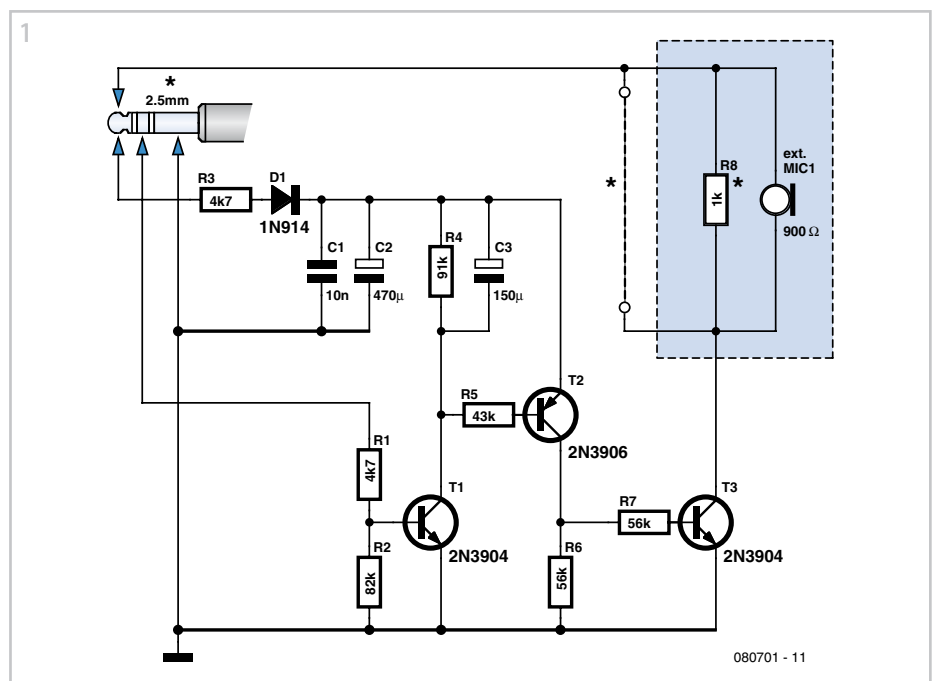
D1 provide a discharge path for the capacitor. C2 ensures that the circuit won't react to spikes caused by interference. As can be seen from the second circuit diagram, use is made of two connectors, a 2.5 mm jack plug for an external headset and a 3.5 mm plug for the PTT function. These connectors are particular to the walkie-talkies we used here. With other types of walkie-talkie you should first check the connection details of the connectors before you connect the circuit up.

When the circuit is used as a baby monitor you should check that the microphone you're using can pick up all the sounds. In our case the microphone didn't appear to be very sensitive. The microphone amplifier has probably been designed for a voice that is near the PMR unit. When used as a baby monitor the microphone should therefore be positioned as close to the baby as possible.

(080701-I)
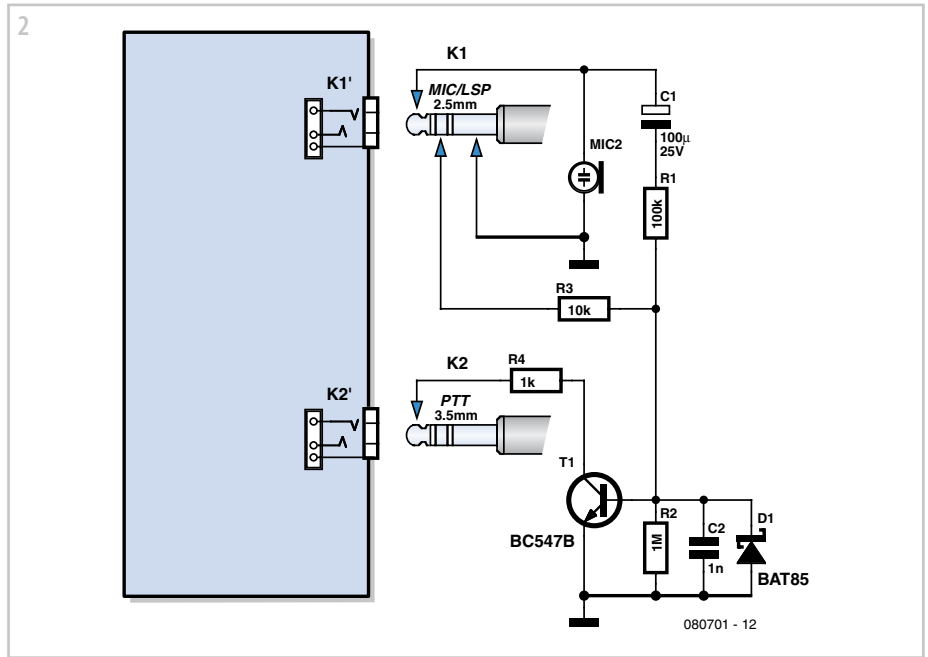
Network RS232

Marcos Agra-Trillo (United Kingdom)

With an ever increasing number of off the shelf electronic modules and boards available at low prices, designers are inclined to use these instead of making all their electronics from scratch. In many cases this makes sense as developing say, a PID motor controller or a GPS receiver from scratch requires considerable skill, time and effort. A surprising number of modules still have an interface based on RS232. No wonder, as RS232 is easy implemented on a microcontroller with two I/O pins and a line driver such as the MAX232. In the case where the master is a PC, the serial port is relatively easy to access on both Windows and Linux. Usually modules implement a text terminal interface that decodes single line commands with arguments and generate a reply like this:

```
Tx: cmd arg0 arg1 ... argX/n
Rx: cmd arg0 arg1 ... argX/n
replyline0/n
replyline1/n
...
replylineY/n
```

A complication occurs when there are a number of RS232 modules in a project, as each requires a serial interface at the master. A hardware solution in the form of an RS232 multiplexer would be a solution but wouldn't it be nice to get this functionality for free!
By deviating from the original aim of RS232 as a point-to-point link, we can have an RS232 network in which all the modules share both transmit and receive lines to one master interface. All modules operate at the same speed,
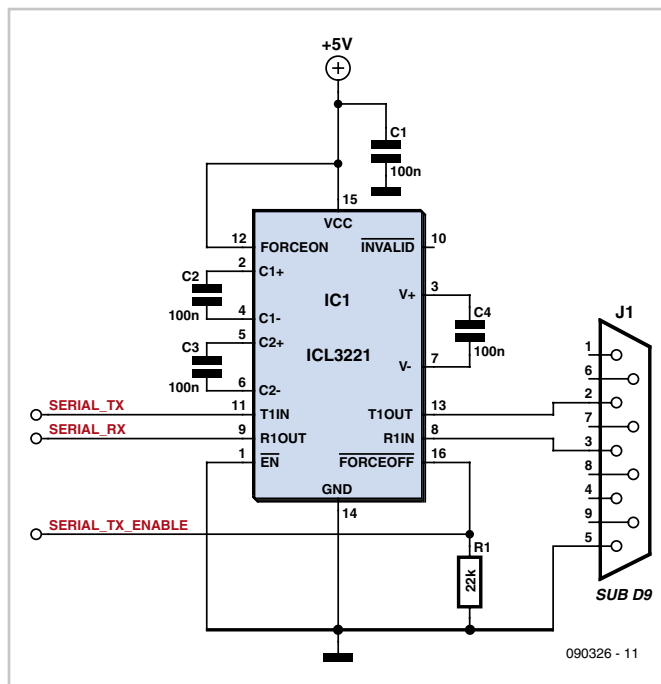
start and stop bits with no flow control. When idle, all the modules are listening for commands from the master and have their transmitters disabled. Each module is configured with an identifier consisting of a number that the master sends as a single line (e.g. '2/n' selects module 2). If a module receives an identifier that matches its own, it is selected and can decode commands and drive its transmitter for the duration of the reply. Conversely, if the identifier does not match it must not decode commands and ensure its transmitter remains disabled.

In addition to some firmware support, the RS232 driver electronics must be able to tri-state the transmitter while keeping the receiver operational. Sadly, the classic MAX232 driver is unsuitable but the ICL3321 and MAX242 are possible candidates for our purpose. These have low-power shutdown modes that power-down the charge pump and transmitters but keep the receivers enabled for monitoring RS232 activity.
The number of modules in your RS232 network is limited by the (nominal) 5 kΩ pull-down at the receiver input of the line driver device. Multiple modules increase the loading

on this signal, reducing the maximum operating speed and cable length. Using the circuit shown here, running an application with five modules at 9,600 bps located within 3 feet of each other did not present any problem.

Modules need a means of enabling the network mode and setting the unique identifier. This can be done via switches, jumpers or, if I/O pins are scarce, by storing the configuration in the user EEPROM/Flash provided by many microcontrollers. If the latter is done, it is reasonable to assume the module will only be configured with normal RS232. Special configuration commands can then be provided that are always decoded irrespective of the identifier match.

It is unlikely that commercially available modules can be tweaked to support 'network' RS232 unless the vendor has used a suitable RS232 line driver and is prepared to provide the firmware code. However, it is possible to implement on DYI modules and perhaps module designers can take note and enhance the functionality of their future designs.

(090326-I)

Simple Wire Link Bender

Louter van der Kolk (The Netherlands)

When you want to mount components on a PCB or a piece of prototyping board, you not only want to do this quickly, but also tidily. The bending of really tidy wire links with the correct pitch is often a tedious chore. The following is a handy aid for doing this.

Using a small piece of 0.1 inch (2.54 mm) prototyping board, you can very easily make a handy bending jig for wire links. With a jigsaw, cut the piece of prototyping board into a staircase shape as shown in the drawing. You can make it as big as you need. Make sure that the horizontal cuts are slightly towards the outside with respect to the holes, so that clear indentations remain in the horizontal sections.

Bending a wire link is now very easy: choose the desired pitch on the jig (dashed line), take

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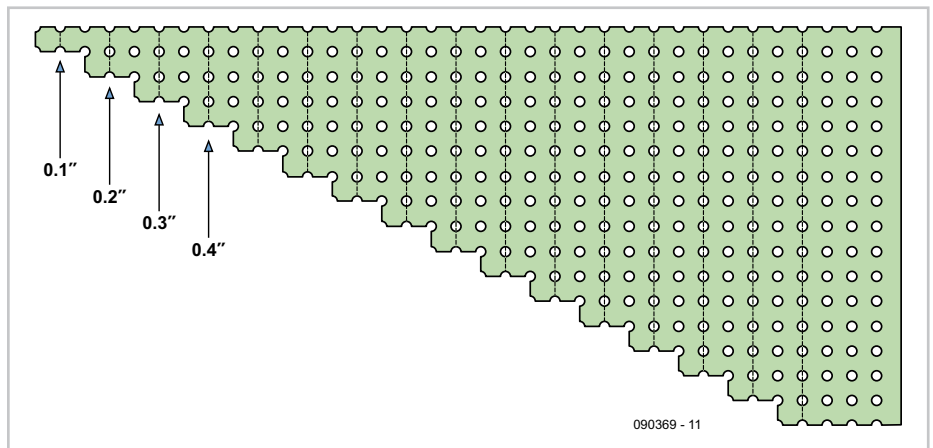
a piece of wire and fold it sharply around the indentations corresponding to the selected pitch. A neat wire link is the result, with exactly the right pitch and ready for soldering tightly into the PCB or prototyping board. With close-fitting wire links the board looks much better and they are also mounted much more quickly.

Tof course he bender is also suitable for resistors with leads.

(090369-I)

Single-cell Power Supply

Harald Broghammer (Germany)

Many modern electronic devices and microcontroller-based circuits need a 5 V or 3.3 V power supply. It is important that these voltages are constant and so a regulator of some kind is essential, including in battery-powered devices. The simplest approach is to select a (perhaps rechargeable) battery whose voltage is rather higher than that required by the circuit and use an ordinary linear voltage regulator. Unfortunately this solution is rather wasteful of precious energy and space: for a 5 V circuit at least six NiCd or NiMH cells would be required.

Both these disadvantages can be tackled using a little modern electronics. A good way to minimize energy losses is to use a switch-

Characteristics
● Input voltage from 0.7 V to 5 V
● Output voltage from 2.5 V to 5.5 V
● Maximum output current 2 A
● Can run from a single cell

ing regulator, and if we use a regulator with a step-up topology then we can simultaneously reduce the number of cells needed to power the circuit. Fortunately it is not too difficult to design a step-up converter suitable for use in portable equipment as the semiconductor manufacturers make a wide range of devices aimed at exactly this kind of application. The Maxim MAX1708 is one example. It is capable of accepting an input voltage anywhere in the range from 0.7 V to 5 V,

and with the help of just five external capacitors, one resistor, a diode and a coil, can generate a fixed output voltage of 3.3 V or 5 V. With two extra resistors the output voltage can be set to any desired value between 2.5 V and 5.5 V.

The technical details of this integrated circuit can be found on the manufacturer's website [1], and the full datasheet is available for download. An important feature of the device is that it includes an internal reference and integrated power switching MOSFET, capable of handling currents of up to 5 A. It is, for example, possible to convert 2 V at 5 A at the input to the circuit into 5 V at 2 A at the output, making it feasible to build a 5 V regulated supply powered from just

two NiCd or NiMH cells. With a single cell the maximum possible current at 5 V would be reduced to around 1 A.

The example circuit shown here is configured for an output voltage of 5 V. The capacitor connected to pin 7 of the IC enables the 'soft start' feature. R2 provides current limiting at slightly more than 1 A. For maximum output current R2 can be dispensed with. Pins 1 and 2 are control inputs that allow the device to be shut down. To configure the device for 3.3 V output, simply connect pin 15 to ground.

090070 - 11
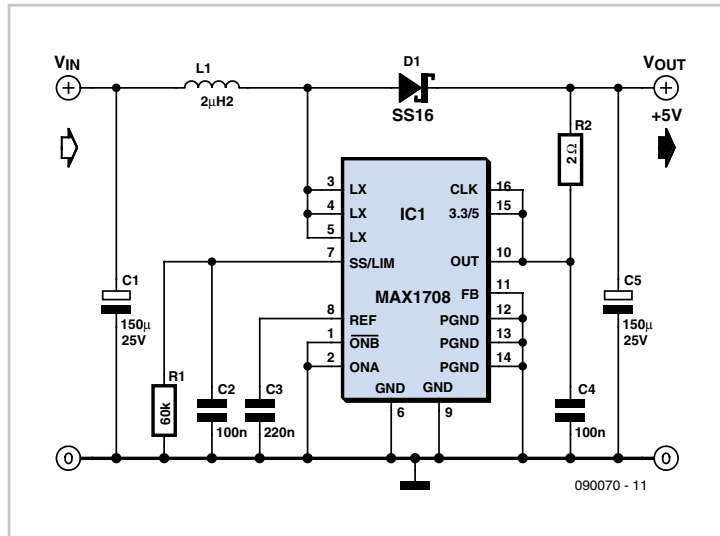
The coil and diode need to be selected carefully, and depend on the required current output. To minimize losses D1 must be a Schottky type: for a 1 A output current the SB140 is a suitable choice. For L1 a fixed power inductor, for example from the Fastron PISR series, is needed. A fundamental limitation of the step-up converter is that the input voltage must be lower than the output voltage. For example, it is not possible to use a 3.7 V lithium-polymer cell (with a terminal voltage of 4.1 V fully charged) at the input and expect to be able to generate a 3.3 V output, as diode D1 would be permanently conducting. On the other hand, there is no difficulty in generating a 5 V output from a lithium-polymer cell.

(090070-I)

Economy Timer

Stefan Hoffmann (Germany)

Windows should be opened only a few minutes for ventilation, and due to the risk of break-ins, you shouldn't leave windows open for hours on end or when nobody is at home.

This circuit detects when a window is open (it can also be used with a door), indicates that the window is open by means of a red LED or a blinking LED, and emits a loud acoustic signal from an intermittent electronic buzzer to remind you to close the window.

The active components consist of a pair of type 555 timer ICs. Switch S1 is a reed switch that is attached to the window frame, and when the window is closed the switch is closed by a magnet attached to the window casement.

When the window is closed, the reed switch connects resistor R1 to the 4.5-V supply voltage. If the window is opened, S1 opens as well and the voltage on R1 drops immediately to 0 V. As a result, the trigger input of IC2 is briefly pulled to ground via C1. IC2 is wired as a monostable flip-flop, and it is triggered by this pulse. After C1 charges, the supply voltage is again present at the trigger input of the monostable flip-flop (via R2). This

090109 - 11

prevents retriggering and allows the monostable to time out normally.
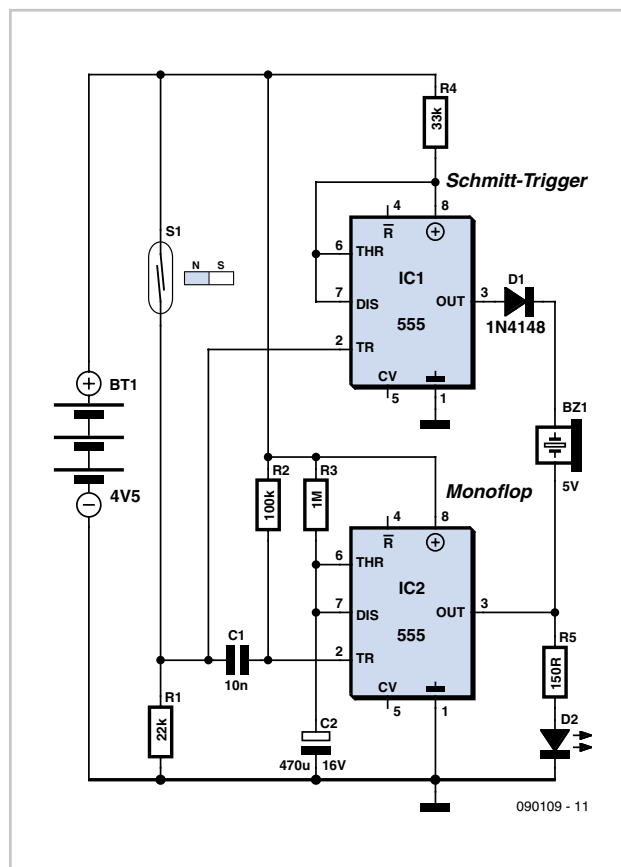
The red LED or blinking LED (user option; select the value of the series resistor accord-

ingly) indicates that the timer is running (pin 3 is logic High). The output of the second 555 IC, which configured as a Schmitt trigger, also goes High when its trigger input is pulled to ground. As a result, the DC buzzer connected between the outputs of the two 555 ICs is not energized because both outputs are High.

If the window is closed within the time interval determined by the R3/C2 network, the output of the Schmitt trigger returns to the Low state. If the output of IC2 is still High, diode D1 prevents any current from flowing through the DC buzzer. After the monostable times out, the outputs of both 555 ICs are Low and the buzzer remains silent.

Things are different if the window is still open when the monostable times out. The Schmitt trigger output remains High, but the monostable output goes Low. As a result, a positive voltage is applied to the buzzer, and it generates an acoustic signal until the window is closed. As befits an intermittent buzzer, it generates an intermittent signal.

The time-out interval of the monostable can be calculated reasonably accurately with the formula

$$t = 1.1 \times C2 \times R3$$

With the indicated component values (1 MΩ and 470 µF), the alarm sounds after approximately nine minutes if the window is still open.

Instead of the reed switch, you can use a light-dependent resistor (LDR) to detect the light from the refrigerator lamp. If you replace R1 with a trimpot and adjust it so that the monostable is triggered when the refrigerator lamp goes on (when the refrigerator door is opened), after the monostable times out the buzzer will remind you to close the refrigerator door (which is often left open). A nice side effect here is that you can use this circuit to definitely answer the age-old question of whether that refrigerator lamp actually goes off when the fridge door is closed ;-).

Full-color Night-flight Illumination

Steffen Schütte (Germany)

There are various types of night-time illumination available for model aircraft. The circuit described here is special in that it allows the color of the RGB LED that is used to be controlled remotely. The circuit can be connected to a spare receiver output channel or in parallel with a channel already in use for other purposes. The color of the RGB LED changes according to the servo position for the selected channel and according to the selected mode of operation.

080060 - 11
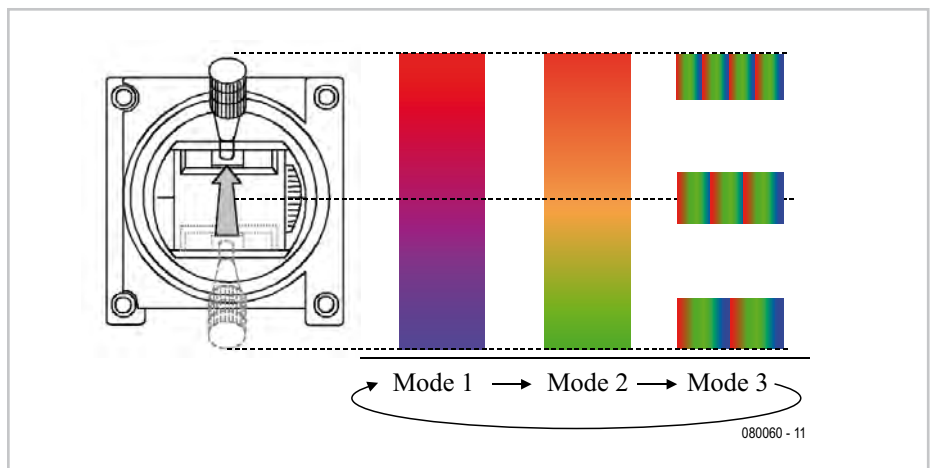
Characteristics
- Supply voltage: 4.8 V (4.5 V to 5.5 V)
- Maximum current for each output: 150 mA
- Maximum current per LED module: 150 mA (50 mA per color)
- Operating modes: 3
- Servo range: ±100 %
- Dimensions (prototype): 32 mm x 25 mm x 7 mm
- Controller weight: 5 g
- LED module weight: 0.7 g

At the heart of the circuit is a PIC12F675 microcontroller (IC1), which is connected to one output channel of the radio receiver: this allows it to measure the corresponding servo position. Depending on its operating mode, the microcontroller generates pulse-width modulated waveforms on three outputs, which in turn drive the connected RGB LED (or LEDs) via transistors T1 to T3 to produce a range of colors. The other main components are the mode button S1 and a four-way connector (K2) used for in-system programming (ISP) of the microcontroller. D1 and D2 are required to prevent a connected radio receiver from interfering with the programming operation.

In contrast to the simplicity of the hardware, the software running in the microcontroller is rather complex. Commented source code is available for free download from the project page at www.elektor-usa.com. The most important parts of the program are the ini-

080060 - 12
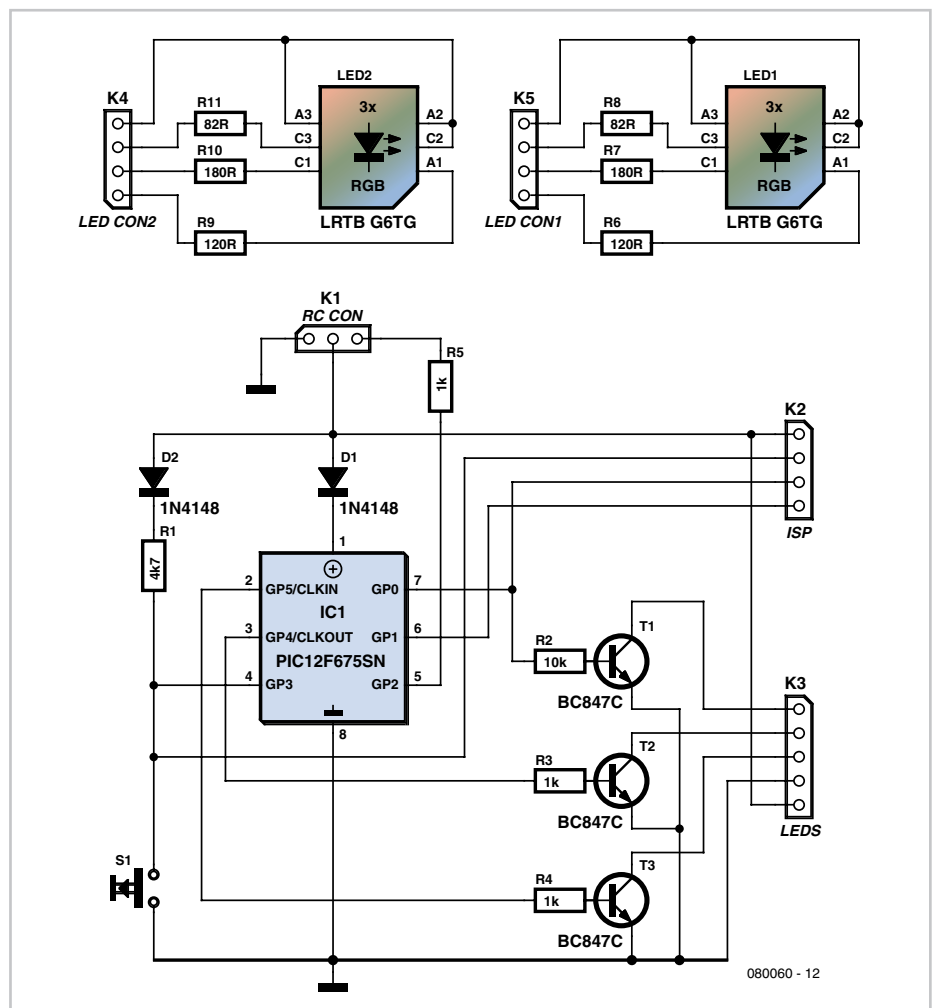
tialisation code, the interrupt routine and the main loop.

The interrupt routine is triggered by a level change on the input port pin connected to the radio receiver. It tests whether the edge is rising or falling: if rising, Timer1 is set to zero to allow the time to the following falling edge to be measured. The pulse width corresponds to the servo position and is output by the receiver every 20 ms. The 20 ms timebase derived from the receiver signal is also used to orchestrate the polling of the mode button. When the mode button is pressed (the input port pin going from High to Low) the device changes mode.

If the device is not in continuously-changing mode the new color for the RGB LED is calculated in the interrupt routine by calling the routine 'calcResult'. If the device is in continuously-changing mode the relevant calculations are performed in the main loop.

Pressing S1 cycles through the following operation modes (see also the accompanying figure). In mode 1 the color changes from blue (minimum servo position) to red (maximum position). A press of S1 advances to mode 2, where the color changes similarly from green to red. A further press enters mode 3, where the color changes continuously, with the speed of the change depending on the servo position. Finally, pressing the button once more returns to mode 1. The most recently used mode is stored in the microcontroller's EEPROM while power is not applied.

When power is applied to the receiver the channel that has been selected for use must be set to its minimum position. This is because the circuit uses the initial value of the pulse width to 'learn' the minimum position. If the channel is not set to its minimum position, the device will never fully reach the color red (in modes 1 and 2) or the maximum possible color-changing speed (in mode 3).

The upper part of the circuit diagram shows how the RGB LED can be connected to connector K3. It is possible to connect multiple LED units in parallel. An extra pin on K3 is taken to ground in order to allow permanently-lit LEDs to be connected alongside the RGB LEDs. It is of course necessary to keep within the maximum permissible current draw from the receiver or battery eliminator circuit (BEC).

(080060-I)

Download

Product

Smoggy

use your Walkman to detect electrosmog

Tony Ruepp (Germany)

Even if your good old (Sony) Walkman sees little use nowadays it would be a shame to get rid of it altogether. The more so when just removing the tape head would allow the built-in audio amplifier to become an outstanding electrosmog detector for a variety of purposes.

Looking at the schematic, readers with RF experience will have no difficulty in recognizing the diodes and coils of the two detector-receivers, which serve to capture and demodulate RF signals. With its coil of four turns (L2) one receiver covers the higher frequency range of the electromagnetic waves, whilst the second detector takes care of the lower frequency range. For this reason a coil with a greater number of turns is required: L1 is an RF choke of about 250 µH. The precise value is not critical and it could equally be 220 µH or 330 µH.

The outputs of both detector-receivers are connected to the cables disconnected previously from the tape heads, feeding the right and left channel inputs to the Walk-

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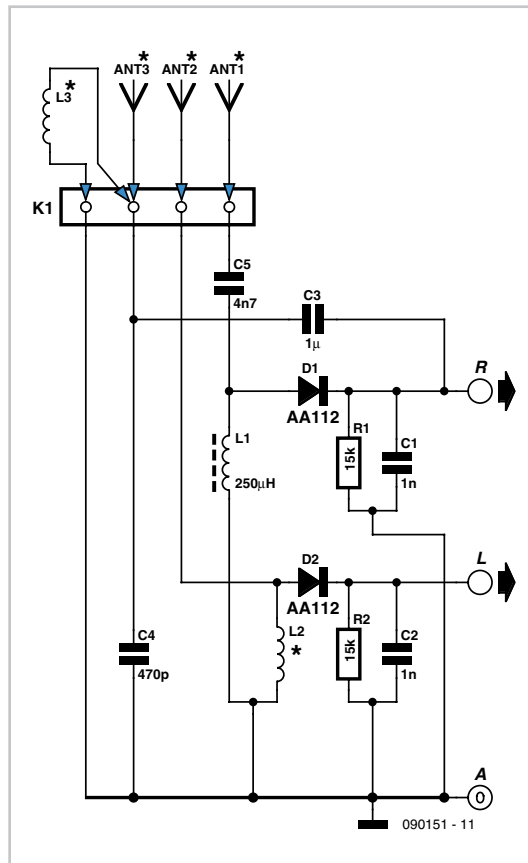
man's audio amplifier. Please note here that the screening of the tape head cable does not have to be absolutely identical to the ground connection of the amplifier circuitry. As we are dealing with a stereo amplifier, we are listening into both channels and thus both RF ranges at the same time.

One channel of the amplifier can also be used to demodulate low-frequency magnetic alternating fields via a capacitor (C3) bypassing diode D1 and connecting either a third coil (L3, for instance; a telephone recording adapter) as the pickup device or else a long piece of wire for acquiring low frequency AC electrical fields. Sources like this are discernible mainly by a distinct 60 Hz (or 50 Hz) humming in the earphones.

Predicting what you may hear down to the very last detail is difficult, since every locality has its own, individual interference sources. Nevertheless, with practice users will succeed in identifying these interference sources by their particular audio characteristics.

To sum up, four different 'sensors' can be connected to the inputs of this circuit: ANT1 (approx. 50 cm long whip antenna), ANT2 (3.5 cm short stub antenna), ANT3 (approx. 1 m long wire antenna for low frequency electrical fields) and a coil for magnetic fields. Finally, two more tips:

1. Use only 'good old' germanium diodes for D1 and D2. Sensitivity will be much reduced if silicon diodes are used, as these have a higher threshold voltage.

2. Smoggy does not provide an absolute indication of field strength and even more so cannot provide any guidance whether anything it detects might be harmful. Its function is to

detect electromagnetic signals and compare their relative magnitude.

Solar-driven Moisture Detector

Christian Tavernier (France)

When we think of solar cells or panels, what springs to mind immediately is producing power — only natural, given the primary purposes of such devices; but we don't necessarily think of using them in applications where the fact they don't produce power in the absence of light may actually be useful. Yet this is just the case in the project discussed here.
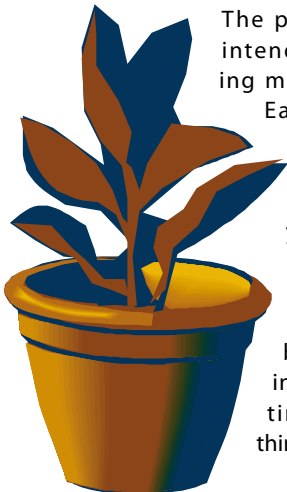
The project, then, is intended for detecting moisture here on Earth using solar power. It's primarily aimed it at those of you who like to brighten up their house or flat with pot plants, but are afraid of inadvertently letting them die of thirst.

Using its two electrodes, formed from two stiff pieces of bare copper wire, it can be stuck into the pot of any plant you want to monitor. As long as the plant isn't thirsty, i.e. the soil in the pot is moist enough, it will just sit there and do nothing at all. But when the soil dries out below a certain threshold (which you can adjust to suit the soil used and the plant being monitored), it starts 'squealing' to tell you it is time to give the poor plant a drink.
But so that your husband/wife/girlfriend/boyfriend (as applicable!) won't throw your plant out of the window because the detector has started squealing in the middle of the night, we obviously want it to work only during the day. This is where the solar cell comes in handy: on the one hand, it is used to power the circuit, making it totally stand-alone; and on the other, the lack of power produced when in darkness means the circuit is automatically silenced at night.
Once we've adopted this principle, the circuit is remarkably simple, using just a single 4093

081174 - 11
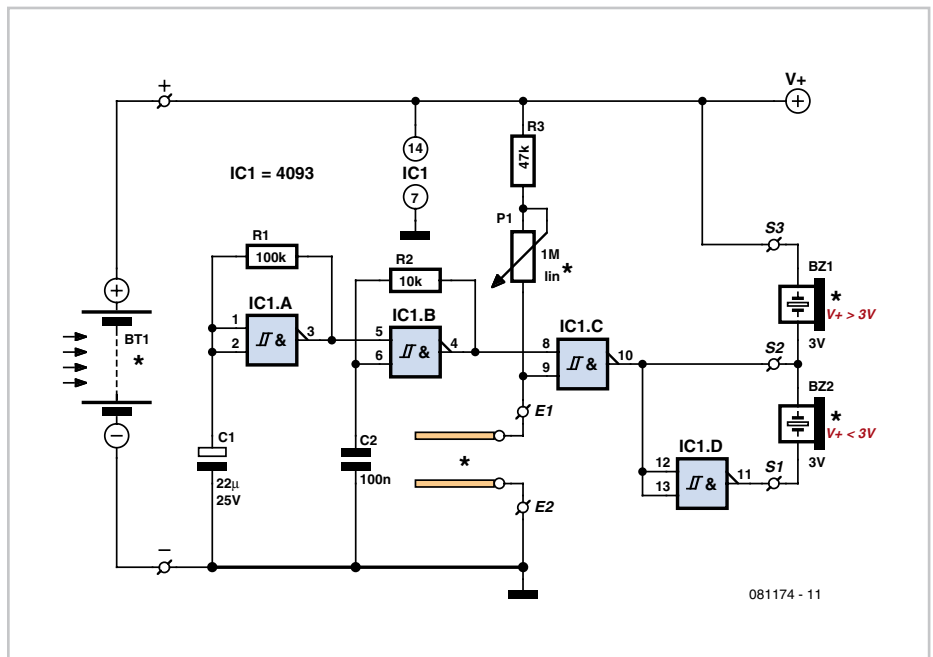
CMOS logic chip, which contains four 2-input Schmitt trigger NAND gates.
The first gate, IC1a, is wired as a very low frequency astable oscillator. When its output is at logic high, which occurs at regular intervals, it enables IC1b, which is also wired as an astable oscillator, but this time at an audible frequency. The signal from IC1b then has to pass through IC1c, which can only happen if

E1 and E2 are not connected, allowing the corresponding input to be pulled up to logic High. You will have realized that E1 and E2 are the electrodes stuck into the soil and so will not be connected if the latter is not sufficiently conductive, i.e. when it starts to dry out. The threshold at which gate IC1c turns on is obviously adjustable using P1.
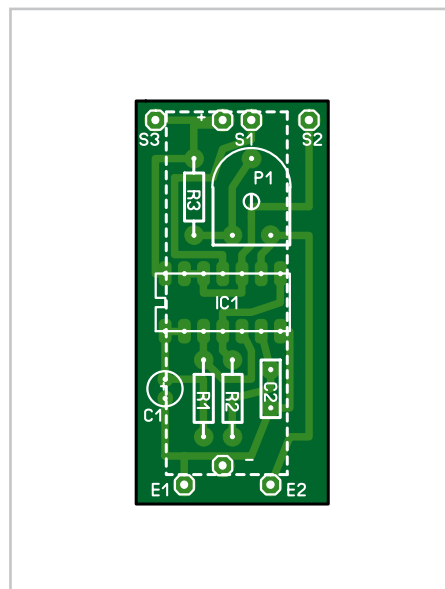
COMPONENT LIST

Resistors
R1 = 100kΩ
R2 = 10kΩ
R3 = 47kΩ
P1 = 1MΩ linear potentiometer

Capacitors
C1 = 22µF 25V
C2 = 100nF

Semiconductors
IC1 = 4093

Miscellaneous
Solar cell (see text)
Piezo buzzer
2 copper wire electrodes
PCB no. 081174-I

Depending on whether or not the circuit is supplied from a voltage greater or less than 3 V — which depends on the solar cell used, as we'll be seeing in a moment — the piezo sounder can be connected either directly between IC1c output and the positive supply, or between the outputs of IC1c and IC1d, which is wired as a simple inverter and so enables you to double the output voltage.

The circuit is very simple to build, and you can just as easily use the suggested board design [1] or build it on a piece of prototyping board. The sounder used must of course be one without built-in electronics, as here it is just being used as a simple transducer. If it's a large-diameter flat type, you could, for example, glue it onto the casing of IC1, while if it's a small-diameter type with rigid pins, it can be soldered directly onto the end of the PCB where its connection pads are located. As for the solar cell, for the prototype Solems devices were used, available for example from Selectronic France [2]; these are marked with a very simple 3-figure code in the form NN/LL/WW, where NN is the number of elements in the cell (each element producing around 0.5 V), LL is the length of the cell,

and WW the width, in mm. Equivalent cells from other suppliers may work equally well though.

Although in theory standard CMOS logic ICs only work above 3 V, the majority of those we tried in our circuit did actually work with a lot less, which means that if you're on a tight budget (or have a lot of plants to monitor!), you can use the cheapest cells, part no. 05/048/016.

If your budget is a little higher, and you don't want to bother selecting the 4093 CMOS ICs, go for a 07/048/016, or better still a 07/048/032, which will allow the circuit to work under excellent conditions as soon as the illumination reaches around 1,000 lux. You can also cannibalize such cells from solar-powered garden lights, which can often be found at giveaway prices in the big DIY stores.

Given the size of the suggested PCB, the Solems cells can be soldered directly onto the copper side of it. But when connecting the cell up, do take care to be very quick soldering the leads to the two silvered pads at each end of it. They are actually metallized directly onto the glass of the cell and so are pretty fragile.

As soon as the cell is connected, if the two electrodes E1 and E2 are 'in mid-air', the circuit should start 'squealing', as long as it is getting enough light. You can then solder two stiff copper wires onto E1 and E2 (e.g. stripped offcuts of 1.5 mm² / AWG16 domestic wiring cable) and spike the circuit into the plant you want to monitor. Then all you have to do is adjust P1 so that the circuit cries for help when the soil has reached the level of dryness you have chosen.

If the frequency of the sound produced doesn't suit you, you can change it by increasing or reducing C2 and/or R2. Likewise, if you don't like its repeat frequency, you can change that by adjusting C1 and/or R1.

(081174-I)

Internet Links
[1] www.elektor-usa.com/081174
[2] www.selectronic.fr

## Download
081174-1 PCB layout (.pdf), from [1]

I²C Display

R. Pretzenbacher (Austria)

Pretty graphical simulators are all very well when developing circuits using microcontrollers, but sometimes there is no substitute for a proper display connected to real hardware. LCD panels based on the Hitachi HD44780 controller are popular as they are cheap and, at least in principle, easy to use. Unfortunately they require a large number of control signals, which in turn means bulky cables and losing the use of many of the microcontroller's I/O pins.

Here we present a solution to the problem in just three characters: I²C!
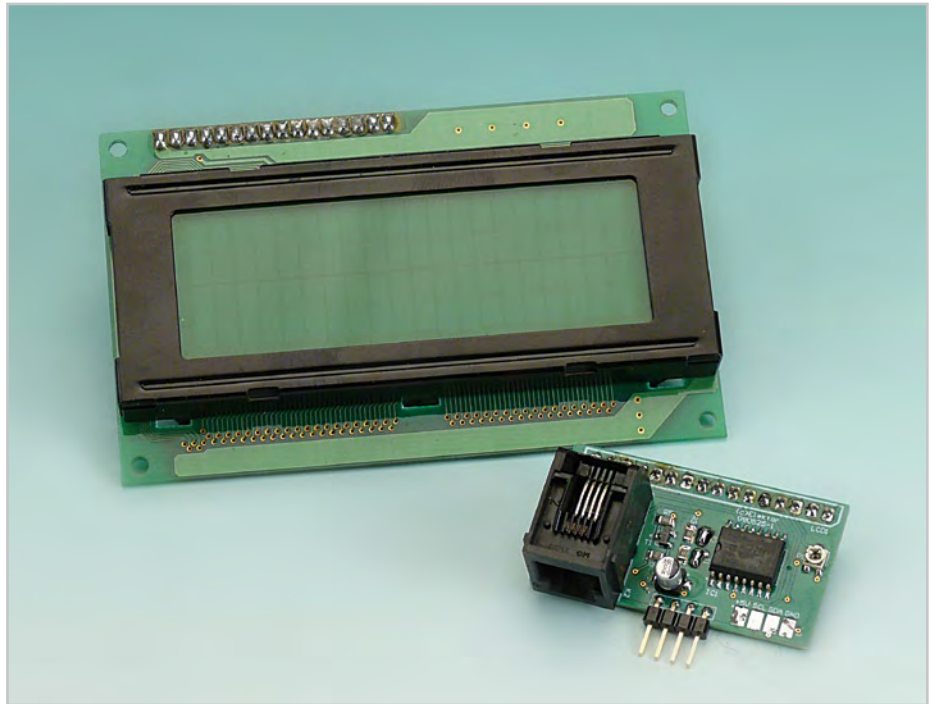
Characteristics
- Universal LCD module for microcontrollers
- Requires just two I/O port pins
- Multiple displays on one I²C bus
- Simple to use with AVR firmware

With the addition of just one extra chip to bridge the gap between the I²C bus and the LCD panel's parallel interface, we can make a universal display module on a simple compact printed circuit board. Besides ground and +5 V power, the module needs just two control lines from the host microcontroller

system: SCL and SDA. This makes the job of interfacing to a display much more straightforward. The Hitachi controller can be operated in its 'four-bit mode', where only four data lines are connected along with three control signals: 'E', 'R/W' and 'RS'. And now we come to the elegant part of this design:

rather than using a microcontroller to drive these seven lines we use a simple I²C bus port expander device offering eight I/O pins. This even leaves us one spare output which we can use to switch the LCD's backlight (or any other LED) on and off.

We selected the PCF8574, which is available in

080525 - 11
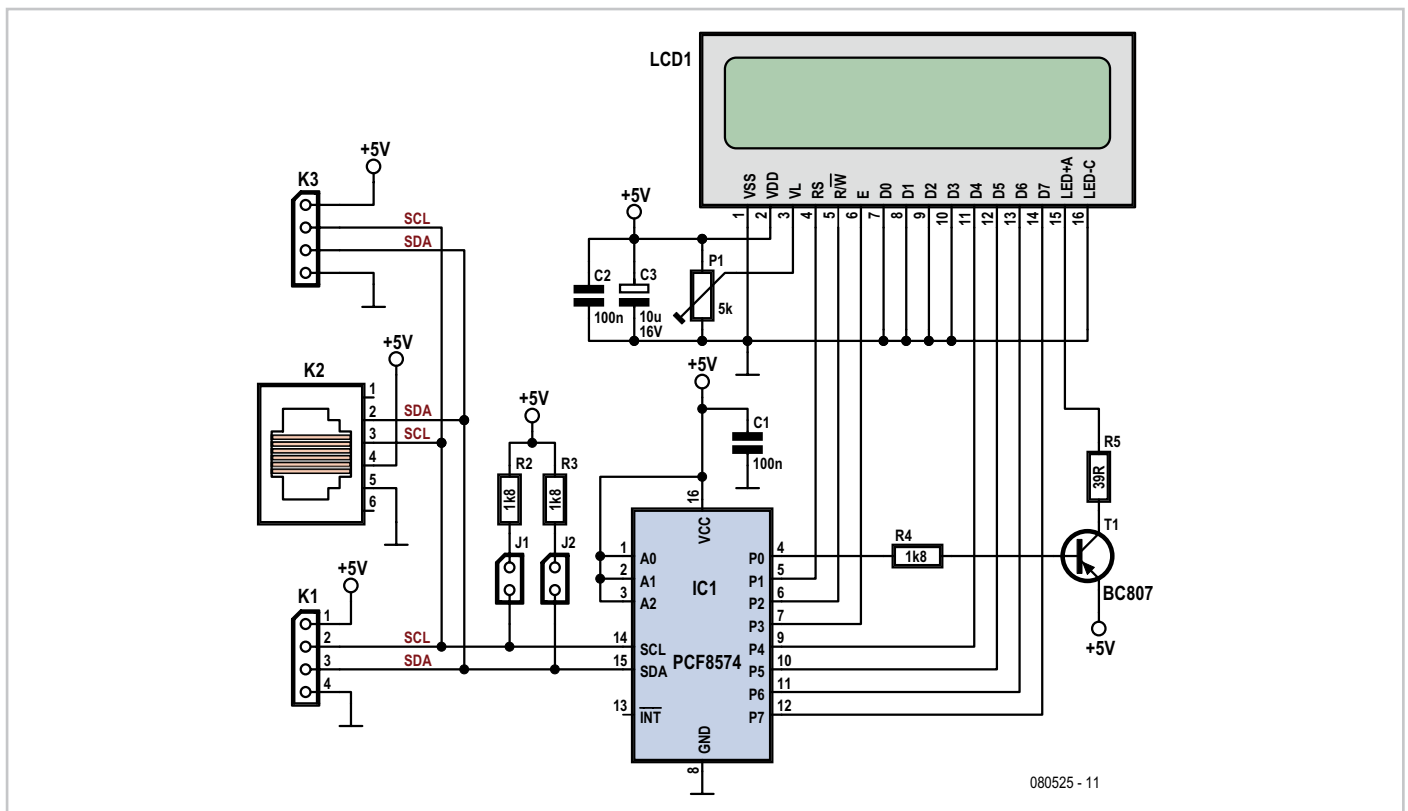
COMPONENT LIST
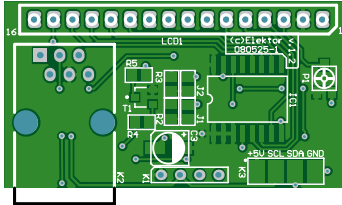
Resistors
P1 = 5kΩ, SMD (Murata)
R2,R3,R4 = 1kΩ8, SMD 0805
R5 = 39Ω, SMD 0805 (see text)

Capacitors
C1,C2 = 100nF, SMD 0805
C3 = 10µF 16V, SMD (Vishay), diam. 4mm

Semiconductors
IC1 = PCF8574 (PCF8574A) (see text)
T1 = BC807, SMD SOT23

Miscellaneous
LCD with HD44780 compatible controller
K1 = 4-way SIL pinheader, lead pitch 0.1" (2.54mm)
K2 = RJ11 socket, PCB mount
K3 = solder islands
J1,J2 = 2-way pinheader with jumper, 0.1" lead pitch
20-way pinheader, 0.1" pitch, for LCD connection
PCB # 080525-1

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two variants. The variants differ in the regions of the I²C address space to which they can be configured to respond: see [2]. As shown the circuit is arranged so that the device responds to he highest address in its range: in the case of the PCF8574 this address is 0x4E and in the case of the PCF8574A the address is 0x7E. Using these two chips it is possible to make two display modules that can be connected to the same I²C bus simultaneously without address conflict and without any modifications to the circuit. If it is desired to use one of the other seven possible device addresses (for example if there is a conflict with another I²C device on the same bus) the wiring of the address bits (pins 1 to 3) needs to be changed appropriately.

The circuit itself is straightforward. The signals from the port expander are taken directly to the pins of the LCD panel, with the exception of output P0 which controls the backlight via PNP driver transistor T1. The value of R5 must be chosen according to the current rating of the backlight, which can be determined from the LCD panel's datasheet. The value of 39 Ω shown is suitable for a typical one-line panel with a rated LED current of 30 mA. Preset P1 is used to adjust the display contrast: frequently the display is only visible over a narrow range of contrast settings. Jumpers J1 and J2 enable the standard pull-up resistors on the SCL and SDA lines: there should only be one pair of such pull-up resistors over the whole bus. The printed circuit board offers a range of possibilities for connection to the bus: header K1, RJ11 socket K2 and solder pads K3.

To simplify using the display the author has written driver software in C, suitable for use with AVR microcontrollers. As usual this is available from the *Elektor* web page for this article [1] and can of course be modified to suit your own requirements. The software is divided into three parts as follows.

1) I²C functions
(may be modified to suit particular AVR microcontrollers)

- i2cInit initialize I²C master
- i2cCheck test whether a slave is responding
- i2cSend send data over the I²C bus
- i2cReceive read data over the I²C bus

2) Low-level display functions
(not normally used in applications)

- whNibb send data nibble to display: call twice to send a byte
- rdsyB read status byte from display (for example, to determine if the display is busy)
- cntrB send control byte to display (for example, to shift the display left or right)
- dataB send data byte to display
- wBusy test whether display is busy

Control byte constants
(for use with 'cntrB')

- dshr 0b00011100 // shift display one position to the right
- dshl 0b00011000 // shift display one position to the left
- curon 0b00001110 // cursor on
- curoff 0b00001100 // cursor off
- curblk 0b00001111 // cursor blinks

3) User-level display functions
(for use in applications)

- Ddisp write character at current cursor position
- DClear clear display
- Dpos set cursor position
- Dinit initialize display
- DBcd2 output a two-digit BCD value
- DHexByte output a byte in hexadecimal
- DWord output an unsigned 16-bit value
- DLong output an unsigned 31-bit value
- DInt output a signed 16-bit value

The user-level functions can be changed as required without needing to know the low-level details of how the display is driven.

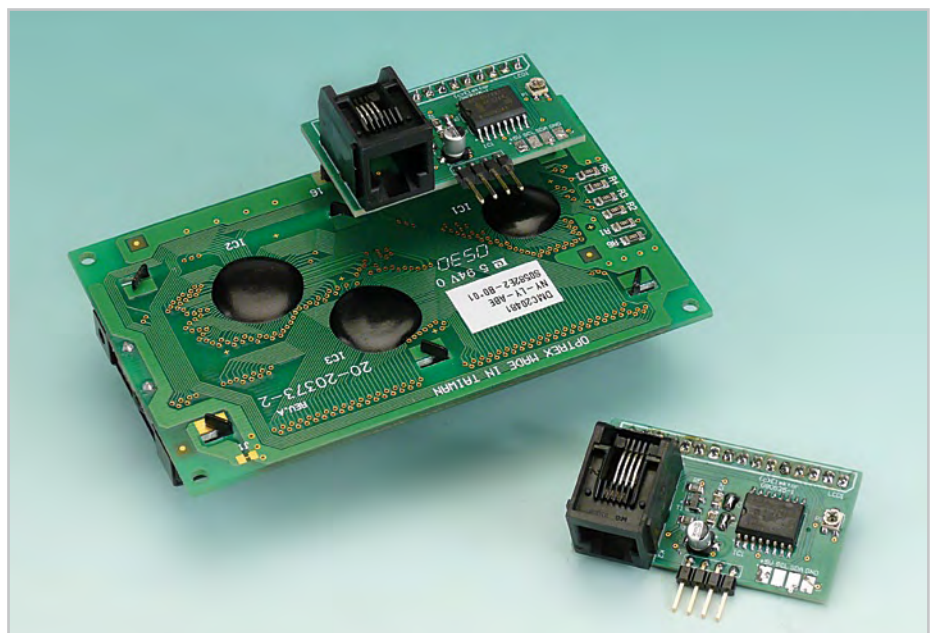(080525-I)

Internet Links
[1 www.elektor-usa.com/080525
[2] www.nxp.com/acrobat_download/datasheets/PCF8574_4.pdf

Downloads
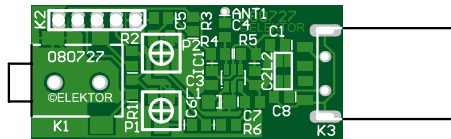080525-1: PCB layout (.pdf), from [1]
080525-11: source code files, from [1]

FM Audio Transmitter

Design: Mathieu Coustans (France)

When the author started thinking about this project he had a simple VHF FM transmitter in mind that could be used to play audio files from an MP3 player or computer on a standard VHF FM radio. The circuit shouldn't use any coils that would have to be wound at home, as is often the case with other FM transmitter designs, because it would add an unwanted level of complexity to the project. Such an FM transmitter can be used to listen to your own music throughout your home. There is also an advantage when you use this transmitter in the car, as there is no need for a separate input to the car stereo to play back the music files from your MP3 player.

To keep the circuit simple as well as compact, it was decided to use a chip made by Maxim Integrated Products, the MAX2606 [1]. This IC from the MAX2605-MAX2609 series has been specifically designed for low-noise RF applications with a fixed frequency. The VCO (Voltage Controlled Oscillator) in this IC uses a Colpitts oscillator circuit. The variable-capacitance (varicap) diode and feedback capacitors for the tuning have also been integrated on this chip, so that you only need an external inductor to fix the central oscillator frequency. It is possible to fine-tune the frequency by varying the voltage to the varicap. Not much is demanded of the inductor, a type with a relatively low Q factor (35 to 40) is sufficient according to Maxim. The supply voltage to the IC should be between 2.7 and 5.5 V, the current consumption is between 2 and 4 mA. With values like these it seemed a good idea to supply the circuit with power from a USB port. A common-mode choke is connected in series with the USB connections in order to avoid interference between the circuit and the PC supply. There is not much else to the circuit. The stereo signal connected to K1 is combined via R1 and R2 and is then passed via volume control P1 to the Tune input of IC1, where it causes the carrier wave to be frequency modulated. Filter R6/C7 is used to restrict the bandwidth of the audio signal. The setting of the frequency (across the whole VHF FM broadcast band) is done with P2, which is connected to the 5 V supply voltage.

Specifications
- Easy to build thanks to the use of a MAX2606
- Can be powered from a USB port on a computer
- Current consumption of just 2 to 4 mA, supply voltage of 2.7 to 5.5 V
- Can be expanded with a pre-emphasis circuit

The PCB designed in the Elektor Labs uses resistors and capacitors with 0805 SMD packaging. The size of the board is only 41.2 x 17.9 mm, which is practically dongle-sized. For the antenna an almost straight copper track has been placed at the edge of the board. In practice we achieved a range of about 6 metres (18 feet) with this. There is also room for a 5-way SIL header on the board. Here we find the inputs to the 3.5 mm jack plug, the input to P1 and the supply voltage. The latter permits the circuit to be powered independently from an AC power outlet, via for example three AA batteries or a Lithium button cell. Inductor L1 in the prototype is a type made by Murata that has a fairly high Q factor: minimum 60 at 100 MHz.

Take care when you solder filter choke L2, since the connections on both sides are very close together. The supply voltage is connected to this, so make sure that you don't short out the USB supply! Use a resistance meter to check that there is no short between the two supply connectors before connecting the circuit to a USB port on a computer or to the batteries.

P1 has the opposite effect to what you would expect (clockwise reduces the volume), because this made the board layout much easier. The deviation and audio bandwidth varies with the setting of P1. The maximum sensitivity of the audio input is fairly

COMPONENT LIST

Resistors (all SMD 0805)
R1,R2 = 22kΩ
R3 = 4kΩ7
R4,R5 = 1kΩ
R6 = 270Ω
P1 = 10kΩ preset, SMD (TS53YJ103MR10 Vishay
    Sfernice, Farnell # 1557933)
P2 = 100kΩ preset, SMD(TS53YJ104MR10 Vishay
    Sfernice, Farnell # 1557934)

Capacitors (all SMD 0805)
C1,C2,C5 = 4µF7 10V
C3,C8 = 100nF

C4,C7 = 2nF2
C6 = 470nF

Inductors
L1 = 390nF, SMD 1206 (LQH31HNR39K03L Murata,
    Farnell # 1515418)
L2 = 2200Ω @ 100MHz, SMD, common-mode choke,

1206 type(DLW31SN222SQ2L Murata, Farnell #
    1515599)

Semiconductors
IC1 = MAX2606EUT+, SMD SOT23-6 (Maxim
    Integrated Products)

Miscellaneous
K1 = 3.5mm stereo audio jack SMD (SJ1-3513-SMT
    CUI Inc, DIGI-Key # CP1-3513SJCT-ND)
K2 = 5-pin header (only required in combination
    wsith 090305-I pre-emphasis circuit)
K3 = USB connector type A, SMD (2410 07 Lumberg,
    Farnell # 1308875)

large. With P1 set to its maximum level, a stereo input of 10 mV$_{rms}$ is sufficient for the sound on the radio to remain clear. This also depends on the setting of the VCO. With a higher tuning voltage the input signal may be almost twice as large (see VCO tuning curve in the data sheet). Above that level some audible distortion becomes apparent. If the attenuation can't be easily set by P1, you can increase the values of R1 and R2 without any problems.

Measurements with an RF analyzer showed that the third harmonic had a strong presence in the transmitted spectrum (about 10 dB below the fundamental frequency).

This should really have been much lower. With a low-impedance source connected to both inputs the bandwidth varies from 13.1 kHz (P1 at maximum) to 57 kHz (with the wiper of P1 set to 1/10).

In this circuit the pre-emphasis of the input is missing. Radios in Europe have a built-in de-emphasis network of 50 µs (75 µs in the US). The sound from the radio will therefore sound noticeably muffled. To correct this, and also to stop a stereo receiver from mistakenly reacting to a 19 kHz component in the audio signal, an enhancement circuit Is published elsewhere in this issue (Pre-emphasis for FM Transmitter, also with a PCB).

Notice. The use of a VHF FM transmitter, even a low power device like the one described here, is subject to radio regulations and may not be legal in all countries.

(080727)

Internet Links
[1] http://datasheets.maxim-ic.com/en/ds/MAX2605-MAX2609.pdf
[2] www.elektor-usa.com/080727

Download
080727-1 PCB layout (.pdf), from [2]

Servo Driver

Gert Baars (The Netherlands)

When it comes to driving a servo you typically have to send a PWM signal to the servo input. The frequency of this signal is about 50 Hz and the duty cycle is variable. The duty cycle is usually between about 5 and 10%, corresponding with a pulse width of about 1 to 2 ms. The conversion of a resistance value into a PWM signal is fairly straightforward when a variable RC time constant circuit is used. Converting a voltage into a PWM signal is a bit more difficult, but it does offer some useful advantages.

When the position of a servo can be controlled via a voltage, it can be implemented via a potentiometer acting as a voltage divider. However, you could also use the output of a sensor such as a Hall sensor, an LDR or an NTC. That way you could easily create a feedback loop that takes account of the position, light intensity or the temperature, and use this to control the servo. This can in turn be used to open or close a gas or water valve, for example. The cir-

090046 - 11
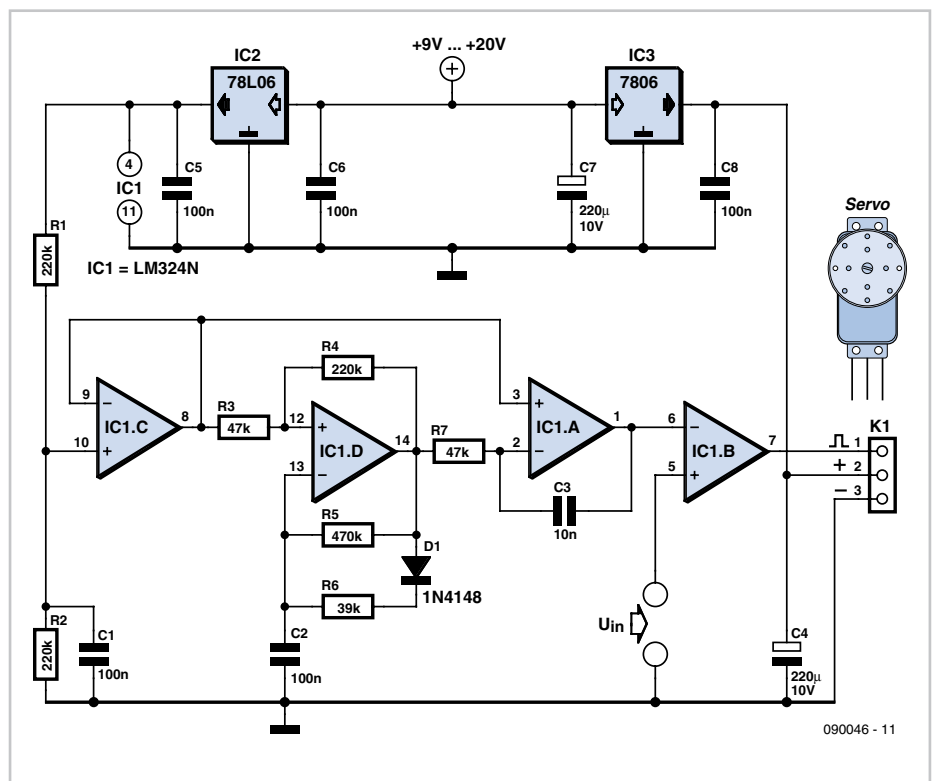
cuit can therefore be said to be reasonably versatile.

There are special purpose PWM modulator ICs available, but it's just as easy to use a quad op amp such as an LM324. In the circuit op amp C is configured to output a bias signal of half the supply voltage. Op amp D is set up as a square-wave oscillator, with its frequency set to about 50 Hz, which is the frequency required by the servo. The duty cycle is fixed and set to a value slightly higher than the maximum 10%.

This is followed by an integrator that changes the waveform of the pulse into a triangular form. Op amp B is configured as a comparator that compares this triangular wave with the DC voltage U_{in}. The output of the comparator is a PWM signal that is suitable to drive the servo directly. The frequency is about 50 Hz and the duty cycle can be varied from just under 5% to a good 10% when U_{in} varies from 0.5 to 4 V. The servo, an RS-2 in our prototype, reacts to this with an angular rotation of about 200 degrees. The transfer function in this case is therefore 200 / (4−0.5) = 57 degrees per volt.

(090046)

Chill Out Loud

Andrew Denham (United Kingdom)

Everyone knows that when the refrigerator door is casually closed it sometimes bounces open again just a little. Enough to put the fridge light on, but that's often un-noticeable even at night unless one looks closely. After a day out, you may come home to sour milk and dodgy chicken. After several mornings with debatable milk, the author decided that something would have to be done, and came up with this little gizmo. The light in his fridge always comes on even with a 2 mm door opening, so that's a promising place to start.

The TEMT6000 phototransistor device from Vishay will 'see' visible light, and is both cheap and readily available. It has negligible dark current and can sink a few µA happily. Since a battery powered device is required, the current for the entire circuit has to be as low as possible. A PIC with 'sleep' mode is a good choice, and the 12F629 fits the bill nicely: small, cheap, easily obtained, with an internal RC oscillator on board, and up to five I/O pins as well. According to the PIC12F629 datasheet [1] all pins have to be set as inputs and pulled high for best low power operation, and every peripheral in use will add some drain. Since the unit is permanently powered from a battery, there is no need for brown-out protection. No A/D or comparators are required, and no watchdog timer either, allowing the lowest power settings in Sleep mode to be exploited. Typical current here is shown as 1.2 nA with a guaranteed maximum of 770 nA at a 3 V supply, reducing to 700 nA at 2 V.

080700 - 11
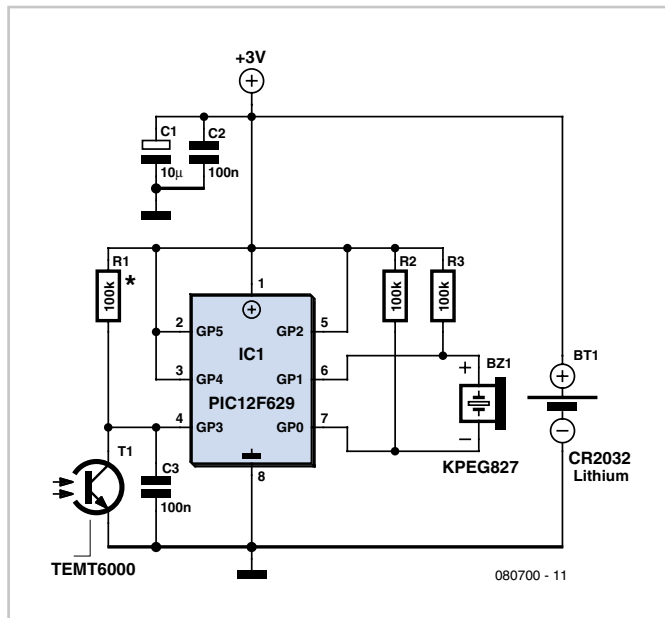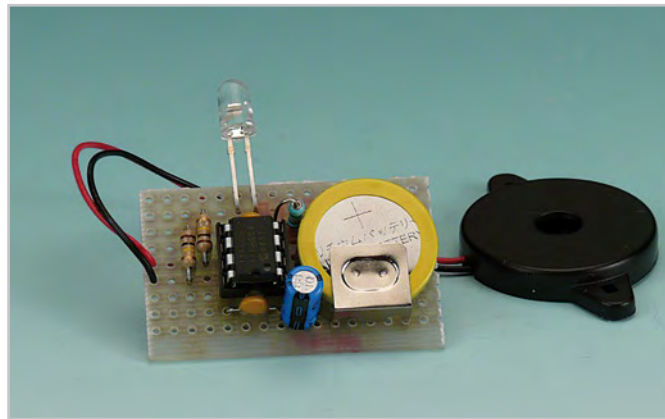
The type CR2032/1HF Lithium cell has a rated capacity of 230 mAh and a nominal voltage of 3 V [2]. On this basis with the typical current in sleep mode the battery would last over 250 years, or effectively for its shelf life, so a CR2032 with tags is worth soldering in to a PCB. Even at the maximum Sleep current, it would last for over 30 years — certainly longer than the fridge! One advantage of a Lithium battery is its long shelf life, and an ability to deliver power at low temperatures.

An obvious choice to make a squawk is a piezo sounder, again cheap and easily obtained. This can be driven from the PIC directly across two ports and will withstand 3 V_{p-p} drive easily. After some testing, a Kingstate KPEG827 [3] proved a worthy candidate. It makes sufficient racket at 3 V drive from about 2.0 kHz to about 4.5 kHz.

The PIC program was developed using MikroElektronika products only: a fully paid up MikroBasic compiler and the BigPIC 4 board. However the final program is so small that it can be compiled using the free version of MikroBasic (free up to 2 K of code, download at [4]).

For the simple reason of ease, the PIC used is the 8-pin DIL version. This can be re-programmed easily using a simple DIL socket adapter. ICP is OK if you have to use SMD but the socket takes up a lot of room and negates the purpose of SMD in the first place on a very small PCB. I used the PicFlash2 programmer again from MikroE, but could have used the on-board EasyPIC4 programmer. The source code used is available free from the Elektor website [5].

The timer will work with anything that can pull the GPIO.3 input Low and hold it Low, so could be used with bi-metallic temperatures sensor, or the software adapted to read a One-Wire temperature sensor. It could also be used to sense over- or under-voltage etc. with some adaptation. The delay before the alarm sounds is adjustable from about 1 to 255 seconds in software.

One word of warning: there are many PIC pro-

grammers out there. If you use other than the MikroE programmer with the code from the Elektor website, make certain that the PIC oscillator configuration is correct. Not all software reads the Configuration correctly; it needs to be set for INT RC OSC, with GPIO.4 and GPIO.5 as I/O. Anything else will stop the oscillator and may damage the PIC! Some programmers need these parameters to be set manually before blowing the chip. In case of doubt, consult the source code listing.

After some tweaking with the port settings, the sample chip consumed an estimated 0.02 µA in Sleep mode. Once triggered the unit consumes about 500 µA for the timer period of 1 minute, then about double that once the sounder is operating. This is well under the maximum current for the cell used (10 mA max. pulsed) and would bleat for about 10 days with a fresh battery, which hopefully will never happen. With a fridge opened say 20 times a day for less than a minute, the battery life expectancy reduces to about 9 years, still a reasonable longevity. The photograph shows a prototype built on a small piece of perfboard by Elektor Labs. Here

the ambient light sensor is a type TEPT5600 (which looks like a UV LED). As opposed to TEMT6000, the TEPT5600 has to be pointed directly to the light source due to its narrower 'viewing angle'. It also requires the value of R1 to be doubled (approximately).

Even on perfboard the circuit is compact enough to be fitted in a small ABS case, preferably one with a battery compartment because that's the ideal place for the sounder. A small hole in the end should allow the sensor to 'see' the light. This hole was filled with clear epoxy resin to act as a window without allowing too much moisture into the case. The latter was achieved by fixing tape over the inside then filling the hole flush. It was then allowed to set whilst the box was fixed upright. The circuit board may be fixed in place with a little hot melt glue. The unit could be mounted to the fridge wall using double-sided adhesive foam strip or Velcro, but space allowing it may equally sit on the shelf.

To start the microcontroller for the first time, or when the battery is replaced, the fridge door should be closed or the sensor covered.

Once the sensor detects light, it takes 60 seconds before the alarm sounds. When in the fridge with the door closed (or the sensor covered) the unit goes back to sleep… peace!

Of course the fridge does have to have a light that works or the unit will think it is in the dark all the time.

(080700-I)

Internet Links

[1] http://ww1.microchip.com/downloads/en/devicedoc/41190c.pdf

[2] www.panasonic.com/industrial/battery/oem/images/pdf/Panasonic_Lithium_CR2032_CR2330.pdf

[3] www.farnell.com/datasheets/16396.pdf

[4] www.mikroe.com

[5] www.elektor-usa.com/080700

Downloads & Products

Programmed Controller
080700-41: programmed PIC12F629.

Software
080700-11.zip: MikroBasic source code and hex files, from [5].

Dimmable Aquarium Light with Simulated Sunrise and Sunset

Jürgen Ollig (Germany)

Electronic ballasts (EBs) for fluorescent lamps, also known as electronic control gear (ECG), have advantages over their conventional cousins: higher efficiency, flicker-free start-up, no 50 Hz (60 Hz) flicker and longer tube life. Moreover, they allow the light to be dimmed. Suitable EBs with a 1–10 V analog control interface are available from all the usual manufacturers, including Osram and Philips. An internet search for 'dimmable EB' will turn up a large number of on-line sales outlets for the devices. For the purposes of this circuit EBs with a digital interface (known as DALI, for Digital Addressable Lighting Interface) are not suitable.

Osram provides an excellent technical description of the 1–10 V interface on their website at [1]. The interface provides an interference-proof DC voltage of up to 10 V, which, when loaded, delivers an essentially constant current of 0.6 mA: in other words, it

090025 - 11
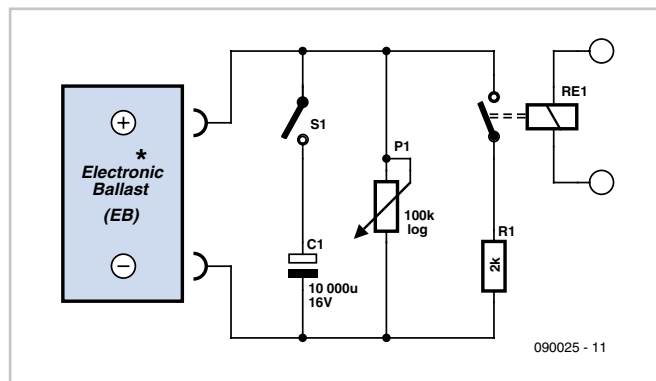
is a constant current source with an open-circuit voltage of 10 V. If a resistor is connected across the interface then the lower its value, the lower will be the voltage across it, and this controls the dimming of the connected lamp. When the control input is open circuit and the voltage across it is 10 V, the lamp is driven at full brightness (100 % of nominal power). If the control input is shorted the control gear dims the lamp to 3 % of nominal power. Between 3 % and 100 % the behavior of the controller is logarithmic.

The very simple circuit described here to drive

the interface has several features that will be of particular interest to aquarium owners.

The circuit is connected across the control input of the EB and therefore the control voltage appears across it. The brightness of the tube can be adjusted using P1. S1 allows electrolytic capacitor C1 to be connected across P1: the charge current (0.6 mA) is very small and the capacitor very large (10000 µF) and so it charges very slowly. This means that the voltage across it, and hence the brightness of the fluorescent tube, will increase only slowly. The larger the value of C1, the slower the rate of brightness increase; with the suggested value the simulated sunrise takes around 12 minutes to complete. As can be seen, the circuit does not need its own power supply. When the EB is switched off C1 discharges into P1 (assuming S1 is closed); when it is next switched on the brightness of the tube will rise slowly as before.

An optional extra is the circuit consisting of relay RE1 and resistor R1. If the contacts of

RE1 close C1 will be slowly discharged into R1. The control voltage will fall gradually and the tube will slowly dim. The larger the value of R1, the slower the simulated sunset will be. When the contacts of RE1 are closed the value of R1 will also affect the maximum brightness that can be achieved by adjusting P1: the greater the value of R1, the higher the maximum brightness.

One possible arrangement is to plug the aquarium light into one timeswitch and drive RE1 from a mains adaptor plugged into a second timeswitch. The relay contact is made to close say 30 minutes before the first timeswitch turns the aquarium light off. When the simulated sunset is complete the relay contact can be allowed to open again.

(090025-I)

Audio Source Enhancer

Thorsten Steurich (Germany)

Vinyl or CD: which has the better sound? It's a question still hotly debated among audiophiles everywhere. We will try to shed a little light on what lies behind the question and look at a simple circuit that can significantly enhance the sound from a CD player.

Sometimes, on first hearing a new low- to mid-range CD player, the sound is not altogether convincing when compared to a record player. It is worth looking at the recording and replay processes as a whole for both CDs and records to see why this might be. Assuming that we start from the same source, or master recording, of a given piece of music, the differences are broadly as follows.

Records and CDs use very different recording technologies. For records the signal first undergoes pre-emphasis similar to that used in FM radio, where the higher frequency components of the signal are amplified. The resulting signal is cut into the lacquer master disc that will be used for pressing. Unlike CD manufacture, this is an entirely analogue process, and it introduces a phase shift into the signal. To compensate for the pre-emphasis the preamplifier in a record player includes a de-emphasis (or 'RIAA') filter which attenuates the higher frequency components. The purpose of pre-emphasis is to improve the overall signal-to-noise ratio of the signal as played back, reducing hiss and crackle. De-emphasis introduces further phase shifts, and as a result the final signal is rather different from that produced by a CD player. The processing involved in CD manufacture and playback can be entirely digital (in the case of 'DDD' recordings) and phase errors are reduced practically to zero.

The circuit shown here uses a quad opamp (two opamps per channel) to produce 'record-like' phase shifts. In the author's experience low- and mid-range CD players tend to have

081083 - 11
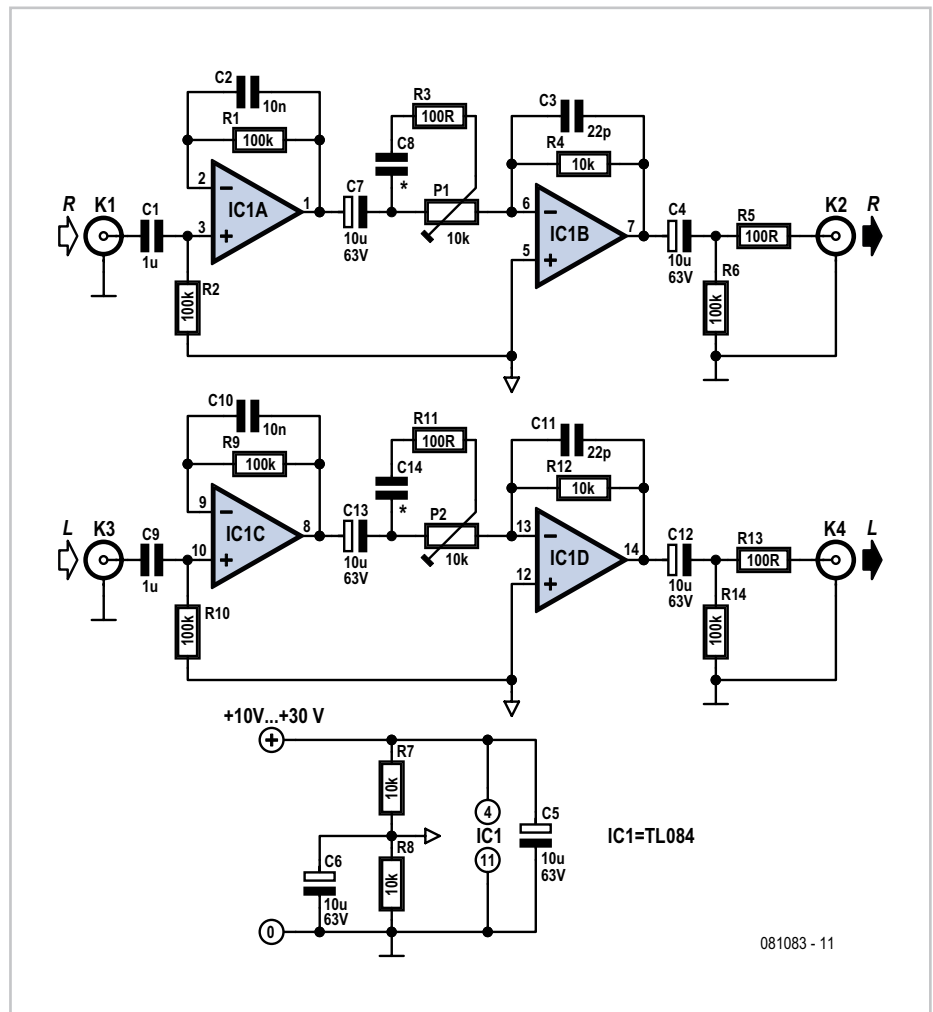
greatly attenuated output at higher frequencies, and the circuit therefore also offers the facility to boost these components to taste. The value of capacitors C8 and C14 may be anywhere between 100 pF and 10 nF according to the frequency response desired. At the low-frequency end the response is more than adequate, thanks to the large coupling capacitors used. The circuit also functions as a buffer or impedance converter, which can help to reduce the effect of cable capacitances. With CD players that have an output impedance of 1 kΩ or more the difference between

cheap cables and more expensive low-capacitance cables can be noticeable. This circuit has an output impedance of just 100 Ω and so cheaper cables should normally be more than adequate.

The circuit can of course also be used with other digital audio sources such as minidisc players, hard disk recorders, DAB tuners, digital terrestrial and satellite television receivers and so on. The supply voltage can be anywhere from 10 V to 30 V. It will often be possible to take power from the CD player's own

supply; if not, a separate AC power adaptor can be used.

The output signal for each channel is inverted (i.e., is subjected to a 180 degree phase shift) by the second opamp (IC1.B and IC1.D). This does not affect the operation of the circuit. By changing the value of feedback resistors R4 (for IC1.B) and R12 (for IC1.D) the overall gain of the circuit can be adjusted so that the output level matches that of other components in the audio system.

(081083-I)

Doubling Up with the PR4401/02

Leo Szumylowycz (Germany)

Among the many interesting applications for the PR4401/02 devices from Prema, some have already appeared in the 2008 edition of Elektor Summer Circuits. Over and above their unbeatable performance, dependable operating range from 0.8 V upwards and minimal reliance on peripheral components all we might ask for might be greater output current, in order to be able to fully exploit a 4-chip LED with 80 mA. It would be handy too if one could replace the 9 V 'block' batteries used in the more sophisticated LCD multimeters. With the fully tested circuit presented here both problems can now be eliminated.

In the schematic shown two of these ICs are connected in parallel via diodes to a single charge capacitor. If the need arises you can connect even more of these ICs in parallel in the same way.

The value of inductance required is calculated in the same way as for standard applications of the IC; 10 µH for the PR4401 with a current of 20 mA and 4.7 µH for the PR4402 with a current of 40 mA.

To power an 80 mA LED with a single 1.5 V battery the circuit shown needs to be equipped with PR4402s and 4.7 µH inductors. If you feel

like constructing the entire project with SMDs, you will need SMD tantalum electrolytics (4.7 µF, 35 V) of style 'A' for C1 and C2 plus SMD inductors such as Murata LQH3C-4.7µH for L1 and L2 (available from RS Components, Farnell and Anglia Components).

(090129-I)

090129 - 11
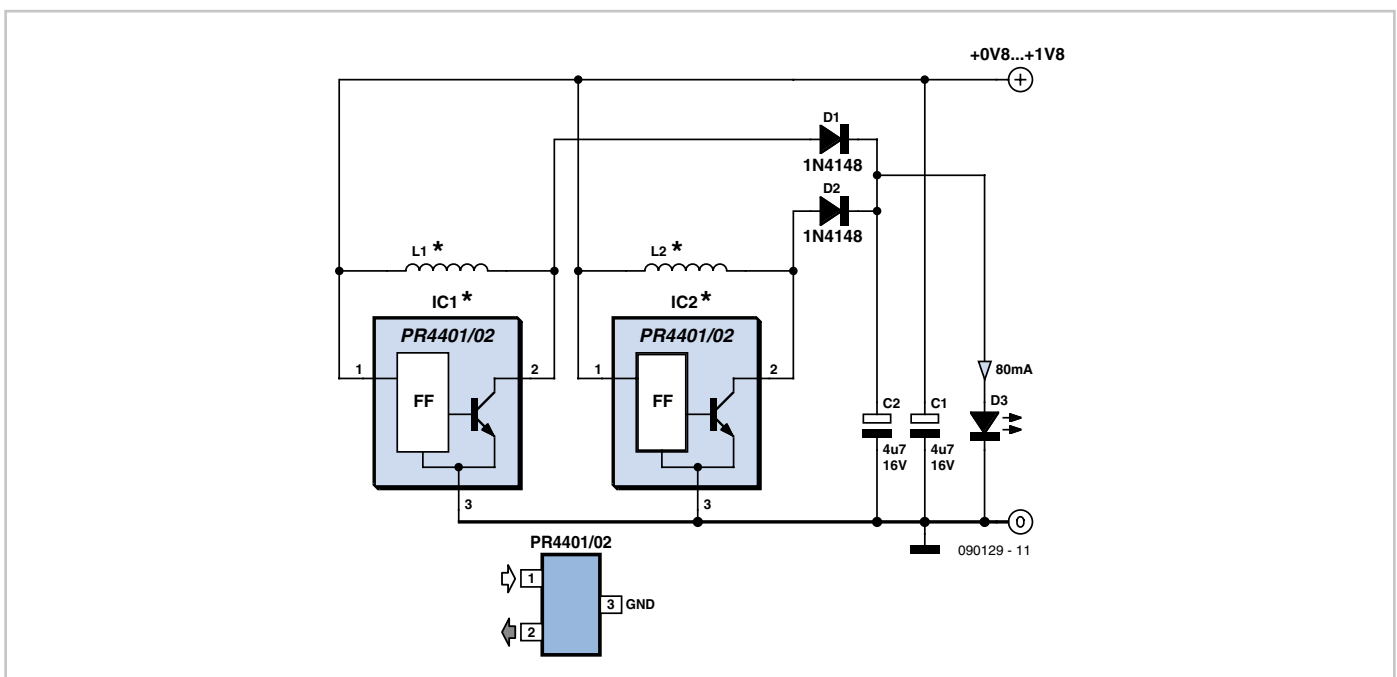
Pre-emphasis for FM Transmitter

Ton Giesberts (Elektor Labs)

Specifications
- Correction network for FM Transmitter 080727
- Also includes a 19-kHz filter
- Current consumption of 3 mA

This circuit was specially designed to be used with the FM Audio Transmitter found elsewhere in this issue, but it can also be useful as an addition to other transmitters.

The circuit uses a dual op amp. The first op amp (IC1A) functions as a mixer and a buffer for the following correction network. The input sensitivity can be adjusted with the help of R3 (a lower value reduces the sensitivity). The 50 μs correction for the pre-emphasis is carried out by C5 and R6. IC1B buffers the signal before it is fed to the transmitter via K1.

Since the FM transmitter is a mono version, a 19 kHz filter has been included to prevent a stereo FM receiver from mistakenly switching to stereo mode due to the presence of 19 kHz components in the received signal. Any signals around 19 kHz are blocked with the help of a simple tuned circuit (L1/C4). R4 ensures that the Q isn't too large. Due to tolerances you may find that the frequency can deviate from 19 kHz (in our prototype the resonance frequency was closer to 20 kHz). In view of the value of the inductor, a through-hole version has been used for this (see component list). Without the parallel circuit the crossover point of the correction network is about 16.7 kHz. This is more than enough for audio via VHF FM. The addition of the parallel circuit causes the amplitude around 10 kHz to increase a little, and the –3 dB point is then reached at 13.5 kHz. In the prototype this cutoff point was about 1 kHz higher due to component tolerances.

The board designed for this circuit has been kept as small as possible through the use of SMDs for most components. The dimensions of the FM transmitter board also played a part here. To make it easier to connect this circuit to the transmitter board, a connector was included on this board. The supply voltage and audio signals are carried via this connector. The board has been designed in such a way that it can either be mounted behind the FM transmitter or alongside it.

When the pre-emphasis board is used R1 and R2 should be removed from the transmitter board. When the circuit is mounted behind the transmitter board it was found that the FM signal strength was clearly reduced, so it would be better if a length of wire was used as aerial and connected to the transmitter board (it just so happens there is a via next to C4).

To measure the effect of the pre-emphasis circuit we first measured the frequency response of the output of a small radio. The result of this can be seen in the graph (1 = without pre-emphasis, 2 = with pre-emphasis). It can be clearly seen that the higher frequency components are attenuated by the de-emphasis filter in the radio. When the pre-emphasis circuit is connected to the transmitter the result is an almost flat response above 1 kHz. The 'bump' around 100 Hz is caused by a type of bass-boost in the radio to improve
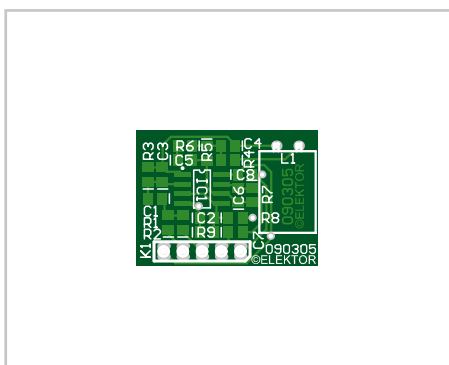
COMPONENT LIST

Resistors (all SMD 0805)
R1,R2 = 22kΩ
R3 = 10kΩ
R4 = 100Ω
R5,R7 = 15kΩ (24kΩ for 75 μs)
R6 = 3kΩ3 (3kΩ6 for 75 μs)
R8, R9 = 100kΩ

Capacitors
C1,C7 = 4μF7 10V
C2,C8 = 100nF
C3,C6 = 47pF
C4 = 2nF2
C5 = 2nF7

Inductors
L1 = 33mH, e.g. 22R336C Murata Power Solutions (Farnell # 1077046)

Semiconductors
IC1 = TLC082CD SO8 (Farnell # 8453713)

the quality of the sound. The low cut-off point has risen slightly due to the inclusion of two extra coupling capacitors in the pre-emphasis circuit, but in practice this will be hardly noticeable. The current consumption of the transmitter is increased by this circuit from 2 to just over 5 mA.

The component values in the circuit diagram are for 50 µs pre-emphasis. For adaptations to 75 µs as used in the USA and other countries, please refer to the parts list.

(090305)

Download
090305-1: PCB layout (.pdf), from www.elektor-usa.com/090305
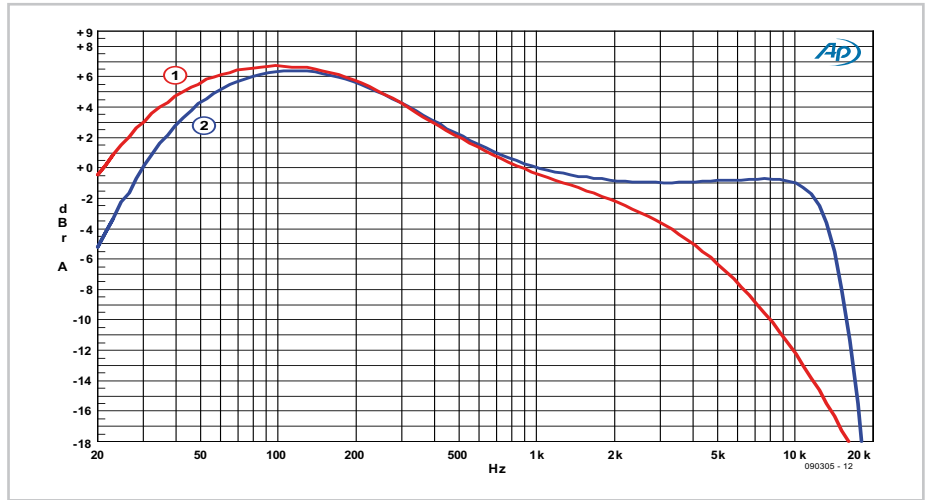
Sensitive Audio Power Meter

Michiel Ter Burg (The Netherlands)

As a follow-up to the simple audio power meter described in [1], the author has developed a more sensitive version. In practice, you rarely use more than 1 watt of audio power in a normal living-room environment. The only time most people use more is at a party when they want to show how loud their stereo system is, in which case peaks of more than 10 W are not uncommon.

With this circuit, the dual LED starts to light up green at around 0.1 watt into 8 ohms (0.2 watt into 4 ohms). Naturally, this depends on the specific type of LED that is used. Here it is essential to use a low-current type. The capacitor is first charged via D1 and then discharged
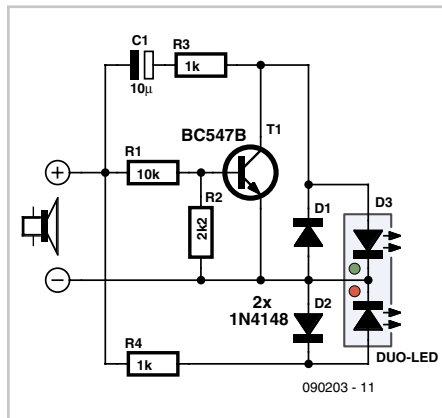
via the green LED. This voltage-doubler effect increases the sensitivity of the circuit. Above a

level of 1 watt, the transistor limits the current through the green LED and the red LED conducts enough to produce an orange hue. The red color predominates above 5 watts.

Of course, you can also use two separate, 'normal' LEDs. However, this arrangement cannot generate an orange hue. For any testing that may be necessary, you should use a generator with a DC-coupled output. If there is a capacitor in the output path, it can cause misleading results.

(090203-I)

Reference
[1] Simple Audio Power Meter, Elektor July & August 2008.

Bathroom Fan Controller

Heino Peters (The Netherlands)

Many bathrooms are fitted with a fan to vent excess humidity while someone is showering. This fan can be connected to the light switch, but then it runs even if you only want to brush your teeth. A better solution is to equip the fan with a humidity sensor. A disadvantage of this approach is that by the time the humidity sensor switches on the fan, the room is already too humid.

Consequently, we decided to build a circuit that operates by sensing the temperature of the hot water line to the shower. The fan runs as soon as the water line becomes hot. It con-

tinues to run for a few minutes after the line cools down, so that you have considerably fewer problems with humidity in the bathroom without having the fan run for no reason. Naturally, this is only possible if you can fit a temperature sensor somewhere on the hot water line and the line does not become warm if hot water is used somewhere else.

We use an LM335 as the temperature sensor. It generates an output voltage of 10 mV per Kelvin. The output voltage is 3.03 V at 30 °C, 3.13 V at 40 °C, 3.23 V at 50 °C, and so on. We want to have the fan switch on at a temperature somewhere between 40 and 50 °C (approx. 100–150 °F). To do this accurately,

we first use the opamps in IC2 to improve the control range. Otherwise we would have an unstable circuit because the voltage differences at the output of IC1 are relatively small.

IC2a subtracts a voltage of exactly 3.0 V from the output voltage of IC1. It uses Zener diode D1 for this purpose, so this is not dependent on the value of the supply voltage. The value of R2 must be selected according to the actual supply voltage so that the current through D1 is approximately 5 mA. It is 600 Ω with a 6-V supply (560 Ω is also okay), or 2400 Ω (2.2 kΩ) with a 15-V supply. If you have to choose between two values, use the lower value.

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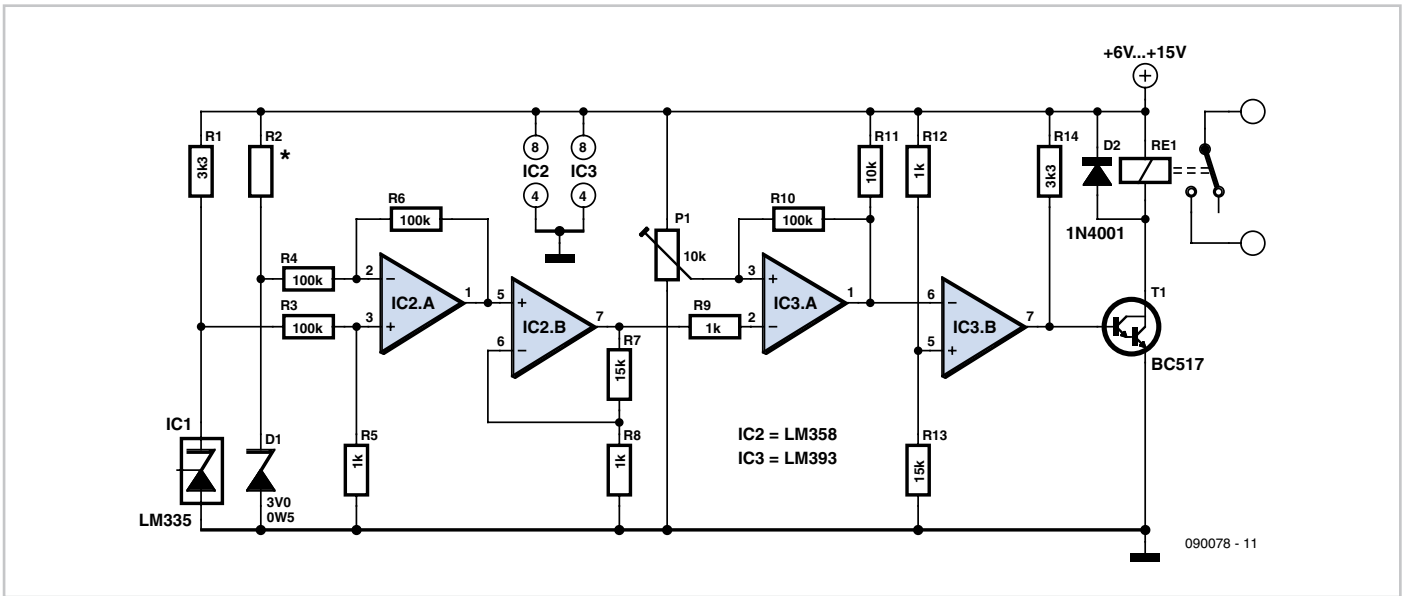
IC2b amplifies the output voltage of IC2a by a factor of 16 ((R7 + R8) ÷ R8). As a result, the voltage at the output of IC2b is 0.48 V at 30 °C, 2.08 V at 40 °C (104 °F), and 3.68 V at 50 °C (122 °F). Comparator IC3a compares this voltage to a reference voltage set by P1. Due to variations resulting from the tolerances of the resistor values, the setting of P1 is best determined experimentally. A voltage of 2.5 V on the wiper should be a good starting point (in theory, this corresponds to 42.6 °C). When the water line is warm

enough, the output of IC3 goes Low. R10 provides hysteresis at the output of IC3a by pulling the voltage on the wiper of the setting potentiometer down a bit when the output of IC3a goes Low. IC3b acts as an inverter so that relay Re1 is energized via T1, which causes the fan to start running. After the water line cools down, the relay is de-energized and the fan stops. If this happens too quickly, you can reduce the value of R11 (to 33 kΩ, for example). This increases the hysteresis.

The circuit does not draw much current, and the supply voltage is non-critical. A charging adapter from a discarded cell phone can thus be used to power the circuit. If the supply voltage drops slightly when the relay is energised, this will not create any problem. In this case the voltage on the wiper of P1 will also drop slightly, which provides a bit more hysteresis on IC3a.

(090078-I)

Backlight Delay

Clemens Valens (Elektor France)

Lots of devices are fitted with a liquid crystal display (LCD). Now LCD implies backlighting — that rather useful option that enables us to read the message being displayed! For devices where there's no need to read the display continuously, the backlight doesn't need to stay lit up all the time — several seconds is often all you need to read the display. This saves a little power and lengthens the life of the backlight. Devices fitted with an LCD also have a processor, and so it's possible to employ a function to control the backlight directly from within the processor software. But sometimes it's not possible to implement this sort of function within the microcontroller, because all the controller's pins are already in use, or because you

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don't have the source codes or tools needed to modify the software. The circuit described
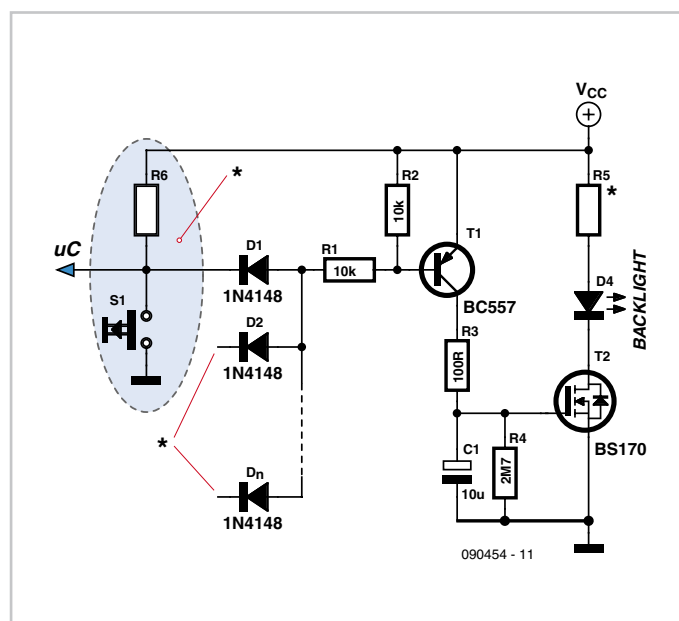
here has been designed for just such cases.

A device using an LCD usually has at least one button that, in most cases, pulls one of the microcontroller inputs down to 0 V when it is pressed. If no such button exists, one can always be added. We can use the signal from this button to control the backlight. As soon as the button is pressed, the backlight is activated, then extinguished a few seconds later by the timer. Using an OR gate, it's possible to use several different buttons to trigger the timer.

It doesn't take many components to build a timer like this. The OR gate consists of a pull-up resistor R1+R2 and as many diodes as there are buttons. Thanks to these diodes, transistor T1 conducts while the button is

pressed, and hence capacitor C1 is charged, the MOSFET T2 conducts, and the backlight comes on. Because R3 has a very low value, capacitor C1 charges very rapidly, so even a very brief press of one of the buttons is enough to trigger the timer. Once the button is released, T1 turns off, and C1 then discharges slowly through R4 alone, since T2

has a very high input impedance. When T2's gate voltage falls low enough, it turns off and the backlight goes out. The time the backlight stays lit after all the buttons have been released is roughly R4 (Ω) × C1 (F) seconds.

Of course, this circuit can be used for other applications too, and can be used to switch

things other than an LED — for example, a relay. The value of R5 depends on the load being switched. For an LED running off a 5 V supply, a value of around 300 Ω will be about right.

(090454-I)

Power On Indicator

Ton Giesberts (Elektor Labs)

Some types of electronic equipment do not provide any indication that they are actually on when they are switched on. This situation can occur when the backlight of a display is switched off. In addition, the otherwise mandatory mains power indicator is not required with equipment that consumes less than 10 watts. As a result, you can easily forget to switch off such equipment. If you want to know whether equipment is still drawing power from the AC outlet, or if you want to have an indication that the equipment is switched on without having to modify the equipment, this circuit provides a solution.

One way to detect AC power current and generate a reasonably constant voltage independent of the load is to connect a string of diodes wired in reverse parallel in series with one of the AC supply leads. Here we selected diodes rated at 6 A that can handle a non-repetitive peak current of 200 A. The peak current rating is important in connection with switch-on currents. An advantage of the selected diodes is that their voltage drop increases at high currents (to 1.2 V at 6 A). This means that you can roughly estimate the power consumption from the brightness of the LED (at very low power levels).
The voltage across the diodes serves as the supply voltage for the LED driver. To increase the sensitivity of the circuit, a cascade circuit (voltage doubler) consisting of C1, D7, D8 and C2 is used to double the voltage from D1–D6. Another benefit of this arrangement is that both halfwaves of the AC current are used. We use Schottky diodes in the cascade circuit to minimise the voltage losses.
The LED driver is designed to operate the LED in blinking mode. This increases the amount of current that can flow though the LED when it is on, so the brightness is adequate even with small loads. We chose a duty cycle of

090400 - 11

approximately 5 seconds off and 0.5 second on. If we assume a current of 2 mA for good brightness with a low-current LED and we can tolerate a 1-V drop in the supply voltage, the smoothing capacitor (C2) must have a value of 1000 µF. We use an astable multivibrator built
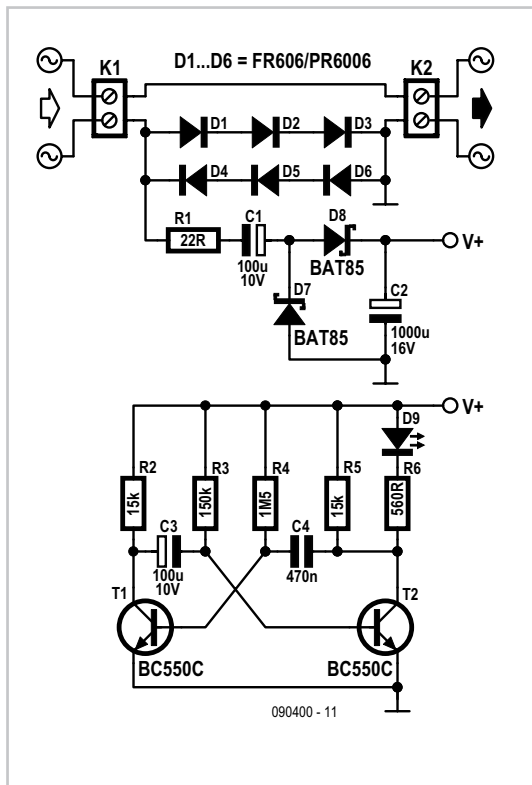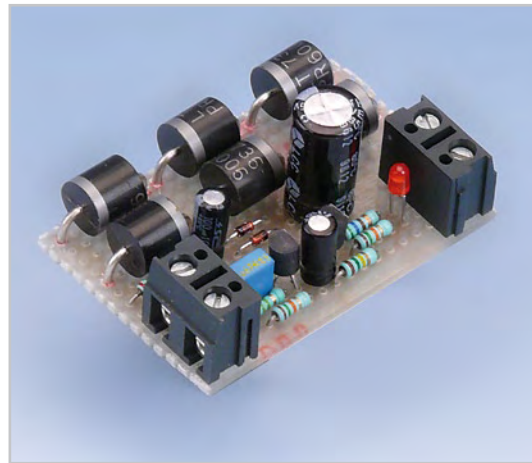
around two transistors to implement a high-efficiency LED flasher. It is dimensioned to minimise the drive current of the transistors. The average current consumption is approximately 0.5 mA with a supply voltage of 3 V (2.7 mA when the LED is on; 0.2 mA when it is off). C4 and R4 determine the on time of the LED (0.5 to 0.6 s, depending on the supply voltage). The LED off time is determined by C3 and R3 and is slightly less than 5 seconds. The theoretical value is R × C × ln2, but the actual value differs slightly due to the low supply voltage and the selected component values.
Diodes D1-D6 do not have to be special high-voltage diodes; the reverse voltage is only a couple of volts here due the reverse-parallel arrangement. This voltage drop is negligible compared to the value of the AC line voltage. The only thing you have to pay attention to is the maximum load. Diodes with a higher current rating must be used above 1 kW. In addition, the diodes may require cooling at such high power levels.
Measurements on D1–D6 indicate that the voltage drop across each diode is approximately 0.4 V at a current of 1 mA. Our aim was to have the circuit give a reasonable indication at current levels of 1 mA and higher, and we succeeded nicely. However, it is essential to use a good low-current LED.

Caution: the entire circuit is at AC line potential. Never work on the circuit with the mains cable plugged in. The best enclosure for the circuit is a small, translucent box with the same color as the LED. Use reliable strain reliefs for the mains cables entering and leaving the box (connected to a junction box, for example). The LED insulation does not meet the requirements of any defined insulation class, so it must be fitted such that it cannot be touched, which means it cannot protrude from the enclosure.

(090400-I)

Two TV Sets on a Single Receiver

Heino Peters (The Netherlands)

With the advent of digital television, it's often necessary to use a separate receiver. If you have several television sets in your house, you have to buy a digital receiver (and accompanying subscription) for each set. The solution described here lets you watch television in two or more places in your home using a single digital receiver, while allowing the digital receiver to be controlled from both locations. The circuit needed for this is powered from one of the two television sets (see **Figure 1**).

You'll need a length of four-way shielded cable (such as Conrad Electronics # 606502) for the connection between the digital receiver and the second TV set. Two shielded conductors are used to transmit the audio signals (L and R) from the receiver to the second TV set, another one is used to transmit the video signal, and the last one is used to transmit the remote control signal from the remote control for the second TV set to the digital receiver located next to the first TV set. The infrared sensor of the second TV set receives the signal from the remote control unit for the digital receiver and sends it via a small circuit to an IR LED aimed at the infrared sensor of the digital receiver near the first TV set. With this arrangement, it's convenient to buy a second (programmable) remote control unit so you don't have to carry the original remote control unit of the digital receiver back and forth all the time.

Most digital receivers have two SCART connectors for connecting a television set and a video recorder. The second SCART connector can be used quite nicely for the signals to be sent to the second TV set (see the connection diagram in **Figure 3**). If this connector is already in use, you can always take the audio and video signals from the Cinch connectors (if present).
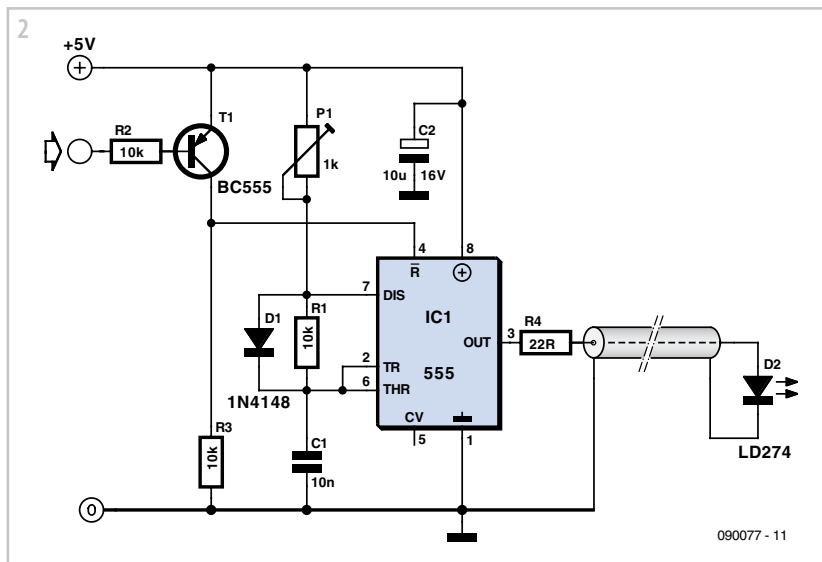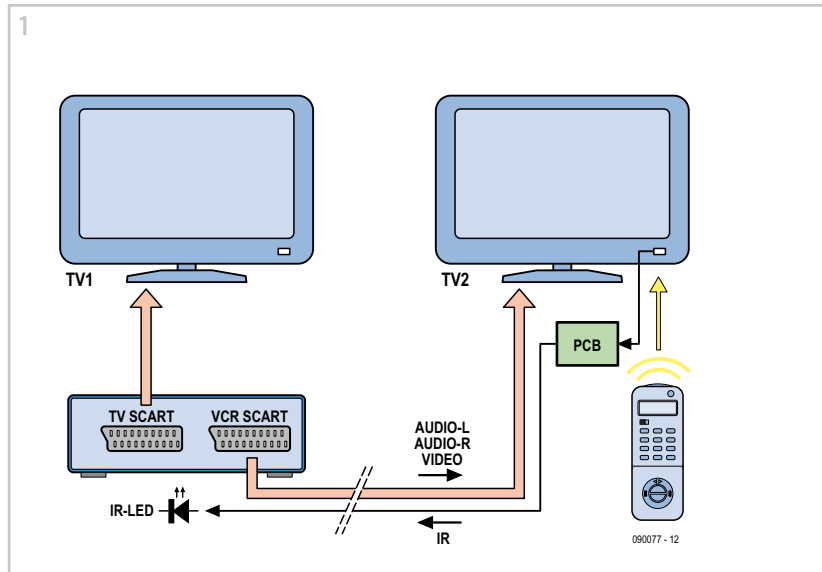
The circuit necessary for converting the infrared signal received by the second TV set into
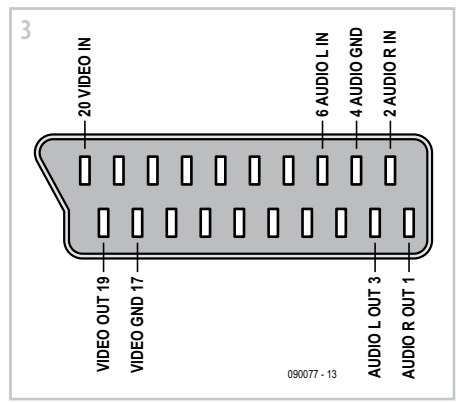
a new signal for driving the infrared LED at the digital receiver location is shown in **Figure 2**).

The infrared signal from the remote control unit consists of short pulse trains of modulated infrared light. The modulation frequency varies from one brand to the next and lies in the range of 30 to 56 kHz (B&O, different as always, uses 455 kHz). Frequencies in the 36–40 kHz range are most often used in practice. The modulation frequency of an infrared sensor is usually indicated in its type number. For example, the TSOP1736 responds to IR light modulated at 36 kHz, the TSOP1738 likes 38 kHz, and so on. **Figure 4** shows a few IR receivers and their pinouts. Infrared sensors also have adequate sensitivity to other frequencies close to their design frequency. Consequently, we assume a modulation frequency of 38 kHz here, which covers the full range from 36 to 40 kHz. The IR receiver demodulates the infrared signal. The demodulated signal forms the input to our circuit, which uses it to generate a new modulated signal for the IR LED located next to the digital receiver.

The author opened up his second TV set (watch out for possible sources of high voltage inside the set!) in order to use the set's built-in IR receiver and tap off power for the modulator circuit. However, you can also fit the circuit with its own IR receiver and use a separate power supply (AC power adapter).

The output signal of the IR receiver is used to trigger an astable multivibrator built around our old friend, a 555 timer IC. The data line of the IR sensor is High in the quiescent state and goes Low when it receives a modulated IR signal. As the Reset input of the 555 responds to an active-low signal, an inverter is built around T1, R2 and R3. The modulation

090077 - 12

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090077 - 13

frequency for IR LED D2 is set to approximately 38 kHz by P1, R1 and C1. Diode D1 allows the duty cycle of the output signal to be less than 50%, which cannot be achieved otherwise. The rise time of the oscillator signal on the Threshold input of the 555 is set by P1 and C1, while the fall time is set by R1 and C1.

The ratio of P1 to R1 determines the duty cycle, which is approximately 30% in this case. With a 5-V supply voltage, P1 is set to 1 kΩ, but it must reduced to a lower value (around 500 Ω) with a lower supply voltage. If possible, use an oscilloscope to adjust the oscillator frequency to 38 kHz

TSOP1736 SFH506 TFMS5360   SFH505A   PIC12043S   IS1U60   TSOP1836 NJL61H380   TSOP4836 SFH5110

090077 - 14
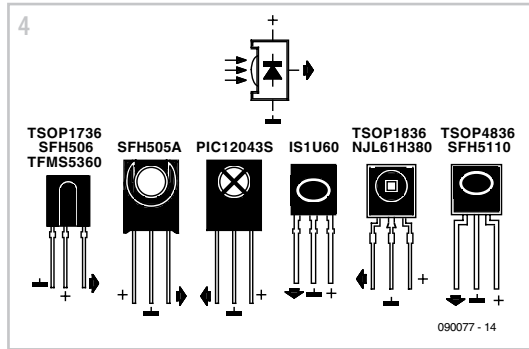
(period: 26.3 µs). To generate a test signal at the 555 output, temporarily connect the circuit input to ground.

Place IR LED D2 in front of the digital receiver so it shines on the receiver's IR sensor. Use the screen of the fourth shielded conductor of the cable between the receiver and TV2 for the negative lead of D2. Resistor R4 is dimensioned for a current of around 100 mA through the IR LED. If you use a 3.3-V supply voltage, R4 must be reduced to 3.3 Ω.

You can also use this circuit for the remote control of audio or video equipment located inside a closed cabinet.

(090077-I)

Tester for Inductive Sensors

Hugo Stiers (Belgium)

This tester uses a LED to indicate whether an inductive sensor is generating a signal. It can be used to test the inductive sensors used in ABS and EBS systems in cars, with engine camshafts and flywheels, and so on.
The circuit is built around an LM358 dual opamp IC. The weak signal coming from the sensor (when the wheel is turning slowly, for example) is an alternating voltage. The first opamp, which is wired here as an inverting amplifier, amplifies the negative half-cycles of this signal by a factor of 820. The second opamp is wired as a comparator and causes the red LED to blink regularly.

In order to judge the quality of the signal from the sensor, you must turn the wheel very slowly. If the red LED blinks, this means that the sensor is generating a signal and the distance between the sensor and the pole wheel (gear wheel) is set correctly. If the distance (air gap) is too large, the sensor will not generate a signal when the wheel is turned

090316 - 11

slowly, with the result that the LED will remain dark, but it will generate a signal if the wheel is turned faster and the LED will thus start blinking. Irregularities in the blinking rate can be caused by dirt on the sensor or damage to the pole wheel (gear wheel).

If you connect an oscilloscope to the LED with the engine running, you will see a square-

wave signal with a pattern matching the teeth of the gear wheel, with a frequency equal to the frequency of the AC signal generated by the sensor.
You can also use this tester to check the polarity of the connecting leads. To do this, first dismount the sensor and then move it away from a metallic object. The LED will go on or off while the sensor is moving. If you now reverse the lead connections, the LED should do exactly the opposite as before when the sensor is moved the same way.

The circuit has been tested extensively in several workshops on various vehicles, and it works faultlessly.

The author has also connected the tester to sensors on running engines, such as the camshaft and flywheel sensors of a Volvo truck (D13 A engine). With the camshaft sensor, the LED blinks when the engine is being cranked for starting, but once the engine starts running you can't see the LED blinking any more due to the high blinking rate.

(090316-I)

USB Radio Terminal

Rainer Schuster (Germany)

In the January 2009 issue of *Elektor* we saw how straightforward it is to connect a low-cost RFM12 868 MHz ISM (licence-free) radio module to an ATmega microcontroller. Sim-

ple example listings in BASCOM demonstrated how to communicate data using the modules [1].

The 'USB radio terminal' circuit described

here connects an RFM12 radio module to the R8C/13 microcontroller board used in the 'Transistor Curve Tracer' project described in the February 2009 issue [2]. The populated board, complete with USB interface connec-

tor, is available from the *Elektor* shop.

The circuit can be used to transfer data (for example from a PC terminal emulator program) wirelessly to another microcontroller and vice versa. Of course, the remote microcontroller also needs to be equipped with a radio module.

As ready-made and tested boards are available (even the radio module is available from *Elektor* [3]) building the circuit does not present any great difficulty. All that is necessary is to connect a total of six pins of K1 on the R8C/13 microcontroller board to pins on the radio module. The 5 V and ground pins are connected directly to their namesakes so that the radio module draws its power from the microcontroller board. The SPI port on the radio module is driven from port pins P1.0 to P1.3 on the microcontroller: see the 'circuit diagram'.

The microcontroller module will receive its power over the USB cable when it is connected to a PC.

The author has written R8C firmware in C, available for download in source or hex format from the *Elektor* website. The C source can be edited and compiled using the 'High Performance Embedded Workshop' IDE by Renesas [2], and further information is available from the R8C pages of the Elektor website [4]. The Motorola hex file can be downloaded over the USB port using the Flash Development Toolkit [2][4]. To enter programming mode jumper JP1 must be fitted on the microcontroller board and the reset button pressed briefly. After programming is complete, don't forget to remove the jumper and press the reset button again.

The firmware mostly consists of the BASCOM routines written by Burkhard Kainka [1], modified and converted into C. Extra functions have been added to handle the UART1 interface, which is connected to the USB interface chip.

On the transmit side, the program waits for characters to arrive over the USB port and stores them in an intermediate buffer. When the sequence <CR> <LF> is received the line of characters is sent to the radio module transmitter using a special protocol.
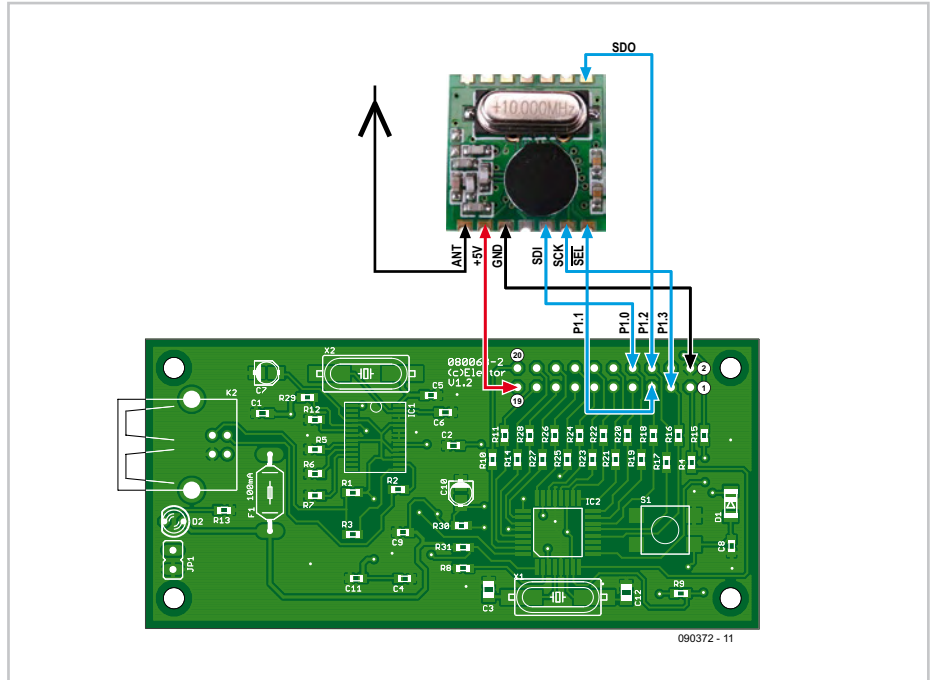
On the receive side, the program waits for characters from the radio module receiver. When the <STX> control code ('start of text', 0x02) is received, the subsequent characters are buffered until the stop code <ETX> ('end of text', 0x03) is received. The transmitted message includes a trailing checksum, so the complete sequence of characters is <STX> <string> <checksum> <ETX>. If the checksum is correct, it, along with the <STX> and <ETX> characters, is discarded, <CR> <LF> is appended, and the resulting string sent out over the USB port to the PC.

Of course, strings and commands can be sent over the radio link to other applications. In some cases the protocol will have to be adapted. In particular, because of the limited available RAM on the R8C/13 (1 kB) the inter-mediate buffer is only 200 bytes long. This should be adequate for most uses.

As configured, the software uses a data transfer rate of 9600 baud with 8 data bits, 1 stop bit, no parity and no handshake. The terminal program (for example, Hyperterminal) must be configured to match these settings.

(090372-I)

Internet Links

[1] www.elektor-usa.com/071125

[2] www.elektor-usa.com/080068

[3] www.elektor-usa.com/090372

[4] www.elektor.com/service/r8c---information.78378. lynkx

Products

071125-71: 868 MHz radio module, populated and tested, available via [3]

080068-91: R8C microcontroller board, populated and tested, available via [3]

Going for Gold

Joseph Kopff (France)

The title refers to a popular TV game show where the contestants each have a big button. The gameshow host asks a question and the first contestant to press their button makes an illuminated indicator light up on their desk. The other contestants' buttons are automatically inhibited, so that everyone can see who was the first contestant to press their button, and so is allowed to answer the question. The project described here shows how to build a similar sort of refereeing device yourself, using simple resources and without needing a microcontroller, which is pretty rare these days! The basic circuit is for just two contestants, but the modular design means it can easily be expanded.

The diagram shows three buttons: S2 and S3 are the buttons for the two contestants, S1 is the button for the host, which allows them to reset the circuit before each fresh question. The 'brains' of the circuit is IC1, a 4013 dual D-type flip-flop, of which only the Set and Reset inputs are used here. This circuit can handle quite a wide supply voltage range, from 3 to 15 V, and so the project can easily be run off

a 4.5 V battery pack (the power consumption is minimal).

IC1 is armed by pressing S1 (reset). In this state, the non-inverting outputs (pins 1 and 13) are at 0 and the inverting outputs (pins 12 and 12) are at 1. Hence line A is pulled high by R1, since diodes D2 and D4 are not biased on. If contestant 1 presses button S2, the non-inverting output of flip-flop IC1a goes to logic 1, and LED D1 lights via T1 to indicate that contestant 1 has pressed the button. At the same time, the flip-flop's inverting output goes to logic 0, making diode D2 conduct. Line A is now pulled down to 0, and consequently contestant 2's button S3 can no longer trigger the second flip-flop. The reverse happens if it is contestant 2 who presses their button S3 first.

The circuit can be extended to 4 or 6 contestants (or even more) by adding a second or third (or more) 4013 IC. All you have to do is repeat the circuit (minus R1, R2, and S1) and connect to the A, B, Vdd, and 0 V lines on the right-hand side.
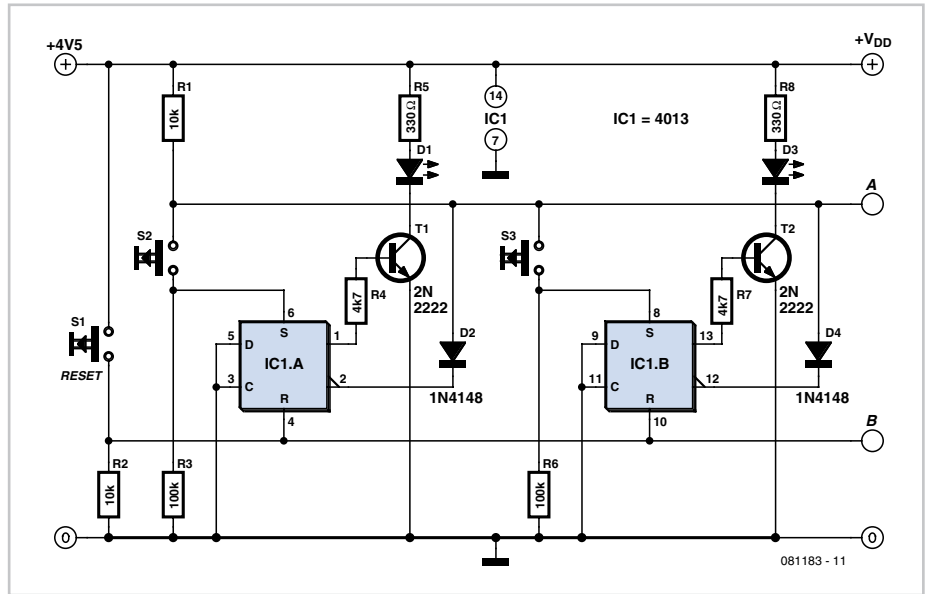
(081183-I)

Cut-rate Motorbike Alarm

T.A. Babu (India)

Motorbikes are often a target for thieves. Here is an alarm that's loud, cheap and simple to build. Arming and disarming the alarm is done with a hidden switch, S1. This tiny circuit does not unduly load the battery, as it draws very little current in the standby condition.

To activate the alarm, turn or press the hidden switch S1 to the 'on' position. If anyone attempts to start the motorbike, +12 volts from the ignition switch (connected to 'B') causes transistor T1 to conduct and switch on T2. The siren (LS1) then sounds for about 20 seconds, the period being determined by FET T3 wired as a monostable timer. The siren is a high-power ready-made piezo horn of the self-oscillating type.

Another piezoelectric component in the circuit has a different purpose — Bz1 detects attempts to tamper with the vehicle, or move it without starting the engine. The piezo transducer element should be mounted in such a way as to faithfully pick up vibration from the motorbike frame due to tampering.

One set of contacts on relay RE1 is used to effectively disconnect the ignition coil to prevent the bike from functioning when someone tries to steal it. Usually, there is a wire running from the alternator (point A) to the ignition coil (TR1), which has to be routed through the N/C (normally closed) contact of the relay. The hidden switch S1 is prefer-ably a miniature type or its electrical equivalent. To deactivate the alarm, the hidden switch should be flipped to the 'off' position to disable the movement sensor and the siren driver/timer circuit when the ignition key is turned… by the lawful owner!
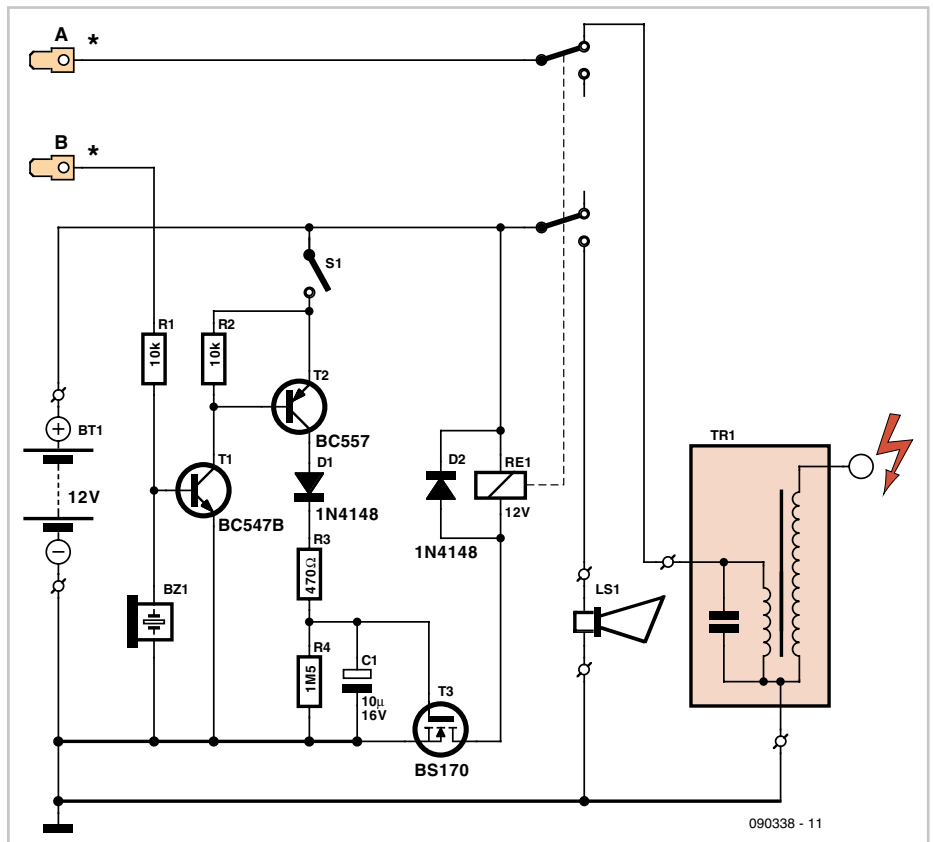
(090338-I)

Digital Sweep and Sinewave Generator

with
direct frequency entry

Wilfried Wätzig (Germany)

The Parallax SX28-based 'Frequency Response Sweep Oscillator' project published in the April 2008 issue of *Elektor* inspired the author to develop a similar circuit based on the ATmega48 microcontroller. As it turns out, the ATmega-based circuit is nearly as capable as the original.

An important characteristic of the design is the maximum direct digital synthesis (DDS) sample rate that can be achieved when generating a sinewave. The specifications are comparable:

SX28 design: f_{DDS} = 50 MHz /
28 cycles = 1.78 MHz

ATmega48 design:
f_{DDS} = 25 MHz /
18 cycles = 1.39 MHz

At 25 MHz, the ATmega48 is somewhat overclocked in this circuit. The maximum specified clock frequency according to the datasheet is 20 MHz. In practice, however, this does not seem to lead to problems.

The other important part of the circuit is the digital-to-analog converter (DAC) connected to Port D of the microcontroller. This takes the form of an *R-2R* network and can approximate a sinewave with a sample rate of 1.39 MHz. The digital values are read from a look-up table.

A passive sixth-order Butterworth low-pass filter with a corner frequency of 500 kHz is used to smooth the DAC output. This is particularly necessary at higher frequencies.

The user interface is principally provided via a twelve-button telephone-style keypad. In sweep mode the four rows of buttons (1-2-3, 4-5-6, 7-8-9 and *-0-#) are used to adjust the marker frequency up and down in coarse or fine steps. In sinewave generation mode the desired frequency is entered directly on the keypad in Hertz. For example, to enter 12 kHz, type '*12000#'. The usable frequency range runs from around 10 Hz to 500 kHz.

In order to ensure that a clean output signal is produced the timer interrupt is disabled during sinewave generation. If a button is pressed a pin change interrupt is triggered which enables the timer so that a new frequency value can be entered.

The sinewave frequency accuracy and stability are determined by the quality of the 25 MHz crystal. There may also be a small error in absolute frequency resulting from rounding errors in the calculation of the DDS phase accumulator increment value.

The DDS phase accumulator increment value is derived from a set of values stored in a look-up table:

$$increment = freq * 2^{24} * cycles / f_{osc}$$

for freq = 2^k, k = 0 to 19. The total increment value is calculated to 24 bits of precision.

The main features of the unit are listed in the text box, and the functions of switches S1 to S3 are given in **Table 1**.

The digital outputs on Port B are protected from short circuits by series resistors. The amplitude of the sinewave output can be set between 0 V_{PP} and 4.5 V_{PP} using P1.

The ATmega48 chip can be programmed using the 10-way ISP interface connector provided. The firmware for this project was written in assembler using the Atmel AVR Studio 4 development system, version 4.14. The project files (source code and hex) are available for free download from the Elektor website [1]. The zip file also includes a screenshot showing the fuse settings required for the microcontroller in AVR Studio 4. As an alternative to the program-it-yourself route, ready-programmed microcontrollers are available from the Elektor Shop.

(080577-I)

Internet Link
[1] www.elektor-usa.com/080577

Characteristics

Digital sweep function:
- Frequency ranges: 100 Hz to 100 000 Hz or 50 Hz to 15 000 Hz,
- logarithmic scale with 256 steps
- 2 sweep rates: 0.2 ms or 0.4 ms per frequency value
  (phase accumulator increment value changed every 0.2 ms or 0.4 ms)

Outputs in sweep mode:
- sine output
- marker frequency (rectangular wave)
- marker position pulse
- trigger pulse at start of each sweep

Digital sinewave operation:
- Direct frequency entry in Hertz via keypad
- Format: '*' = start of entry
       digit(s) 0 to 9
       '#' = end of entry, start sinewave generator

Outputs in sinewave mode:
- sine output (0 V_{PP} to 4.5 V_{PP})
- frequency/marker pulse (rectangular wave)

Table 1. Function of switches S1 to S3

	Open	Closed
S1 (frequency sweep range)	50 Hz to 15 kHz	100 Hz to 100 kHz
S2 (sweep rate)	0.2 ms	0.4 ms
S3 (sinewave/sweep output)	sinewave output	sweep output

080577 - 11
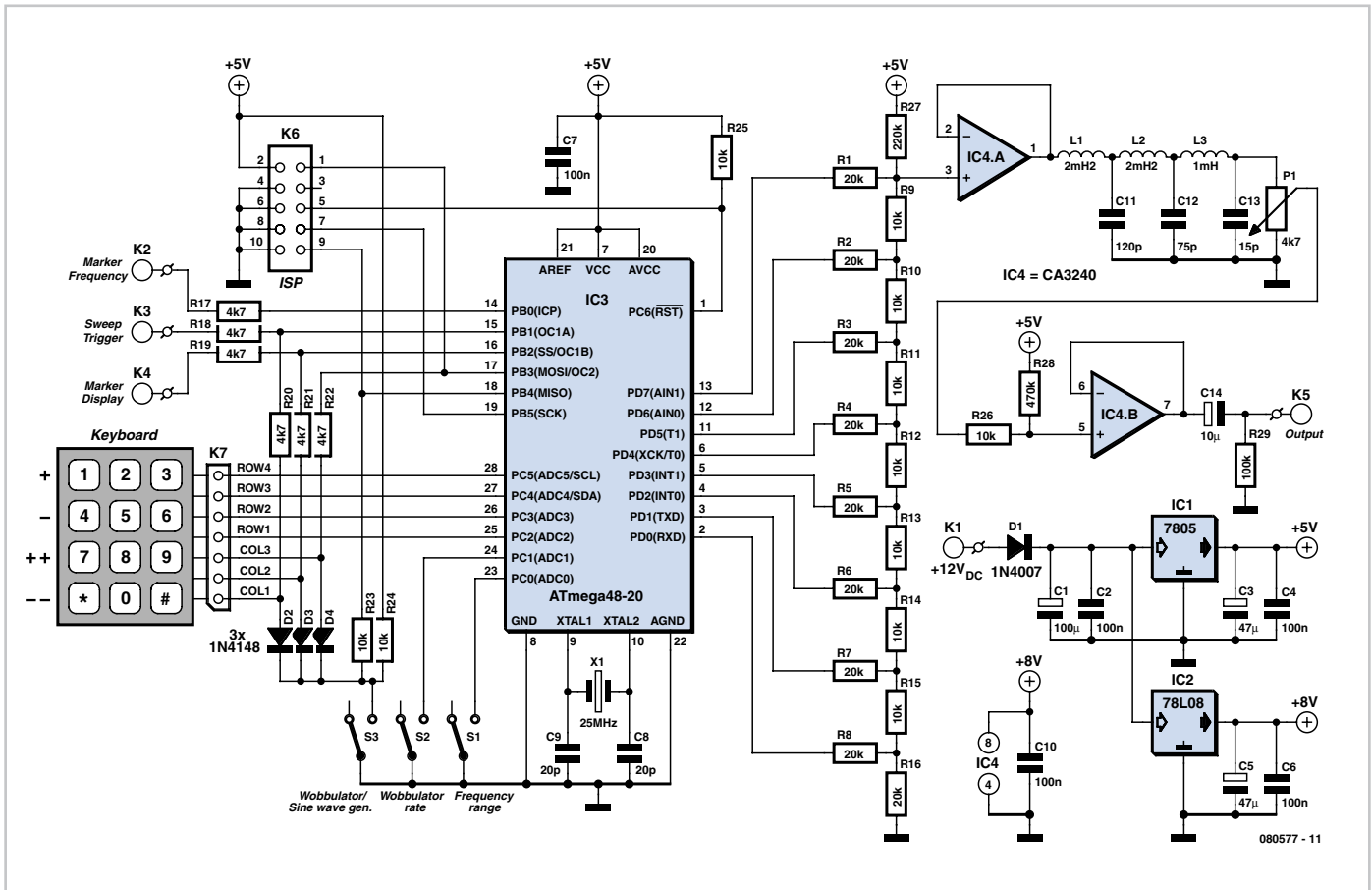
Guitar Amplifier PSU

Malcolm Watts (New Zealand)

Tubes (thermionic valves) have never departed from the amplified instrument scene and the majority of guitarists, including very young ones, wouldn't use anything else. Some diehards think that the H.T. (high tension) rectifier should also be a piece of glassware and some manufacturers are still producing amplifiers incorporating one. The nett effect is really that a rectifier tube acts as a relatively effective heat-dissipating resistor, causing the HT rail to sag as output signal loading increases, generating a compressive characteristic which is fundamentally added distortion ('crunch').

The traditional arrangement uses a cen-

tre-tapped HT winding on the power transformer but this has a number of drawbacks for an adequately rated core size including increased voltage stress, small wire size and a poor utilization of the available winding window.
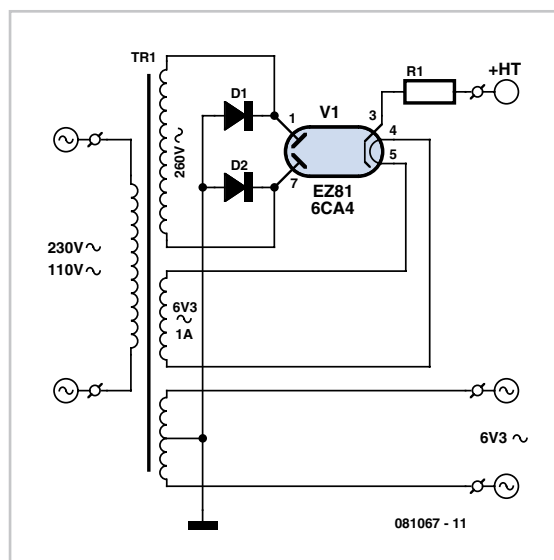
The example arrangement shown here reduces both of these problems and for a given core increases the current delivery capability of the winding by allowing the use of a heavier wire gauge. Normally some resistance is added in series to each anode to limit peak cathode current to minimise cathode-stripping during the high current pulses delivered to the input filter capacitor at each voltage peak. Even if one includes such resistance (and a single resistor in series with the cathode or winding achieves

081067 - 11

the same end albeit with double the device dissipation) the benefits to the transformer of reduced voltage stress and increased wire insulation thickness (which scales with wire diameter) along with decreased heating in the windings, are obvious.

Alternatively, a smaller winding window (reduced core size) may be employed without diminishing power-handling capacity.

The circuit shown here should is typically intended for the amplifier preamp and phase splitter stages. Due to the use of the EZ81 (6CA4) tube its maximum output current is about 100 mA. Higher currents call for a more powerful rectifier tube and diodes to match.

(081067-I)

Acoustic Distress Beacon

Werner Ludwig (Germany)

An ELT (Emergency Locator Transmitter, also known as a distress beacon) is an emergency radio transmitter that is activated either manually or automatically by a crash sensor to aid the detection and location of aircraft in distress. This acoustic ELT project is intended for radio-control (RC) model aircraft, which every now and then decide to go their own way and disappear into the undergrowth.

The audio locating device described here enables model aircraft that have landed 'off limits' to be found again and employs its own independent power supply. The small camera battery shown in the circuit activates an acoustic sounder when radio contact is lost and produces a short signal tone (bleep) every ten seconds for more than 25 hours. Current consumption in standby and passive (with jumper J1 set) modes is negligible. The timing generator for the alarm tone is the Schmitt trigger AND-gate IC1.B; its asymmetric duty cycle drives a 5 V DC sounder via

090037 - 11
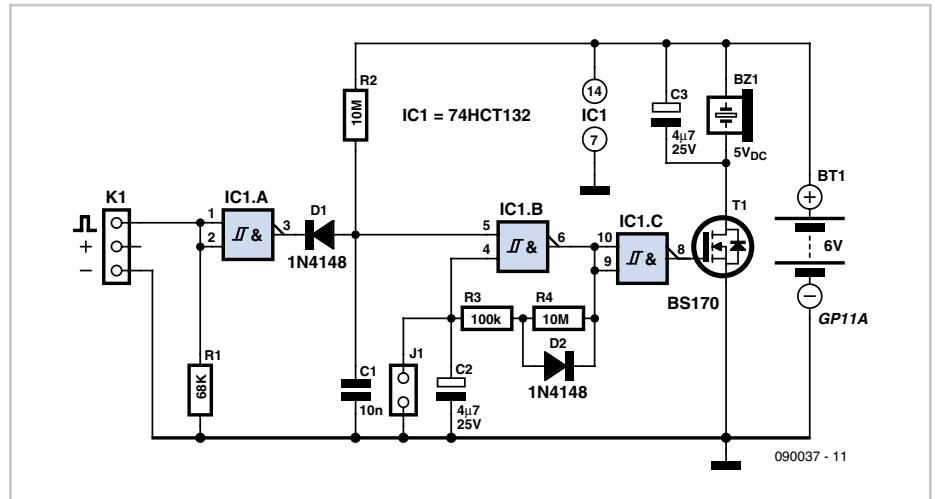
MOSFET transistor T1. All the time that the RC receiver output is delivering positive pulses, the oscillator is blocked by IC1.A and diode D1. Setting jumper J1 parallel to C2 also disables the oscillator and serves to 'disarm' the distress beacon.

(090037-I)

Internet Link

http://en.wikipedia.org/wiki/Emergency_Position-Indicating_Radio_Beacon

Measuring Milliohms with a Multimeter

Klaus Bertholdt (Germany)

Low values of resistance can be troublesome especially when large currents flow through them. A current of, say, 10 A passing through a terminal with a contact resistance of 50 mΩ will produce a voltage difference of 0.5 V. This resulting power loss of five watts is dissipated in the termination and can give rise to a dangerously high temperature which may degrade insulation around the wires.

080851 - 11
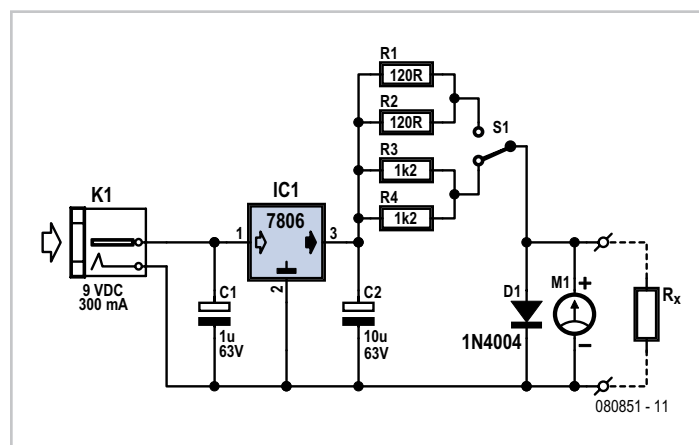
multimeter. The circuit consists of little more than a 6 V voltage regulator and a mains adapter capable of supplying around 300 mA at 9 to 12 V.

The circuit supplies a fixed current output of 100 mA or 10 mA selected by switch S1. This connects either the 60 Ω or 600 Ω resistor into the constant current generator circuit. The resistor values are produced by paralleling two identical resistors; 120 Ω and 1.2 kΩ from the E12 standard resistor range. Two test leads with probes are used to deliver current to the test resistance. The resultant voltage drop is measured by the multimeter (M1).

Measuring low values of resistance is not easy. Low cost multimeters do not include a milliohm measurement range and specialist equipment is expensive. The simple circuit described here allows milliohm measurements to be made safely on a standard

With the test current set to 100 mA a measurement of 1 mV indicates a resistance of 10 mΩ. At 10 mA (with S1 in the position shown in the diagram) a measurement of 1 mV indicates a resistance of 100 mΩ while 0.1 mV is equal to 1 mΩ. Diode D1 protects the meter from too high an input voltage.

With the voltmeter connected as shown in the diagram it measures not only the voltage drop across R_X but also that produced by the resistance of the test leads, and probes. To make a true measurement, first touch the probes close together on the same lead of the test resistance and note the reading, now place the probes across the test resistance and note the reading again. The first reading measures just the test leads and probes while the second includes the resistance R_X. Subtract the first measurement from the second to get the value of R_X.

The accuracy of the measurements are influenced by the contact resistance of switch S1, the precision of resistors R1 to R4, the 6 V supply level and of course the accuracy of the measuring voltmeter.

For optimum decoupling C1 should be fitted as close as possible to pin1 of IC1. An additional electrolytic capacitor of around 500 µF can be used at the input to the circuit if the input voltage from the AC power adapter exhibits excessive ripple.

(080851)

Snail Mail Detector

Philippe Temporelli (France)

Since his letter-box is outdoors and quite some way from the house, the author was looking for a simple means of knowing if the postman had been without having to go outside (contrary to popular belief, the weather isn't always fine in the South of France). Circuits for this kind of 'remote detection' come up regularly, but always involve running cables between the letter-box and the detection circuit in the house. Seeking to avoid running any extra cables, the author had the idea of using the existing cables going to the doorbell, conveniently located adjacent to his letter-box.

The letter-box has two doors: one on the street side for the postman, and one on the garden side for collecting the post. A microswitch is fitted to the street-side door, to light an indicator in the house showing that the postman has been. A second microswitch is fitted to the door on the garden side, to turn off the indicator once the post has been collected. The only difficulty then remains to connect these detectors to a remote circuit in the house that remembers whether the postman's been or not.

The idea was to use the alternating half-cycles of the AC signal on the cable going to the doorbell to transmit the informa-

090481 - 11

090481 - 12
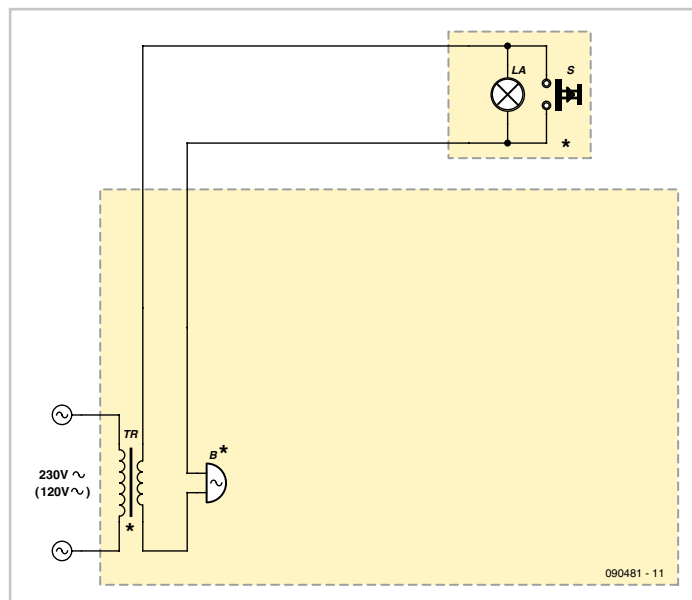
tion, according to the following logic:

- Both half-cycles present: no change in the status of the mail detector.
- An interruption (even brief) of one half-cycle: indicator lights permanently.
- An interruption (even brief) of the other half-cycle: the indicator goes out.

Note that the signal is tapped off across the doorbell coil via R6 and the pair of diodes connected in inverse-parallel (to limit the signal, particularly when the bell is rung). The signal is then filtered by R2/C1, before being used by IC1, which is wired as a comparator with hysteresis. The trigger threshold is adjusted by P1, using a pair of inverse-parallel diodes as a voltage reference (positive or negative according to the output state):
For the detection to work, there has to be continuity in the bell-push circuit — this is generally ensured by the little lamp illuminating the bell-push. Resistor R1 is added just in case the lamp is blown or not present.
To keep things simple, the circuit is powered directly from the doorbell transformer itself (8 V secondary). The author managed to fit the little circuit within the doorbell unit, with the LED poking through a hole in the casing so it is readily visible in the hall of his house.

(090481-I)

DMX Transmitter

Gerald Weis (Austria)

Lighting effects are always popular at special events, whether large or small. For example, a spotlight with a moving head can be used to project a company logo or other image on the wall or ceiling. These special-effect light sources are controlled by the widely use DMX protocol [1], for which many PC-based programs are available. However, providing some sort of PC and setting up the USB and DMX hardware involves a certain amount of extra effort and expense. Consequently, the

because the MSP430 has an internal oscillator. If you use the internal oscillator, it's important to adjust the frequency precisely using resistor R6 = R_{OSC} (also shown in the schematic diagram). The microcontroller data sheet [3] lists the appropriate values. To check the frequency of the internal oscillator, it should be fed out to an I/O pin and measured.

A LED that indicates that the transmitter is operating is driven via port pin P2.0. Extensive information on the DMX driver (IC3) and its circuitry is available on the Web [4].

As with every project, this one also has room for improvement. If you use the internal oscillator of the MSP430, the DMX bus may not operate at the right speed if the temperature changes. However, this could be compensated by measuring the temperature with the temperature diode in the MPS340 and making suitable adjustments. A display would also be a nice addition. Anyone who is interested in expanding on the current design is welcome to contact the author [7].

(081158-I)

081158 - 11

author built a small stand-alone DMX transmitter that can easily be configured using three buttons.

The entire circuit is based on a Texas Instruments MSP430F2112 microcontroller, along with an SN65HVD10QD RS485 transceiver IC from the same manufacturer (note: both ICs can be obtained from TI as samples).

In addition, it requires a small circuit board, a female XLR connector, three pushbutton switches, and a few resistors and capacitors. The circuitry around the MSP430 (including the JTAG port) is standard. More information about the microcontroller is available on the Web [2]. The schematic diagram shows a quartz crystal, but it can be omitted if desired

The author wrote the firmware for the microcontroller, which must be adapted to the actual DMX device that is used. The author's C source file for this project can be downloaded from the Elektor website [5]. IAR Kickstart Edition, which can also be downloaded from the Elektor website [6], can be used as the development environment.

The code for initializing the serial interface is also shown on the TI website. The program transmits 25 DMX channels at once. Interrupts are used to handle pushbutton input and transmit the DMX data. In the author's example software, one button is configured for the tilt motion of the Futurelight MH-640 moving head unit, while the other two buttons are unused.

Internet Links

[1] http://en.wikipedia.org/wiki/DMX512-A

[2] www.ti.com

[3] http://focus.ti.com/lit/ds/symlink/msp430f2112.pdf

[4] http://focus.ti.com/docs/prod/folders/print/sn65hvd10.html

[5] www.elektor-usa.com/081158

[6] www.elektor-usa.com/081041

[7] hihi85@gmx.at

Download

Software
081158-11: source code files, from [5]

Single Lithium Cell Charger

Steffen Graf (Germany)

Using the BQ24002 from Texas Instruments it is possible to build a simple and small charger module for single lithium-ion (Li-ion) cells. The device is available in a SSOP20 package and so does not require heroic assembly and soldering skills.

Individual cells are becoming available from the main catalog suppliers, but a much cheaper option is to rescue cells from defunct notebook batteries. In most cases only a couple of cells are faulty and the others can still

Characteristics

- Designed for a single Li-ion cell
- Suitable for all lithium chemistry cells with a final voltage of 4.1 V or 4.2 V (lithium-cobalt, lithium-manganese and lithium-polymer)
- Configurable 4.1 V or 4.2 V final voltage
- Input voltage from 4.5 V to 10 V (depending on charge current)
- Charge current up to 1.2 A
- Charge current configurable via shunt resistor
- Linear regulator topology
- Precharge function for deeply-discharged cells
- Charge status indicated by two LEDs
- Two package options: SSOP20 or QFN
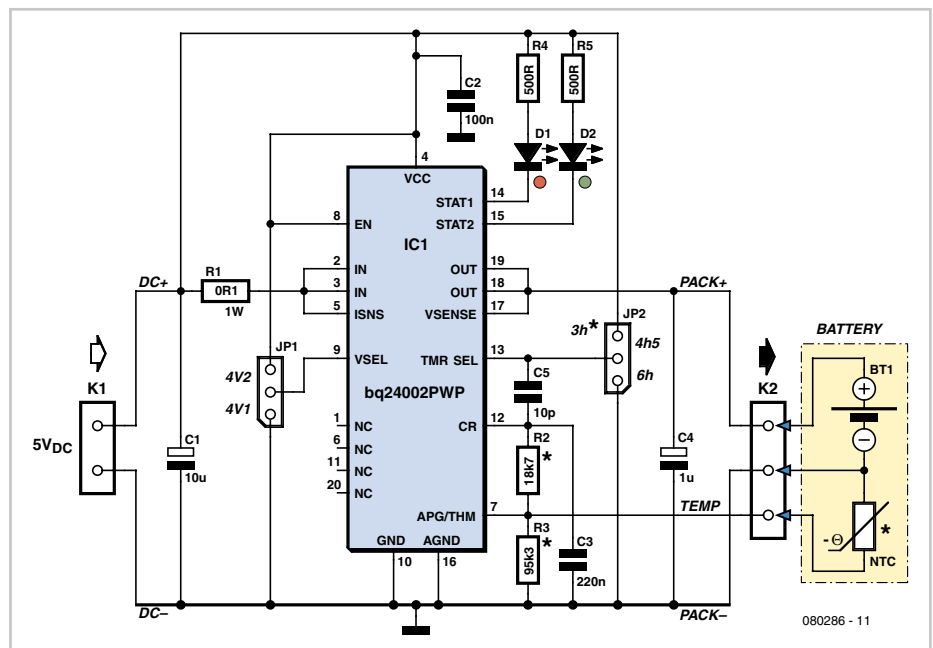
look forward to a long and useful life. A single cell is ideal for any equipment that needs a 3.3 V power supply, and will generally give a good operating life. The charger circuit requires a 5 V input, which can readily be obtained from a USB port or from any 5 V power supply.

The charge process begins with a trickle charge current. When the cell terminal voltage is sufficiently high the charger switches to a higher constant charge current. Charging is terminated when the cell voltage reaches a preset limit (the 'final voltage'). The charger described here is suitable for cells with a final voltage of 4.1 V or 4.2 V, configured using jumper JP1: pin 9 is taken to ground to select 4.1 V or to V_{CC} to select 4.2 V.

It is important **never** to exceed the maximum permissible cell voltage: if in doubt, **consult the manufacturer's specifications for the definitive value**.

The charge current is determined and monitored by input shunt resistor R1. A value of 0.1 Ω gives a charge current I_L of 1 A: the general formula is $I_L = 0.1$ V / R1. In this example,

the input voltage should be no greater than 5.3 V to ensure that the maximum allowable power dissipation of the IC is not exceeded. With a charge current of 0.5 A (R1 = 0.2 Ω), the maximum allowable input voltage is 7.6 V. The circuit offers a charge time limit and cell temperature monitoring. The charge time limit is set using JP2. If the jumper is not fitted charging will always stop within three hours, even if the cell has not reached its final voltage. If the jumper is fitted to pull pin 13 to V_{CC}

(the supply voltage) the time limit is four and a half hours, and if pin 13 is pulled to ground the time limit is six hours. If the final voltage is reached early, charging will of course cease before expiry of the time limit. The LEDs allow the charge process to be monitored. Red LED D1 lights during charging and flashes to indicate that a fault has been detected. When the cell is more than 90 % charged the red LED is extinguished and the green LED lights.

Pin 7 (APG/THM) is the input to a window comparator with a lower threshold of 0.56 V and an upper threshold of 1.5 V. If the voltage on this pin is over 1.5 V or below 0.56 V the IC regards this as a fault and aborts the charging process. Charging can only occur if the voltage on the pin lies between the two thresholds. The window comparator can be used either to monitor the IC's supply voltage or to monitor the temperature of the lithium cell. In the circuit shown we have used the input in a temperature monitoring configuration: the voltage on pin 7 is determined by a voltage divider comprising R2, R3 and an NTC thermistor, which is arranged to sense the temper-

ature of the lithium cell and which is wired in parallel with R3 via connector K2. Pin 12 (CR) carries a reference voltage of 2.85 V; so that charging is possible under normal conditions the thermistor and the voltage divider of which it forms a part must be dimensioned so that the voltage on pin 7 lies within the comparator's voltage window when the cell is running at a safe temperature. The values shown for R2 and R3 will allow charging as long as the resistance of the thermis-

tor lies between 4.8 kΩ (upper temperature limit) and 26.6 kΩ (lower temperature limit). Using a typical 10 kΩ thermistor (such as the Vishay 2381 640 63103) this means that charging will occur as long as the cell temperature is between approximately 5 °C and approximately 43 °C. A 12 kΩ thermistor from the same series gives an upper limit of 48 °C: this is the arrangement used in Texas Instruments' evaluation module [1].

Formulae are given in the datasheet [2] to help with the calculation of component values in the voltage divider. Alternatively, the TempSense Designer software [3] can be used: it offers a graphical user interface and a number of other features.

(080286)

Internet Links

[1] http://focus.ti.com/lit/ug/sluu113/sluu113.pdf
[2] http://focus.ti.com/lit/ds/slus462e/slus462e.pdf
[3] http://focus.ti.com/docs/prod/folders/print/bq24002.html

Long Duration Timer using ATtiny2313

Jürgen Stannieder (Germany)

This timer circuit is designed to switch on a 12 V load in a solar-powered installation for a preset period at the press of a button. When the period has expired a latching relay disconnects both the load and the controller circuit from the 12 V supply. The length of the period can be configured by making suitable changes to the microcontroller's source code.

When button S1 is pressed a voltage appears across relay coil L1, and the relay switches the load on. Since the relay is a latching type, it remains in this state when the button is released. There is now a supply to the 78L05 voltage regulator (a low-dropout type such as the LP2950CZ-5.0 may also be used) and the microcontroller is powered up. In the microcontroller the timer program runs until the configured time interval has elapsed. Around 90 % of the way through the time period LED D2 lights as a warning that the load will shortly be switched off, and this time
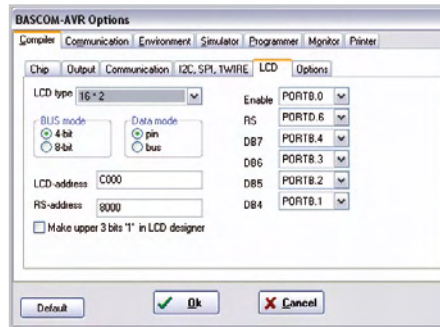
can also of course be configured by changing the software.

When the full time interval has elapsed the microcontroller sets an output (pin 7) high, which triggers the CNY 17-3 optocoupler and in turn drives relay coil L2. The relay returns to its initial state, disconnecting the load as well as the controller (which is also powered via the relay contact) from the 12 V supply.

The author used a miniature 16-by-2 LCD panel type HMC16223SG in his prototype, measuring just 52 mm by 20 mm. It is of course possible to use any standard LCD

module that uses an HD44780-compatible controller. Note that P1 is used to adjust the contrast of the LCD: if the display appears blank it is worth checking the contrast setting before suspecting a more serious problem! If desired, the LCD can be dispensed with, along with the corresponding parts of the source code.

The upper line of the LCD shows the total time period, in seconds, for which the software is configured, while the lower line shows the time, in seconds, since the button was pressed.

The screendump shows the LCD settings under BASCOM-AVR. The source code for the program is available for download at [1].

(080584-I)

Internet link

[1] www.elektor-usa.com/080584

Download

080584-11: source code, from [1]
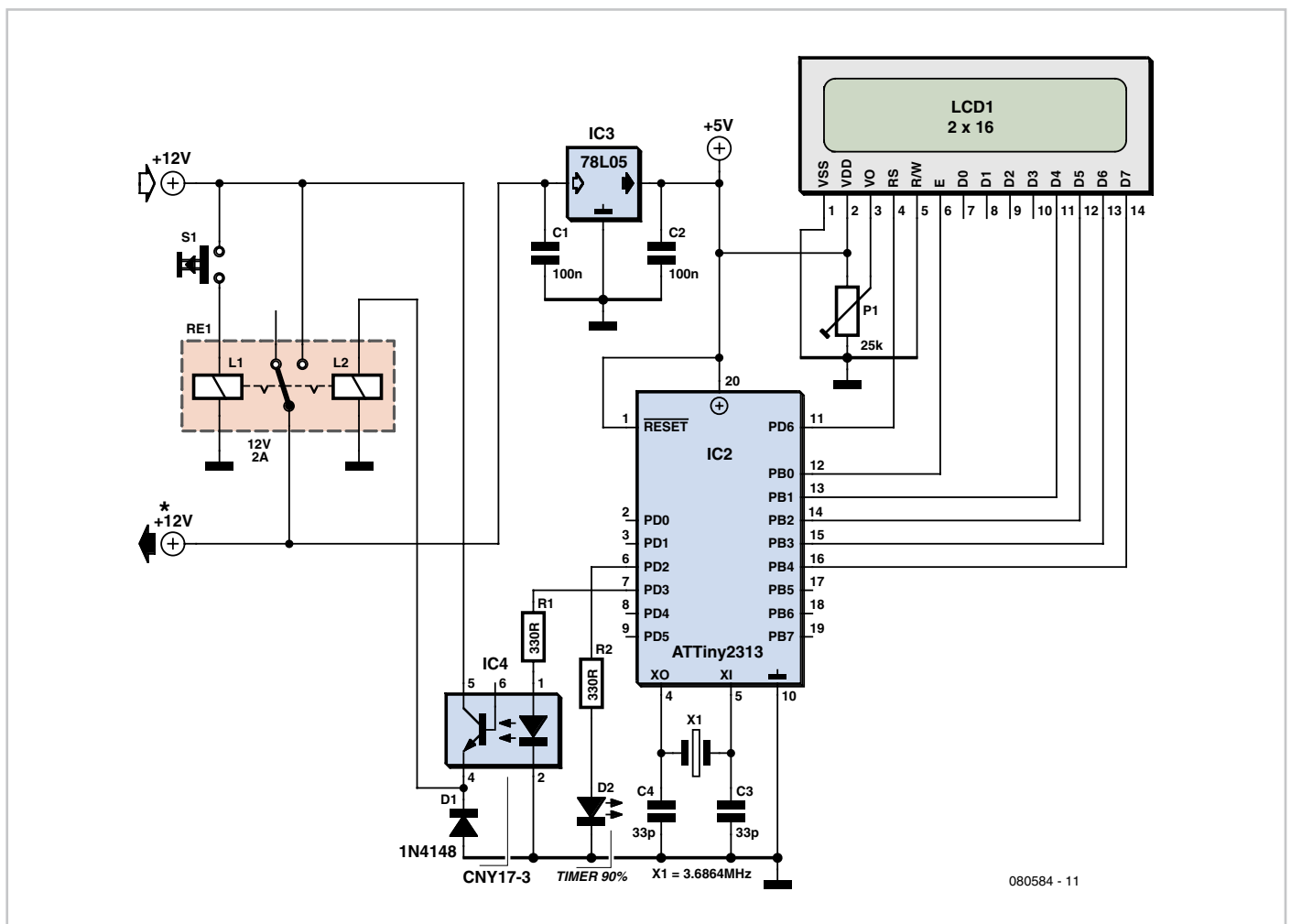
080584 - 11

Quartz Crystal Tester

Christian Tavernier (France)

Although most passive components are usually fairly easy to test, the proper functioning of a quartz crystal cannot be checked using any standard measuring instrument. A quartz crystal is actually a very simple device in principle, since all it consists of is a slice of quartz, accurately cut, of course, held between two metal electrodes, or with metallic contacts deposited on it to serve the same purpose. But sadly, owing to its being made like this, an ohmmeter or capacitance meter will not measure anything across a crystal, since it will have a resistance of several megohms (MΩ) and a stray capacitance of only a few picofarads (pF) — regardless of whether it's working or not. So the only solution available to us is to fit the crystal into a circuit, i.e. an oscillator, and see if it oscillates or not. This is just what our tester does — and at a ridiculously low cost.

As the frequencies of the crystals we deal with may cover a very wide range — the vast majority of them will be typically between 1 MHz and 50 MHz — we need to build an oscillator that will be capable of working over a very wide frequency range. This task is given to transistor T1, which is arranged as an aperiodic oscillator — i.e. it is not tuned to any particular frequency. If you are familiar with this type of oscillator circuit, you'll note that the feedback capacitor C1 has an unusually high value, which enables this circuit to cope with almost any type of crystal with a frequency between 1 and 50 MHz.

So if the crystal is good enough, a pseudo-sinewave signal at the crystal's fundamental frequency will be present at the emitter of T1. This signal is rectified by D2 and charges capacitor C4 via D1. As soon as the voltage across this reaches a high enough value, transistor T2 turns on and lights the LED in its collector circuit, thereby indicating that the crystal is usable.

Clearly, because of its operating principle, this circuit doesn't let us check the actual operating frequency of the crystal, but experience shows that, when a crystal is faulty, it will fail to oscillate at all, but that when it does oscillate, it will do so at the frequency for which

it was made, or one of its harmonics (see below). If it's important for you to measure this frequency, you can connect a frequency

meter or oscilloscope across resistor R2. The circuit itself is very simply and can be built on the little dedicated PCB whose design

we have suggested for you [1], or on a piece of prototyping board (perfboard, Veroboard etc.). In either case, it is essential for the base material to be fiberglass and not paxolin, because of the high frequencies that may be involved.

To achieve the connection to the crystal to be tested, two HC6/U and HC18/U sockets can be soldered in parallel to accommodate crystals using these pin-out formats. Crystals that have wire leadouts can easily be connected to one or other of these two sockets.

The power supply is provided by a source of 9 V. A simple 9 V PP3 battery is ideal, given the circuit's low power consumption and above all the fact that it's only ever used for a relatively short time.

As previously explained, the circuit works for any crystal with a frequency between 1 and 50 MHz — i.e. virtually all the crystals on the market. It's important to appreciate that, even though you do find crystals marked with frequencies higher than 50 MHz, they rarely actually operate directly at this frequency, which is in fact the harmonic frequency to which the oscillator in which they are fitted needs to be tuned. So their fundamental oscillating frequency is in fact normally below 50 MHz, by a ratio of 2 or 3, depending on which harmonic (or overtone) is to be used. The reason for this curious way of going about things lies in the manufacturing technology for these devices, which requires the slice of quartz to be finer and finer as the actual operating frequency (or 'fundamental frequency') is increased. And so, if they try and go too high with direct oscillation at the fundamental frequency, the slice becomes so fragile that it may break all of its own accord.

(081178-I)

Internet Link
[1] www.elektor-usa.com/081178

Download

PCB
081178-1: PCB layout (.pdf), from [1].

COMPONENT LIST

Resistors
R1 = 22kΩ
R2 = 1 Ω
R3 = 880Ω

Capacitors
C1 = 1nF
C2 = 100pF
C3 = 2nF2
C4 = 10nF
C5 = 100nF

Semiconductors
D1, D2 = 1N4148
T1 = BF494
T2 = BC547
LED1 = LED

Miscellaneous
Socket for HC6/U and/or HC 18/U type xtal

Improved Hybrid HeadPhone Amplifier

Tuck Choy, PhD (Singapore)

Jeff Macaulay's excellent single tube ECC82/ 12AU7 'Hybrid Headphone Amp' (HHA) published in [1] spurred the author to implement some modifications culminating mainly in an additional input preamp. The resulting project was then slightly reworked in the Elektor Audio Labs and the result is shown here, along with a PCB design to Elektor standards.

Specifications

- Warm up time: min. 30 minutes
- Load impedance: 33 Ω
- Supply voltage: 12.1 VDC
- Current consumption: 235 mA
- Gain (33 Ω load): 4.5
- Max. output voltage: 730 mV
  (THD = 3%, clipping audible)
- THD + N: 0.13 % (1 mW/1 kHz/B = 80 kHz)
- S/N: 87 dB (ref. 1 mW, B = 22 kHz)
- Bandwidth: 17 Hz – 3.5 MHz (at 1 mW)
- Output impedance: 2 Ω
- DC output voltage: 1 mV (33 Ω load)
  3 mV (150 Ω load)

080310 - 11
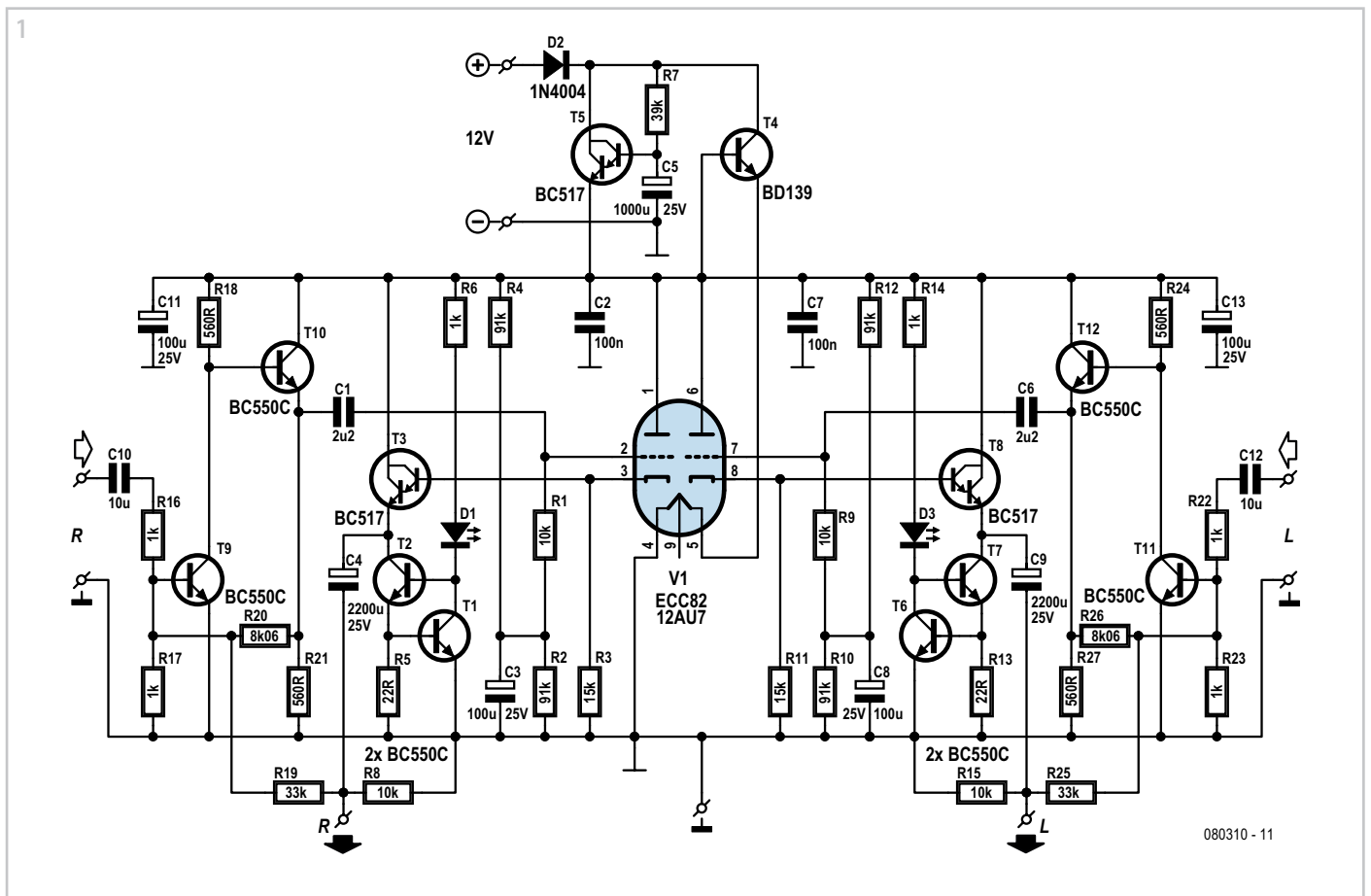
The original HHA was designed for line inputs of the order of 1 V$_{rms}$ and an output impedance of about 35 ohms. Unfortunately there do not seem to be hard and fast international standards for headphone output levels or impedances. Higher end headphones such as the AKG type K601 (impedance 125 ohms) and K701 (impedance 62 ohms), coupled a hi-fi preamplifier system like the author's Rega Mira (which supplies only 600 mV$_{rms}$ out) resulted in a compromized dynamic range and low loudness performance especially on older CD recordings.

Initial experiments with modifying the BC517 Darlington output of the HHA were rather unsuccessful. The low anode current from the tube requires this specialized gain stage and any efforts to boost the output seems to modify the system from a tube based amplifier into a transistor one and the resulting audio performance was also not encouraging. The main problem with the original HHA is both its strength and weakness, as the unity-gain tube cathode follower does not offer any voltage gain in the first place. The low noise and distortion due to the tube is no doubt offered by its low anode voltage and hence low noise and distortion characteristics.

Referring to the circuit diagram in **Figure 1** a

the **Specifications** listed here were obtained with feedback in place. Without feedback, the outputs carry no direct voltage. The negative feedback feature was found quite useful such as with the AKG K701 to further boost performance, but this is a rather subjective feature you might like to experiment with for yourself. Capacitor C1 (C6) gives the circuit a reasonable specification for its low-frequency roll-off.

In the prototype of the amplifier, the ECC82/12AU7 required about 15 minutes of warming

from the project webpage. You'll notice that the solder side of the board has large copper fill areas to maximise the ground plane surface, which helps to keep noise and all sorts of interference down to a minimum. The tube socket has a rather spacious footprint as well as large holes to allow sockets from different suppliers to be used.

(080310-I)
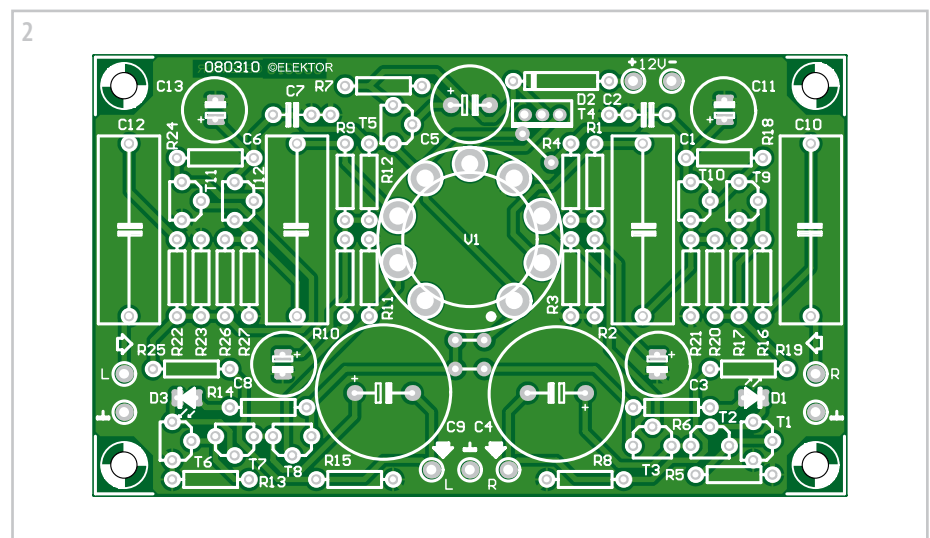
Measurement data

Voltages measured w.r.t. circuit ground	
T1/T6 base	0.7 V
T2/T7 base	1.4 V
T3/T8 base	3.8 V
T3/T8 Emitter	2.8 V
ECC82 grid	4 V
T10/T12 Emitter	6.2 V
T9/T11Base	0.67 V
ECC82 anodes	10 V
ECC82 pin 5	9.4 V
D2 (across device)	0.8 V
T5 VCE	1.3 V
R6/R14 (across device)	6.85 V

Component List

Resistors
R1,R8,R9,R15 = 10kΩ
R2,R4,R10,R12 = 91kΩ (E96: 90kΩ9)
R3,R11 = 15kΩ
R5,R13 = 22Ω
R6,R14,R16,R17,R22,R23 = 1kΩ
R7 = 39kΩ
R18,R21,R24,R27 = 560Ω
R19,R25 = 33kΩ
R20,R26 = 8kΩ06

Capacitors
C1,C6 = 2µF2 100V, lead pitch 22.5mm (WxL = 10 x 26 mm abs. max.)
C10,C12 = 10µF 63V, lead pitch 22.5mm (WxL = 10 x 26 mm abs. max.)
C2,C7 = 100nF, MKT, lead pitch 5mm or 7.5mm
C3,C8,C11,C13 = 100µF 25V, lead pitch 2.5mm, diam.

8.5 mm max.
C4,C9 = 2200µF 25V, lead pitch 7.5mm, diam. 18mm max.
C5 = 1000 µF 25V, lead pitch 5mm, diam. 10 mm max.

Semiconductors
D1,D3 = red LED
D2 = 1N4004
T1,T2,T6,T7,T9,T10,T11,T12 = BC550C
T3,T5,T8 = BC517
T4 = BD139

Miscellaneous
V1 = ECC82 or 12AU7
9-pin ('Noval') PCB mount socket, e.g. Conrad Electronics # 120529
PCB, # 080310-1 from www.thepcbshop.com

stereo amp is shown, as opposed to a mono-block for the original HHA. The hunt for a suitable input voltage amplifier to slightly boost the voltage gain resulted in the use of a dual BC550C inverting shunt feedback amplifier with a voltage gain of about 8. Being an inverting amplifier it conveniently allows some negative feedback (about 3%) to be introduced using 33 kΩ resistor R19 (R25). The feedback causes a direct voltage of a few millivolts at the amplifier outputs, and

up before normal operation was obtained. This is due to the relatively low heater voltage of about 9.4 V from the BD139 series pass element. The functions of T5/C5 and T4 are explained in some depth in the original article.

The single-sided circuit board design shown in **Figure 2** allows a stereo amplifier to be built. The copper track layout for making your own PCB can be downloaded free of charge

Reference
[1] Hybrid Headphone Amp, Elektor July & August 2006; www.elektor.com/050347

Downloads & Products
PCB design
No. 080310-1 (.pdf) at www.elektor-usa.com/080310

Braitenberg Robot

Abraham Vreugdenhil (The Netherlands)

In 1984 Valentino Braitenberg published a nice demonstration to show the behavior of robots. The question is: what IS behavior or what do we THINK behavior is. This demonstration uses simple robotic vehicles, each of which contains a very simple program. Each robotic vehicle has two driven wheels and two light sensors at the front. These sensors look towards the front and each drive a motor. The robots also have a bumper to sense whether they have hit anything. This can be either a wall or another robot. Now, in the simplest form of the robotic vehicle, the left front light sensor is connected with the right rear wheel. Likewise the right front light sensor is connected to the left rear wheel. If we now place the robotic vehicle in a space with a light source, the robotic vehicle will move towards the light source.

There are, however, also vehicles where the left front sensor is connected to the left rear wheel and the right front sensor to the right rear wheel. Such a robotic vehicle will avoid a light source instead. Now, suppose you have multiple light sources which are repeatedly turned on and off, as well as multiple robotic vehicles with different behaviors, what will happen? You will first see that all the light seekers go towards the light source and all the light avoiders move away. When the light sources subsequently move, all the robots will spring into action and this results in new activity. If you're an outsider or you do not know in advance what sort of program is contained in the robotic vehicles, then it is nice to discuss what is happening here. People have the tendency to attribute various kinds of human behavior to certain devices and robots. This one is 'aggressive', the other 'evasive' or passive. Whole discussions are started based on a few robotic vehicles driving around with each ultimately containing a very simple program. Perhaps this says more about the method of thinking or the behavior of the spectators then it does about the behavior of the robotic vehicles themselves.

How can this experiment be repeated in a simple way? You need a number of small and cheap robots that can easily be programmed and changed to suit your needs. A few years ago the company Arexx [2] introduced a trim robot construction kit onto the market, the Asuro. This robot is available from Conrad Electronics [3], among others. The Asuro contains an Atmel ATmega processor with a built-in hex loader. You can write programs for the Asuro in C or (simpler) in Bascom [4]. Using an IR interface (with the supplied RS232 IR transceiver) the hex program can be sent to the Asuro. A USB IR transceiver is also available.

The Asuro also has an experimenting board available. Here the board is used for three purposes. You connect two bumper supports, mount two light sensors and finally add a piezo-element (according to **Figure 1**). For the light sensors on the experimenting board you use the two IR diodes normally mounted underneath the Asuro (these are T9 and T10). Fit these with a little plastic tube.

On the expansion board you use the connections for the red LED D11 to connect the piezo element. To distinguish between the different robotic vehicles you give each a different colour by wrapping the battery compartment in paper of different colours. You can also give each robotic vehicle an unique number internally. While driving around the robots can continuously transmit their behavior, i.e. decisions via the IR transceiver. If you

090348 - 11
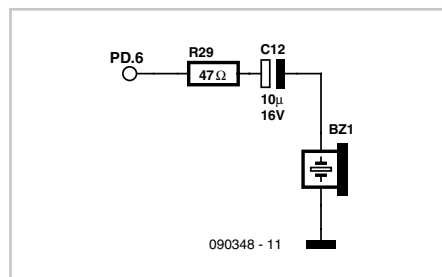
mount an IR transceiver above the 'playing field' you can follow everything the robots 'do' on the computer.

The program, written by the author for this purpose, can be downloaded from the Elektor website [1]. A general overview of what the program does is given here. After it starts up it first waits for a second in the INIT routine. If a bumper is pushed during this time, the light seeking behavior is activated. If the bumper is not pushed then the behavior will be light avoiding. After a short beep it waits to check whether the number of the robot has be changed or not. This is done by pushing the bumper a number of times. If not, the EEPROM is checked to see if it already contains a number. If a valid entry is found then that number will be used, otherwise the number 10 is used. The main loop consists of three parts: a bumper part (A), a light avoiding/seeking part (B) and a random component (C).

The program is written in Bascom AVR. For more information refer to the program listing (download # 090348-11). The Bascom AVR generated hex file is transferred to the Asuro using the Flash.exe program supplied with the Asuro. You can then start again, determine the behavior by pushing the bumper, followed by entering a number by pushing the bumper a few times and the Braitenberg-Vehicle is on its way. Get ready for long discussions on what these robots are doing and what behavior is taking place.

To produce the random light changes on the playing field, the author designed a circuit with a 98C2051 and a few solid-state relays, which ensures that four incandescent lamps at the side of the playing field light up in different combinations every 25 seconds. This effect ensures that the robotic vehicles will continue to search and avoid.

(090348-I)

Internet Links

[1] www.elektor-usa.com/090348

[2] www.arexx.com

[3] www.conrad-int.com

[4] www.mcselec.com

Download

Software

090348-11: Bascom and hex file, from [1]

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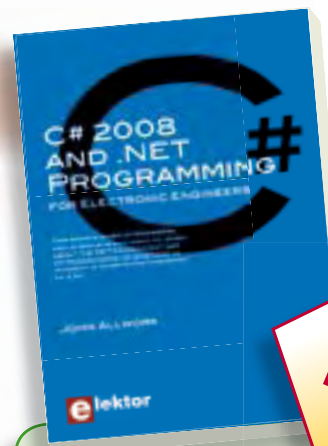
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An E-Blocks IR RC5 Decoder

José Basilio Carvalho (Portugal)

The infrared (IR) decoder described here was designed to enable an Elektor E-Blocks development system [1] to process commands from RC5 (compatible) remote controls typically used for Philips audio/video equipment. The E-blocks complement consists of

1 x PICmicro USB Multiprogrammer EB-006 with 4 MHz xtal;
1 x EB-007 (8 push to make switches) connected to PORTC;
1 x *EB-005 imitation LCD board (16x4)* connected to PORTA;
1 x EB-004 LED board or 8-Relay board connected to PORTD;
1 x EB-004 LED board connected to PORTE (or just one LED and a 470 Ω resistor on RE1).

The original EB-005 E-Block has a 16x2 LCD. For the purpose of this project, an EB-005 was reverse-engineered and replicated on prototyping board and wired to accommodate a 4x16 LCD. The home made board has a SIL socket strip that also accepts 16x1 and 16x2 LCDs, all of which were found to be pin compatible. Photos of the author's DYI EB-005 are available at [2]. The proposed IR decoder board is connected to PORTB.

Once fully debugged and tested in terms of hardware and software, an E-blocks system may be 'undressed' and replicated as a stand-alone circuit with just the basic elements and running firmware. In most cases, the circuit boils down to no more than a (PIC) micro with some I/O devices around it like switches, sensors, relays and LEDs. If changes or extensions are required, you build up the E-blocks constellation again, do whatever is necessary to get it all to work, save the new .fcf and make the system blow a fresh PIC for inserting into the stand-alone system. Here the PIC16F877 microcontroller runs at 4 MHz to decode signals matching the Philips RC5 protocol. The complete E-Blocks layout can be used to test remote controls with suspected faults, and to switch 8 devices using a 'known good' control. The address and command decimal values appear on a 16x4 LCD display. The decoder proper (**Figure 1**) is just a standard application circuit of the TSOP1736 IR decoder IC with some components around it for connectivity with the E-blocks PORTA (based on sub-D connectors). Keys 1 to 8 of the remote are used to control

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eight bits of PORTD individually, switching on or off any AC or DC devices by way of an 8-way relay board or similar. The Standby key is used to switch all eight outputs on and off. There are also eight push-to-make switches to manually toggle the state of any output. By pressing switch 1 and 2 at the same time you switch all outputs on or off. The state of the outputs is shown on the LC display. Bits 6 and 7 of PORTB are used to select the address mode of the output control; 00 =TV, 01 = VCR,

10 = SAT, 11 = Hi-Fi.
The program was designed with Flowcode, the graphical software design utility for E-blocks. A part of it is shown in **Figure 2**. The resulting .fcf file is available free of charge from the Elektor website [2].

The main flowchart allocates the LC display to PORTA, initialises ports, reads the state of bits 6 and 7 into variable 'mode', enables RB0/INT interrupts and starts a loop.

A 1 to 0 transition on the RB0/INT pin will call the 'start' macro, which is only used to set a variable and call the 'ir_dec' macro. Inside the 'ir_dec' macro, some delays are present to read RB0 near the end of the S1 bit, as well as during the start and second half of the S2 bit. If they are '010', the signal is recognised as coming from a valid RC5 remote control. Some more delays effectively skip the toggle bit (not used here) and start to read the five address bits and six command bits into the 'adr' and 'cmd' variables respectively. During the 'ir_dec' macro, 14 300-μs pulses are generated on the RE0 pin to enable an oscilloscope to show detailed timing of the RC5 preamble and address/command bits.

After a successful IR decoding, the 'ir_dec' macro calls the 'output' macro. Inside the 'output' macro the display shows address and command values in decimal notation, compares 'adr' and 'mode' variables to validate the device mode used, and sends the value of the 'cmd' variable to PORTD, displaying the output state in binary. A blinking LED on the RE1 pin reveals the activity of any non-RC5 remote controls (like Sony, Panasonic, etc.). The main loop also calls the 'sw_key' macro to read PORTC switches to control the PORTD outputs manually.

(080996-I)

Internet Links
[1] www.elektor.com/eblocks
[2] www.elektor-usa.com/080996

Downloads
Software
080996-11.zip: Flowcode (.fcf) file, from [2]

Supplementary Information
080996-12.zip: Photos of DIY EB-005, from [2]

Remote Control for Network Devices

Werner Rabl (Germany)

Many devices connected to a local area network (LAN) are left on continuously, even when they are not needed, including DSL and cable modems, routers, wireless access points, networked hard drives, printer servers and printers. The power consumption of all these devices can add up to a considerable fraction of one's electricity bill. With the simple circuit described here we can ensure that all these devices are only powered up when at least one selected host device (such as a PC or a streaming media client) is turned on. We insert a relay in the AC line supply to the devices whose power is to be switched, along with a driver circuit controlled from the host device over a two-wire bus. Optocouplers provide galvanic isolation. One way to implement the bus is to use the spare pair of conductors that is often available in the existing LAN cable.

The circuit diagram shows an example configuration where there are two controlling host devices (a streaming media client and a PC) and three network devices (a DSL router, a networked hard drive and a networked printer). We will assume that all the media files are held on the networked hard drive. The DSL router (to provide an internet connection) and the hard drive are to be powered up when either the PC or the media client is powered up; the printer only when the PC is powered up.

We can think of the devices as being in two groups, the first group consisting of the DSL router and the hard drive, the second just the printer. An optocoupler is powered from each of the controlling host devices: these ensure that the devices are isolated from one another and from the rest of the circuit. The relay circuit, located close to the networked devices, is controlled from the outputs of the optocouplers. The relay circuits are powered from (efficient) AC adaptors: modified cell phone chargers do an admirable job.

In the circuit shown a 5 V supply from the controlling devices is used to drive each optocoupler. Host 1 (the streaming client) drives optocoupler IC1, host 2 (the PC) drives optocouplers IC2 and IC3.

Optocouplers IC1 and IC2 both control the networked devices in group 1: networked device 1 is the DSL router, switched by relay RE1, and networked device 2 is the hard drive, switched by relay RE2.

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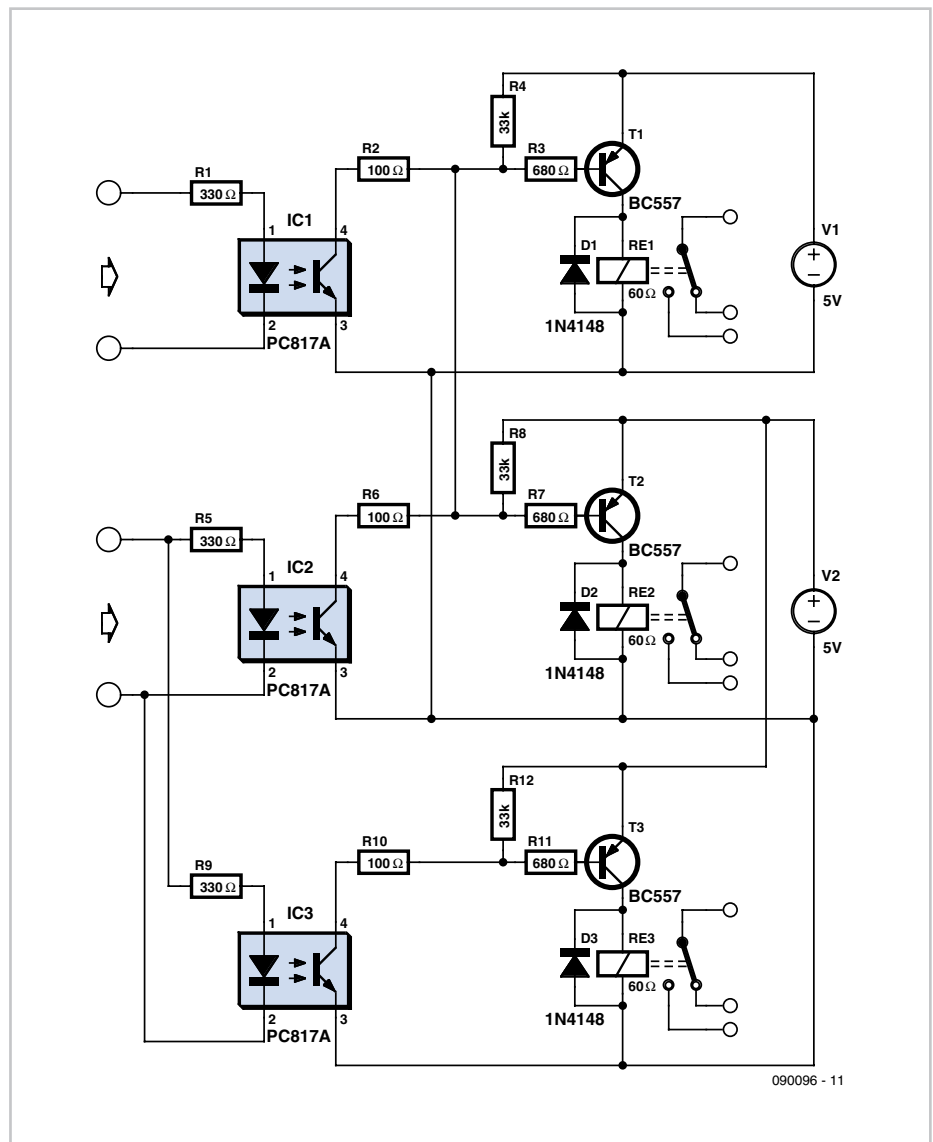
Optocoupler IC3 controls the networked device in group 2, namely the printer. This is switched by relay RE3.

The connections between the optocouplers and the relay stages can be thought of as a kind of bus for each group of devices. The devices in a given group can be switched on by simply shorting its bus, and this gives an easy way to test the set-up. Resistors R2, R6 and R10 at the collectors of the transistors in the optocouplers protect them in case power should accidentally be applied to the bus.

The supply voltages V1 and V2 shown in the example circuit diagram are derived from the AC power adaptors as mentioned above and are used to power the relays. We have assumed that the networked hard drive and the printer are located near to one another, and so it is possible to use a single AC power

adaptor to provide both voltages. Another possibility would be to add a third wire to the bus to carry power: this would allow all relays, wherever they were located, to be powered from a single supply.

It is worth noting that network attached storage (NAS) devices such as networked hard drives normally require an orderly shutdown process before power is removed. Devices that use Ximeta's NDAS technology do not suffer from this problem.

(090096-I)

Automatic Bicycle Light

Ludwig Libertin (Austria)

This automatic bicycle light makes cycling in the dark much easier (although you still need to pedal of course). The circuit takes the ambient light level into account and only turns on the light when it becomes dark. The light is turned off when no cycling has taken place for over a minute or if it becomes light again. The biggest advantage of this circuit is that it has no manual controls. This way you can never 'forget' to turn the light on or off. This makes it ideal for children and those of a forgetful disposition.

To detect when the bicycle is used (in other words, when the wheels turn), the circuit uses a reed switch (S1), mounted on the frame close to the wheel. A small magnet is fixed to the spokes (similar to that used with most bicycle speedometers), which closes the reed switch once for every revolution of the wheel. Whilst the wheel turns, pulses are fed to the base of T1 via C1. This charges a small electrolytic capacitor (C2). When it is dark enough and the LDR therefore has a high resistance, T2 starts conducting and the lamp is turned on. With every revolution of the wheel C2 is charged up again. The charge in C2 ensures that T2 keeps conducting for about a minute after the wheel stops turning. Almost any type of light can be connected to the output of the circuit.

With a supply voltage of 3V the quiescent current when the reed switch is open is just 0.14 µA. When the magnet happens to be in a position such that S1 is closed, the current is 3 µA. In either case there is no problem using batteries to supply the circuit. The supply voltage can be anywhere from 3 to 12 V, depending on the type of lamp that is connected. Since it is likely that the circuit will be mounted inside a bicycle light it is important to keep an eye on its dimensions. The board has therefore been kept very compact and use has been

made of SMD components. Most of them come in an 0805 package. C2 comes in a so-called chip version. The board is single-sided with the top also acting as the solder side.

The print outline for the LDR (R5) isn't exactly the same as that of the outline of the LDR mentioned in the component list. The outline is more a general one because there is quite a variety of different LDR packages on the market. It is therefore possible to use another type of LDR, if for example the light threshold isn't quite right. The LDR may also be mounted on the other side of the board, but that depends on how the board is mounted inside the light.

For the MOSFET there are also many alternatives available, such as the FDS6064N3 made by Fairchild, the SI4864DY made by Vishay Siliconix, the IRF7404 made by IRF or the NTMS4N01R2G made by ONSEMI. The reed switch also comes in many different shapes and sizes; some of them are even waterproof and come with the wires already attached.

For the supply connection and the connection to the lamp you can either use PCB pins or solder the wires directly onto the board. The soldered ends of the pins can be shortened slightly so that they don't stick out from the bottom of the board. This reduces the chance of shorts with any metal parts of the light.

Do take care when you use a dynamo to power the circuit — the alternating voltage must first be rectified! The same applies to hub dynamos, which often also output an alternating voltage.

Please Note. Bicycle lighting is subject to legal restrictions, traffic laws and, additionally in some countries, type approval.

Download

090102-1 PCB layout (.pdf), from www.elektor-usa.com/090102

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COMPONENT LIST

Resistors
R1 = 1MΩ (SMD 0805)
R2,R4 = 100kΩ (SMD 0805)
R3,R6 = 1kΩ (SMD 0805)
R5 = LDR e.g. FW150 Conrad Electronics # 183547

Capacitors
C1 = 1µF 16V (SMD 0805)
C2 = 10µF 16V (SMD chip type)

C3 = 100nF (SMD 0805)

Semiconductors
T1 = BC807 (SMD SOT23)
T2 = STS6NF20V (SMD SO8)

Miscellaneous
S1 = reed switch (not on board) + 2-way right angle pinheader
BT1 = 3–12V (see text)

PC Power Saver

Wolfgang Gscheidle (Germany)

This circuit is designed to help minimise the quiescent power consumption of PCs and notebooks, using just our old friend the 555 timer and a relay as the main components. The circuit itself dissipates around 0.5 W in operation (that is, when the connected PC is on); when switched off (with the relay not energized) the total power draw is precisely zero. A prerequisite for the circuit is a PC or note book with a USB or PS/2 keyboard socket that is powered only when the PC is on.

The power saver can be used to switch PCs or even whole multi-way extension blocks. The unit can be built into an ordinary AC power adaptor (which must have an earth pin!) as the photograph of the author's prototype shows. The PC is plugged in to the socket at the output of the power saver unit, and an extra connection is made to the control input of the unit from a PS/2 (keyboard or mouse) socket or USB port. Only the 5 V supply line of the interface is used.

When button S1 on the power saver is pressed the unit turns on, and the monostable formed by the 555 timer is triggered via the network composed by R4 and C7. This drives relay RE1, whose contacts close. The connected PC is now tentatively powered up via the relay for a period determined by P1 (approximately in the range from 5 s to 10 s).

If, during this interval, the PC fails to indicate that it is alive by supplying 5 V from its USB or PS/2 connector (that is, if you do not switch it on), the monostable period will expire, the relay will drop out and any connected device will be powered down. No further current will be drawn from the supply, and, of course, it will not be possible to turn the PC on. Whenever you want to turn the PC on, you must always press the button on the power saver shortly beforehand.

If, however, 5 V is delivered by the PC to the input of optocoupler IC2 before the monostable times out (which will be the case if the PC is switched on during that period), the transistor in the optocoupler will conduct and discharge capacitor C6. The monostable will now remain triggered and the relay will remain energized until the PC is switched off and power disappears from its USB or PS/2 interface. Then, after the monostable time period expires, the relay will drop out and the power saver will disconnect itself from

the AC. There is no need to switch anything else off: just shut down the system and the power saver will take care of the rest. It is also possible to leave the machine as it updates its software, and the power saver will do its job shortly after the machine shuts down.

Power for the unit itself is obtained using a simple supply circuit based around a miniature transformer. Alternatively, a 12 V AC power adaptor can be used, as long as a relay with a 12 V coil voltage is used for RE1. In his prototype the author used a relay with a 24 V coil connected as shown directly to the positive side of reservoir capacitor C2, the 555 being powered from 12 V regulated from that supply using R1 and D1. A fixed resistor can of course be used in place of P1 if desired. If the adjustment range of P1 is not sufficient (for example if the PC powers up very slowly) the monostable period can be increased by using a larger capacitor at C6.

The relay must have at least two normally-open (or changeover) contacts rated at at least 8 A. The contact in parallel with S1 is

used to supply power to the device itself, and the other contact carries all the current for the connected PC or for the extension lead to which the PC and peripherals are connected.

Pushbutton S1 **must be rated for 230 VAC (US: 120 VAC) operation**: this is no place to make economies. The coil current for the relay flows through LED D5, which must therefore be a 20 mA type. If a low-current LED is used, a 120 Ω resistor can be connected in parallel with it to carry the remaining current. The Fujitsu FTR-F1CL024R relay used in the author's prototype has a rated coil current of 16.7 mA.

Optocoupler IC2 provides isolation between the circuit and the PC, and is protected from reverse polarity connection by diode D4.

The power saver should be built into an insulated enclosure and great care should be taken to ensure that there is proper isolation between components and wires carrying the mains voltage and the other parts of the circuit. In particular, the connection to the PC and associated components (R6, C5, D4 and IC2) should be carefully arranged with at least a 6 mm gap between them and any part of the circuit at AC line potential.

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Hexamurai – Who'll be the one to beat it?

Game designer: Claude Ghyselen (France)

Following our usual tradition, we're offering you an outsize game in this double issue. Hiding behind what looks like a pretty colored flower lurks a fearsome Hexadoku Samurai, or Hexamurai for short. Those who enjoy Hexadoku (and modern art) are bound to appreciate this grid that goes beyond tough. And in the (unlikely) event you can't manage to solve it, at least you'll always be able to hang it on the wall.

The Hexamurai is a Hexadoku grid based on the Samurai model, i.e. 4 standard Hexadoku grids linked to a fifth one in the middle. But unlike a normal Samurai game, the Hexamurai doesn't let you solve

each of the grids separately — you have to solve them all together, obeying the Hexadoku rules for each grid in turn.

The instructions for solving this puzzle are the same as for a standard Sudoku (with a few modifications!)
Like Hexadoku, Hexamurai uses the figures of the hexadecimal system, namely 0 to F.
Fill in the grid in such a way that **all** the hexadecimal figures from 0 to F (0–9 and A–F) are used **once and only once** in each row, column, and square of 4×4 boxes (identified by different colors) of a sub-Hexadoku (identified by a thicker line). Certain figures are already

entered into the grid, defining the starting point for you.

If you can solve this puzzle, there are some nice prizes to be won. All you have to do is send us the **five figures** in yellow, reading from **top to bottom**.

The puzzle is also available as a **free download** from the Elektor website.

Solve Hexamurai and win!

Correct solutions received from the entire Elektor readership automatically enter a prize draw for an E-blocks Starter Kit Professional worth US$ 425.00 (rrp) and three Elektor Electronics SHOP Vouchers worth US$ 55.00. We believe these prizes should encourage all our readers to participate!

Participate!

Please send your solution (the numbers in the grey boxes) by email to hexadoku@elektor-usa.com

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

Subject: **hexamurai 07-2009 (**please copy exactly).

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

Alternatively, by fax or post to:
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The closing date is **1 September 2009.**

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

Prize winners
The solution of the May 2009 Hexadoku is: **857C9**.
The **E-blocks Starter Kit Professional** goes to: Marcel Delomenede (France). An **Elektor SHOP voucher** goes to: Adrian Bradshaw (UK); Thomas Raith (Germany); Heinz-Dieter Richter (Germany).

Congratulations everybody!

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GPS Datalogger

There are plenty of projects that deal with GPS and microcontrollers, many of which covering navigation only. But what if you wanted to log the path of a bike or car trip? Sure, you could export the data for processing into some other application that does this, but you could also make use of a very popular application called Google™ Earth. This is made possible by the combination of a GPS module, a BASIC Stamp® microcontroller module , a Parallax Memory Stick Datalogger and some clever software enabling GPS coordinates to be stored as a KML file on an ordinary USB memory stick — and read back on your PC.
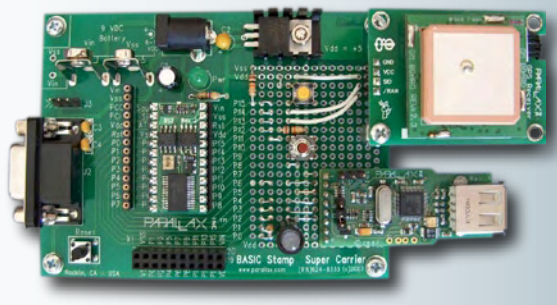
New: E-Labs Inside

Starting this September Elektor Labs, the hub & foundry of all technical wizardry you can read about every month in Elektor will occupy the center four pages of the magazine. There we will cover all issues our laboratory workers first fuss about and then care to make public like equipment reviews, tips and tools of the trade and techno talk.
For the first instalment the intention is to report on practical experience with a new Yokogawa oscilloscope our lab guys got on loan for a month or was it a bit longer. What did they like and dislike about the instrument? Read all about it in the next issue of Elektor.
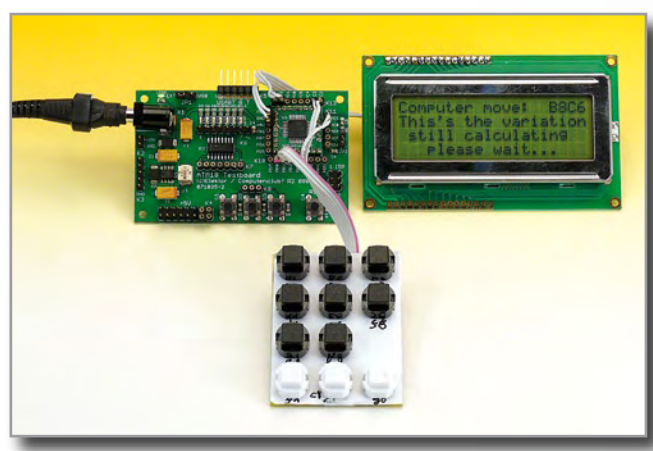
ATM18 Mini Chess Computer

The Elektor ATM18 microcontroller system can be used to make a surprisingly simple and effective chess computer. The only additional hardware required is a few low-cost pushbuttons. The software for the project is written in C, and it was far from an easy task to fit the program in the 8 kB of program memory offered by the ATmega88.

Article titles and magazine contents subject to change, please check 'Magazine' on www.elektor-usa.com for updates and announcements.
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