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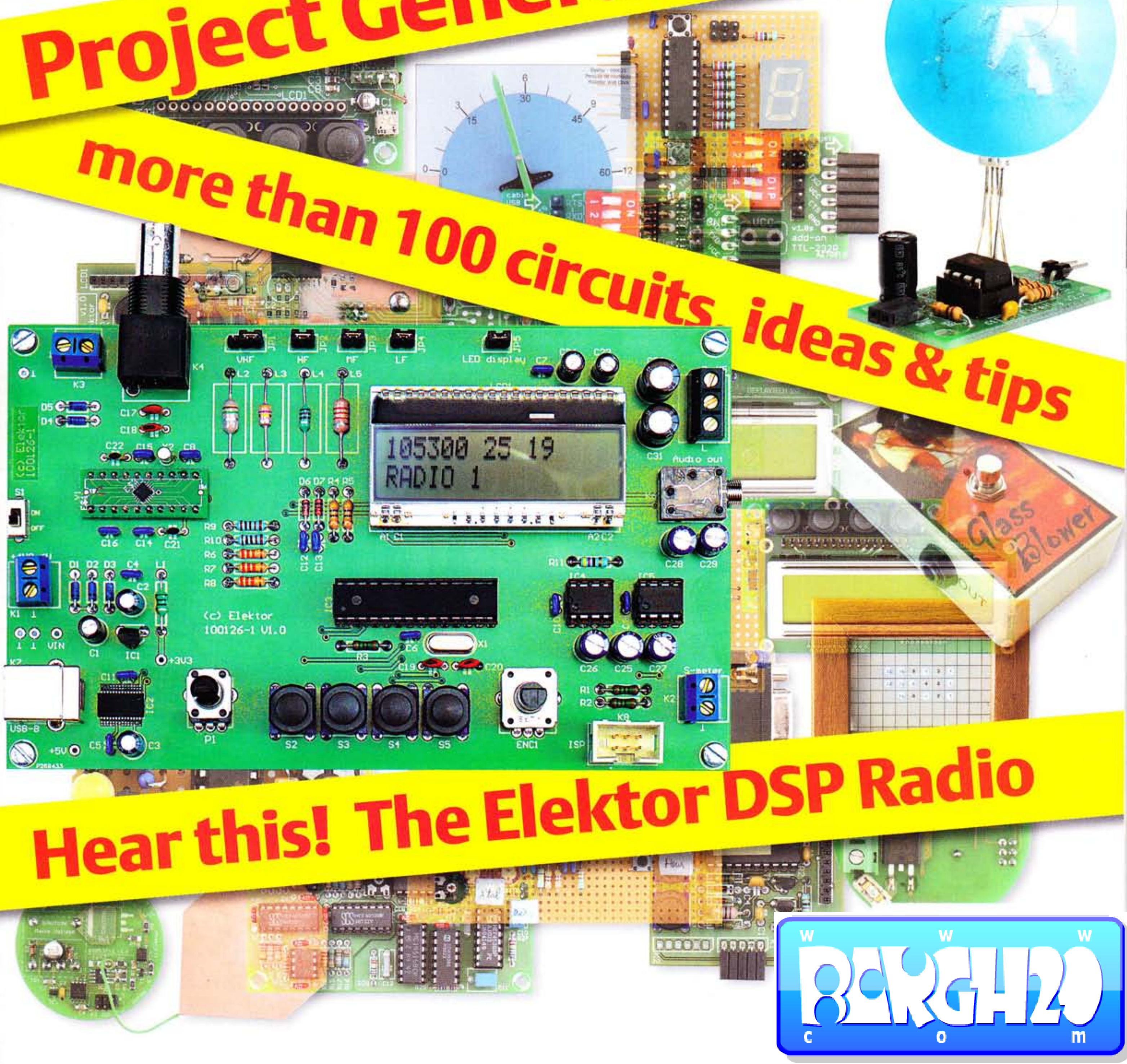

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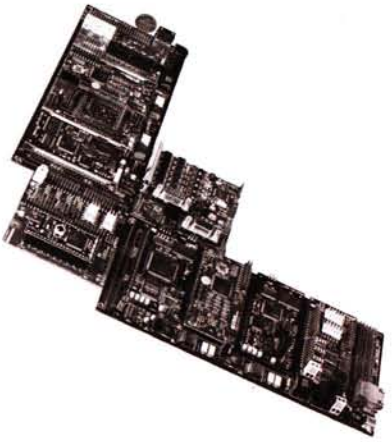

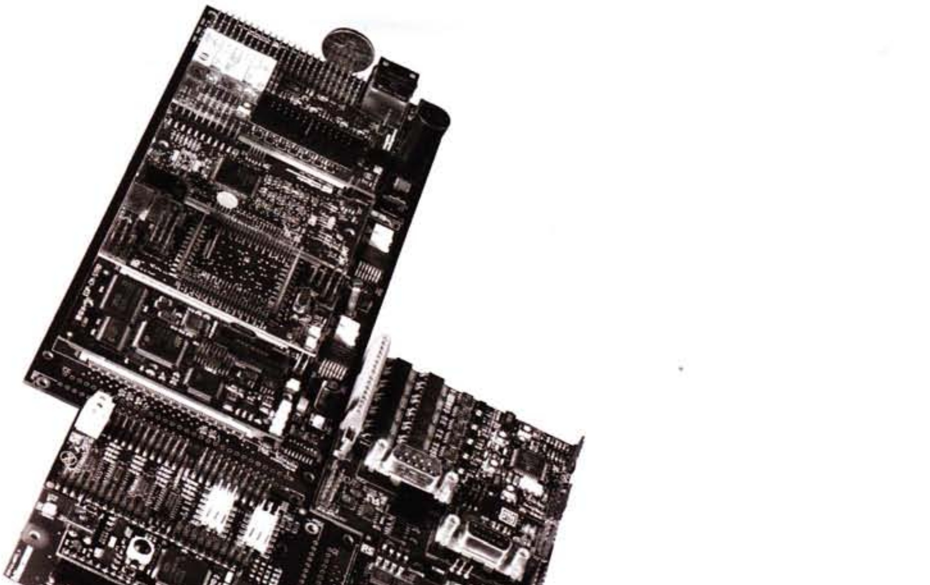

@ Elektor

Welcome to yet another Summer Circuits edition of Elektor — it's the thirty-sixth for the UK edition, and the second for the fledgling US edition. This year, for the first time, if a PCB was designed for a specific project, the copper track and component mounting plan are no longer printed on the page but available in a .pdf file on what we normally call the 'project page' on our website. The file is both free and easy to find. On www.elektor.com, click on Magazines, then select July & August 2010, then the article title from the alphanumerical list. The same for the components list and any software if applicable for the article. As a shortcut, simply locate the article production number at the end of the text and affix it to: www.elektor.com/, for example, www.elektor.com/090944.

December 2010: *Embedded Guide to the Universe*

These past few weeks, the editorial teams, lab and DTP staff here at Elektor have been burning their midnight oil to get this Elektor double edition ready in time for mailing to you or to selected bookstores and other retail outlets. During one of our editorial meetings the idea was kicked around to compile a special edition for the Christmas Holidays period, focussing on microcontroller (embedded) designs, ideas, software, circuits, tips & tricks, projects — the works! As a matter of course, the team is open to suggestions from you, our readership, to fill this edition with projects and other state of the art stuff on bits and bytes. So, if you have anything to share, let Jan know on his email address editor@elektor.com. As usual, we've 'fitting remuneration' available for those of you actually making to publication.

Elektor Foundation Award

This year, second time around, we're actively seeking nominees for the Elektor Foundation Award. Please send us your recommendations for persons out there with verifiable achievements in the field of electronics. This might cover a product development, a tailored project in electronics education, or even an electronics related company having gone through a development you think is remarkable in a positive way. Please send your suggestions to award2010@elektor.nl.

It's all happening...@Elektor.

Wisse Hettinga, Editor in Chief

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Plus

SUMMER CIRCUITS 2010

Colour of title indicates category.
Bold type = PCB design available on Elektor website.

Audio, Video & Photography

Computers, Software & Internet

Hobby, Games & Modelling

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July & August 2010
no. 403/404

elektor | international media bv

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

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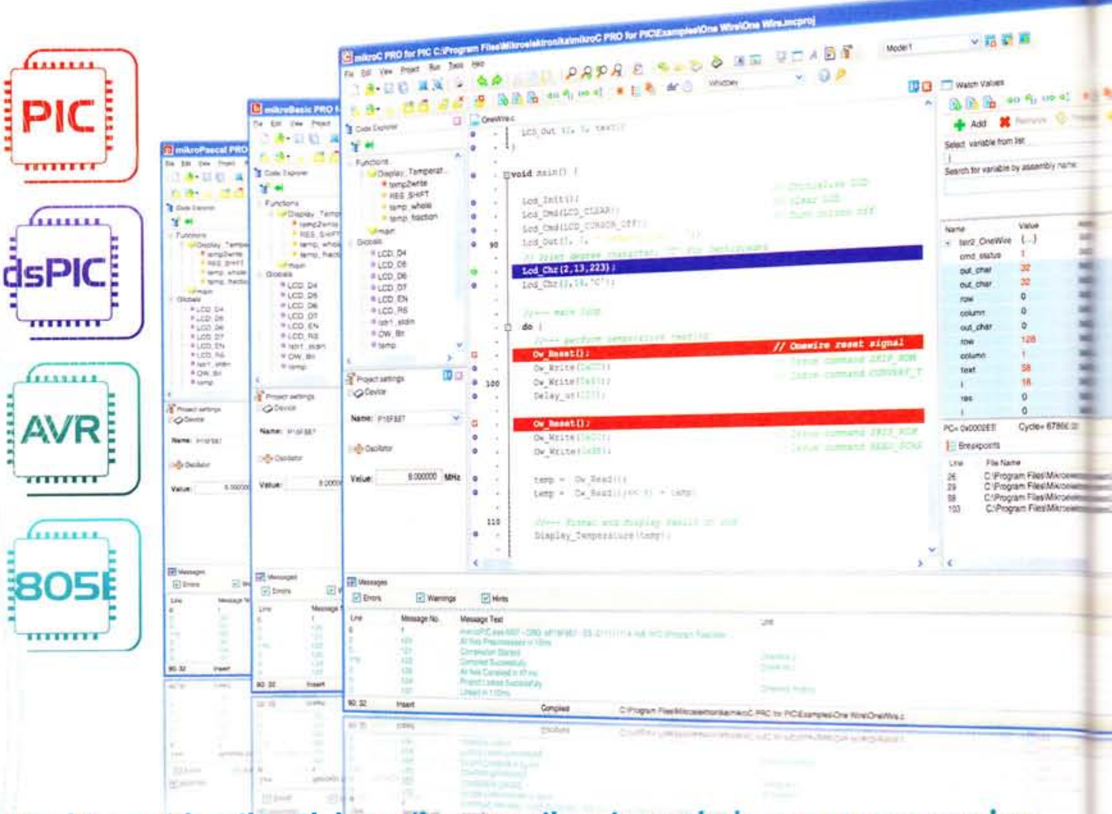

1 FREE LIFETIME TECH SUPPORT

We are always thinking one step ahead and we are carefully analyzing and "feeling the pulse" of our users in order to present them with the best solutions before they even ask a question. We all know how important it is that we can rely on someone in moments when we are stuck with our projects, facing a deadline, or when we just want to ask a simple, basic question, that's pulling us back for a while. We do understand how important this is to people and therefore our Support Department is one of the pillars upon which our company is based. **MikroElektronika offers Free Lifetime Tech Support**, so if something goes wrong, we will be ready and willing to help!

2 FREE UPGRADES

Let's say you purchase a new TV. You bring it home, plug-in the cable and enjoy your favorite shows until TV breaks. Which can be in many, many years. In the world of compilers, if you want to keep up-to-date with new features, new libraries, and bug fixes, you have to pay for each and every upgrade. This does not make sense to us. **MikroElektronika charges the customer only once, and all upgrades and technical support are free.**

3 BEST PRICE/ PERFORMANCE

Price of mikroC compiler is $249.00, but if you order it with one of our development boards it will cost you 20% less, so with the board price of the compiler will be $199.00. **We strongly believe we have the best price/ performance ratio on the market today.** mikroBasic and mikroPascal are even cheaper and the price for them is $149.00 if purchased along with development boards and $199.00 without.

Working with mikroElektronika compilers is a whole new programming experience. You will be so excited how things work around here. Everything is achievable, and solutions are already here! You'll be amazed how pleasant and easy it is to work with what we have to offer

We, in mikroElektronika, like to do things the right way. When it comes to our command line compilers, we put a lot of effort to make them cutting-edge in excellence. We tend to introduce modern and fast solutions, to implement optimizers of great performance, and excellent intializer, code generator, linker. Output code produced by our compilers is very efficient, fast and optimized. We introduced powerful SSA optimization for dsPIC which reduces code size by 5-30%. This way you can relax while coding, and let the compiler help you boost your efficiency! All of our compilers will soon be eqiupped with this powerful feature.

Saving programmer's time

We also spend the same amount of time developing the visual working environment, because it is the place where programmers spend most of their time. What's really important is how easy can things be done. While validating compiler, one shouldn't just look at the output code size or effective code optimization. Compilers are a place where all that final code has to be written first. Compiler is much more than pure optimization. It should save programmer's precious time, without making his life more difficult than it already is. You will see for yourself that what we have to offer surpasses our competitors in many fields.

Best User Experience Rating

Every programmer should be demanding an intuitive working environment, large number of easy-to-use libraries with lots of useful examples, additional tools that boost productivity and facilitate development, fast and reliable support and resourceful help file.

Let's put these demands in a single parameter, which we'll call User Experience Rating, a kind of usability index. And, from now on, let's not just look whether something is available in a compiler or not. This time let's have a look how it really feels to be working with it. Compare our compiler to any other on the market today, and you will find that this kind of tool for easy development can be found nowhere else.

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We want to provide users the full experience of testing, and give them freedom to explore the compiler. Therefore our demo compilers are only limited to 2K of program words and no other restrictions are implemented! You don't even have to make your mind right away, because there is no time limit! So, just go to www.mikroe.com and start downloading!

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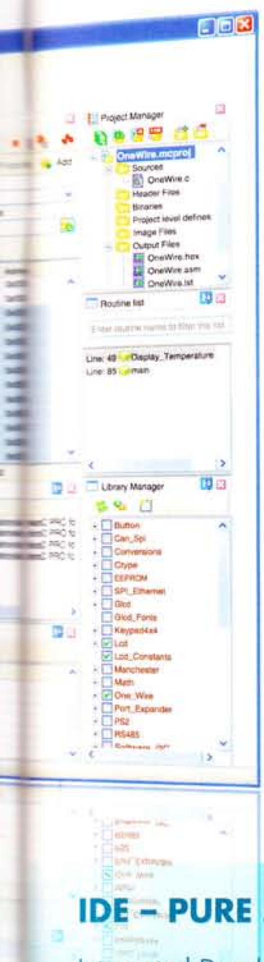

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Fast and efficent code, stability and optimization are among the postulates of our compilers. We have introduced sbit type, a clever approach that reduces code size over 20%. Fast code generation means no more waiting for long project compilation. Many useful linker directives give you powerful control over your code and program organization.

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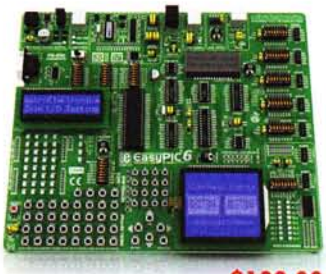

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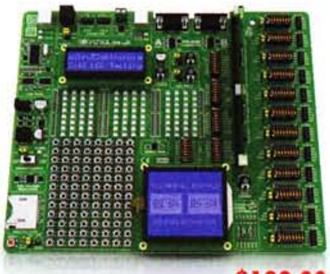

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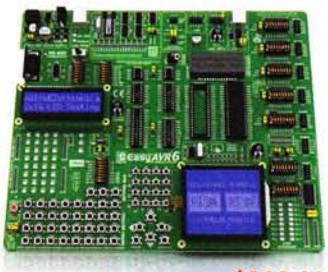

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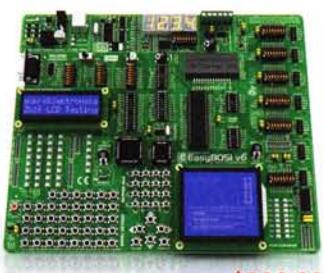

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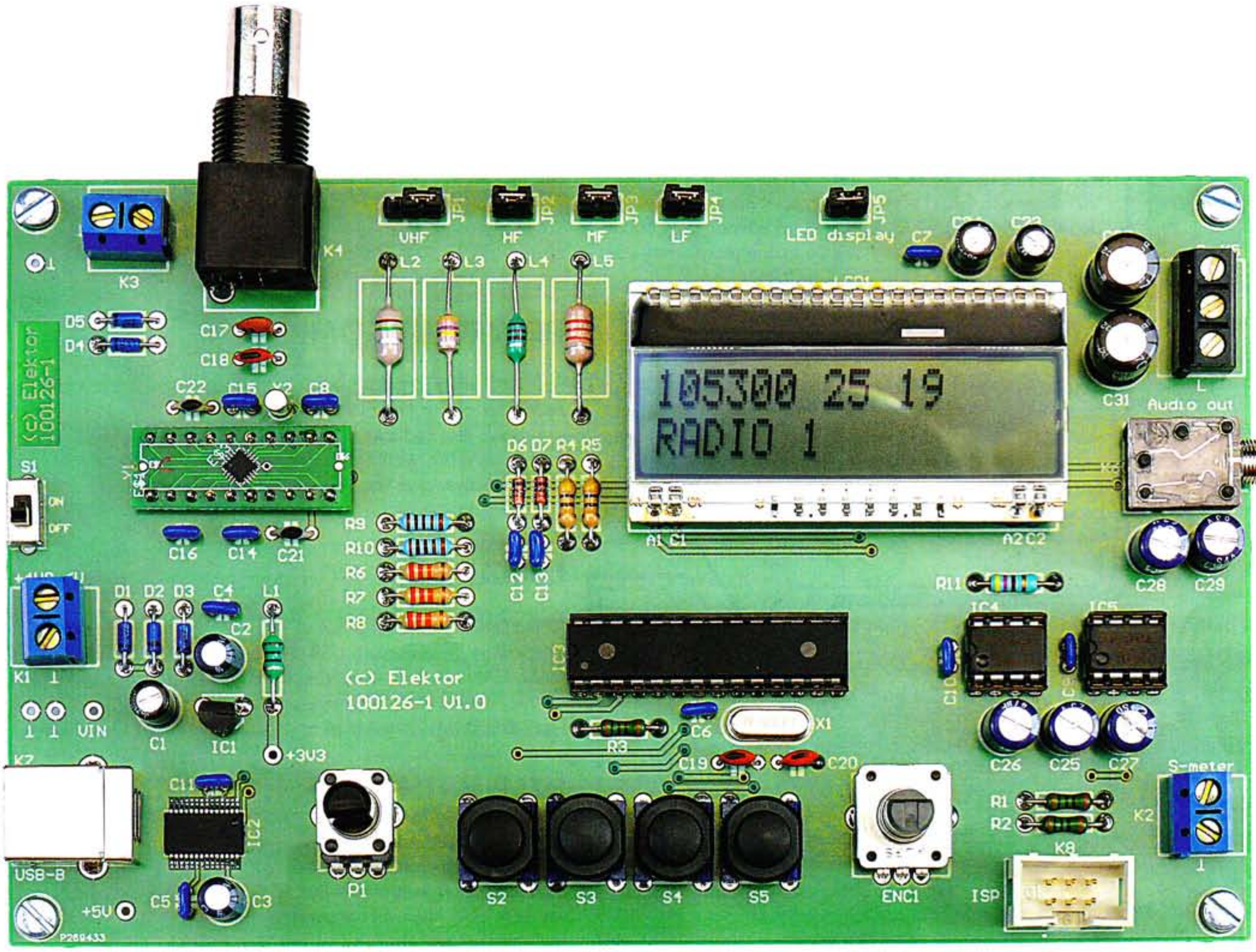
The *Elektor* DSP radio

DSP world receiver with USB interface

Burkhard Kainka (Germany)



A world receiver that needs no set-up adjustments? It's possible using DSP technology. All the main functions are done in a Si4735 DSP radio IC measuring just 3 mm by 3 mm, with the help of an LCD-based user interface, a stereo audio amplifier and an interface that allows the receiver optionally to be controlled from a PC.

Many radio amateurs in practice use two receivers, one portable and the other a fixed receiver with a PC control facility. The Elektor DSP radio can operate in either capacity, with a USB interface giving the option of PC control. An additional feature of the USB interface is that it can be used as the source of power for the receiver, the audio output being connected to the PC's powered speakers. To allow portable 6 V battery operation the circuit also provides for an audio amplifier with one or two loudspeakers.

Features

Any radio receiver worth its salt should of course offer high-quality FM reception, preferably in stereo and with RDS station information display. The proof of the radio is in the hearing, and this receiver will not disappoint: it has very high FM sensitivity and sound quality. The Si4735 device that we use, unlike its less sophisticated sibling the Si4734, includes an RDS decoder. The Si4734 has recently been finding its way into an increasing number of portable radios.

The second requirement of a world receiver is that it should be able to tune in to distant

Features

- no set-up adjustments required
- Si4735 DSP receiver IC
- ATmega168 microcontroller
- USB interface using FT232R
- backlit 2 x 16 LCD panel
- battery voltage 4.8 to 6 V
- current consumption approximately 50 mA
- 3.3 V internal power supply
- power from PC over USB interface
- stereo audio output
- stereo audio amplifier (2 x LM386)
- RDS display
- AM from 153 kHz to 21.85 MHz
- automatic station search
- antenna signal strength indication in dBµV
- signal strength meter connection
- diode switching of AM band
- automatic tuning of AM resonant circuit
- switchable AM bandwidth
- optional PC control over USB
- tuning using rotary encoder
- four control pushbuttons
- station memory (30 AM presets and 30 FM presets)
- open-source firmware (free download)
- in-system programming interface
- printed circuit board available ready-populated and tested*

* see http://www.elektor.com/100126
and the Elektor shop pages at the back of this issue

AM transmitters. Here the receiver is in a class of its own, offering excellent shortwave reception. In particular it has very good sensitivity in the presence of strong nearby interfering signals, which allows the use of longer antennas. A highly effective automatic level control system brings the signal level into the optimal range, to the point where it can often be difficult to distinguish different antennas. Selectivity is also very high, and the receiver bandwidth can be adjusted in several steps, a feature previously reserved for only the most expensive equipment.

The DSP radio is also capable of receiving mediumwave and longwave signals, with the external antenna input allowing the connection of antennas for any frequency range. If a simple whip or other indoor antenna is used, it will often the the case that too much wide-band interference will be picked up. An alternative is the (optional) connection of a ferrite antenna.

SSB and DRM reception are, unfortunately, not possible. This is a result of the receiver structure. The radio IC uses an homodyne (that is, zero intermediate frequency) IQ mixer with configurable DSP-based filters and demodulator (**Figure 1**). For tuning a PLL is initially activated, and then the receiver locks on to the carrier of the AM signal.

The circuit

The circuit of the receiver (**Figure 2**) does not look, at first sight, much like a traditional RF design. This is because all the important functions are integrated into the Si4735. Only the antenna connection betrays the RF nature of the circuit: the antenna signal arrives at BNC socket K4 or at screw terminals K3 and passes through a diode limiter comprising D4 and D5. L2 is an FM coil with an inductance of 0.1 µH. In normal operation jumper JP1 is set to bridge pins 2 and 3, which connects the end of the FM coil to the AM input.

What is not visible from the circuit diagram is that in FM mode the receiver sets its internal AM 'variable capacitor' to 500 pF, which, as far as RF is concerned, shorts the end of the FM coil to ground. In AM mode, however, the signal from the antenna passes via L2, which now acts to increase the effective antenna length, to the AM resonant circuit comprising L3, L4, L5 and the automatically tuned 'variable capacitor' inside the Si4735 at pin 4 (AMI). Which of the fixed inductances is actually used is determined by IC3 using the switching circuit comprising 1N4148 diodes D6 and D7, which can effectively short a selected part of the inductance in the circuit to ground. In normal use jumpers JP2, JP3 and JP4 are closed; opening these jumpers allows the connection of alternative antenna input circuits or of a ferrite antenna. For example, a mediumwave ferrite antenna can be connected at JP3 or a shortwave loop antenna at JP2. If a whip antenna is to be used for FM reception only, set JP1 to bridge pins 1 and 2.

The stereo audio output of the Si4735 is taken to a stereo jack socket via C28 and C29, for connection to an external amplifier or powered speakers. The output is short-circuit proof, with an output impedance of 10 kΩ and an amplitude of about 80 mV_{eff}. Two LM386 ICs are also provided as a power amplifier, with loudspeakers connected at K5. The maximum output power into 8 Ω is around 300 mW. Surprisingly there is no stereo volume control potentiometer in the

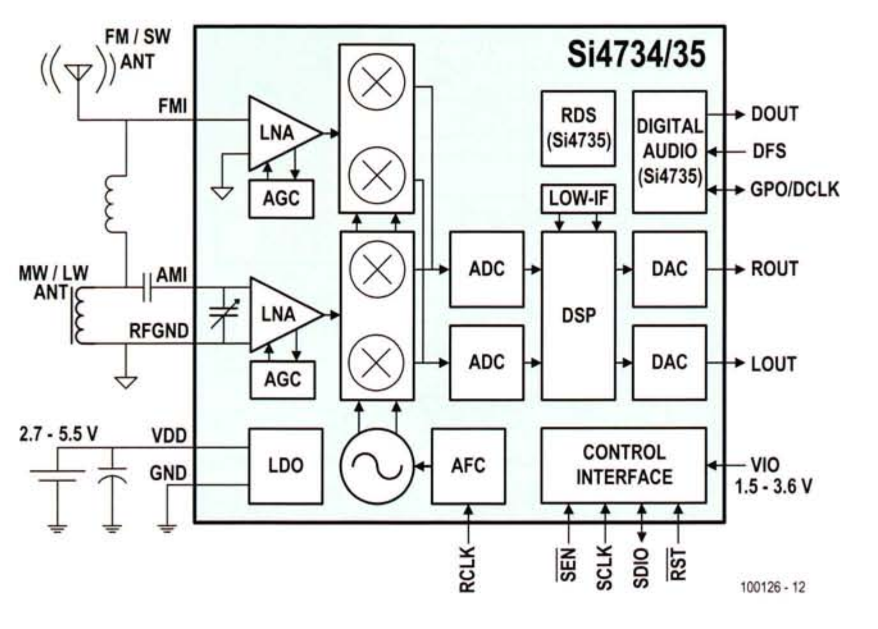


Figure 1. Block diagram of the Si4735 DSP radio IC (courtesy http://www.silabs.com)

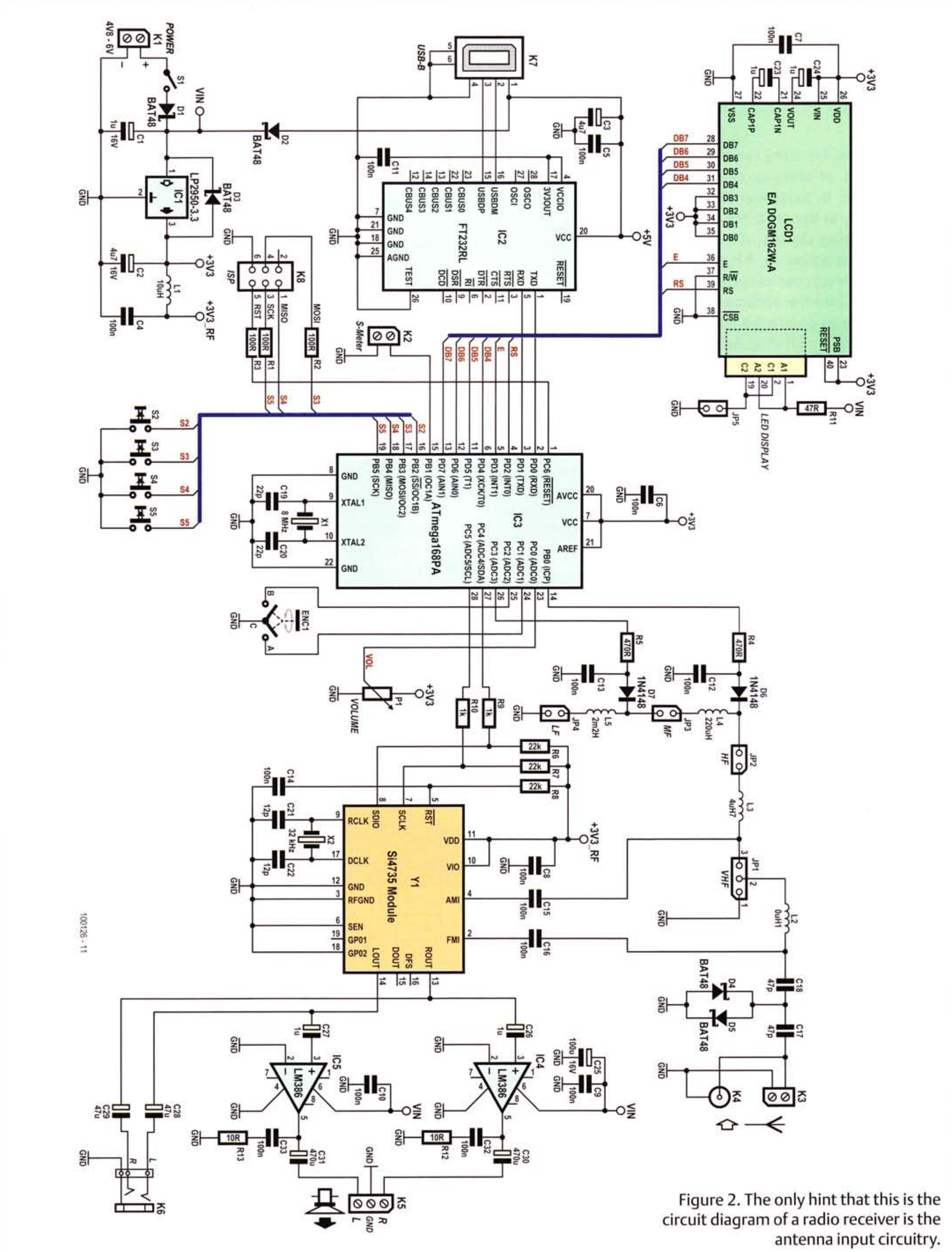


Figure 2. The only hint that this is the circuit diagram of a radio receiver is the antenna input circuitry.

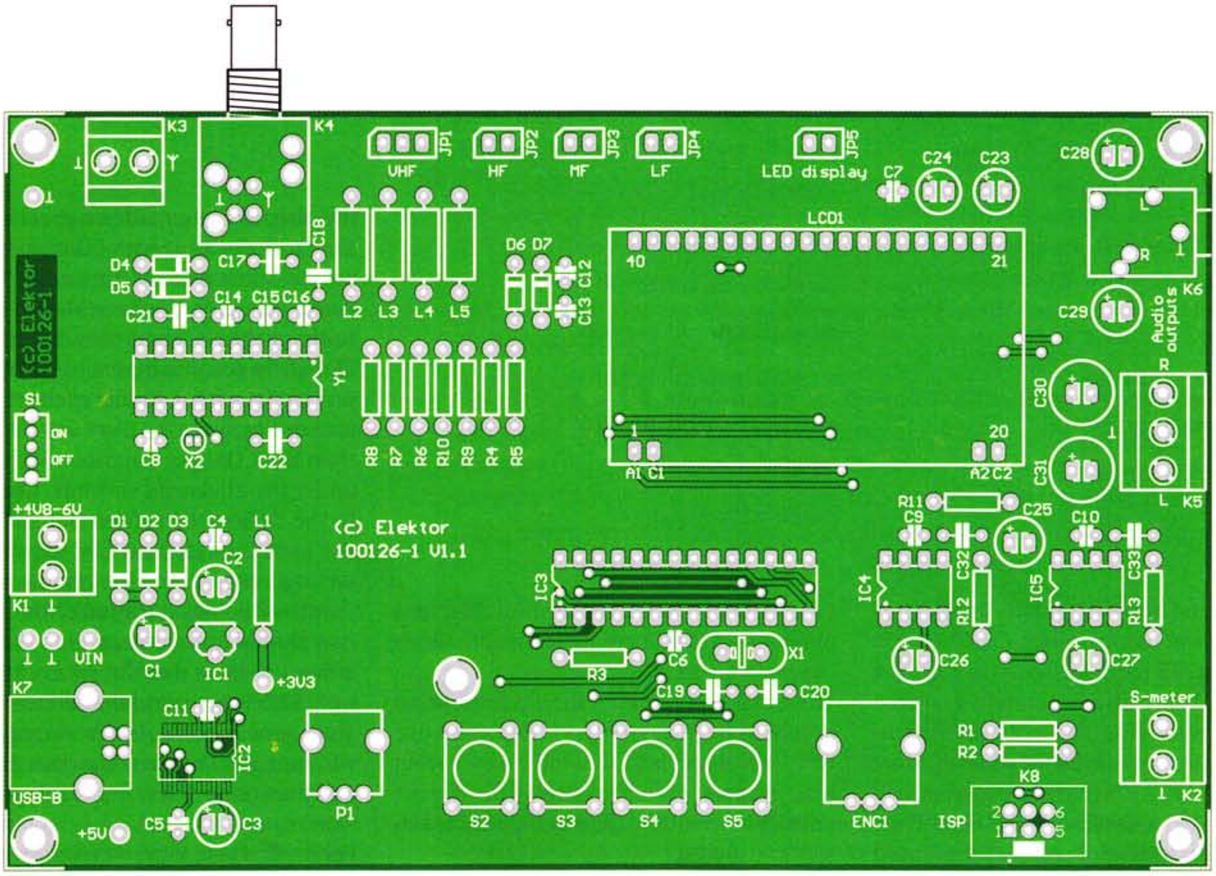


Figure 3. The printed circuit board is Eurocard-sized. All user controls are mounted on the top side of the board for convenience. Gegenüber dem Labormuster auf den Fotos wurden noch einige Bauteilpositionen geändert.

circuit: this, and all other functions of the Si4735 are controlled by microcontroller IC3 (an ATmega168) in software over the SDA and SCL I²C bus signals. The microcontroller reads a voltage from (linear) potentiometer P1 using analogue input ADC0 and translates this into the appropriate commands for the Si4735. The tuning control is implemented as a rotary encoder (ENC1) connected to two port input bits. Pushbuttons S2 to S5 comprise the remaining user controls: their function will be described in detail below. Finally, a PWM output is provided for connection of a signal strength meter, taking the form of a 500 Hz squarewave with a variable mark-space ratio. The average output voltage varies between 0 V and 3.3 V, and almost any meter with a full-scale deflection of up to 1 mA can be connected using a suitable series resistor.

The ATmega168 is clocked at 8 MHz. This clock is independent of the reference in the receiver, which is derived from a dedicated 32.768 kHz watch crystal.

There are three alternatives for powering the radio: over the USB connection, using a 6 V mains adaptor, or from a four-cell battery pack (4.8 V to 6 V). The voltage at V_{IN} directly powers the two LM386 ICs and the LCD backlight, and also forms the input to voltage regulator IC1 (an LP2950-3.3) which provides the regulated 3.3 V supply for the radio IC, the microcontroller and the LCD. Power switch S1 only controls power from K1 (from a battery or mains adaptor): USB power is not switched. Power can be saved by removing JP5, which will turn off the LCD backlight: the display is perfectly legible in ambient light. The receiver will work without problems with a battery voltage as low as 4.0 V. This, together with the relatively low current consumption of 50 mA, means that the circuit will give good battery life.

Figure 4. The Si4735 module consists of a daughter board with the DSP IC mounted on it.

Populating the board

The Eurocard format (100 mm by 160 mm) printed circuit board (**Figure 3**) is designed to be built into an enclosure along with loudspeaker and battery holder. All the controls are located on the top surface of the board. If it is important that no components hang over the edge of the board, do not fit BNC socket K4 and audio socket K6. The printed circuit board is available ready-assembled and tested in this form from the *Elektor* shop (order code 100126-91: see the pages at the back of this issue). The layout and parts list are available for download from the *Elektor* web pages for this project [1], and the unpopulated board (order code 100126-

Table 1. The most important terminal commands (38400 baud)	
f5955 <Enter>	tune to 5955 kHz AM
f102800 <Enter>	tune to 102.8 MHz FM
m5 <Enter> 6075 <Enter> DW <Enter>	store AM preset 5: 6075 kHz, label 'DW'
n3 <Enter> 95100 <Enter>	store FM preset 3: 95.1 MHz
p9 <Enter> 1 <Enter>	AM de-emphasis on
p10 <Enter> 0 <Enter>	set AM bandwidth to 6 kHz
p10 <Enter> 1 <Enter>	set AM bandwidth to 4 kHz
p10 <Enter> 2 <Enter>	set AM bandwidth to 3 kHz
p10 <Enter> 3 <Enter>	set AM bandwidth to 2 kHz
p10 <Enter> 4 <Enter>	set AM bandwidth to 1 kHz
p13 <Enter> 0 <Enter>	disable AM soft mute

1) can also be ordered on-line. Ready-programmed microcontrollers (100126-41) and the Si4735 module shown in **Figure 4** (090740-71) are also separately available from the *Elektor* shop, and so if you wish you can populate the main board yourself. Start with IC2, the FT232RL: a little experience in soldering SMD ICs will be useful here. Then fit the USB socket and connect the board to a PC for testing. If the USB interface IC is recognised by the PC, then you have cleared the first hurdle.

The two pin headers have to be soldered to the Si4735 module so that it can be fitted into a normal IC socket.
When assembling the LCD, note that the backlight board must first be soldered in under the LCD panel itself. Then the assembled LCD module can be mounted in a header socket to increase its height above the main board.
The other components should present no problems to anyone with a little experience with a soldering iron. It hardly needs saying that you must of course observe the correct polarity when fitting the electrolytic capacitors and diodes.

Powering up

If you have not previously used an FT232R with your PC, you will first need to install a driver. Run the program CDM_Setup.exe, part of the software download available at [1], and then connect the radio to the PC using a USB cable. When the radio is first connected the driver will be loaded and a COM port allocated. If a connection has already been made several times with the same device, a high COM port number will be allocated. In this case it can be worth using the Windows device manager to change the port number, for example to COM2. To rename a port open the device properties with a double click on the relevant device; go to the 'Port Setting' tab, and then the COM port number will be found under the advanced settings. Change this to the desired value (even if marked as 'in use') and then click on 'OK' to put the new setting into effect. A warning may appear that the double allocation of the interface may lead to problems: confirm that you do indeed wish to use the new setting. The new COM port number will not immediately appear in the device manager, but it will appear of you close the device manager and then re-open it.

For the first test of the receiver you will need a short length of wire, about half a metre, to use as an antenna. After applying power (or plugging in the USB cable), the message 'Elektor DSPradio' should appear on the upper line of the LCD panel. The receiver will then automatically search for the first station in the FM band, starting at a frequency of 87.5 MHz. It is possible that a signal will be detected at 88.0 MHz, which is the eleventh harmonic of the microcontroller crystal frequency (eleven times 8 MHz). However, this will be rejected immediately, and the search will proceed to the next frequency. The display indicates the frequency of any station found in the format '88300' (meaning 88.3 MHz); immediately next to the frequency the display (**Figure 5**) shows the signal strength at the antenna in dBµV and the signal-to-noise ratio, or SNR, in dB. The signal strength meter will also be driven: for testing purposes, a voltmeter can be connected at K2. The maximum input level of 80 dBµV will give an output voltage at K2 of 3.3 V. For permanent display connect an analogue voltmeter or a moving-coil meter with a suitable series resistor to K2.

After a brief pause the lower row of the LCD panel will show the RDS station identification string; shortly after that, the time of day as transmitted by the station. The potentiometer allows the output volume

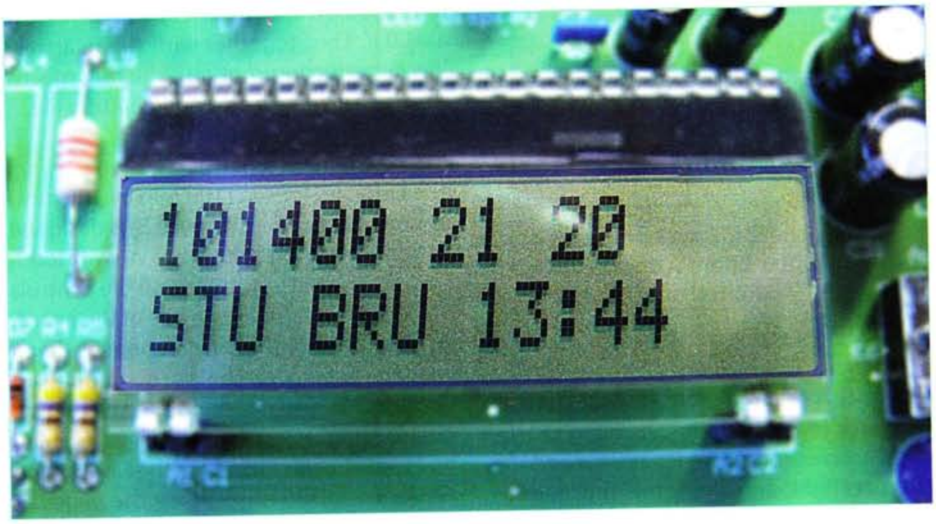


Figure 5. The display shows the currently tuned frequency, the signal strength at the antenna in dBµV, and the signal-to-noise ratio (SNR) in dB. When receiving an FM station the lower line of the display shows the RDS station identifier and time of day.

In detail, the pushbuttons function as follows:

S2: Switch to FM band/automatic search. A brief press starts an automatic station search with increasing frequency; a longer press (more than 0.5 seconds) starts a decreasing-frequency search.

S3: Switch to AM mode and select between longwave and 16 m shortwave bands. In each case the radio tunes to the lowest frequency in the band. A brief press switches to the next higher band, while a longer press selects the next lower band. If S3 and S2 are used to switch between AM and FM, the previously-tuned station will be remembered and tuned to. This allows easy switching between a local FM broadcaster and a distant AM broadcaster.

S4: AM automatic search. With a brief press, search in the direction of increasing frequency; with a longer press, in the direction of decreasing frequency. The automatic search will not stop at the end of a frequency band. The display is continuously updated with the current frequency; if a sufficiently strong station is found the search will stop, the display showing the station frequency, signal strength and SNR. Also, the capacitance in the tuner circuit (in picofarads) will be shown in the upper right of the display. If no station is found, the search can be stopped by turning the rotary encoder (which switches to manual tuning) or by selecting a new AM band.

S5: Station preset. Up to thirty FM presets and thirty AM station presets can be stored. A brief press of the button stores the currently-tuned station as a preset, and the number of the new preset memory appears on the display, for example as 'M25'. A longer button press allows you to select which preset memory is to be recalled by turning the rotary encoder. Preset recall mode is exited by pressing S2, S3 or S4, or by a further press of S5. A very long press (more than two seconds) transfers all preset stations to EEPROM, from where they can be reloaded at next power-up. After you have been using the radio for some time, it is possible that you will have accumulated a large number of presets, not all of which will still be useful. The preset memory can be cleared by holding down S5 for two seconds while power is switched on to the radio.
Using a terminal emulator program you can associate a text label with each AM station, for example giving its name, that will be shown in the lower row of the display.

to be adjusted, and the output is simultaneously present on the audio jack socket and at the loudspeaker outputs. Turning the rotary encoder will tune the radio over the whole of the FM band to pick up other stations. The four buttons allow manual access to a range of functions such as station search, AM band selection and preset storage.

DSPradio: a user's manual

By default the radio starts up in the FM band. Using button S3 you can switch to the AM band, and S2 returns to the FM band. S4 starts an automatic station search, and finally S5 is used to store stations in the microcontroller's internal EEPROM. The radio uses standard predefined frequency bands, although with manual tuning or with the automatic station search it is possible to tune to frequencies beyond the ranges normally associated with these bands. The lowest frequency in each band is as follows:

Longwave: 153 kHz
Mediumwave: 549 kHz
75 m band: 3965 kHz
49 m band: 5800 kHz
41 m band: 7200 kHz
31 m band: 9400 kHz
25 m band: 11600 kHz
22 m band: 13550 kHz
19 m band: 15150 kHz
16 m band: 17400 kHz
FM: 87.5 MHz

Firmware and PC control

It is almost inevitable that when you have used a device for a while, there are things you wish you could change in its user interface. In this case it is possible: the underlying program, written using BASCOM, is available in source code and as a hex file from the *Elektor* pages for this project [1], and there is a connector on the printed circuit board to allow in-circuit programming of the ATmega168. So there is no reason why you should not modify the firmware yourself. If that is not your cup of tea, there is also a wide range of options for controlling the radio over its USB port: in most cases all you need is a simple terminal emulator program, although you could also develop your own program on the PC side to interact with the radio in more sophisticated ways.

Communication over the virtual COM port runs at 38.4 kbaud. **Table 1** gives an overview of the most important commands available for configuring and tuning the receiver from the PC. Among the options are configuring bandwidth, de-emphasis and soft muting, and storing frequencies and station names in the radio's preset memory.

In the next issue we will look at more advanced antenna configurations and go into more detail regarding the features and subroutines in the radio's firmware, including suggestions for developing PC-based control software to gain access to the various features of the Si4735 as well as direct control of the LCD panel.

So, as you can see, the *Elektor* DSP radio is no common-or-garden world receiver. Using PC-based software it is possible to add features that were not even thought of when the radio was designed, and, thanks to its open-source firmware and in-circuit programming facility, any keen developer can create his or her own style of user interface.

(100126)

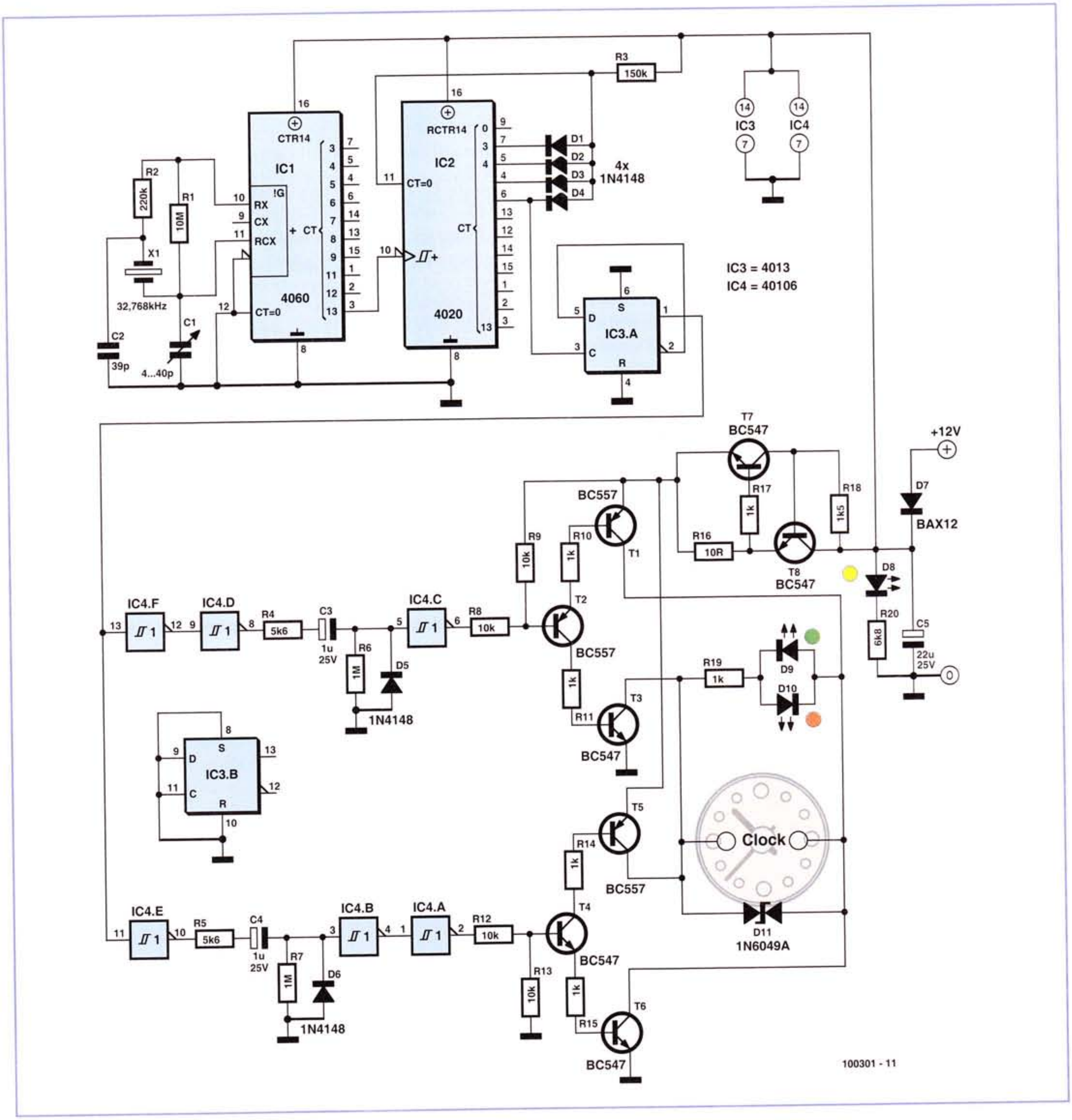
[1] www.elektor.com/100126
(project pages including parts list, downloads and other additional information)

Clock Pulse Generator

Ed Flier (The Netherlands)

For many years the author has been approached by people who have managed to lay hands on an 'antique' electric clock and need an alternating polarity pulse driver. This is immediately followed by the question whether an affordable circuit for this is available. The design described here has been working very nicely for years in three of the author's clocks. To keep the circuit simple and thus inexpensive, the author dispensed with automatic adjustment for summer and winter time.

A 32.768 kHz oscillator is built around IC1. X1 is a crystal of the type that can be found in almost every digital watch, especially the cheaper ones. The frequency can be adjusted with trimmer C1 if necessary.
The clock signal is divided by IC1 and IC2 to obtain a signal on CT=6 (pin 6) of IC2 with a frequency of one pulse per minute. IC3.A is wired as a divide-by-2 circuit to maintain a constant signal during each 1-minute period. IC4.E and IC4.F buffer this signal, and IC4.D inverts the output of IC4.F.
When CT=6 of IC2 goes high, IC3.A receives a clock pulse and its Q output goes High. IC4.F and IC4.D then charge C3 via R6 (1 MΩ), and the output of IC4.C remains low for approxi-



mately 1 second. This drives T2 into conduction, and with it T1 and T3. The resulting current through the clock coil causes the green LED to light up. When CT=6 of IC2 goes high again after 1 minute, IC3.A receives a new clock pulse and its Q output goes Low. Now C4 is charged by IC4.E via R7 and the output of IC4.B is low for approximately 1 second, so the output of IC4.A is logic High. This drives T4 into conduction, and with it T5 and T6. The resulting current through the clock coil causes the red LED to light up. In this way the clock is driven by pulses with alternating polarity.

Diode D7 protects the circuit against reverse-polarity connection of the supply voltage. Diode D8 is lit constantly when the supply voltage is present. Transistors T7 and T8 provide current limiting if a short circuit occurs in the clock mechanism. The peak pulse current can be increased by reducing the value of R16 (minimum value 2.2 Ω). Diode D11 is a dual suppressor diode that clips any voltage spikes that may occur. This diode is fairly expensive, so it was omitted in the circuits actually built. This has not led to any problems up to now, but it may be advisable with heavy-duty clocks or multi-pulse clocks.

Note: this circuit is only suitable for pulse-driven clocks that operate at 12 V. The circuit must be modified for models that operate at 24, 48 or 60 V. As these models are less common, or in many cases can be converted to 12 V operation, this option is not described here.

(100301-I)

Simple RF Noise Source

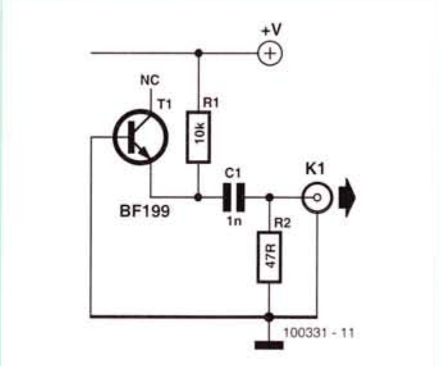
By Fred Brand (Netherlands)

A noise generator with a wideband output signal is always handy to have around when you're adjusting receivers and other types of HF equipment.

The noise generator circuit described here uses the base–emitter junction of a transistor (in this case a BF199) operating under reverse bias. As a result, it acts as a Zener diode and generates a wideband noise signal. The noise signal passes through a 1-nF capacitor to the output connector (female BNC), which means that its low-frequency components do not appear at the output. The 47-Ω resistor gives the noise generator an output impedance of nearly 50 Ω.

You can easily fit the entire noise generator in a small metal enclosure equipped with a BNC connector. The supply voltage is not critical; anything in the range of 8 to 15 V will do.

(100331-I)

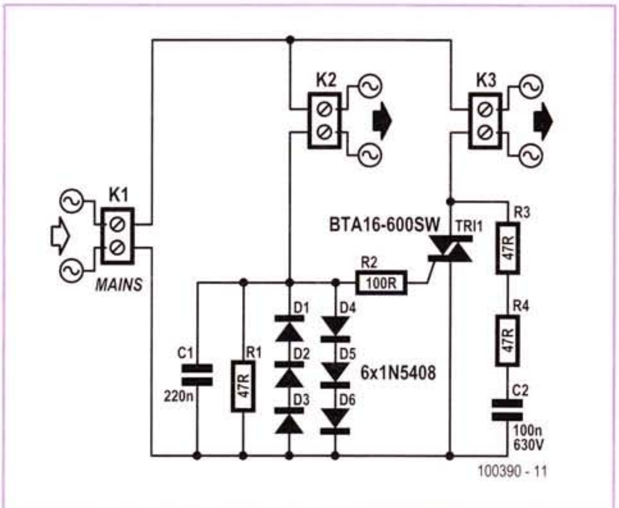


Intelligent AC Power Bar

Ton Giesberts (Elektor Labs)

This circuit is a modified version of the circuit found at [1]. The purpose of the circuit is to ensure that AC power is not supplied to devices connected to K3 unless the device connected to K2 is drawing sufficient power.

Six power diodes connected in series with the load plugged into to K2 generate a voltage drop of approximately 2 V if the load is switched on. This voltage drives a triac, which in turn supplies power to the load plugged into K3.



Capacitor C1 reduces the sensitivity of the circuit to spikes. To avoid premature switching due to power drawn by an AC line filter, stand-by operation or the like, R1 can be used to raise the threshold level. It will be approximately 10 watts with a 47 Ω resistor, but this is strongly dependent on the characteristics of the triac and the waveform of the load current. If the current is not sinusoidal or R1 is too small, the triac will trigger later and may not be able to supply sufficient power to K3, in which case the circuit will act as a sort of dimmer.

Be careful when modifying the value of R1. Remember that the entire circuit is at AC line potential. Unplug everything before working on the circuit.

The combination of C2, R3 and R4 forms a snubber network that suppresses switching spikes, such as are produced by inductive loads.

We selected an ST triac that can handle more current than the TIC225 used in the original circuit, but which still has a reasonably low trigger current. The BTA16-600SW is rated for 16 A continuous or 160 A peak. Here the suffix 'SW' is especially significant. This is what is called a 'logic level' triac, with a maximum trigger current requirement of only 10 mA, symmetric

in quadrants I and III. This is not true of the TIC225. If the trigger sensitivity is not the same in both quadrants and the trigger conditions are marginal, the triac may trigger in only one quadrant. This results in rectification, which most equipment cannot handle. At minimum this will cause fuses to blow.
The resistance of the snubber network consists of two resistors connected in series (R3 and R4). Standard resistors are often not suitable for use at AC grid voltages. Over the longer term, spikes can also cause resistor failure, which leads to triac failure.

Pay attention to the maximum load current. The triac can handle around 1 A without cooling, but at this level it is actually too hot already. Fit a small heat sink if the current through the triac will be more than 0.5 A. The maximum allowable triac junction temperature is 125 °C, but in practice it's better to work on the basis of 70 °C, since high temperatures shorten the life of semiconductor devices.
The circuit is very compact and can probably be built into the power distribution bar.

(100390-I)

[1] www.electronicsweekly.com/blogs/gadget-freak/2008/09/flavio-plugs-into-smart-extens.html

Crystal Tester

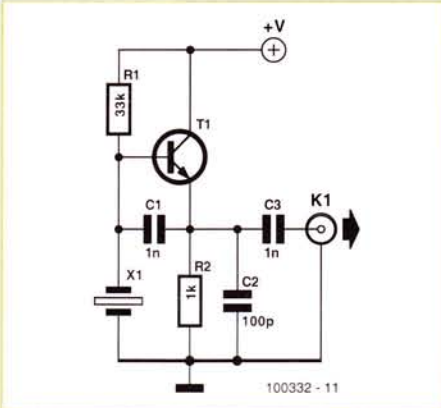
Fred Brand (The Netherlands)

This crystal tester is very straightforward. Fitting a crystal or switching on the supply voltage generates a 'start pulse' resulting from the fact that the crystal briefly pulls the voltage on the base of T1 low. This directly affects the operating point of the transistor via feedback capacitor C1, with the result that the transistor starts oscillating.

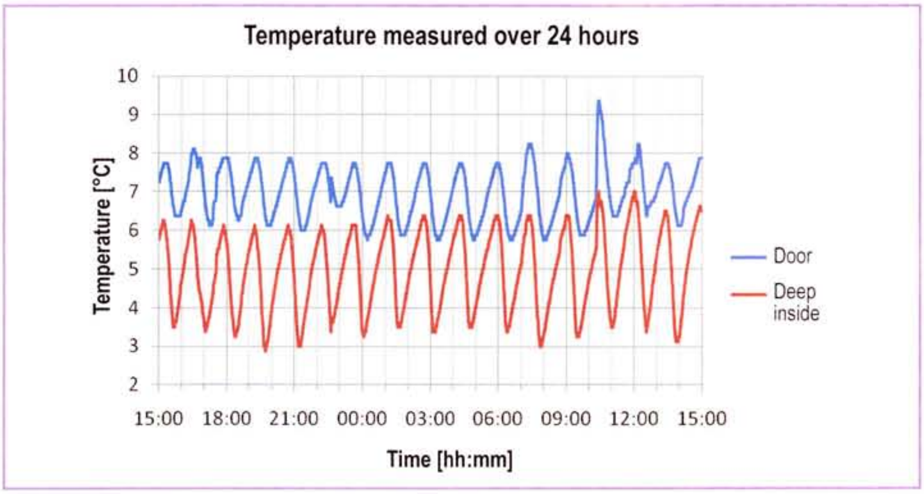
Resistor R2 limits the maximum operating current of the transistor. A 100-pF capacitor (C2) is connected in parallel with R2 for decoupling, and capacitor C3 is used to prevent the DC voltage on the emitter from appearing at the output.
An AC signal will therefore be present at the output if the crystal is OK. You can put together your own indicator circuit to make this visible, such as an HF probe connected to a meter or a transistor with an LED.

Another tip: if you connect two LEDs in reverse parallel in series with the ground lead of the crystal, they will both light up when the crystal oscillates.

(100332-I)



Temperature Logger for the Fridge



Fons Janssen (The Netherlands)

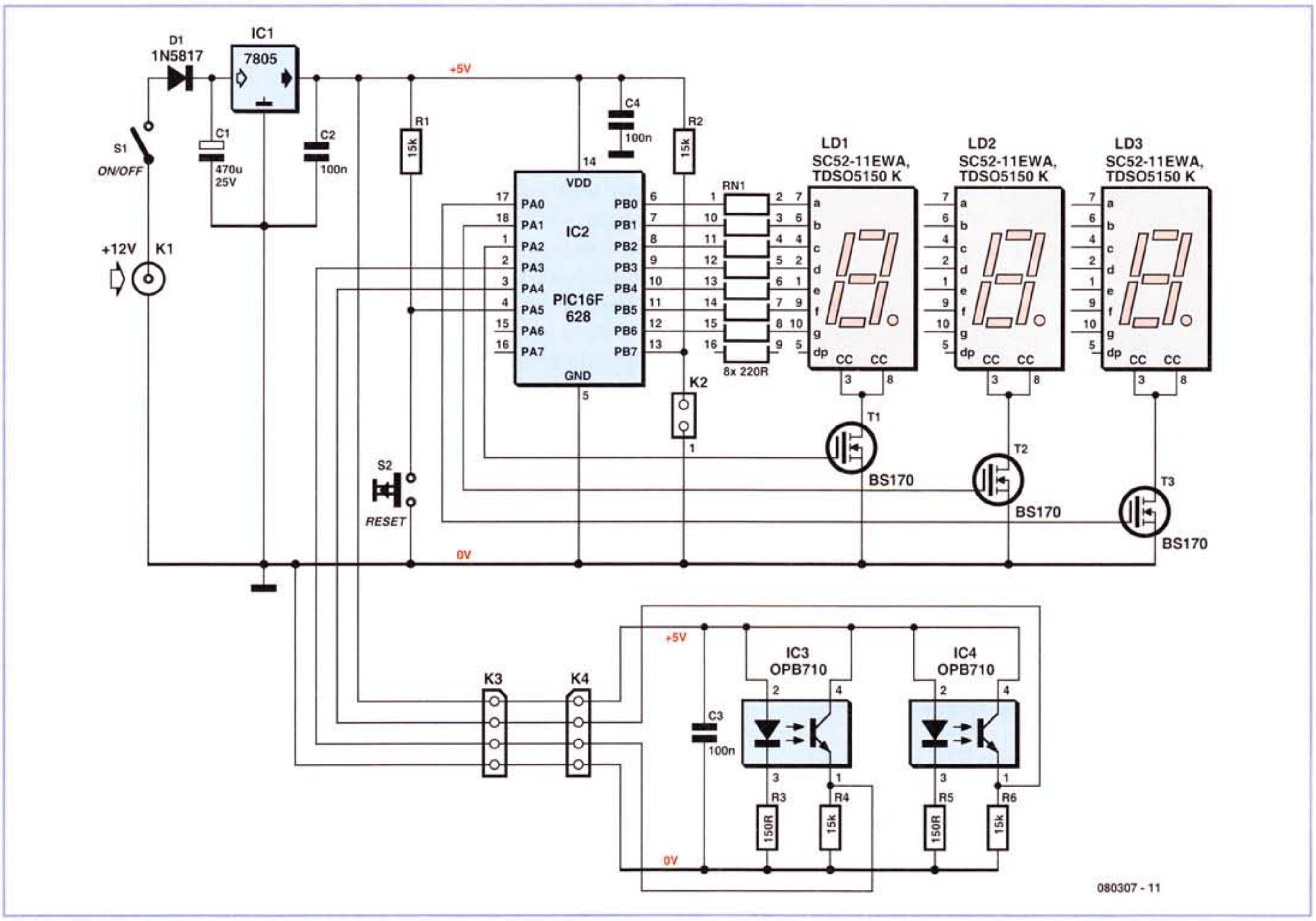
Most National Health Departments and Councils seem to agree that the recommended fridge temperature should be between 2 °C and 7 °C (35 °F to 44 °F). The lower the temperature, the slower the growth of bacteria and the longer perishable foods will keep fresh. You can check the temperature with an ordinary thermometer, but that only tells you what the temperature is at that particular time. But what happens to the temperature during the whole day?

To get a good idea of the temperature over a period of time the DS1921Z made by Maxim comes in very handy. It is an autonomous temperature logger in an iButton package [1]. This is a strong metal button the size of about four small coins put on top of one another. The DS1921Z has an internal temperature sensor (range: –5 °C to +26 °C, accuracy: ±1 °C), 4 Kbit memory, a real-time clock and a battery, which lasts between 2 and 10 years, depending on the log frequency. The iButton can log temperatures at a rate between once per minute up to once every 255 minutes. The memory has room for 2048 values, which means it's possible to store a measurement every minute for a full day (24×60=1440). The (free) 1-Wire viewer software makes it a piece of cake to configure the iButton and to read the results after the measurements are complete. Apart from the iButton you also need a USB dongle (the DS9490 made by Maxim) to connect the iButton to the PC.

In the graph you can see the result of the measurements during a 24-hour period, where one iButton was placed in the door and another at the back of the bottom shelf. It is clear that there is a temperature variation of about 2 to 3 °C in both places as a result of the thermostat in the fridge. According to the advice of the Health Department the door wouldn't really be cold enough to store perishable items in this case, whereas it would be safe to store them at the back of the bottom shelf.

(091091)

Daggerboard Position Detector



Hermann Sprenger (Germany)

In sailing regattas it's handy to have a daggerboard that can be raised and lowered vertically. As the winding handle or positioning motor needs to rotate the spindle of the lifting device some 100 to 150 times throughout its full range it would be extremely handy to have a quick idea of its current position. An electronic count of the number of revolutions would be ideal. Thank goodness most sailors now have a 12-V supply available!

To get this to work you need to apply white and black markings to the spindle, each covering half of the circumference. Next, mask off two electric eye devices (reflected light sensors) next to one another (approximately 10 mm apart). For secure detection both sensors should be positioned not more than 5 mm from the paint markings.

The markings to be read by the sensor should be displaced laterally, so that the direction of rotation can be recognised in addition to the number of revolutions counted.

At the heart of our circuit is a PIC16F628 from Microchip, which as usual can be bought ready programmed from Elektor or you can do this bit yourself by downloading free firmware (for details of both see [1]).

At pins 1 of the two reflected light sensors IC3 and IC4 we need to 'see' more than 2.0 V from the white segment and less than 0.8 V from the black mark (with an operating voltage between 4.5 and 5.5 V). The two signals detected are taken to plug connector along with the operating voltage and ground. It's convenient if you also provide a connector from the microcontroller as well, so that the sensor and the controller board can be linked by a test lead.

The multiplexing of the three seven-segment displays is programmed at a rate of 100 Hz. Acceptable values for the revolution count are between 0 and 140. If the count exceeds or falls below these limits, then the counter is not incremented. The RESET key S2 sets the counter back to zero. Jumper K2 enables you to reverse the direction of counting. The count is retained if the operating voltage is removed and is loaded again when next powered up.

The source code can also be downloaded from the website mentioned above, making it possible (for instance) to define alternative counter limit values (the maximum value is defined in the line #define max 140). For compiling the code you can use the CC5X compiler, of which there is a free version (www.bknd.com/cc5x).

(080307)

[1] www.elektor.com/080307

Ground-free DVM Module Supply from 5 V

Heinz Kutzer (Germany)

The majority of hand-held digital volt meters use an LCD screen and are powered from a nine volt battery. Inside is most probably an ICL7106 chip (or something compatible). This takes care of measuring the input and driving the LCD. This IC is very popular and can be found in other laboratory and homebrew equipment where it offers a simple solution for both measuring current/voltage and driving the display. So far so good, there is however one feature of this device which needs careful consideration. The power supply to the chip (both the positive and negative connection) must not have any direct connection to either of the two measuring input terminals. It requires floating supplies. This is not a problem for battery powered equipment but needs more thought when the ICL7106 is fitted into mains powered equipment.

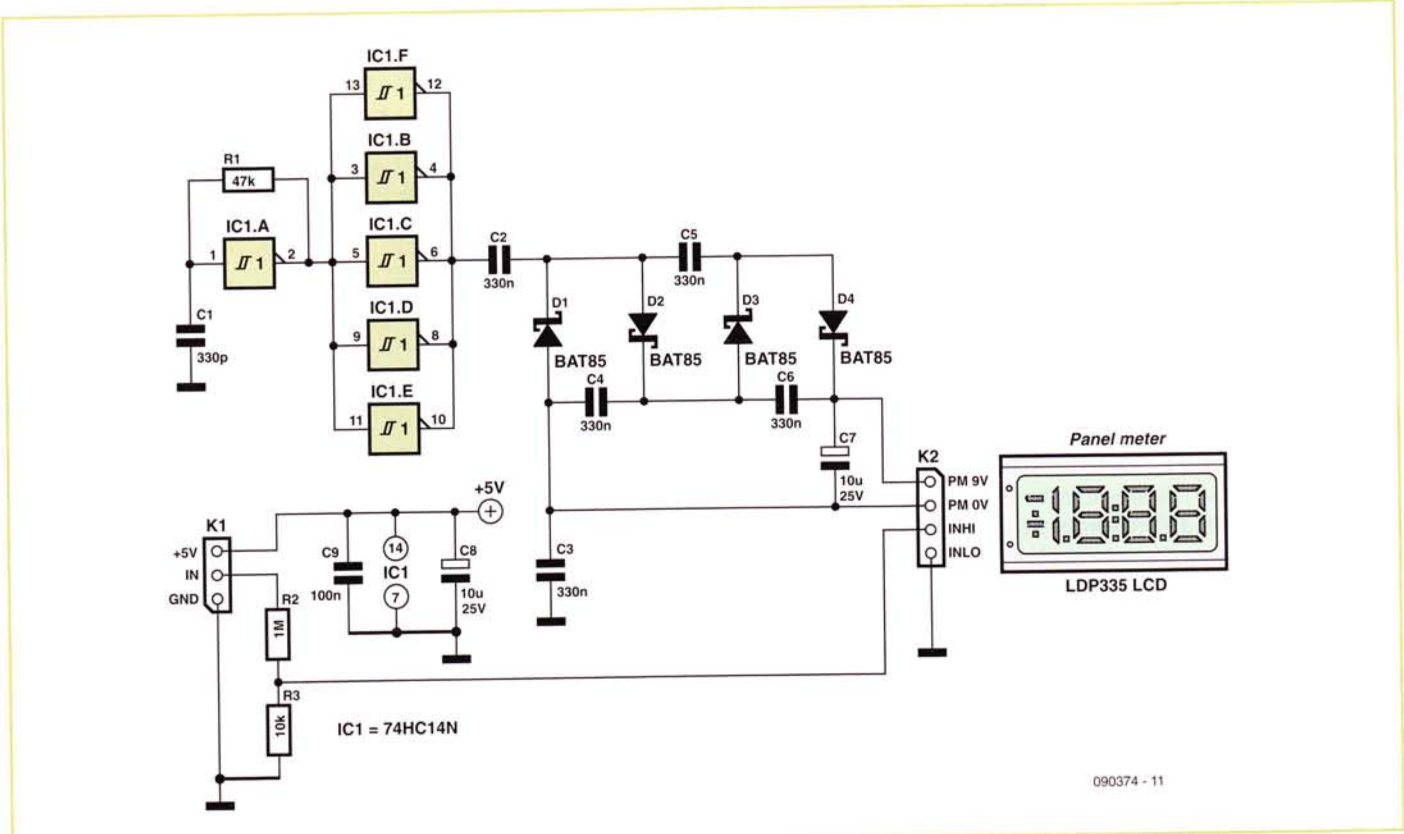
The simplest, most expensive solution is to use two independent power supplies in the equipment. A battery could also be used as an isolated supply but in a mains powered device it would seem a bit out of place and inconvenient.

In this case the term 'floating supplies' means that it is possible to have two separate DC levels. This level of isolation can be achieved with capacitors to separate the two DC supplies. Back in 2003 we published a circuit in the July/August edition of Elektor (circuit number 75) which used a NE555 IC. Unfortunately this design required a supply voltage upwards of 10 V. If the DVM module is fitted to equipment which only uses a 5 V supply (as is often the case) the circuit will not be of much use. The author has solved the problem by modifying the original circuit, using a hex Schmitt trigger inverter type 74HC14N instead of the NE555. One of the inverters generates a square wave of about 75 KHz. The remaining five inverters are wired in parallel to provide more output drive current for the voltage multiplier stage.

DC isolation is provided by capacitors C2 and C3. A classic voltage multiplier configuration is made up of capacitors and diodes. The circuit generates an output of around 8.5 V at a load current of 1 mA. This is sufficient to power the DVM chip. The 5 V supply for the circuit must be stabilised.

The values of the input voltage divider resistors R2 and R3 are independent of the chip's power supply and must be selected according to the desired measurement range.

(090374)

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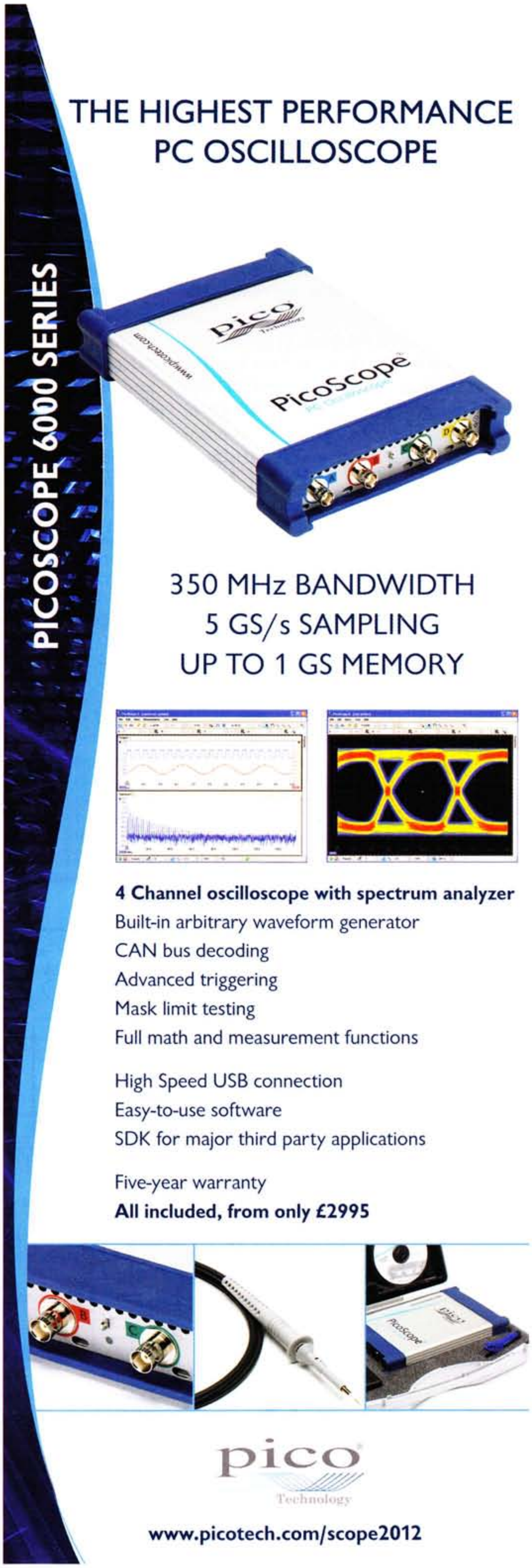
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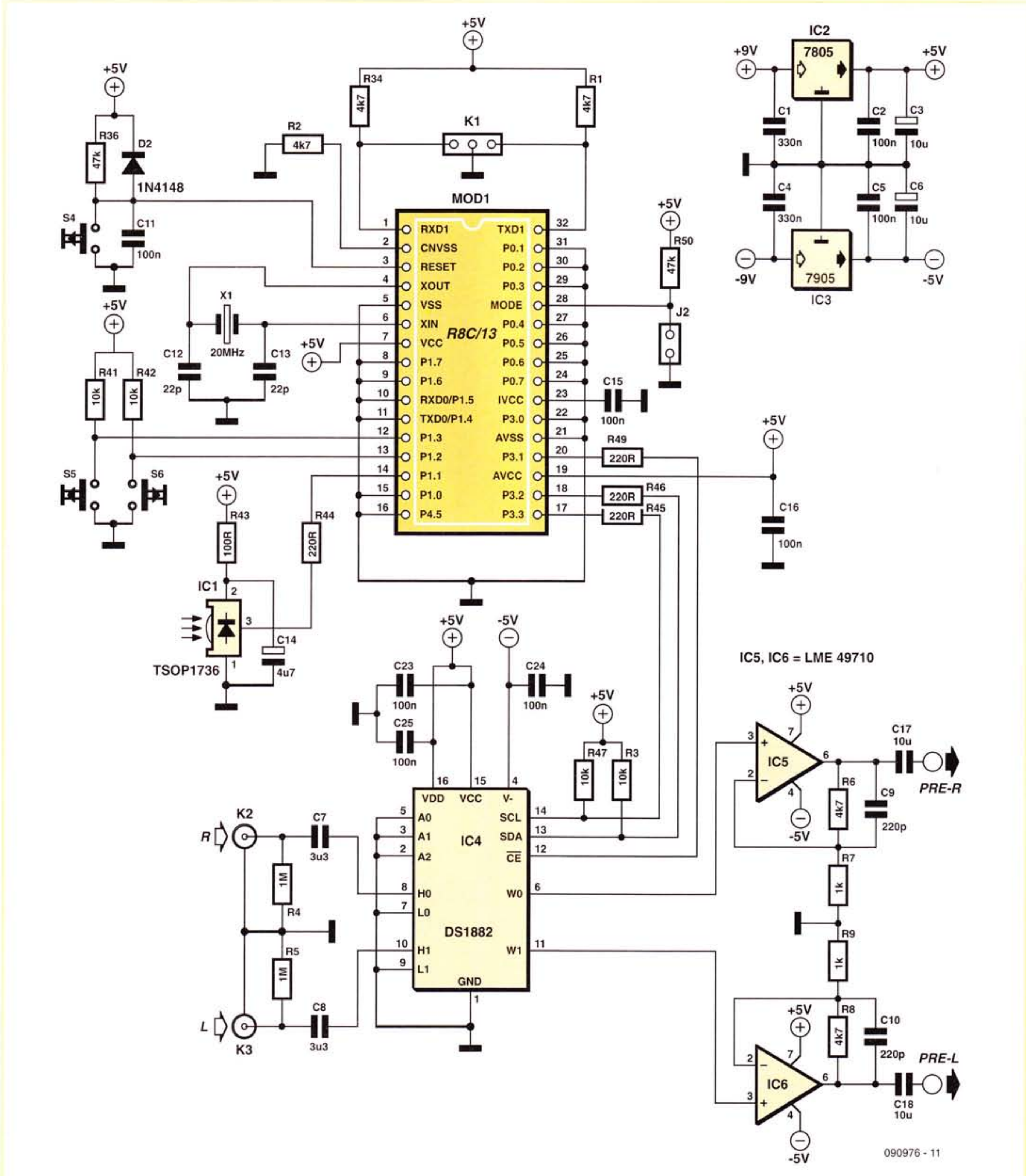
Remote-controlled Preamp with Digital Pot

Michael Hoelzl (Germany)

This circuit is a simple but high-quality preamplifier using a DS1882 digital potentiometer, a device specially designed for audio applications. The potentiometer is controlled over an I^{2}C interface by an R8C/13 microcontroller. The main features of the design are its remote control and lack of moving parts.

The circuit is controlled by two buttons (volume up and volume down) and an infrared receiver connected to the microcontroller. The software in the microcontroller, written in C, is designed to interpret RC5 codes and supports the following commands:



- volume up;
- volume down;
- mute.

Other commands could of course be added. The audio signal arrives via phono sockets and is taken to the digital potentiometer via coupling capacitors. The potentiometers are configured as voltage dividers with an overall resistance of 45 kΩ. The wiper position is adjusted over the I²C interface.
At the output of the potentiometers there are two operational amplifiers in non-inverting configuration to buffer the high-impedance attenuated signal. They provide a gain of 5.7. The capacitors in the feedback network are dimensioned to provide a signal bandwidth of around 150 kHz with unloaded output.
The value of the output coupling capacitors depends on the input impedance R_{in} of the following power amplifier stage. As a rule of thumb a value of $C=1/(100R_{in})$ is suitable, and so the value of 10 µF shown in the circuit diagram is easily large enough in most cases.
In some situations it is useful to connect the outputs to ground via high-value resistors to provide a definite DC level.
The ±5 V supply voltages for the opamps and the DS1882 are decoupled using 100 nF capacitors. The lower-cost NE5532 opamp can be used instead of the specified device without noticeable signal degradation. All unused pins on the microcontroller are taken to ground.

As has already been described in detail in Elektor [1], the R8C includes a serial debugging interface and boot code that allows a program to be downloaded into its flash ROM. The serial connections are brought out at K1. To connect to a PC an RS232-to-TTL level adaptor (typically incorporating a MAX232) is required; to connect via a USB port, use a USB-TTL cable [2]. TxD from the PC should be connected to RXD1 on the R8C, and RxD on the PC should be connected to TxD1 on the R8C. J2 must be fitted for programming, taking pin 28 (MODE) on the R8C to ground. Then apply power to the circuit (for a power-on reset) or press reset button S4. The program FlashSTA can be used for programming: the web pages accompanying this article [3] have this software available for free download, along with the firmware for the microcontroller.

One possibility for expansion would be to add an input selection switch, which could be implemented using an analogue switch IC. The IC could also be controlled over the existing I²C bus.

The structure of the RC5 remote control code has been described previously in *Elektor*: see the free 'RC5 Code' download at [4]. The protocol specifies a five-bit address for the type of device to be controlled remotely (such as a television or VCR). In the author's set-up the preamplifier was controlled using the remote control from a Hauppauge TV card, and so the firmware was configured to use the address reserved for TVs ('00000'). If a different remote control is to be used, the address in the firmware must be modified accordingly. The address appears in the file 'preamp.h' as '#define IR_DEV_ADDRESS 341', where the value 341 is the Manchester-coded form of the address '00000'. The coding procedure is relatively straightforward: with the address written in binary, convert each zero into '01' and each one into '10'. For the address '00000' this results in '0101010101'. For convenience the commands and addresses are converted into decimal, in this case giving 341.

A timer module in the R8C is used for clocking out the RC5 signal, and the whole process is kicked off using an interrupt.

It is worth noting that the infrared sensor does not work reliably if placed near to fluorescent or low-energy light bulbs, as these emit a considerable amount of light in the infrared part of the spectrum.

(090976)

[1] www.elektor.com/050179-2

[2] www.elektor.com/080213

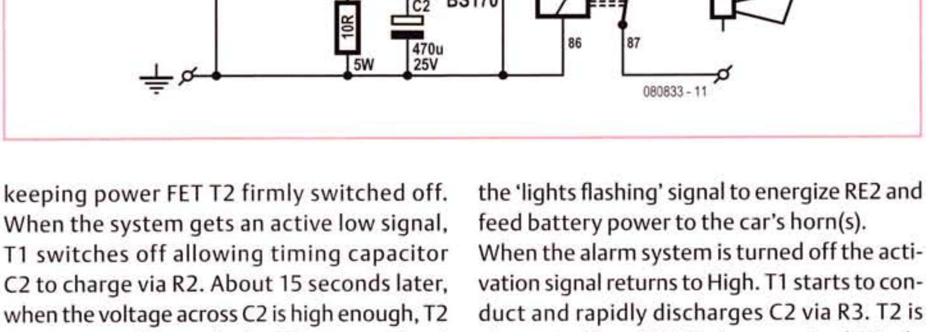
[3] www.elektor.com/090976

[4] www.elektor.com/071149

Car Alarm Sound Booster

Hagay Ben-Elie (Israel)

For car alarms, emphasis should be put on hearing the audible alert and identifying it as belonging to your 'wheels'. Unfortunately, modern car alarm systems seem to have more or less the same alarm sound — especially if they are from the same brand. Also, to comply with legal noise restrictions, the alarm sound is not always loud enough to be heard if the car is parked down the road.
The circuit shown here is designed to help boost the alarm sound by also activating the car's horn(s) when the alarm goes off.
Internally the car alarm system often provides a signal that activates the (optional) engine immobilizer and/or volume (ultrasound) sensors. This signal usually goes Low upon system triggering and high again when the alarm system is deactivated.
The alarm activation signal is fed to the circuit through D1. When in idle state, T1's gate is High and consequently the FET conducts, keeping power FET T2 firmly switched off. When the system gets an active low signal, T1 switches off allowing timing capacitor C2 to charge via R2. About 15 seconds later, when the voltage across C2 is high enough, T2 starts to conduct and relay RE1 is energized. This, in turn, provides the required path for the 'lights flashing' signal to energize RE2 and feed battery power to the car's horn(s).
When the alarm system is turned off the activation signal returns to High. T1 starts to conduct and rapidly discharges C2 via R3. T2 is then cut off and RE1 is de-energized. Diode D2 suppresses back EMF from RE1.



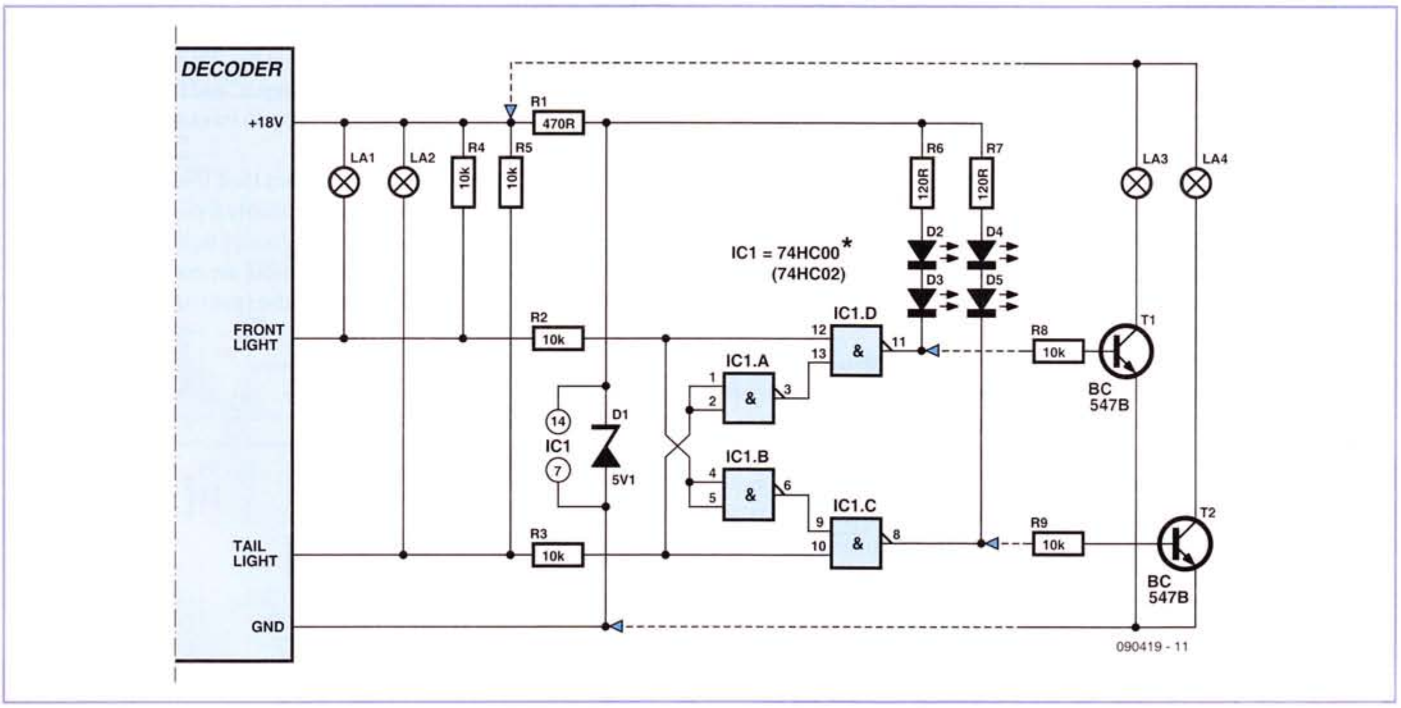
The circuit draws less than 2 mA when idling. When activated the circuit's current consumption is virtually that of the RE1 coil.
RE1 is any simple SPST or SPDT relay, capable of switching about 0.5 A (at 12 V). The coil rating is for 12 VDC and a current requirement as low as you can find. Fuse F1 should be a slow blow type and rated about twice RE1's coil current.

The BS170 in position T2 can sink a continuous current of about 0.5 A. However, a value of 1.2 A pulsed is specified by Fairchild for their devices. To keep the FET's d-s current due to C2 discharging within safe limits, R2 may be increased, C2 decreased and R3 increased, all proportionally. A factor of 2 will keep the FET out of harm's way with maybe a slight change in the 15-second delay and the sensitivity of the circuit.
C1 is used as a smoothing capacitor and F2 should be rated in accordance with the horn(s) maximum current draw.

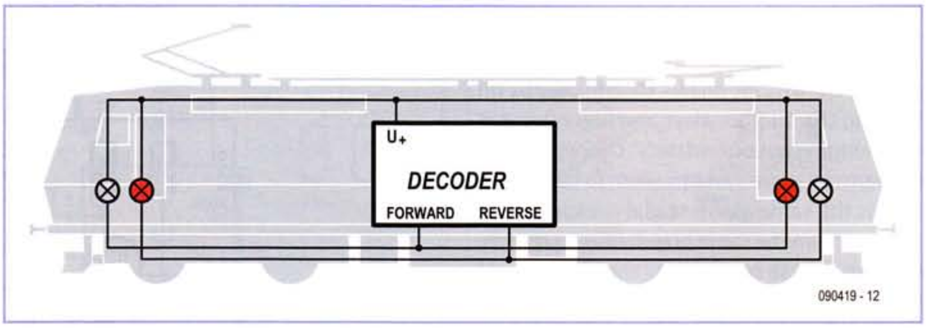
(080833)

Caution. The installation and use of this circuit may be subject to legal restrictions in your country, state or area.

Shunting Lights for DCC Locomotives



Dr Stefan Krauss (Germany)



Digital decoders in model locomotives usually have two outputs for lighting functions. One switches the front lights for forward travel, and the other for reverse travel. If the locomotive has red rear lights, they are also connected to the two outputs.

Many digital decoders include function mapping capability, which allows the switch functions to be assigned as desired. For example, with function mapping you can control the lighting not only for normal running, but also for shunting yard operations with the lights lit at both ends of the locomotive.

However, in case of model locomotives fitted with rear marker lights it is necessary to switch off the red lights for shunting operation. This can be done by connected the rear lights to their own, suitably programmed decoder outputs. Unfortunately, decoder outputs are a scarce commodity that we would rather use for other tasks, such as switchable cab lighting.

The remedy here is a simple circuit that causes the red rear lights to be disabled when both light outputs are active (on).
The circuit is inserted in the leads to the two sets of rear lights, and it essentially consists of a bit of logic circuitry formed from the four NAND gates of a 74HC00, which drive the LEDs directly. Series resistors R6 and R7 as well as R1 are dimensioned for a current of somewhat more than 10 mA. Pull-up resistors R4 and R5 can be omitted if incandescent lamps are used for the rear lights, as indicated here. However, they are necessary when LEDs are used. The combination of Zener diode D1 and resistor R1 provides a 5-V supply voltage for the logic IC.

An alternative circuit with transistors T1 and T2 for driving incandescent lamps used as rear lights is also shown here. As the transistor stages act as inverters, with this version of the circuit a 74HC02 (quad NOR) must be used for IC1 instead of a 74HC00 (quad NAND). The value of R1 can also be increased to 2.2 kΩ to reduce the power dissipation. Connect the front and rear (tail) marker lights as follows:

Locomotive front marker lights: D2 and D3 (LED version) or LA4 (incandescent lamp version).

Locomotive tail marker lights: D4 and D5 (LED version) or LA3 (incandescent lamp version).

The circuit can easily be built on a small piece of prototyping board and fitted in the locomotive. If you're an old hand with a soldering iron, we suggest using an SMD device for IC1 and making the connections with short pieces of enamelled copper wire; the entire assembly can then be packaged in a length of heat-shrink tubing.

(090419-I)

Line Input for Zoom H2

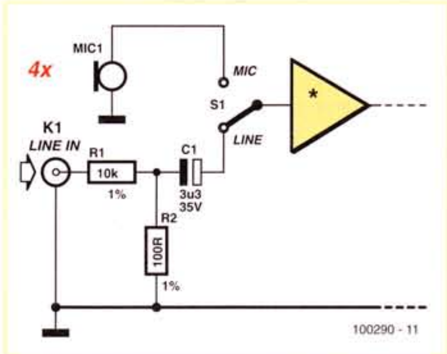
Berto Aussems (The Netherlands)

The Zoom H2 is a popular portable audio recorder. This recorder can record four tracks simultaneously, but unfortunately this only applies to the signals from the four built-in microphones.

The modification described here also lets you record four signals at line level. For this we add four phono sockets to the recorder, where the signals are attenuated by 40 dB via a resistor network. The capacitor blocks the supply voltage for the electret microphones, which would otherwise appear at the line inputs, which is obviously not desirable. Two switches are used to select either the line input or microphone as the source. A short YouTube movie [1] shows all the steps required to modify the H2.

(100290)

[1] www.youtube.com/watch?v=N1vJq13ukrk

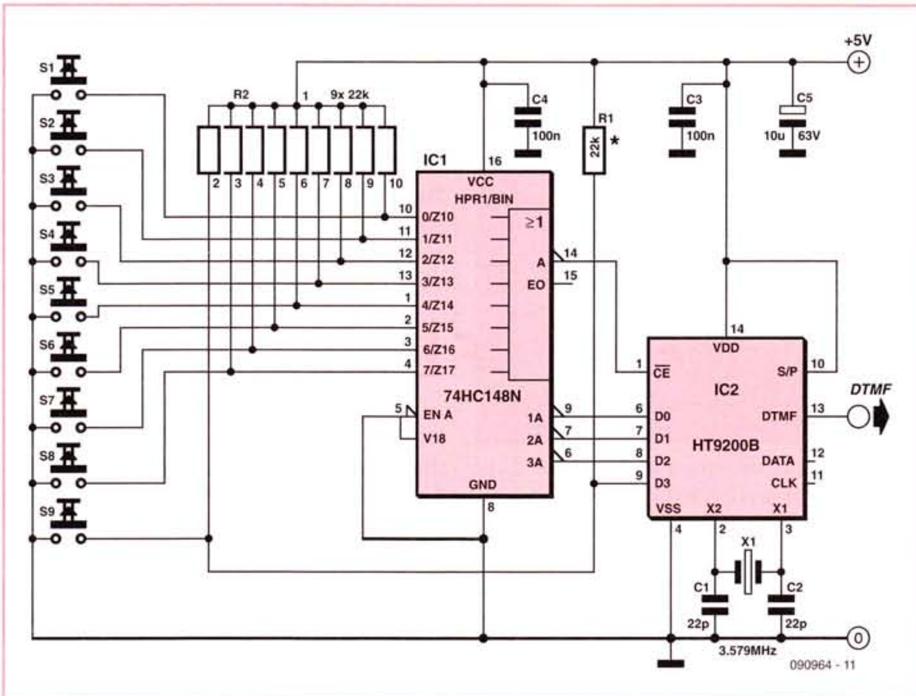


8-channel DTMF Link: Encoder

Angelo La Spina (Italy)

Generated millions of times every day by our telephone keypads, the eight DTMF frequencies were chosen so that the harmonics and intermodulation do not generate significant in-band signal levels. The signal is encoded as a pair of sine waves, ensuring that no frequency is a multiple of the other and the sum and difference between two frequencies does not match any single tone — and that's why DTMF sounds so ugly!

The DTMF encoder circuit shown here is based on the HT9200B tone generator device produced by Holtek and distributed by Futurlec (www.futurlec.com) among others. The encoder is complemented by a decoder elsewhere in this publication. The HT2900B is supplied as a nice old fashioned 14-pin device. It can be instructed by a microcontroller to generate 16 dual tones and (in serial mode only) 8 single tones from the DTMF pin output. Its 8-pin 'younger brother' the HT9200A provides a serial mode only whereas the HT9200B contains a selectable serial/parallel mode interface for various applications such as security systems, home automation, remote control through telephone lines, communication systems, etc.



A 74HC148 8-to-3 priority encoder is used to convert the 'keypad' information from S1–S8 into 3-bit tone selection words the HT9200B wants to see at its input. The ninth switch, S9, is connected to input D3 on the encoder chip. Pressing one of the switches S1–S8 generates a complementary 3-bit binary word at outputs A0, A1, A2 of IC1. IC2 then generates the dual tones accordingly to these binary codes.

Pressing S1–S8 generates the dual tones for DTMF digits C, B, A, #, *, 0, 9 and 8. By press-

ing and holding down S9 the DTMF digits 7, 6, 5, 4, 3, 2, 1 and D are generated.
To generate the eight single frequencies accurately a 3.58 MHz crystal quartz is connected to pin 2 and 3 of IC2. Pin 13 of the HT9200B supplies a DTMF signal of about 150 mV at a 5 KΩ load.
Pull-up resistor array R2 may be omitted if you substitute the 74HC148 with a 74LS148. R1 must be present in that case, otherwise it can be omitted.
The circuit consumes about 2 mA from a regulated 5 V supply. It should be easy to build on a small piece of prototyping board.

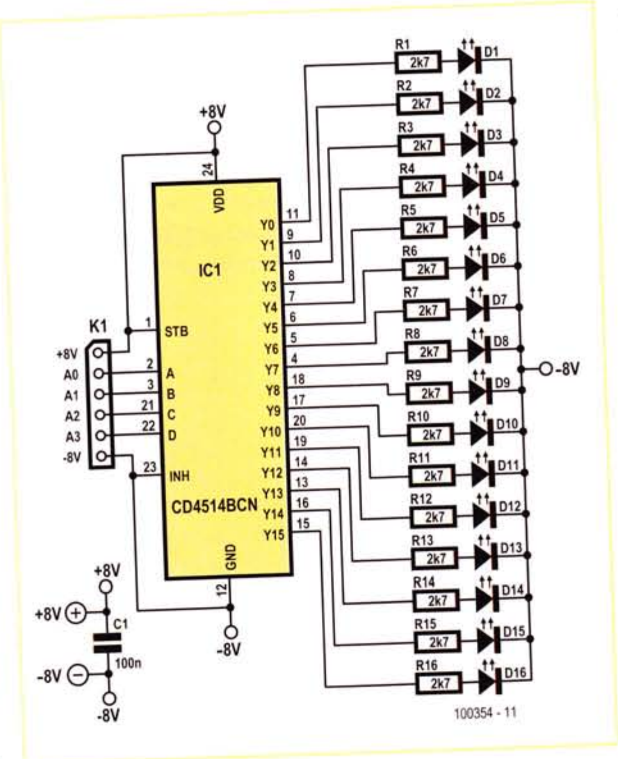
(090964)

Indicator for Dynamic Limiter

Ton Giesberts (Elektor Labs)

The indicator described here is specifically designed for adjusting the dynamic limiter described elsewhere in this edition and checking whether the maximum level of the reference voltage (P1) needs to be modified. Here we use a 4-to-16 decoder IC (type 4514) to monitor the state of the four-bit up/down counter in the limiter circuit. This IC can be powered from the ±8 V supply voltages of the limiter. The limiter board has a 6-way connector (K5) that provides access to the four counter outputs and the supply voltages. Connector K1 of the indicator circuit can be connected to K5 on the limiter board.

One output of the 4514 goes high for each unique 4-bit combination on its inputs, while the other outputs remain logic Low. A separate current-limiting resistor is connected in series with each LED. It was not possible to use a common cathode resistor here because most LEDs have a maximum reverse blocking voltage of only 5 V, while the supply voltage here (16 V) is a good deal higher.



The 16 LEDs arranged in a row provide a 'fluid' indication of the control process. You can enhance the display by using different colours for the first and last LEDs, such as red for D1 (maximum gain) and green for D16 (minimum gain), with yellow for the rest of the LEDs. While observing signals from various sources (TV set, DVD, media player, etc.), you can easily use the 16 LEDS to monitor the behaviour of the limiter and adjust the setting of potentiometer P1 in the limiter circuit. It must be set such that D16 only lights up at the maximum signal level. If this is not possible and D16 remains lit a good deal of the time regardless of the position of P1, it will be necessary to increase the value of P1. Of course, it is also possible to adjust P1 so the strongest signal source extends slightly above the control range of the limiter.

This circuit can easily be assembled on a small piece of prototyping board. The current consumption is around 4 mA.

(100354-I)

8-channel DTMF Link: Decoder

Angelo La Spina (Italy)

In the decoder designed for the DTMF Link project a Holtek HT9170B does the main job. The natural counterpart of the HT9200B used in the associated encoder (described elsewhere in this publication), the HT9170B is a Dual Tone Multi Frequency (DTMF) receiver with an integrated digital decoder and band-split filter functions. Then IC uses digital counting techniques by means of a 3.58 MHz crystal to detect and decode all the 16 DTMF tone pairs into 4-bit words. Highly accurate switched capacitor filters are employed to divide DTMF signals into low and high group signals. A built-in dial tone rejection circuit is provided to eliminate the need for prefiltering. The HT9170B is pin to pin equivalent to the famous (and dearer) MT8870 from Mitel. Both DTMF decoder chips can be ordered from Futulec (www.futurlec.com).

The table shows the correspondence between the frequency pairs and the 4-bits words obtained from the decoder output.

In the circuit, a CD4099 acts as an 8-bit addressable latch. Data is held on the D input, and the address of the latch into which the data is to be entered is held on the A0, A1, and A2 inputs. When the Enable input is taken Low, the data is copied through to the addressed output. The data is stored when the Enable input transitions from logic Low to High. All unaddressed latches will remain unaffected. With Enable logic High, the device is deselected, and all latches remain in their previous state, unaffected by changes on the data or address inputs. To eliminate the possibility of entering erroneous data into the latches, Enable should be held High (i.e. inactive) while the address lines are changing.
When the DTMF decoder receives a valid tone pair, its STD output goes High; otherwise it remains Low. Since the Enable input of latch IC2 needs a negative-going pulse for 'strobing' an output, the logic condition has to be reversed by means of transistor T1.
The state of the individual Q0–Q7 outputs

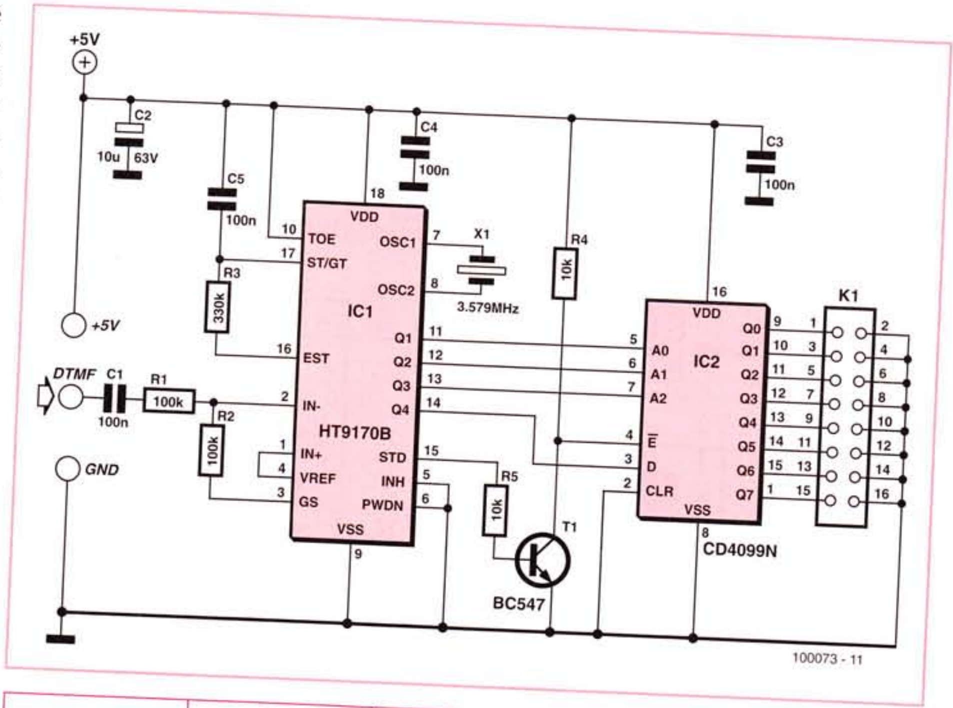
(brought out to pins on K1) represents the active/inactive active state of pushbuttons S1–S9. Only one of the Q0–Q7 outputs switches its logical state. Actually the correspondence is in reverse order, i.e. by pressing S1 on the encoder output Q7 will be affected, S2 will affect Q6, S3, Q5 and so on until S8 which will control the Q0 output.

The output signals on K1 have CMOS swing and the maximum output sink/source current specification of the CD4099 must be observed – the specification will differ between manufacturers so find that datasheet in case of doubt. As examples that will work safely in most cases, low-current LEDs with commoned cathodes may be connected up to K1 via 2.2 kΩ resistors. The same value for the LEDs in type TIL199 optocouplers, while 470 Ω is recommended for a MOC3020M. Whatever you connect up to K1, make sure the CD4099 outputs are not overloaded.

Like the encoder, the decoder can be built on prototyping board, but feel free to design your own PCB.

The encoder/decoder combination may communicate either via a 2-wire line (of considerable length), wirelessly using an approved audio transmitter and a receiver, or over AC powerlines using suitable interfaces.

(100073)



	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	0001	0010	0011	1101
770 Hz	0100	0101	0110	1110
852 Hz	0111	1000	1001	1111
941 Hz	1011	1010	1100	0000

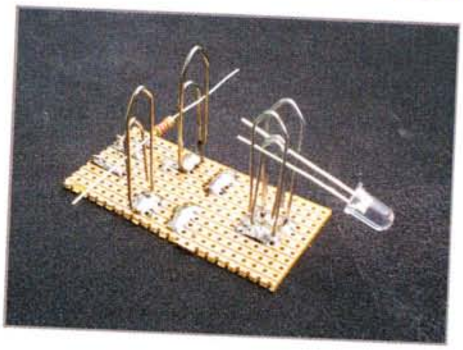
Rapid Test and Measurement

Leo Szumylowycz (Germany)

Pictures are worth a thousand words, so this will be the shortest ever article for an electronics magazine. Recently our overweight cat decided to dive-bomb my carefully sorted tray of LEDs. The result was a thousand or more LEDs of 40 different varieties all mixed up together! The photo shows my quick and dirty test setup, which you can use with a variable power supply with digital current and voltage displays.

The paper clips are the standard size, nickel plated (not plastic!). You can solder banana plugs or other connectors to the little test board's test leads. A nice refinement would be small rubber feet to avoid problems on a conductive work bench surface.

(090969)



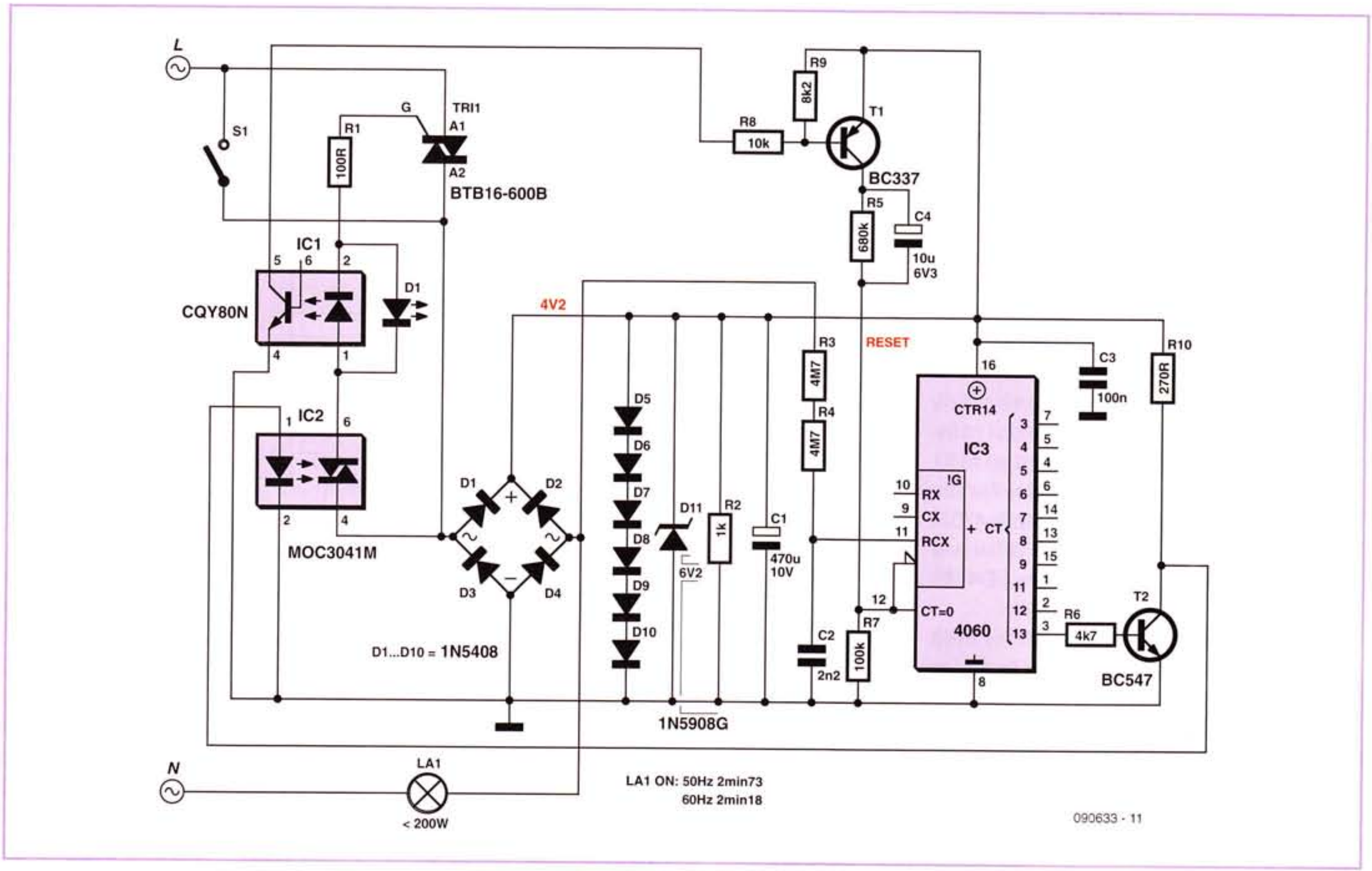
Outdoor Lighting Controller

Harald Schad (Germany)

When you step out of your brightly-lit house into the darkness, it takes a while for your vision to adjust. A solution to this problem is this outdoor light with automatic switch-off. As a bonus, it will also make it a little bit easier to find the keyhole when returning late at night.

Often no mains neutral connection is available at the point where the switch-off timer is to be installed, which makes many circuit arrangements impractical. However, the circuit here is designed to work in this situation. The design eschews bulky components such as transformers and the whole unit can be built into a flush-mounted fitting. The circuit also features low quiescent current consumption.

The circuit is started by closing switch (or pushbutton) S1. The lamp then immediately receives power via the bridge rectifier. The drop across diodes D5 to D10 is 4.2 V, which provides the power supply for the delay cir-



cuit itself, built around the CD4060 binary counter.

When the switch is opened the lighting supply current continues to flow through Tri1. The NPN optocoupler in the triac drive circuit detects when the triac is active, with antiparallel LED D1 keeping the drive symmetrical. The NPN phototransistor inside the coupler creates a reset pulse via T1, driving pin 12 of the counter. This means that the full time period will run even if the circuit is retriggered.

The CD4060 counts at the AC grid frequency. Pin 3 goes high after 2^{13} clocks, which corresponds to about 2.5 minutes. If this is not long enough, a further CD4060 counter can be cascaded. T2 then turns on and shorts the internal LED of opto-triac IC2; this causes Tri1 to be deprived of its trigger current and the light goes out. The circuit remains without power until next triggered.

The circuit is only suitable for use with resistive loads. With the components shown (in particular in the bridge rectifier and D5 to D10) the maximum total power of the connected bulb(s) is 200 watts. As is well known, the filament of the bulb is most likely to fail at the moment power is applied. There is little risk to Tri1 at this point as it is bridged by the switch. The most likely consequence of overload is that one of diodes D1 to D6 will fail. In the prototype no fuse was used, as it would not in any case have been easy to change. However, that is not necessarily recommended practice!

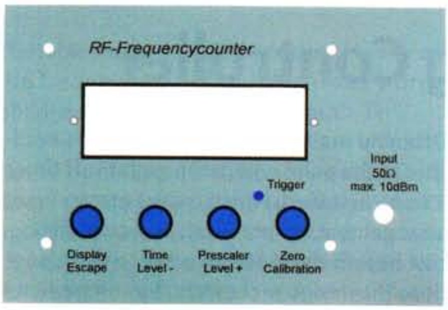
Circuits at AC line potential should only be constructed by suitably experienced persons and all relevant safety precautions and applicable regulations must be observed during construction and installation.

(090633)

Front Panels the Mouse Mat Way

Kai Riedel (Germany)

Putting professional-looking legends on front panels is a problem for many electronicists. Transparent plastic films ought to work but the high-gloss surface of most of the types available in shops make them unsuitable for our purposes. Ideally we want something with a textured finish on the top (front) surface, in order to avoid undesirable glints and reflections. In professional circles a popular choice is the 'Autotex InkJet' film produced by MacDermid [1] and if you click on the Where To Buy link there's a contact form that will put you in touch with a distributor. People looking for only small quantities will find the price rather high, however.



A more attractive alternative is mouse mat film, as used in the Folex DIY mouse mat kit. [2]). Using this special film (lightly textured on one side, A4 format) you can print your design with an inkjet printer to achieve excellent front panel overlays quite rapidly. To produce the end product the author uses the following process:

- Design the layout of the front panel in a

graphics program (e.g. CorelDraw).
- Print the mirror image of this design onto the reverse side of the special film.
- Leave ink to dry 24 hours and spray the rear side with a light grey undercoat (universal primer in aerosol cans from DIY shops).
- When the paint is completely dry apply double-sided adhesive tape to the reverse side of the film. Conrad Electronics [3] order code 529478-62 is ideal.
- Create cut-outs and holes for displays, switches and operating controls with a craft knife and hollow punches (achieved commercially with plotter or laser cutters).
- Fix film to front panel.

This method can also be used for making professional-looking front panel lettering on industrial prototypes.

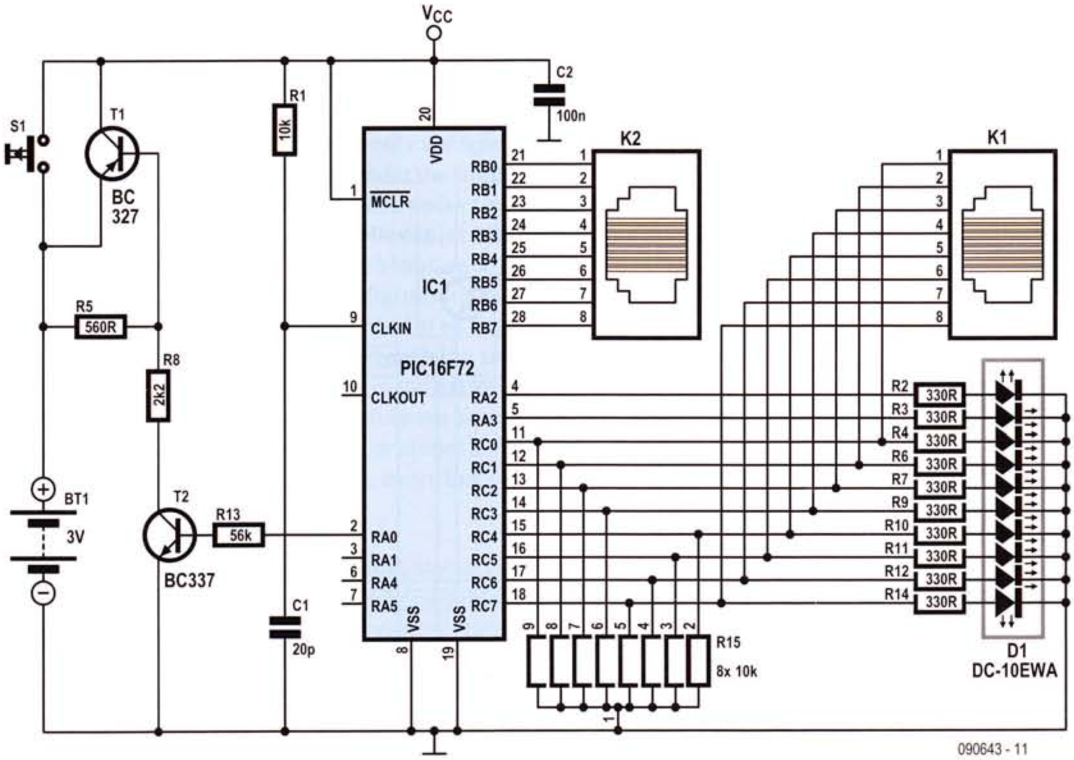
(090426)

[1] www.macdermidautotype.com/auto-type.nsf/webfamilieseurope/AUTOTEX

[2] www.amazon.co.uk/ and enter "Folex mouse mat kit"

[3] www.conrad-uk.com

PIC RJ-45 Cable Tester



Pascal Coulbeaux (France)

This RJ-45 cable tester automatically checks cable continuity and tests the connection configuration. Each of the eight connections is checked independently and short-circuits are detected.

The circuit can be built using either a PIC16C62B or a PIC16F72. This microcontroller was chosen, as it has 22 input/output pins. Each RJ-45 socket uses eight input/output pins, i.e. 16 in all, plus two I/Os are used for two LEDs.

The tester described is built using the PIC16C62B, which can work with a supply voltage of 3 V, justifying the use of a power unit with two batteries. Unfortunately, this microcontroller can only be programmed once. It is possible to use the PIC16F72, which is reprogrammable and pin-compatible, but you'll need to use a three-battery power unit to achieve a voltage of 4.5 V.

The clock circuit is formed by R1/C1, a cheap solution, since we don't need an accurate clock frequency.

The circuit is started using push-button ??BP, the power is maintained and controlled by transistors T3 and T2. It stops automatically, after a delay generated using Timer0. When Timer0 overflows, an interrupt is produced which leads to pin RA0 going low, and in this way transistor TQ2 turns off, followed by T3. The LED bargraph allows us to follow the testing of each connection. The first LED (pin 1), controlled by RA2, lights if the cable is good. The second LED (pin 2), controlled by RA3, lights if the cable has a wiring or continuity fault. Both LEDs light if the cable has a short-circuit. The other eight LEDs show how the cable is connected. If the cable is all right, we see a left>right chaser; but if the cable is crossed over, we get a back-and-forth chaser — just like Kitt in the cult TV series 'Knightrider'.

The software in assembler is available on [1]

(090643-I)

www.elektor.com/090643

3D LED Pyramid

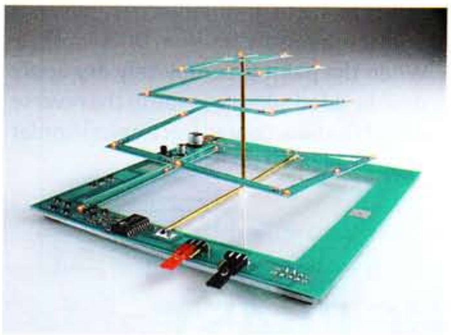
Lothar Goede (Germany)

The author 'just wanted to do a bit of microcontroller programming'. However, the project rapidly grew into this impressive and visually attractive pyramid. The circuit consists essentially of a specially-sawn printed circuit board, 23 LEDs and a microcontroller. Despite the fact that the microcontroller is a rather modest Atmel ATtiny2313, the author nevertheless has found room in the 2 KB flash memory for 16 different light sequences.

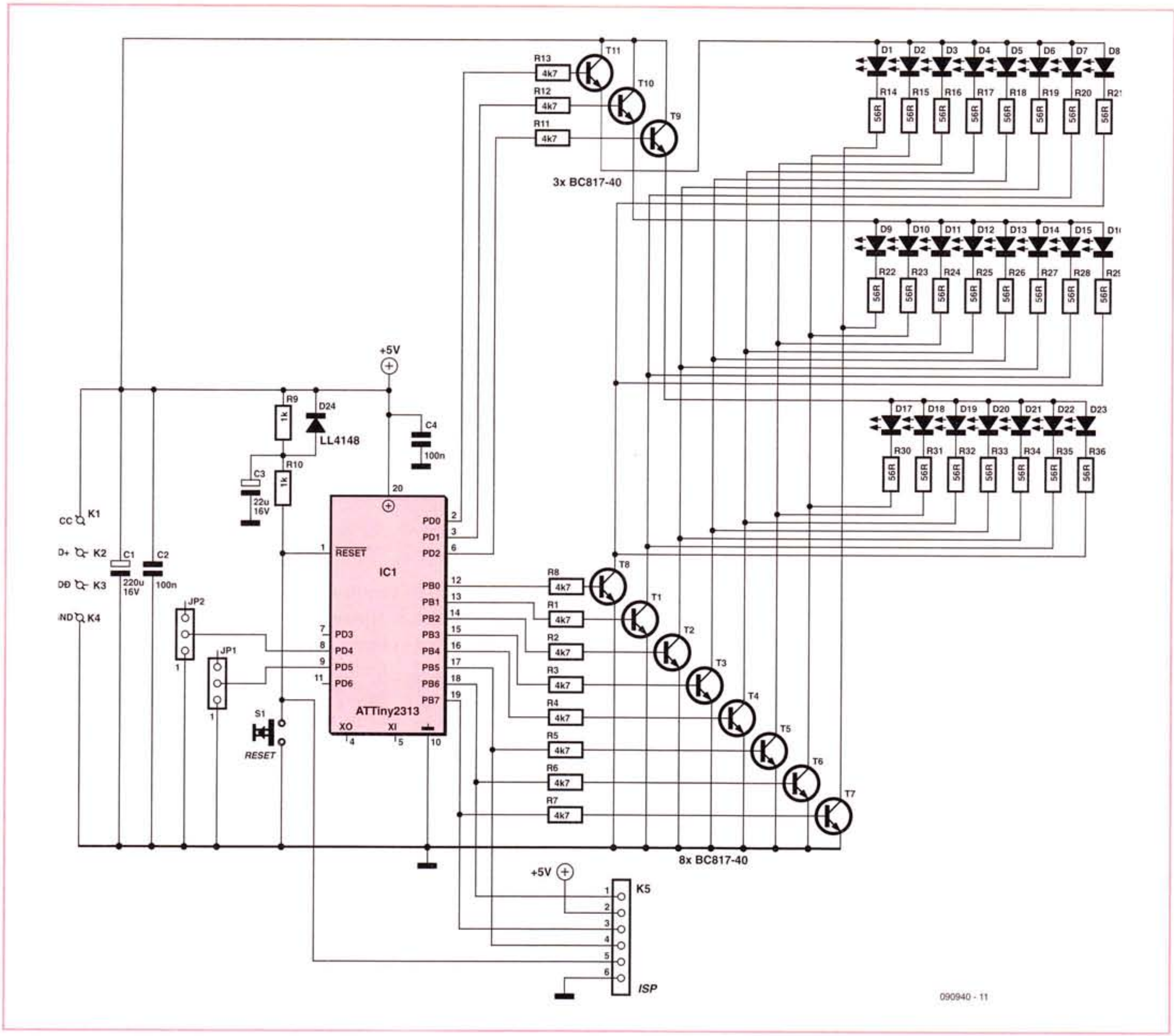
The 23 LEDs are divided into three groups. The lower and middle sections consist of eight LEDs, while the upper section has just seven. The microcontroller has only 20 pins, and so it is not feasible to provide a direct individual drive for each LED. The multiplexing approach adopted uses just eleven output port pins. Buffer transistors are used to increase the current drive capability of each output.

The software was written in assembler and can, as usual, be downloaded from the Elektor web pages accompanying this article [1] as either source code or as a hex file. The printed circuit board layout files are also available from the same place, as well as a link allowing purchase of ready-made boards and pre-programmed microcontrollers.

Populating the printed circuit board is straightforward: there are some surface-mount components to be soldered, but



space is not tight. For best results, it is best to choose LEDs with the widest possible viewing angle so that the pyramid looks its best even when seen from the side. The author



used type LO L296 orange LEDs from Osram, which have a viewing angle of 160 °. A six-way connector is provided to allow in-system programming (ISP) of the microcontroller. The configuration fuses are set to enable use of the internal 4 MHz clock source, which is divided down to 0.5 MHz by an internal divider. If the fuses are not correctly programmed the light sequences will run too quickly, too slowly, or even not at all!

When everything is working, take an 11 cm length and a 5.5 cm length of 1.5 mm² solid copper wire and solder one end of the shorter piece to the middle of the longer piece to make a 'T' shape. Pull the printed circuit board spiral apart so that the T-shaped wire assembly fits underneath, and then solder it to the two pads as shown in the photograph. Fine-bore brass tubing can also be used instead of solid copper wire.

As well as the ISP connector a USB interface is provided, whose job is solely to provide a 5 V supply. An external 5 V mains adaptor would do the job equally well. Two jumpers affect the behaviour of the light pyramid: JP1 determines whether the sixteen sequences follow one another in strict order or at random; and JP2 determines whether the light patterns are displayed or whether all LEDs will be continuously lit. S1 is a reset button, which will come in handy if you wish to experiment with modifying the software.

(090940)

[1] www.elektor.com/090940

Cheap Bicycle Alarm

Gerard Seuren (The Netherlands)

The author wanted a very cheap and simple alarm for some of his possessions, such as his electrically assisted bicycle.

This alarm is based on a cheap window alarm, which has a time-switch added to it with a 1-minute time-out. The output pulse of the 555 replaces the reed switch in the window alarm. The 555 is triggered by a sensor mounted near the front wheel, in combination with a magnet that is mounted on the spokes. This sensor and the magnet were taken from a cheap bicycle computer.

The front wheel of the bicycle is kept unlocked, so that the reed switch closes momentarily when the wheel turns. This triggers the 555, which in turn activates the window alarm. The circuit around the 555 takes very little current and can be powered by the batteries in the window alarm. There is just enough room left inside the enclosure of the window alarm to mount the time-switch inside it.

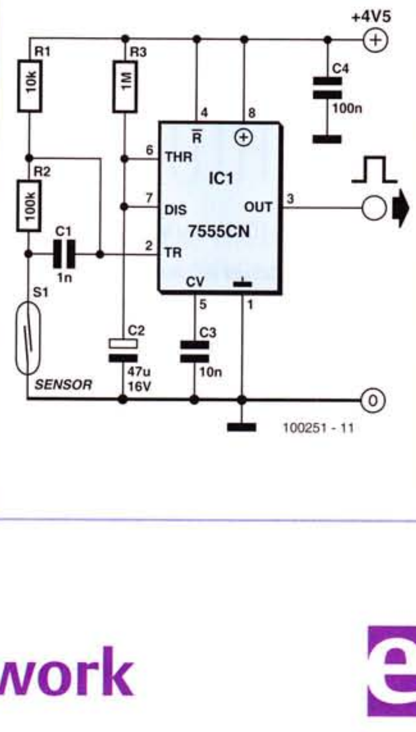
The result is a very cheap, compact device, with only a single cable going to the reed switch on the front wheel.

And the noise this thing produces is just unbelievable! After about one minute the noise stops and the alarm goes back into standby mode. The bicycle alarm should be mounted in an inconspicuous place, such as underneath the saddle, inside a (large) front light, in the battery compartment, etc.

Hopefully the alarm scares any potential thief away, or at least it makes other members of the public aware that something isn't quite right.

(100251)

Caution. The installation and use of this circuit may be subject to legal restrictions in your country, state or area.

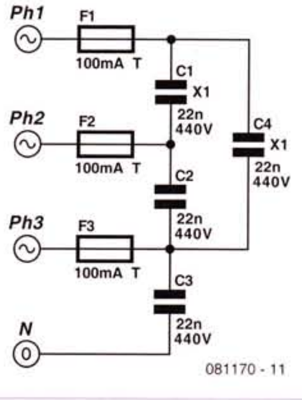


Phase Coupler for PLC or X10 Network

Christian Tavernier (France)

As long as the AC power grid does not carry too much interference, power line carrier communications (PLC) works very well in homes with single-phase AC. Unfortunately, this is not the case with a 3-phase installation. If the transmitter and receiver find themselves on different phases, they cannot communicate. The only coupling between the phases is actually at the supply company's transformers, and as the high-frequency signals used for the powerline carrier cannot travel beyond the user's electricity meter, they never reach the coupling point and so no coupling takes place. In this event, it is necessary to use a coupler fitted before the meter*.

Such a coupler is very easy to build; the circuit involves just four capacitors which form a high-frequency bridge between the phases.



Construction is perfectly simple, but for safety reasons it is vital to use Class X1 capacitors designed for use on 440 VAC grids (e.g. Farnell # 1166428). In theory, the fuses are not strictly essential, but they do offer additional protection in the event of a capacitor's failing.

The PCB [1] fits into a case designed for use on DIN rail, which lets you install the circuit into any modern distribution box. The case to use is a 2-module wide Boss type BE350/605T (Farnell # 1171699).

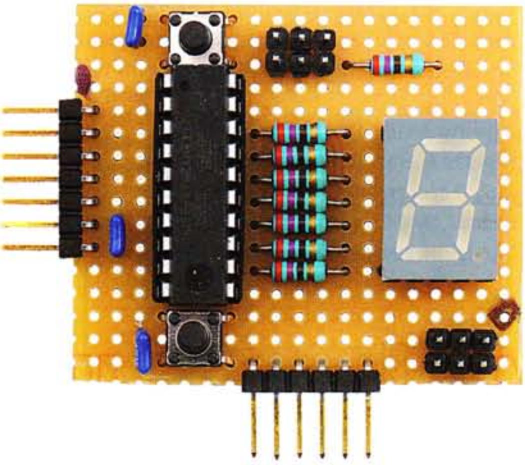
Take the usual precautions when connecting up to the AC grid — after being sure to turn off the main switch, of course! The circuit will work right away. The only problem that may arise is where the AC powerline carrier transmitter is connected to phase 3 in the circuit. Capacitor C3 then has an adverse effect on the high-frequency signals generated by the transmitter, as it will tend to short them out. In this situation, the simplest solution is to disconnect the coupler's neutral terminal connection, which removes this capacitor from the circuit.

(081170-I)

* The installation of this circuit is restricted to qualified electrical engineers. The circuit may not work in all countries or areas.

[1] www.elektor.com/081170

Digital Thumbwheel Switch



Per Stegelmann (Denmark)

Thumbwheel switches are remarkably expensive and always playing hard to get. Here's a cheaper, digital equivalent with the ability to remember the value it was set to. It is programmable to different modes such as inverted or non-inverted BCD code output, programmable READ pin active level, and the choice of hexadecimal or decimal BCD count.

The main elements in the circuit are an ATtiny2313 microcontroller with built-in RC oscillator, a 7-segment LED display (you choose the size and colour!) and two small pushbuttons. All functionality of the circuit is within the firmware of the microcontroller.

The project source code files may be downloaded free from [1]. Examining the code you'll discover the following functionality based on jumper settings.

JP1 = on: READ input PD4 responds to active High. JP1 = low: READ input PD4 responds to active Low. When the thumbwheel value is read, the UP/DOWN switches are effectively disabled.

JP2 = on: inverted BCD code. JP2 = off: standard BCD code.

JP3 = on: hexadecimal count (0-F) with auto rollover. JP3 = off: decimal count (0-9) with auto rollover.

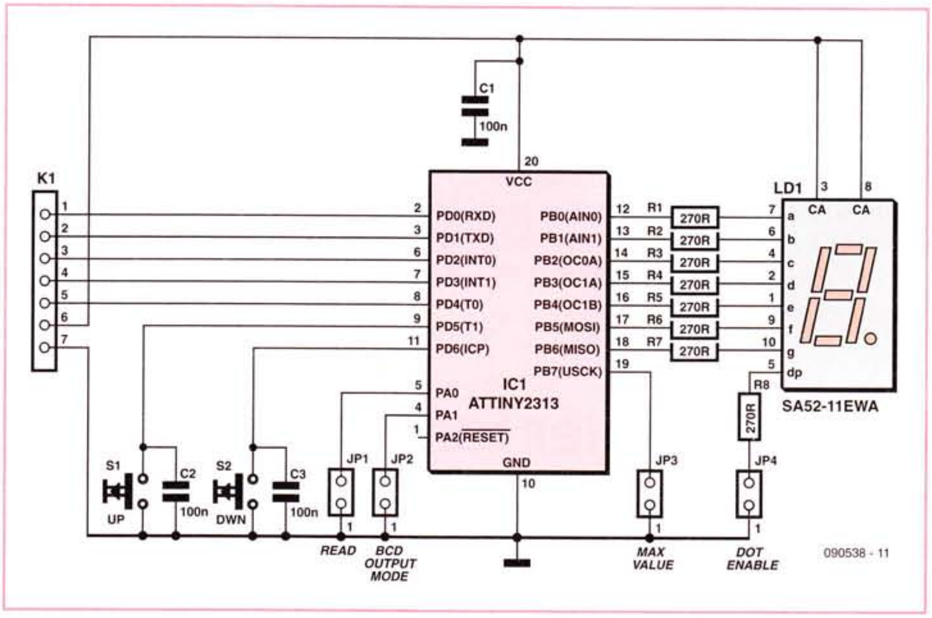
JP4 = on: decimal point ON. JP4 = off: decimal point OFF.

When the thumbwheel switch value hasn't changed for about 10 seconds, the current value is stored into the microcontroller's internal EEPROM to be recovered at power-up. The BCD output pins are then changed to inputs and tri-stated when the READ input (PD4) is not active. This allows multiple outputs of a number of these 'ersatz' circuits to be connected to the same 4 bit 'bus'. By multiplexing (using a 1-of-16 MUX IC) one 'switch' can be selected at a time to read its value. In this way up to 16 switch circuits can be read by the same 8-bit microcontroller bus to minimise I/O count.

When the EEPROM value is higher than the counter's maximum it will return to zero. This is to avoid problems when a value of 15 is loaded from EEPROM and the counter maximum is 9 (decimal mode).

(090538)

[1] www.elektor.com/090538



Deep Discharge Protection for 12 V Batteries

Jürgen Stannieder (Germany)

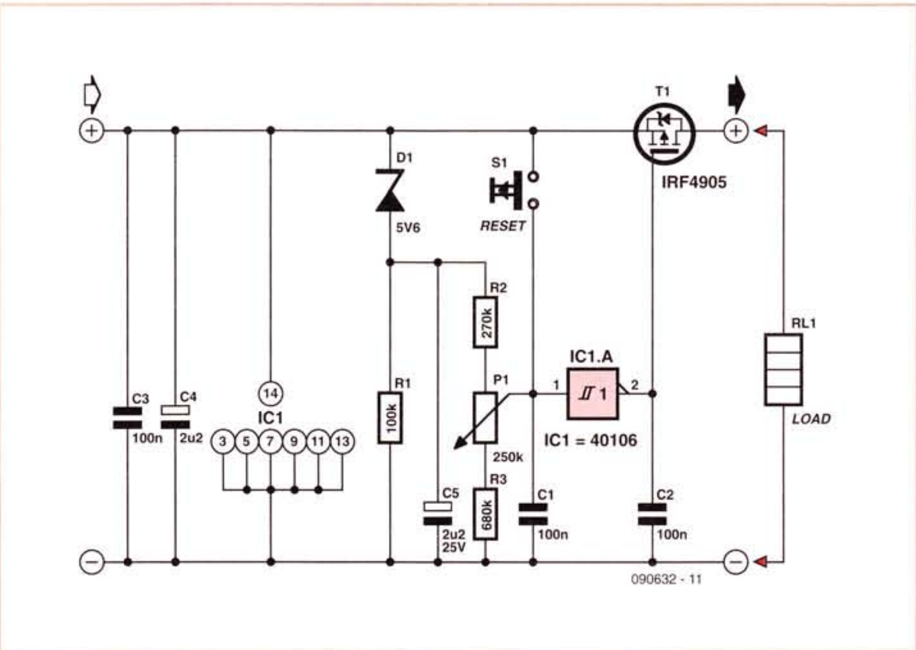
For load currents up to 4 A the author has used a bistable relay to disconnect the load on a 12 V battery to avoid deep-discharge. How can we provide the same function at higher levels of load current?

The solution here is to use a P-channel HEXFET power MOSFET as a semiconductor relay to disconnect the load. The very low $R_{DS(ON)}$ of these devices is not much greater than a relay's contact resistance. The device used here is the IRF4905 from International Rectifier [1]. The IRF4905 has an $R_{DS(ON)}$ of 0.02 Ω and can handle an $I_{D(MAX)}$ of 74 A. It is used in the circuit to pass a current of up to 20 A and disconnect the load when the battery voltage falls below a preset threshold. On a practical note make sure that all interconnect cables

between the battery and load has sufficient cross-sectional area to handle the expected load current. The transistor must be mounted on a suitable heat sink in order to dissipate the power (approximately 4.5 W at 15 A) developed in the transistor.
The current consumed by the circuit itself is in the order of 0.5 mA which is really insignificant in comparison to the battery's inherent self-discharge rate.
P1 adjusts the falling voltage level trigger point for the circuit to disconnect the load. The load remains disconnected even when the battery voltage has risen again after recharging. Pushbutton S1 is used to switch T1 back on and reconnect the load.
Ensure that any unused inputs of the 40106 hex Schmitt inverter chip are tied to ground.

(090632)

[1] www.irf.com/product-info/datasheets/data/irf4905.pdf



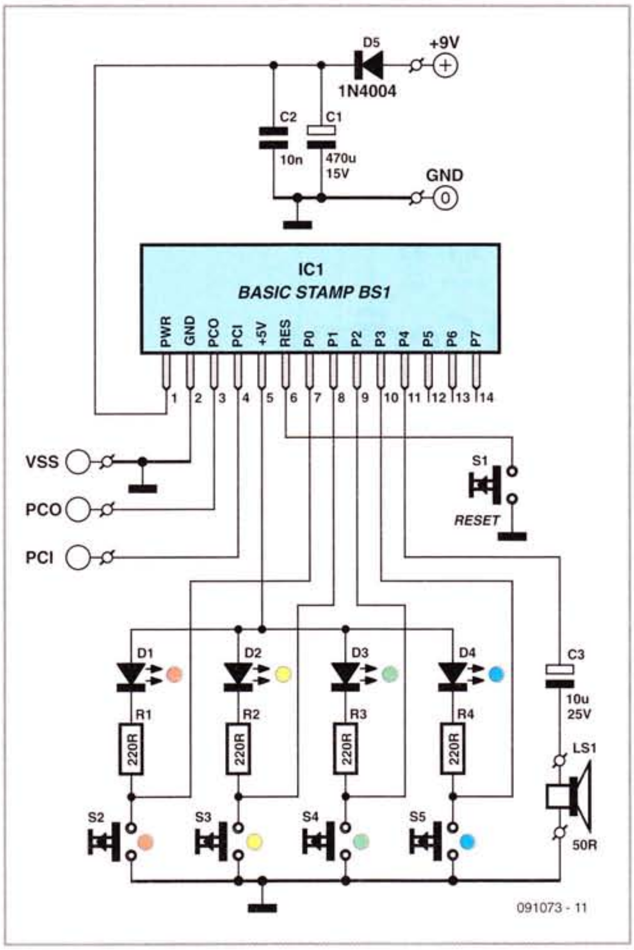
Play 'Simon'

Christian Tavernier (France)

The electronic game Simon comes in the form of a large, round console with four red, green, blue, and yellow illuminated buttons. These buttons light up in a random order with longer and longer sequences, accompanied by musical notes. The object of the game is to reproduce these sequences precisely by pressing the buttons in the same order and the same number of times as they lit up. So apart from the entertainment value, this game also stimulates visual and aural memory.

You can use an 'old' Basic Stamp I to build your own 'Simon' game. It has enough input/outputs lines to drive the LEDs and read the buttons needed by the game. To simplify construction in practice, the illuminated buttons are reproduced here by associating a button and an LED of the same colour connected to the same port.

The circuit is very simple, thanks to the Basic Stamp I, and above all the fact that its ports, P0–P3 in this instance, can operate as inputs, where they are used to read the buttons, and as outputs, where they are used to directly drive the LEDs. Line P4 is used as a output only to drive the loudspeaker that reproduces the musical notes that accompany the lighting of the LEDs.



The power supply uses a voltage between 7 and 15 V, which can come from a 9 V battery, for example, since the circuit goes into standby automatically when not used.

For the loudspeaker, make sure you choose a miniature 50 Ω type. And as for buttons S1–S5, if you want to use our PCB design, you'll need to use the square D6 type from ITT. These types also have coloured lenses that are particularly useful here. On the subject of the PCB, do note that the LEDs and buttons can equally well be fitted on the component or track side, in order to make it easier to fit the circuit into a case.

You can organize the layout of the LED and button colours however you like. However, it is important to wire each output (P0–P3) with an LED and a button of the same colour, so as to respect the logic of the game.

The program to be loaded into the Basic Stamp is available for free download from the Elektor website [1] as well as from the author's own website [2].

The circuit has an automatic power-on reset, and you can force a reset at any time by pressing S1. Following a reset, the LEDs light up in turn to encourage you to play. If you don't put in an appearance by pressing any button, other than S1, or course, after a few seconds the game goes into stand-by; all the LEDs go out and the consumption drops to just a few tens of µA.

To start the game up again, all you have to do is perform a reset using PS1, or press any other button for at least 2 s. The game lights the first LED and plays the corresponding musical note. You must then press, within the next second or so, the button of the same colour. Simon then lights two LEDs in succession (this may be the same one twice!) and generates the two corresponding musical notes. You in turn then have to press the two corresponding buttons in the same order. The game then continues with a sequence that gets longer each time, up to the point where you make a mistake reproducing it. Simon makes a groaning noise to indicate the slightest error, ending the current round and starting another. Have fun!

(091073-I)

[1] www.elektor.com/091073

[2] www.tavernier-c.com

Adjustable Low-voltage Power Supply

Vladimir Mitrovic (Croatia)

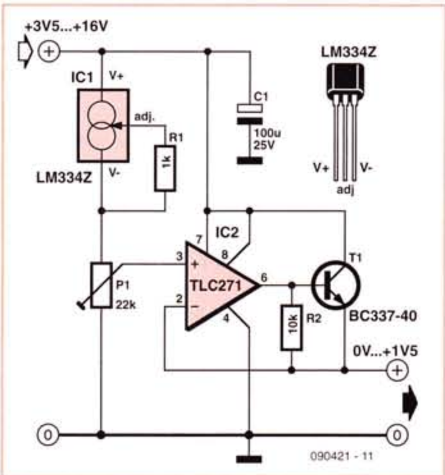
If you want to check the behaviour of an electronic circuit at low voltages, an adjustable power supply as shown here may be helpful. Powered from a 3 to 16 volts source (DC for sure), it will provide a stable output voltage in the 0 to 1.5 V range.

Multiturn trimpot P1 allows the output voltage to be adjusted with good precision. The BC337-400 output transistor raises the output current to about 200 mA bearing in mind that the minimum supply voltage is 3.5 V. The transistor's dissipation should be taken into account, and a more powerful type used if necessary.

T1 may be omitted and R2 replaced with a wire link if you are happy with 3 mA at 3 volts out, 10 mA at 6 V or 20-30 mA at 10-16 V.

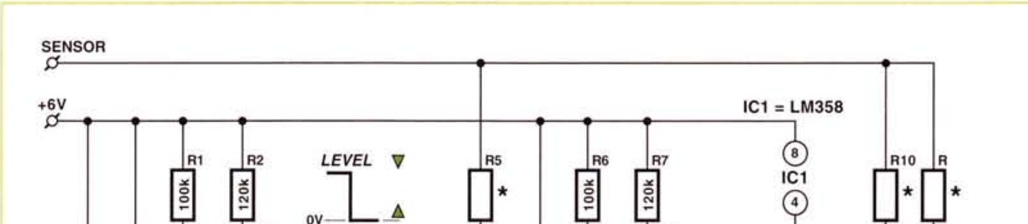
These values represent the maximum output current of the TLC271 op amp. Without T1, the minimum supply voltage is 3.0 V.

(090421)



Petrol/Diesel Level Sensor

Paul de Ruijter
(The Netherlands)



This sensor is particularly suitable for use in small spaces, such as the petrol tank of a motorbike. It has the advantage of not having any moving parts, unlike a conventional sensor with a float and float arm that make it difficult to fit in a tank.

The sensor circuit is made from standard, inexpensive components and can be put together for little money.

The operating principle is based on measuring the forward voltages of two identical diodes (check this first by measuring them). The forward voltage of a diode decreases with increasing junction temperature. If a resistor is placed close to one of the two diodes, it will be heated slightly if it extends above the surface of the petrol. For best results, the other diode (used for reference) should be located at the same level. If the diodes are covered by the petrol in the tank, the heat-

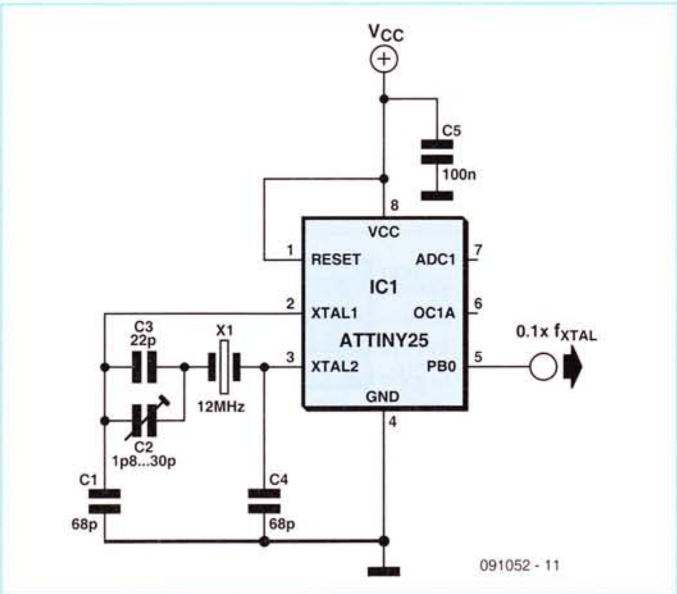
ing resistor will not have any effect because it will be cooled by the petrol. An opamp compares the voltage across the two diodes, with a slightly smaller current passing through the reference diode. When the petrol level drops, the output of the opamp goes high and the output transistor switches on. This causes a sense resistor to be connected in parallel with the sensor output. Several sensor circuits can be used together, each with its own switched sense resistor connected in parallel with the output, and the resulting output signal can be used to drive a meter or the like.
Using this approach, the author built a petrol tank 'sensor strip' tank consisting of five PCBs, each fitted with two sensor circuits. With this sensor strip installed at an angle in the tank, a resolution of approximately 1.5 litre per sensor is possible. Many tanks have an electrical fitting near the bottom for connection to a lamp on the instrument panel that indicates the reserve level. The sensor strip can be used in its place.

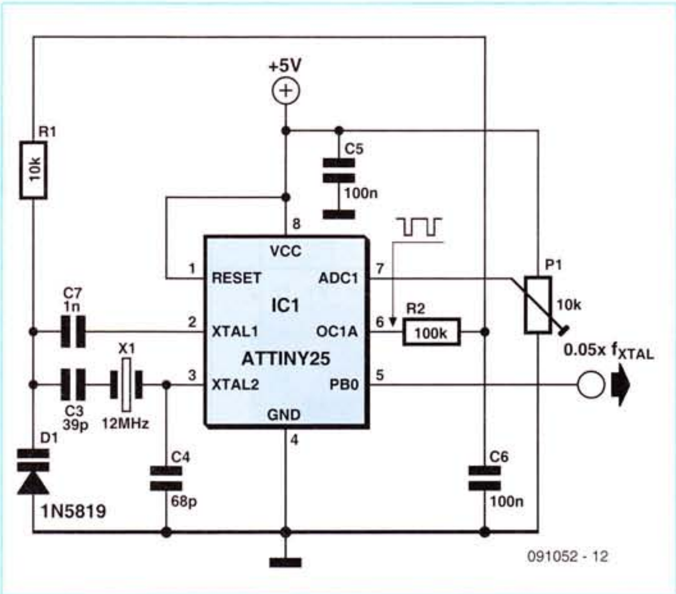
You will have to experiment a bit with the values of the sense resistors, but do not use values lower than around 100 Ω. It is also important to fit the diodes and heater resistor in a little tube with a small opening at the bottom so that splashing petrol does not cool the heater resistor, since this would result in false readings.
The circuit should be powered from a regulated supply voltage of 5 to 6 V to prevent the heating resistors from becoming too hot.
After testing everything to be sure that it works properly, it's a good idea to coat the circuit board with epoxy glue to provide better protection against the petrol.
Tip: you can use the well-known LM3914 to build a LED display with ten LEDs, which can serve as a level indicator. Several examples of suitable circuits can be found in back issues of Elektor.

Note: this sensor circuit is not suitable for use in conductive liquids.

(100335-I)

Crystal Pulling





Rainer Reusch (Germany)

In microcontroller circuits quartz crystals provide the highest accuracy for keeping everything on frequency. With frequency and time measurement (and for commissioning master clocks) fine adjustment of crystal oscillators may also be necessary, so we will now investigate in detail how crystal frequencies can be 'pulled'. Although we have taken the ATtiny25 AVR microcontroller from Atmel as our example, the methods indicated can in fact be applied to just about all microcontrollers.

The oscillator in a microcontroller consists of an inverter that is timed externally by just a quartz crystal and two capacitors (Pierce oscillator). The value of the capacitance is matched accurately to the selected crystal, in order that any deviation from the nominal frequency is contained to the minimum possible (see controller data sheet). Crystals can display some tolerance, however, and to compensate for this effect we have to increase the two (parallel) capacitances significantly to drag down the frequency. To make this adjustment possible a trimmer capacitor is fitted in series with the crystal. We select the two parallel capacitors (C1 and C4) so as to be large enough to make the oscillator operate below its nominal frequency at maximum series capacity (C2 and C3). Adjusting the trimmer capacitor (C2) then allows us to pull the crystal upwards.
Carrying out this adjustment in a practical manner calls for a frequency counter of course. In this case its test probe must not be connected to the inverter input of the oscillator (XTAL1)! The capacity of the test probe would alter the frequency and in fact this effect can even be detected at the oscillator output (XTAL2), even if not so pronouncedly. The best solution is to load the microcontroller (or expand the firmware correspondingly) with a program that produces a squarewave signal on one port.

The following little program in C needs only five steps for one cycle in the main loop. Therefore a signal appears at port PB0 with a frequency that is one tenth of the crystal frequency.

```
#include <avr/io.h>
```

```
int main(void)
{
  DDRB|=(1<<PB0);
  for(;;) PORTB^=(1<<PB0);
  return 0;
}
```

But why set the frequency manually when the microcontroller can do this equally well? The relevant preset parameters can be retained in an EEPROM for example. To simplify the circuitry we do this by varying the parallel capacitance at the oscillator input (even though this is less effective than altering the series capacity). Capacitor C1 is replaced by a varactor diode, which means we now require a control voltage for this diode in order to set the capacitance and hence the crystal frequency. The controller is programmed so that at its PWM output we get a squarewave signal with an adjustable pulse width (the AVR can do this without having to execute a line of the program). An R-C element (R2 and C6) smoothes the pulses into a DC voltage that is fed to the diode via R1. In our circuit the varactor diode used is a 1N5819 Schottky rectifier diode, which functions impeccably! That said, the supply voltage must remain at 5 volts to ensure an adequate adjustment range. If you are happy to rely on manual adjustment alone the circuit will also work off 3.3 volts.

In this second circuit the fixed series capacitor C3 pushes the crystal frequency upwards. The programmable capacitor D1 pulls the frequency downwards, together with the second parallel capacitor C4. The sole task of capacitor C7 is to isolate the DC control voltage from the oscillator input. For this reason the control voltage level should be significantly higher than the supply voltage!

In our (experimental) circuit we need some 'user input' in order to tell the controller which control voltage to produce (as before the actual calibration is carried out manually). For this we simply hook up a trimpot to an A/D converter input. The digitised potentiometer setting is transferred direct into the register that determines the pulse width of the PWM signal.

Once more we measure the crystal frequency on port PB0, although this time the firmware no longer outputs a tenth of the crystal frequency. Using a couple of NOP commands the frequency relationship is trimmed to one twentieth. In the example illustrated we would therefore expect to see 600 kHz at this output.

The values for the capacitors surrounding the oscillator depend primarily on the actual crystal selected (the values in the photos should be taken as generic standard values). Some 'suck it and see' fiddling around will also be hard to avoid when selecting the varactor diode.

All source code and hex files of the microcontroller programs can be downloaded free from a dedicated Elektor web page [1] or the author's project pages [2].

(091052)

[1] www.elektor.com/091052

[2] http://elektor.reworld.eu

Whistler: Electronic Trainer/Coach

Noël Demissy (France)

This device makes it possible to generate beeps at chosen regular time intervals for timing track race training. Each time interval is indicated by a beep, and the end of a performance test is indicated by a double beep. Two types of test are allowed:

Tests 1–4 offer a certain number of cycles, each comprising two periods, a running period followed by a rest period. For example, test 1 offers six cycles comprising a 15 s running period followed by a 15 s rest period. The first three tests have preset values, while test 4 is fully adjustable.

Test 5 lets you determine Maximum Aerobic Speed (MAS) by making the athlete run in

2 min blocks at increasing speeds. Lengths are run between markers that are either 20 m or 25 m apart, according to choice. You can choose the initial speed and maximum speed values for the test. After 2 min, the speed increases by 1 km/h. In a constant two minute period, the number of lengths run in a shorter time increases. The MAS represents the highest speed the athlete reaches without letting up.

The circuit is very simple and just consists of a microcontroller, five buttons, a 2-line × 16-character display, an LED, and a sounder. A quartz crystal is required in order to obtain a sufficiently accurate timebase.
At power on, the system is stopped. Pressing the Run/Pause button turns the system on and the LED lights. Pressing the same button again puts the system into Pause mode. A training session can be restarted without losing the current values. On the other hand, a final stop (by pressing Escape) resets the values for the training underway.

The software (BASIC source and HEX file), the pre-programmed microcontroller, and the detailed, copiously-illustrated manual (in French only!) are available from [1].

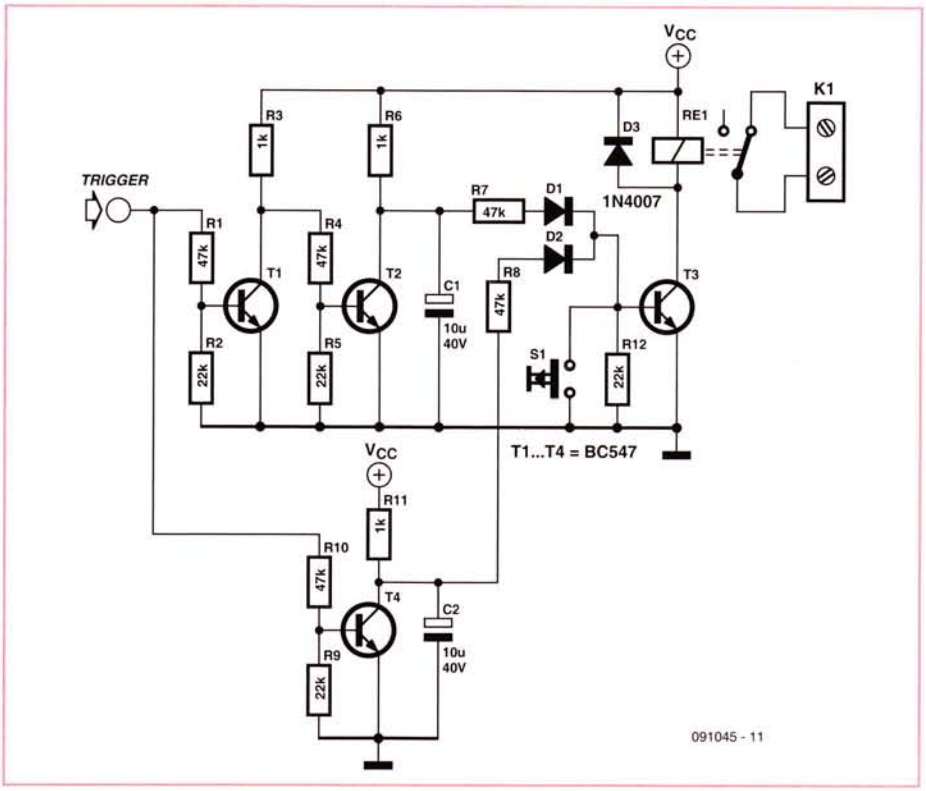
(100203-I)

Internet links

[1] www.elektor.com/100203

Emergency Stop

Jacob Gestman Geradts (France)



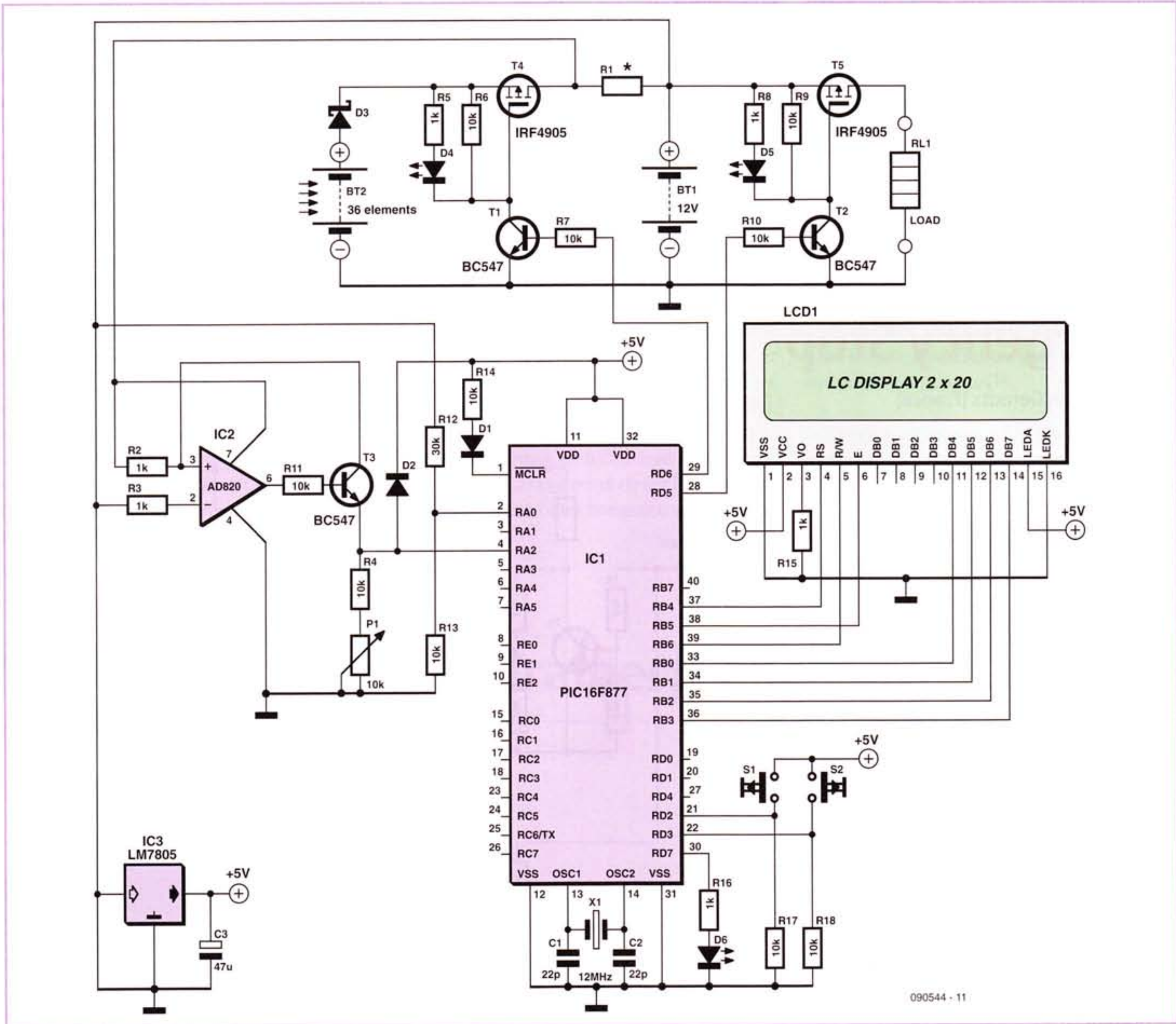
The big fear of every developer of a microcontroller or computer-driven control system is that the computer or controller could crash while it is in the middle of controlling something and that the output signal will remain on 'full throttle'. In this scenario motors could continue to spin faster and faster or a heating element could become red hot, without the system taking any corrective action. In reality, any control system needs some sort of emergency stop, which will turn everything off the moment something goes wrong.

Microcontrollers or computers will usually have a spare TTL output, which can be used for this purpose. By adding a few lines of code to the program, this additional output can be made to toggle high and low periodically. This can save a lot of trouble and damage. Should the computer or controller crash, then the toggle signal on this output will stop as well. The circuit then, does little more than check whether this toggling (TTL-) signal is still present. The computer or controller will be turned off as soon as this control signal is missing.
The heart of the circuit is formed by transistors T2 and T4, which follow the control signal. The accompanying capacitors C1 and C2 are charged via resistors R6 and R11. During a logic High signal, T4 will conduct and discharge 'its' capacitor (C2). Since T2 is preceded by an inverter circuit built around T1, T2 will discharge its capacitor when the control signal is 'low'.

Provided that the control signal changes often enough between high and low, both capacitors will remain nearly completely discharged and nothing else happens. If the control signal now hangs at the high level, then the capacitor connected to T2 will no longer be discharged and the capacitor voltage will increase quickly. On the other hand, the voltage across the capacitor connected to T4 will increase quickly if the control signal is stuck at the 'low' level. Via the dual diode circuit, which acts as an OR gate, T3 will be activated as soon as the voltage across one of the two capacitors builds up sufficiently. The relay that is controlled by T3, has to have a normally closed contact. The moment that the control signal stops changing, the control system will be permanently turned off via the normally-closed contact. To turn the system back on, pushbutton S1 needs to be pressed until the control signal reappears at the input of the circuit.
The circuit will operate over a wide range of power supply voltages, including 5, 9 and 12 Volts. The component values are not critical and the value of the capacitors depends on the frequency of the control signal. The time constant with a value of 10 μF amounts to 10 ms, so that the capacitors will have to be discharged at least one hundred times per second to prevent the emergency stop from operating. With higher values of capacitance the capacitors can be discharged at a proportionally slower rate. A 1N4007 can be used for the free-wheeling diode across the relay. The two diodes for the OR gate can be practically any type of signal diode. The circuit will also work with other types of transistors that have comparable specifications.

(091045-I)

Solar Cell Battery Charger/Monitor



Matthijs Hajer (The Netherlands)

During the past year the author has built a standalone solar panel system, which included the construction of the panels themselves. Such a system stores the generated energy in a battery. This is in contrast to a mains-connected system where the excess energy generated is fed back into the national electricity grid.

A battery charger/monitor was designed in order to charge the battery correctly, protect it from deep discharges and to monitor its performance. Specifications for the solar panels: 150 watts maximum at 14.5 volts. With all the losses (glass, temperature, cables, etc.) taken into consideration, the measured current from the combined panels was about 7.5 A during sunny weather (the peak values stated by the manufacturer are rarely reached in practice).

This isn't a fast charger. This charger is intended to be used with solar panels and the like (wind and water energy), where the maximum charging current is much less than 0.1 of the battery capacity *C*.

The circuit is built around a PIC 16F877 microcontroller. The battery voltage is measured via input RA0 with the help of a 1:3 resistive divider. To measure the current, a 'high-side' reading is taken via R1 (with a value of about 0.03 Ω, using a number of resistors connected in parallel). IC2 amplifies the measured voltage across R1 and buffers it with T3. The resulting 350 mV/A signal is fed to input RA2 of the PIC. The opamp used for the current measurement needs to have a good rail-to-rail performance and a low input offset. The gain here is (R4+P1)/(R2) and the voltage across the resistor (R4+P1) is directly proportional to the measured current. The offset at the output, which is created by the opamp itself, is measured as soon as the 'info screen' is closed (pressing S1 or S2) and used as a 'null-offset' for the current measurement. D2 protects the PIC against too large a voltage at the input.

From the measured current and battery voltage the energy input and the capacity are calculated. This information is shown on the 4x16 LCD display.

FET T4 connects the solar panels to the battery to charge it and removes the connection once the battery is fully charged. FET T5 connects the load to the battery when the voltage is high enough and disconnects it when the battery voltage becomes too low. The Schottky diode prevents the battery from slowly discharging into the solar panel when it is dark. T1 and T2 are required to drive the FETs, which work at the battery voltage, with the 5 V outputs of the PIC. LED D4 and D5 indicate when the corresponding FET is turned on.

The Schottky diode, the current resistor and the FETs have to be provided with small heatsinks.

The code for the PIC is written in C and compiled using the HI-TECH C Pro (Lite mode) compiler included with MPLAB. The code uses very little memory and isn't very time-critical. The only thing you have to make sure of is that the firmware runs at a rate of about 10 times per second in order to obtain an accurate value for the capacity measurement [Ah].

Following a reset, the PIC loads the capacity values [Ah] & [mAh] from its EEPROM and an 'info screen' appears next. This shows the firmware version, the voltages at which the load is turned on and off, and the voltage at which the charger stops charging. When either of S1 or S2 is pressed, the PIC takes 10 measurements in order to determine the offset of the current measurement stage (IC2). The average is taken of these 10 measurements and that value is then used to correct all subsequent current measurements.

When S1 is pressed, the main program is started, where the battery voltage determines whether the load is turned on or off. When S2 is pressed, the load is immediately connected until the battery voltage drops below 11.5 V.

The main program is called 10 times per second; the LCD is refreshed at a rate of 2 Hz. In the main program the A/D converters are read first, after which the values for V, I, P and C are calculated. The results determine whether the charger and load are turned on. When the main screen is displayed, only S1 has a function: When this switch is pressed, the capacity [Ah] & [mAh] is stored in the EEPROM and the info screen is shown.

The watchdog function of the PIC has been enabled in this project. This way the PIC will be reset if the software crashes. In this case the info screen will appear again, and the charger and load are turned off, which is a safe state. In this way the battery is protected against over-charging or a complete discharge due to a crashed PIC micro. When programming the PIC you have to remember to set the configuration bits for the watchdog timer. At the start of the C code they are also set.

The limits for charging the battery were taken from the datasheet from Yuasa. This type of maintenance-free gel lead-acid battery is perfectly suitable for a small solar energy system. If you use a different type of battery you may have to adjust the voltages in the code somewhat. The values used here are:

14.5 V: Gassing voltage

13.6 V: Float voltage (small charging current)

12.7 V: No load, 100% charged voltage (no charging current)

11.5 V: 50% empty with small load ($I < 0.01\ C$)

The charger turns on as soon as the battery voltage drops below 13.6 V. Should the voltage rise above 14.5 V during the charging, the charger will be turned off. Because the battery will be about 80% charged (according to the datasheet), the voltage will drop below 13.6 V again. When this happens, the charger will turn on again after 10 seconds and the battery voltage will rise. This process will repeat itself, but the 'charger-off' period will become longer the more the battery is charged. Overnight, a fully charged battery will slowly drop to 12.7 V.

Every 5 seconds the PIC transmits a text string via pin RC6/TX (2400 baud, 8n1), which shows the current state. This string could for example be sent to a web server or data-logger. An example string:

K_+12055|mV_+00826|mA_+00694|Ah_+00685|mAh–

The structure is as follows:

<Length>_<value>|<unit>_<value>|<unit>_<value>|<unit>>_<value>|<unit><CRC>

<Length> = length of the string incl. CRC (+ offset of 32 to stay within ASCII range)

_ = separator

<value> = field-value

| = separator

<unit> = units of the value

<CRC> = sum of the previous characters mod 256.

The source and hex code files for this project are available free from the Elektor website as archive file # 090544-11.zip. A programmed controlled is available under product number 090544-41.

(090544)

DIY Front Panels

Henk van Zwam
(The Netherlands)

This issue includes an article on a handy DIY front panel design program called Galva. Once your design is ready, the next question is how to convert it into a real front panel. One option for this is described here.

There is material available that you can print using your own printer. It is called waterslide transfer paper or waterslide decal paper, and it is the same as the decal material well known to many builders of model aeroplanes. You loosen the decals from the base material in water and then place them on the model aeroplane.

The material looks the same as photo paper, and it is available in two types: one for laser printers (including colour printers), and the other for inkjet printers. Transparent sheets and sheets with a background colour are available in both types. The letter colour is determined by the printer. A lot of information on this material, including demo videos, is available at a website we came across while researching this article [1].

It's just as easy to use as simply printing a normal sheet of paper. If you use a laser printer (colour or monochrome), the toner is melted into the material and is therefore well bonded. If you use an inkjet printer, you need to fix the ink to the material after printing. Spray cans with a special fixing agent are available for this purpose.

Now let's examine the process of applying the material to the front panel. After degreasing the aluminium front panel, coat it with several layers of matt grey undercoating for car paint (applied with a spray can). Cut the lettering segments out of the printed sheet and immerse them in water, one at a time. After half a minute or so, depending on the water temperature, you can take the transfer out of the water and feel whether it slides around on the paper. If it does, you can place the transfer where it belongs on the panel. Using tweezers, hold the transfer in the proper place and wipe it carefully with a cotton bud to squeeze out the water underneath the transfer. After the front panel is finished and well dried, it's a good idea to use apply several thin coats of matt varnish to the surface of the panel (use a spray can for this). Let the front panel dry for half an hour after each coat before applying the next one.

Tips:

1. Use demineralised water if you have hard tap water.

2. Do not use dish detergent to break the surface tension of the water, since it causes soap spots.

If you google "waterslide transfer" or "waterslide decal paper", you will find a lot of information and locations where you can buy it. Some suppliers even sell transfer paper by the sheet, so it's worth looking.

(100387-I)

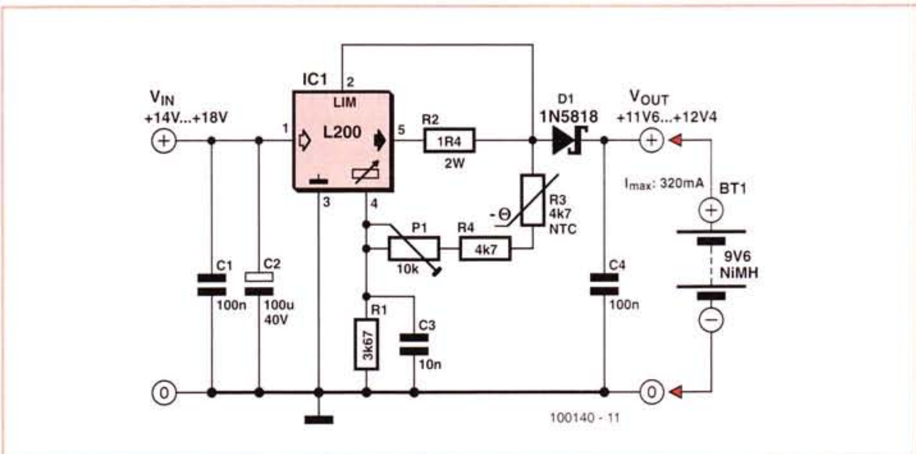
[1] www.papilio.com/laser%20water%20slide%20decal%20paper%20original%20pas.html

L200 charger circuit

Wolfgang Driehaus (Germany)

This circuit came about as the result of an urgent need for a NiMH battery charger. No suitable dedicated IC being immediately to hand, the author pressed an L200 regulator and a 4.7 kΩ NTC thermistor into service. Those components were enough to form the basis of a charger with a cut-off condition based on cell temperature rise rather than relying on the more common negative delta-V detection.

The circuit uses the L200 with the thermistor in the feedback loop. When 'cold' the output voltage of the regulator is about 1.55 V per cell; when 'warm', at a cell temperature of about 35 °C to 40 °C, the output voltage is about 1.45 V per cell and the thermistor has a resistance of about 3.3 kΩ. This temperature sensing is enough to prevent the cells from being overcharged. P1 adjusts the charging voltage, and R2 limits the charge current to 320 mA. The IC is fitted with a small 20 K/W heatsink as it dissipates around 1.2 watts in use.



The charger circuit can be connected permanently to the battery pack. Charging starts when a 'wallwart' adaptor is connected to the input of the charger. The unregulated 12 V supply used by the author delivered an open-circuit voltage of 18 V, dropping to 14 V under load. Even though the charge voltage is reduced when charging is complete, the cells should not be left permanently on charge.

The author uses the circuit to charge the battery in a torch. After three years and some 150 charge cycles the cells are showing no signs of losing any capacity.

(100140)

AM Receiver with Quadrature Mixer

Gert Baars (The Netherlands)

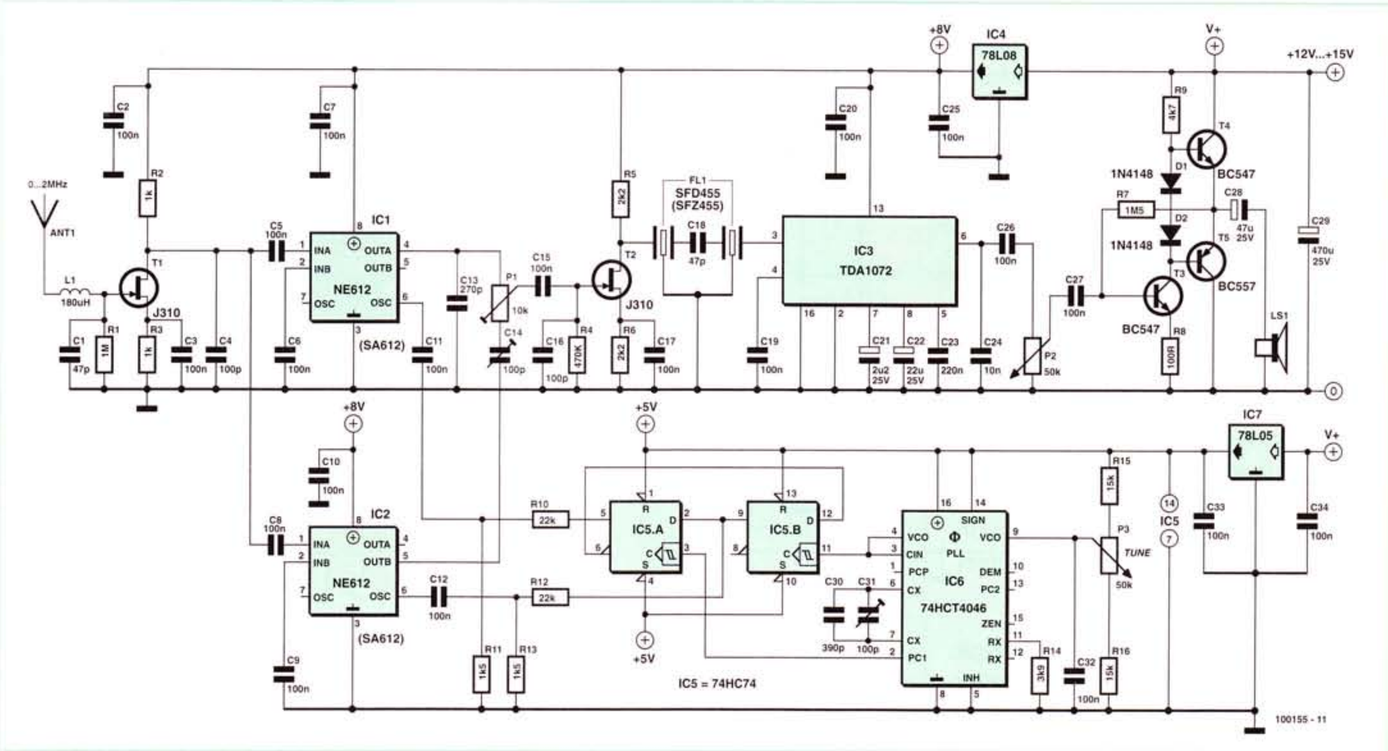
This circuit is for a superheterodyne receiver where the image frequency is suppressed without the use of an input filter. Instead, it uses two NE(SA)612 type mixer ICs that each work 90° out of phase. With a quadrature front-end, the image frequency is rejected and the noise associated with it disappears. In theory, this increases the sensitivity of the receiver by 6 dB.

The phase shift of the local oscillator (LO) is provided by two D-type flipflops configured as a ring counter. The outputs of the flipflops always change in the same order. The result is a frequency that is half that of the oscillator, but with a 90° phase shift between them. These signals are normally called 'Q' (quadrature) and 'I' (in phase).

Phase shifting of the output is provided by two simple RC networks. For the Q mixer the phase shift is set to –45° using a capacitor; for the I mixer it is set to +45° using trimmer (C14). The total phase difference is therefore 90°. The signals are added very simply, using a preset (P1). In this configuration the input frequency is equal to $f_o - f_{if}$ and the image frequency $f_i = f_o + f_{if}$, where the latter is suppressed.

With a low IF, such as used in Software Defined Radio, the phase shifting following the mixers has to cover a relatively wide band, because the IF frequency is low compared to the IF bandwidth. This is much easier to achieve using software rather than a complex phase shifting RC network. With this AM receiver the IF bandwidth is small compared to the centre IF frequency of 455 kHz and the maximum phase error is almost negligible even when a simple RC network is used.

We've used a standard IC for the demodulation: the TDA1072. To drive a loudspeaker



we've added a simple amplifier stage using a pair of transistors (BC547 and BC557) along with a potentiometer (P2) for the volume control.

When setting up the receiver the lowest frequency of the VCO can be configured such that DC can be received. This can be done by ear because the noise disappears and a 50 Hz hum becomes audible. Setting up the phase shifting can be done with the help of a station that's on the same frequency as the image frequency.

It could happen that the fixed phase shift at the output of the Q mixer isn't exactly –45°, but could be –43°, for example. If you now adjust the trimmer such that the phase shift becomes +47,° the difference becomes 90° again. This is a matter of making small adjustments to the preset and trimmer alternately, while the suppression becomes progressively better until the station is no longer audible due to the image rejection.

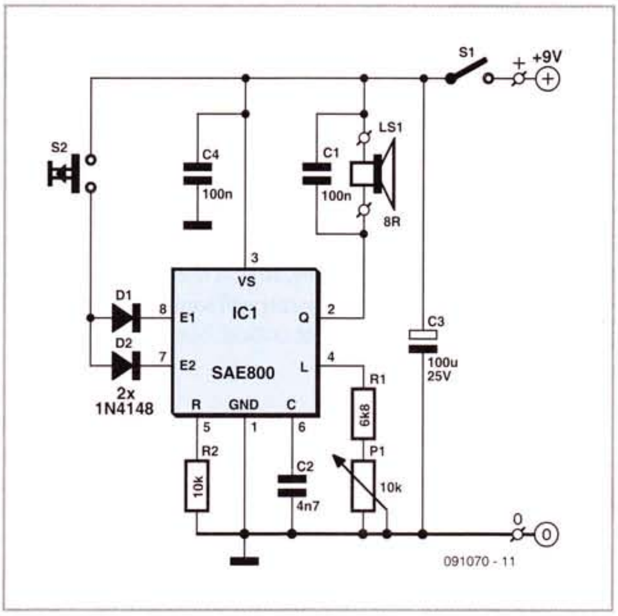
(100155)

Musical Horn for ATBs

Christian Tavernier (France)

If you are both an all-terrain biker and handy with a soldering iron, then we suggest you build this musical horn which, apart from the fact of having a much pleasanter sound than a simple bell, will usually make passers-by turn to you with a broad smile, so surprised will they be to hear these few notes coming from an ATB or mountain-bike.

To achieve this, we have repurposed the SAE800 integrated circuit, which is theoretically designed for doorbells or musical chimes for houses. It takes only a very few external components and can run off any voltage between 2.8 and 18 V. So even with a seriously flat battery, it will go on working — though admittedly at the expense of sound volume. This is relatively high and can be adjusted, to a certain extent, by potentiometer P1.



Switch S1 is only vital if you want to make the battery last as long as possible. When the circuit is not activated, i.e. when push-button S2 is not pressed, it goes automatically into standby-by mode, when it consumes only a measly 1 µA or so.

IC1 produces three different sounds, depending on whether E1 or E2, or both together, are activated. This is what we've decided to do here using diodes D1 and D2, as this lets us obtain the most attractive sound, consisting of three notes at 440 Hz, 550 Hz, and 660 Hz, partly overlapping and of decreasing amplitude for around 7 s. Of course, there's nothing to prevent you choosing a different option by fitting only D1 or D2 and leaving the unused input floating.

The project doesn't present any specific difficulties, but it will need to be fitted into a watertight plastic case, to protect it from rain. For the same reason, it would be wise to choose a loudspeaker with a Mylar (plastic) cone, because the traditional fibre cone doesn't get on very well with humidity.

Switch S1, if used, and push-button S2 will also need to be chosen to be relatively resistant to humidity. The types available with a small rubber 'boot' are ideal.

(091070-I)

Caution. The installation and use of this circuit may be subject to legal restrictions in your country, state or area.

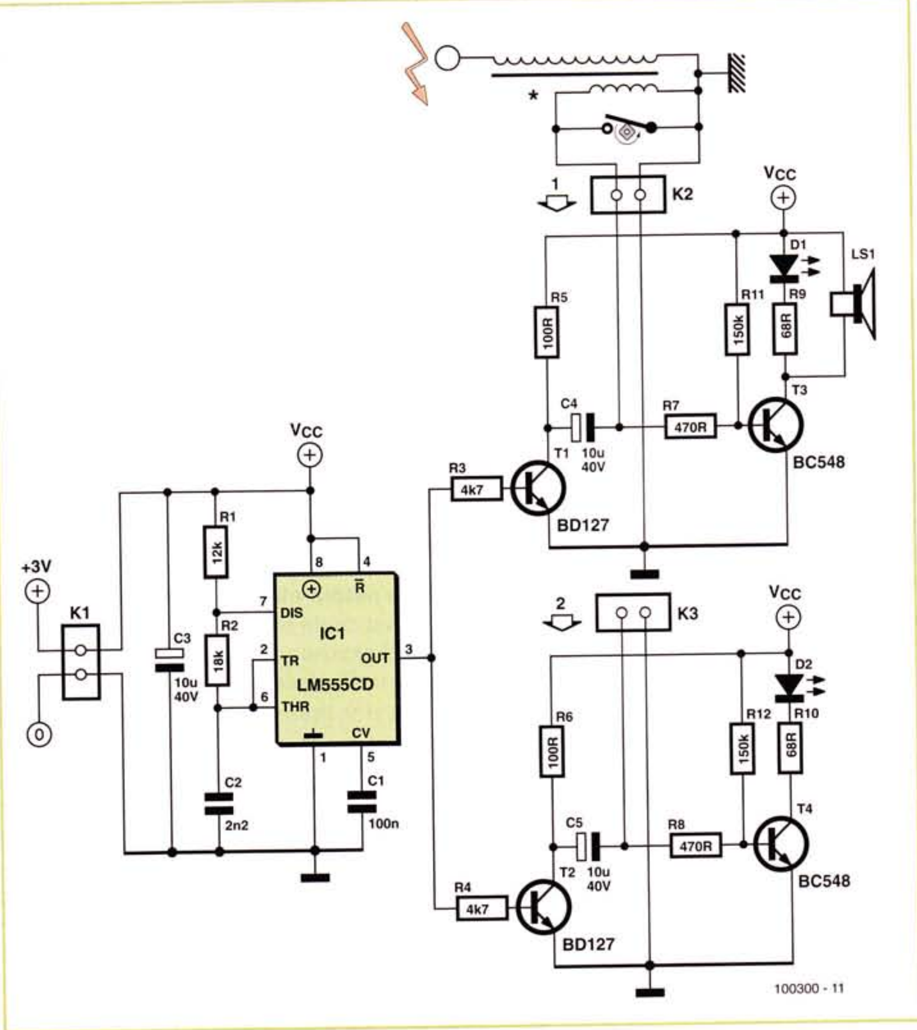
Ignition Timer

Philip Muylaert (B)

This circuit is a tester for flywheel-based ignition systems in small aeroplane engines. Basically the same ignition coils are also seen in other small combustion engines used in/on mopeds and lawn mowers — in brief, engines without a battery.

The part to be tested comprises a primary coil in parallel with the contact breaker. The timing of this contact breaker has to be adjusted correctly. Since the coil's primary has a very low resistance it is difficult to determine whether the contact breaker is open or closed. However, you can determine that reliably with this circuit, using an LED and a beeper. The circuit is implemented twice because aviation engines (Cessna, Piper and similar) always have two ignitions in parallel to increase reliability. For two-cylinder engines, well the purpose is obvious.

The circuit consists of a 555 and a few transistors. The 555 supplies a square wave of about 3000 Hz. This signal goes to power transistors T1 and T2; these can supply quite a bit of power and are robust enough to withstand the voltage transients from the big coils. The test connection (K2 and K3 respectively) are connected in parallel with the contact breaker to be tested, which itself is in parallel with the ignition coil. The frequency of 3000 Hz is either short circuited by the contact breaker or — if the points are open — is amplified somewhat by the resonance of the coil itself. This allows you to reliably detect the difference between a closed and open contact breaker, despite the low resistance of the coil, which is in parallel with it. When the contact breaker is open the amplified pulses will turn on T3 and T4 respectively, so that the relevant LEDs turn on and the buzzer will sound.



The components are not critical, but do use a sensitive type for the piezo buzzer. The power supply is 3 V (2 times AA or AAA batteries).

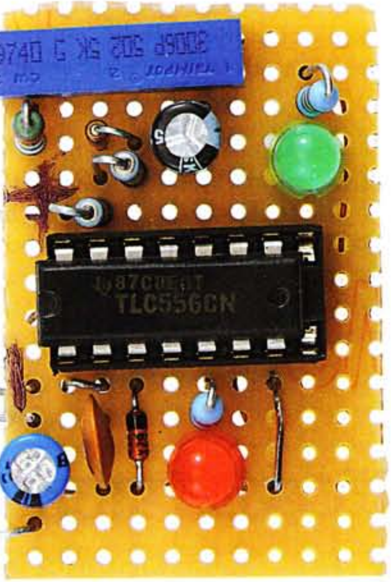
(100300-I)

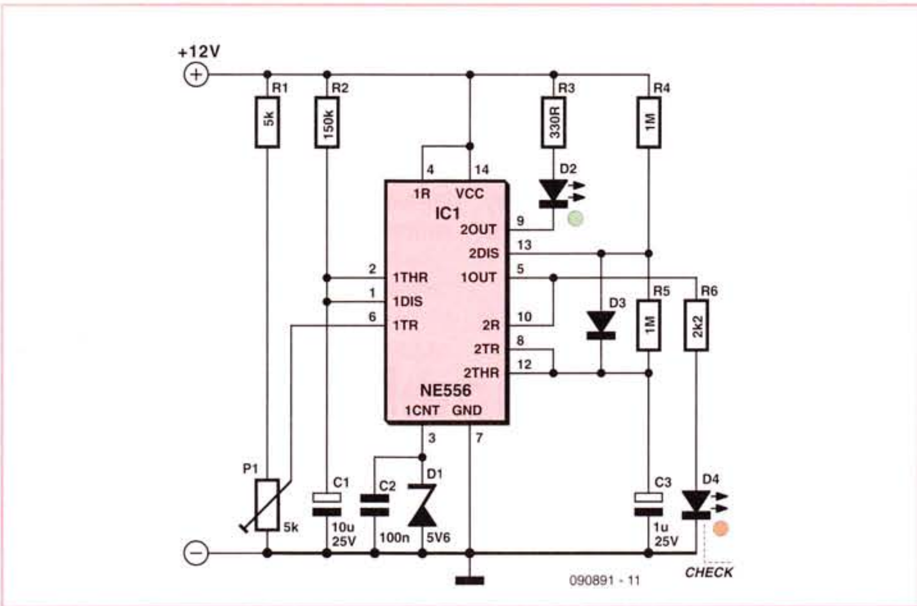
Voltage Monitor

Jürgen Okroy (Germany)

This voltage monitor circuit is based on an Elektor design with a 555 timer IC in the book *302 Circuits*, which uses two LEDs (red and green) to indicate whether the voltage is within range (bad or good). However, in practice this circuit has some shortcomings because the change in the indicated colour when the voltage drops below the threshold often goes unnoticed.

The circuit described here is designed to mon-





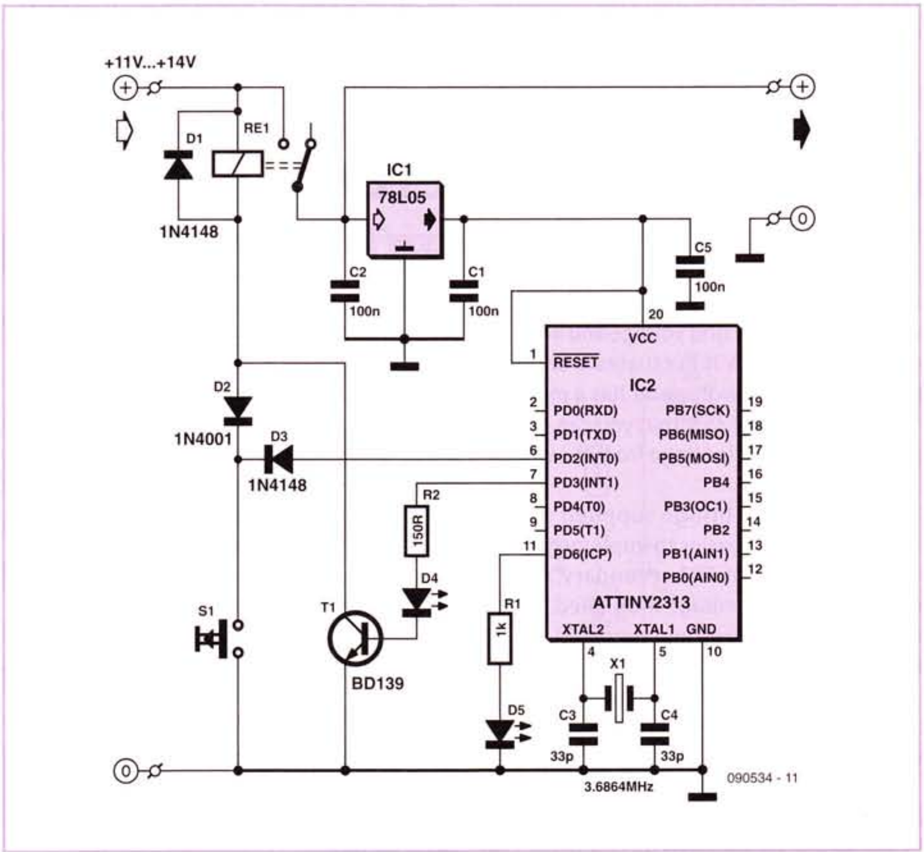
itor a 12-V supply voltage (such as voltage of the electrical system in a car) and signals an undervoltage situation with a blinking green LED, which is more likely to be noticed. The small red LED also lights up in case of undervoltage to provide confirmation.
The 556 IC used here contains two 555 timers. One of them detects the switching threshold, and the other provides the blinking function.
The threshold voltage for the undervoltage warning can be set to the desired value with potentiometer P1.
The current consumption of the circuit depends on the type of LED used. If a low-current LED is used as the blinking indicator, the value of the series resistor (here 330 ohms) must be increased significantly.

(090891-I)

Universal Timer with Zero Standby Current

e

Jürgen Stannieder (Germany)



This design came about when the author wanted better control of his 12 V solar-charged garden lighting installation. It is however a versatile circuit which can also be used to switch other types of equipment. Pressing pushbutton T1 energises the relay K1 connecting the supply to the circuit, powering the 78L05 and generating a 5 V supply for the ATtiny2313 microcontroller. The output PD3 (pin 7) will now be switched High by the microcontroller to turn on the transistor and hold in the relay, keeping the lighting on for a pre-programmed length of time defined in firmware. A press of the same button can either turn off the lights or extend the lighting period.

Pushbutton T1 is connected via D3 to input PD2 (pin 6). A press of T1 (a minimum of three seconds after timer start) will stop the timer, turn the lights off and disconnect the circuit from the power supply.

The on-time can also be extended: one minute before the timing period ends the LED on PD6 (pin 11) will light up, warning that the switched equipment (the garden lighting in the author's case) will shortly be turned off. Pressing button T1 (start/stop) now restarts the counter and extends the on time for a further period. As before the timer can be terminated at any other time by a press of T1.

The timing periods can be easily changed by altering the values defined in the source code (download from [1]) for the ATtiny2313 and recompiling the program.

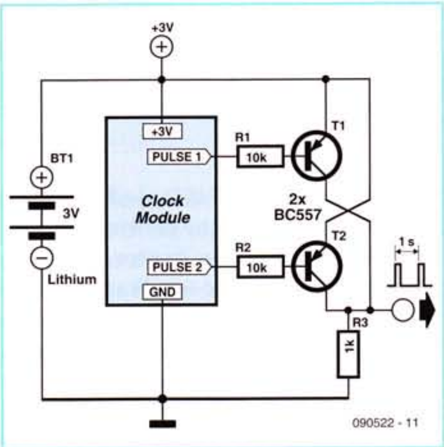
Diode D3 prevents current flowing through the relay and into the I/O pin of the microcontroller when the circuit is in its off state. Without D3 the circuit would be continuously switched on.

In its off-state the circuit (including the 78L05 voltage regulator) is disconnected from the supply giving a total standby current of zero!

(090534)

[1] www.elektor.com/090534

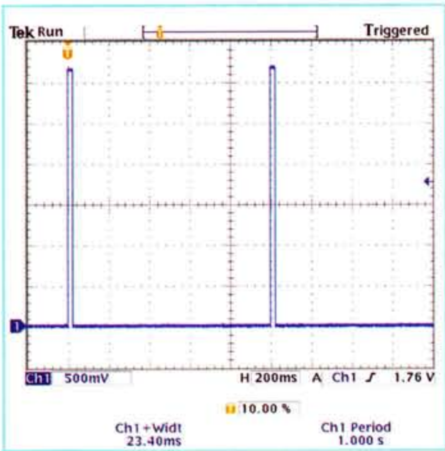
Quartz Clock Timebase



Claus Torstrick (Germany)

Many electronic projects call for a timebase generator, accurate to a second or so. One way of producing this is with a microcontroller, quartz crystal and some software. But a far cheaper and simpler approach is to recycle an old analogue quartz clock. After investigating a number of clocks the author discovered that they all use the same drive method: a tiny solenoid coil is pulsed by a current that reverses direction once a second. In the module illustrated this coil is connected between pins Pulse1 and Pulse2. Most of the time both pins are 'high' at supply voltage but every second the clock electronics pull first one and then the other of the pins down to ground for about 25 ms.

We need just five additional components to complete the circuit (see diagram). When either of the pulse pins is at ground potential, the corresponding PNP transistor conducts. Once a second a narrow pulse is produced, which is ideal for our own digital circuitry. The author himself uses one of these clock modules as timebase for a data logger with excellent results. Although the clock originally

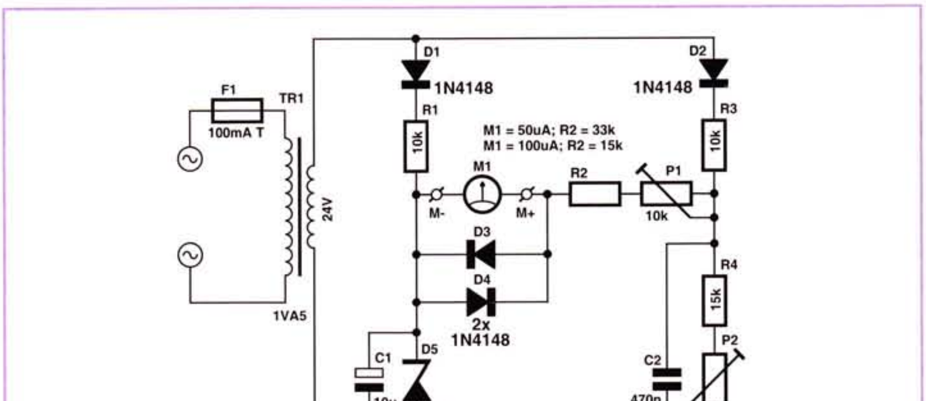


used a 1.5 V supply, this new arrangement works fine with a 3-V lithium battery. After three months using the same battery there have been no problems whatsoever.

(090522)

Powerline Voltmeter

Christian Tavernier (France)



Here's a rather special voltmeter that will let you measure the AC grid voltage and also see very accurately how it fluctuates around its nominal value. The voltmeter has a measuring range of around 35 V that you can centre around the nominal voltage from the grid.

The circuit uses a bridge supplied at low voltage to make it easier to implement. The voltage available at TR1 secondary, which reflects the mains voltage multiplied by the transformer ratio (fixed and constant), is rectified by D1, filtered by C1, and stabilized at 12 V by D5. This same voltage is also rectified by D2, but this time is not stabilized and is only slightly filtered by C2 so that the circuit remains responsive. Given the value of R3, R4, and P2, the voltage at the junction of R3 and R4 can be adjusted to 12 V when the mains is at its nominal value. Any increase or decrease in it will then vary the voltage at this point and change the reading of meter M1 accordingly.

There's no need to use a centre-zero meter, thanks to the adjustment available via P1 and P2. All you have to do is decide that when the needle is at the centre of its travel, this corresponds to 230 V. In this way, you'll have a margin in both directions for indicating any increase or reduction. The circuit diagram gives you a choice between two types of widely-available meter, but by modifying R2, and possibly R3 and R4, it can be adapted to use practically any reasonably sensitive meter.

It's not difficult to adjust this circuit, but you do need to have access to a variable transformer (variac). As these aren't particularly common, contact your local technical college, for example, where you should be able to borrow one just long enough for your adjustments. Remember, most variacs are autotransformers, i.e. they do not afford electrical isolation. To adjust set P1 to mid travel and adjust the variac to 230 V. Now adjust P2 so that the meter reads 0. Then turn the variac up to 240 V and set P1 so the meter reads full scale. Do watch out, though, as the simplicity of the circuit means there is some interaction between the two adjustments, so you'll need to work by successive approximation to achieve the best compromise — but it'll still only take you a few minutes.

All that is left for you to do is to graduate the meter scale from, say, 215 to 240 V, and you'll have a magnificent expanded-scale voltmeter that will let you follow the slightest variation in the AC powerline voltage.

(081181-I)

[1] www.elektor.com/081181

Simple LED Constant Current Source

Rainer Schuster (Germany)

Chip manufacturers are always coming up with ever more sophisticated constant current driver chips for LEDs. We have included this design for those of you who prefer a more cheap and cheerful solution.

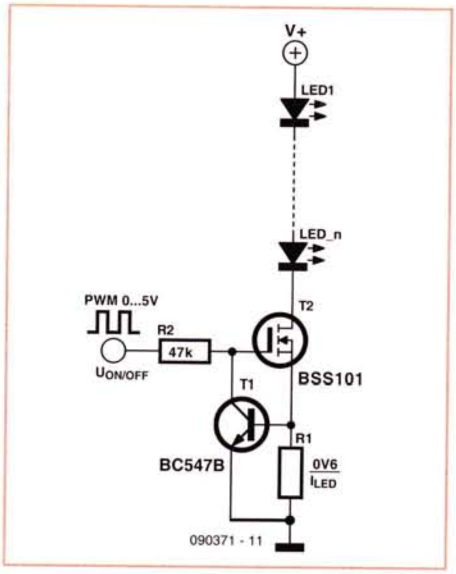
Current through the LEDs produces a voltage drop across resistor R1. As the current rises to a level to produce a voltage drop of 0.6 V across R1 it will cause T2 to start conducting and shunt the gate voltage of T1 to ground. This produces a constant current I = 0.6 V/R1 through the LEDs.

The control input allows the LEDs to be switched on by applying a voltage in the range of 5 V up to around 12 V and switched off by applying a voltage of 0 V. When this input is driven by a pulsewidth modulated signal it gives the possibility to change the LED brightness.

The supply voltage for all the series connected LEDs can be as high as practical providing the maximum drain-source rating of T2 is not exceeded. The choice of T2 and any necessary heat sink will depend on the power dissipated in this device. This can be calculated from:

(Supply voltage minus the voltage drop across the LEDs) × I_{LED}

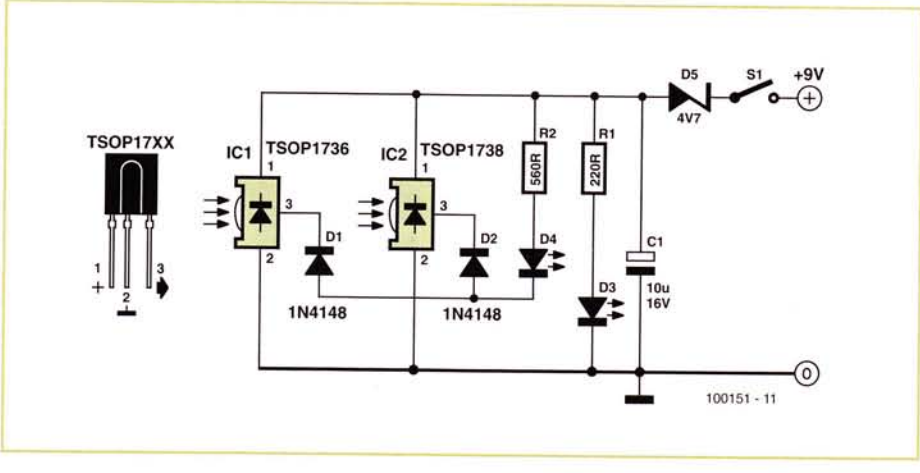
(090371)



Universal IR Remote Control Tester

Leo Szumylowycz (Germany)

This tester consists of two integrated remote control receivers whose outputs drive an LED to indicate when a suitable infrared signal is received. To cover all current infrared remote controls, one receiver (the TSOP1736) has maximum sensitivity to carriers at 36 kHz, the other (the TSOP1738) to carriers at 38 kHz.



The outputs of the two ICs are connected to indicator LED D4 via D1, D2 and R2. If the output of either of the two ICs goes low the LED will light, and the diodes isolate the outputs of the ICs from one another.

The other LED (D3) indicates when power is applied. The LEDs are white with a minimum output of 20,000 mcd at 20 mA, which means that even at 5 mA (the maximum output current of the receiver ICs) the indicator LED will light reasonably brightly. In his prototype the author used 5 mm LEDs with an output of typically 55,000 mcd at 20 mA.

The Zener diode reduces the supply voltage for the receiver ICs to about 4.3 V. In fact, they will operate reliably down to about 3.2 V. The circuit is powered from a 9 V PP3-style (IEC: 6LR22) battery, and will function until the battery voltage falls to about 7 V.

(100151)

Tiny Timer

Wilfried Wätzig (Germany)

Developing a lighting control unit recently, the author found that available analogue or mechanical timers were not sufficiently accurate or convenient. Without further ado he developed a timer switch driven by a small AVR controller of the type ATtiny2313.

The device presented here can switch a load on and off with 1-second accuracy for a period ranging from one second to 99:59:59 hours. By using a very compact LCD display (the HMC16223 with dimensions of just 52 mm x 20 mm) it was possible to construct the prototype inside a standard wall outlet box.

The ATtiny2313 is timed using a 4.9152 MHz crystal to produce an internal timebase of exactly 1 second. The LCD is driven in 4-bit mode. Data input is by press buttons, making use of the pull-up resistors built into this little controller. The miniature transformer (9 V, 1.5 W) provides electrical isolation between the AC grid and the operating voltage for controller and LCD.

For small switching loads (below 200 W) the power relay can be replaced by an all-electronic solid state relay (e.g. Sharp S202 S02).

AC powerline voltage circuits are not for beginners and it's vital to observe the relevant safety guidelines at all times!

You are recommended to divide the circuit between two separate boards: LCD, microcontroller and press buttons on one and transformer, rectifier and switching relay on the other.

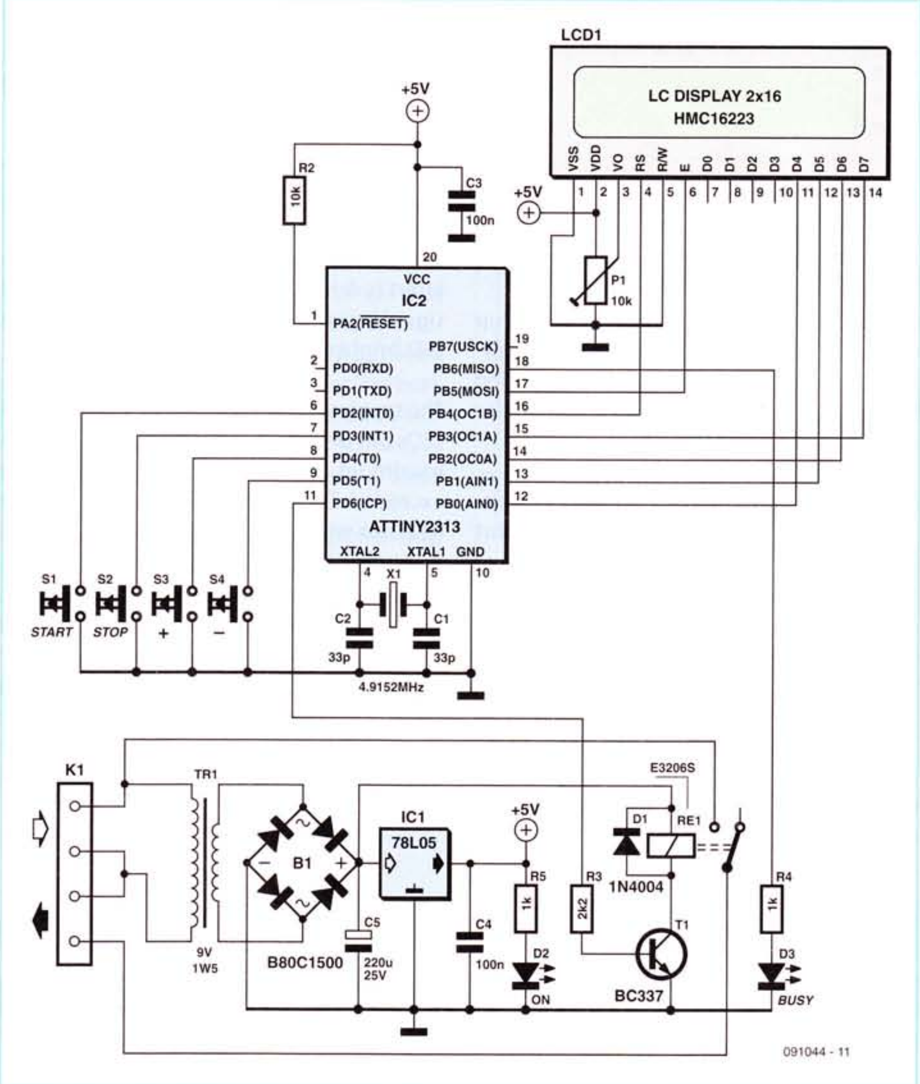
Here's how you use the timer switch:
When the timer is running the preset time period and time remaining are displayed on the readout:

PRESET 1:10:08
COUNT 0:09:59

An alternative format can be selected if you wish:

PRESET 1h 10m 8s
COUNT 0h 9m59s

The four function buttons are used as follows:



START:	Start timer for the preset period
STOP:	Stop timer, select menu for setting values and options
PLUS:	Increment the selected value by 1
MINUS:	Decrement the selected value by 1

The following values can be set:

Menu 1:	SET HOURS 00
Menu 2:	SET MINUTES 00
Menu 3:	SET SECONDS 00
Menu 4:	SET DISPMODE 0

Push buttons PLUS und MINUS alter the selected value and pressing them both simultaneously resets the value to zero.

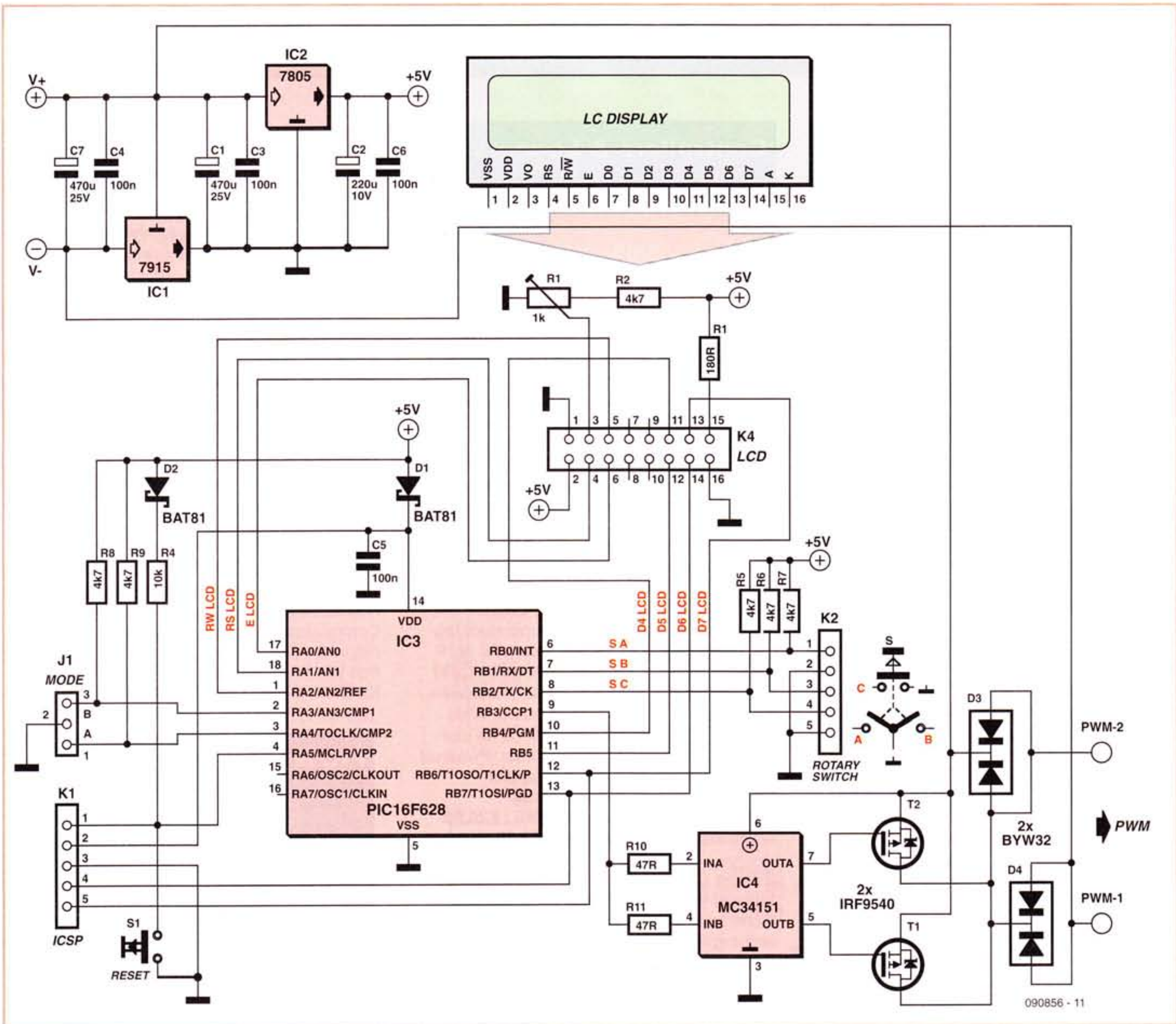
A programmed controller is available from the Elektor shop under order code 091044-41 (www.elektor.com/091044). If you enjoy doing the programming yourself, the fuses of the ATtiny2313 should be set as follows:

EXT. byte: 0xFF - (brown out det. off, no CKDIV8)
HIGH byte: 0xDF - (ext. crystal > 3 MHz)
LOW byte: 0xFD - (64ms start up)

As usual the hex and source code can be downloaded free from the Elektor website (www.elektor.com/091044).

(091044)

Universal PWM Driver



Herbert Musser (Austria) and Alexander Ziemek (Germany)

PWM drivers are used in analysing, testing, installing and powering all kinds of electronic and electrical devices. We have published a few designs in Elektor over the years: here we present a 'de luxe' version suitable for a very wide range of applications. As usual the software for the project (source code and hex file) can be downloaded for free from the accompanying pages on the Elektor website [1], and ready-programmed microcontrollers are also available. Additionally, the authors' Eagle design files for the printed circuit board are available for download.

The main user control, used for adjusting almost all the settings, is an Alps incremental rotary encoder. This is accompanied by a mode switch used to select the operating mode from among 'off', 'PWM' and 'full power': a three-position centre-off switch is suitable. The two controls are connected via headers (K2 and J1). The current settings of the circuit are shown on a standard LCD panel with two rows of sixteen characters, which is connected to the PCB via a standard connector.

At the heart of the circuit is a PIC16F628 microcontroller (a PIC16F628A may also be used). An output stage consisting of two power FETs wired in parallel, along with heavy-duty flyback diodes, allows the circuit to drive DC motors at up to 30 V and rated currents of up to 10 A directly and comfortably. The circuitry is capable of working at even higher currents, but then careful attention must be paid to the cross-sectional area of the conductors: tin the current-carrying circuit board tracks, or add wires in parallel with them.

The motor drive application was foremost in the authors' minds when designing the circuit. A useful feature in this application is the 'boost function', which helps DC motors to start up reliably. The output is switched on at full power for the configured boost time, regardless of the PWM duty cycle setting in force.

For reasons of safety, when the circuit is powered up the output will remain off until the mode switch is set to 'off' and then to one of the 'on' settings. This means, for example, that a connected motor will not suddenly start up when the electricity supply is restored after a power cut.

In normal operation the display shows the current PWM frequency and the duty cycle (as a percentage). The duty cycle can be adjusted using the incremental encoder.

The basic settings can be configured in the set-up menu. This menu is reached by setting the mode switch to 'off' and pressing in the incremental encoder for a few seconds.

The menu includes the following options:
Boost: on / off
Boost time: 1 second / 2 seconds / 5 seconds
PWM frequency: 1 kHz / 2 kHz / 5 kHz
PWM step: 1 % / 2 % / 5 % / 10 %

Choosing 'exit' leaves the set-up menu.

The 'PWM step' parameter determines the amount by which the duty cycle increases or decreases in PWM mode for each step of the rotary encoder.

The settings are stored in the EEPROM of the PIC16F628 and so are not lost when power is removed.

The authors' prototype of this circuit has given sterling service, outputting a clean and stable drive waveform even at a frequency of 5 kHz.

(090856)

[1] www.elektor.com/090856

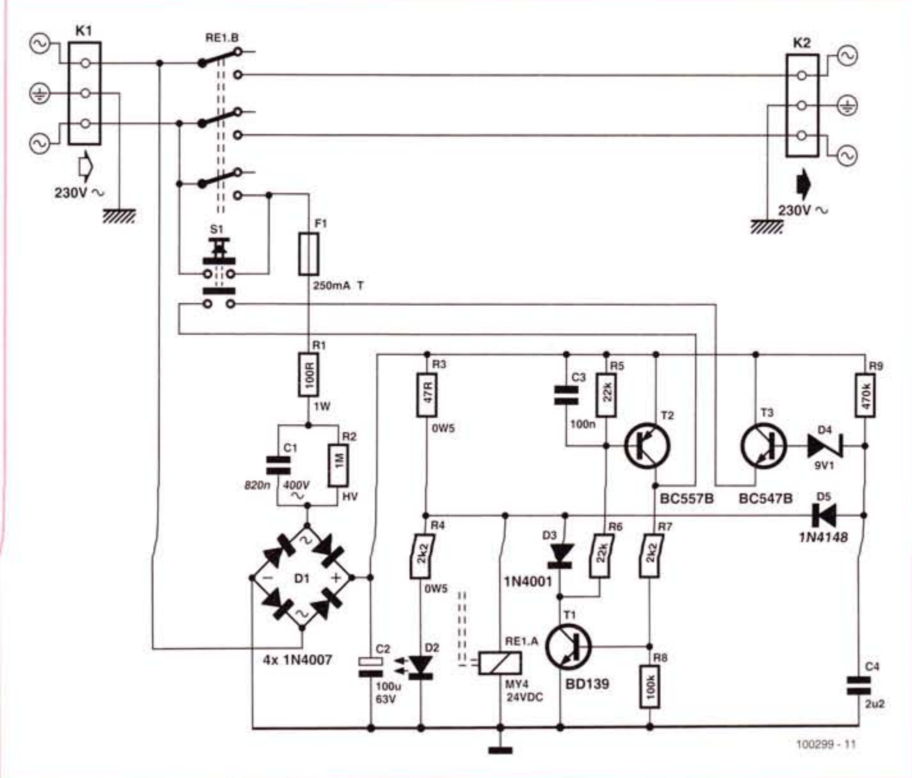
Economical On/Off Power Switch

Joost Waegebaert (Belgium)

Many appliances these days are switched on and off with the simple push of a 'soft' on/off button. In the 'off' position the appliance is merely in the sleep state and continues to use a small amount of energy — and that is just 'not done' nowadays. This circuit not only retains the feature of switching on and off with one simple pushbutton but also reduces the power consumption in the off-state to zero.

When pushbutton S1 is pressed, the circuit receives its power supply voltage via the capacitive voltage divider containing C1. The rectified voltage across C2 energises the relay RE1.B via R3. LED D2 lights up. One set of the relay contacts is connected in parallel with S1, so that the relay will continue to be energised when S1 is released. The remainder of the circuit has no effect during turn on. C3 ensures that T2 blocks and capacitor C4 is not charged yet. Both conditions ensure that T1 does not have any base current and is therefore off. The relay can now close and the mains voltage across K1 is switched through to K2.

After power on, C4 will charge slowly. After about 0.25 sec the voltage is high enough to turn T3 on via zener diode D4. There is now a voltage at the emitter of T3. If S1 is now pressed then T1 will receive base current via T3 and the second contact of S1. T1 conducts and shorts the voltage across RE1.B, which de-energises the relay. At the same time T2 ensures that the circuit latches: T1 provides base current, via R6, for T2. This will conduct and provide base current for T1 via R7. So T1 will continue to conduct, even after S1 is released. C2 is discharged via R3. In this way the power supply voltage for latch T1-T2 will eventually disappear, so it will unlatch. Timing capacitor C4 is also discharged, via D5, so that the circuit is now ready for the next start. The entire circuit is completely disconnected from the mains, the current consumption is



literally zero!

The value of capacitor C1 mainly depends on the relay that is used. As an example we are using an Omron MY4-24VDC [1]. The relay is a 24V-type which is happy with a coil current of 40 mA and has contacts that allow for a load of up to 5 A. At 24 V across the relay there is a current of about 10 mA through LED D2. The total current when switching on is therefore about 50 mA. The value of capacitor C1 is roughly determined as follows:

$X_{C1} = U_{C1}/I_{C1} = (230\text{ V} - 24\text{ V})/50\text{ mA} = 4.12\text{ k}\Omega$
$C1 = 1/2\pi f X_{C1} = 1\ /\ (2 \times 3.14 \times 50 \times 4120) = 773\text{ nF}$

We select the next bigger value: 820 nF. It is absolutely essential that this capacitor be suitable for at least 250 VAC and is preferably a Class X2 type, for example one from the MKP 336 2 X2 series made by Vishay [2]. The capacitor actually limits the total current that can flow through the circuit. When T1 conducts, C1 limits the current through T1 to about 50 mA. The magnitude of this current also gives an indication of the apparent power that the circuit draws:

$P_S = U \times I = 230\text{ V} \times 50\text{ mA} = 11.5\text{ VA}.$

The actual real power of the circuit is smaller than this value, since the cos φ of the circuit is certainly smaller than 1.

Resistor R2 discharges capacitor C1 after switching off. This also has to be a type rated for 250 VAC (for example the MBE/SMA 0414 series [3]). Switch S1 too needs to be appropriate for 230 V operation. It is possible to replace R2 with two 'ordinary' resistors of 470 kΩ in series. Resistor R1 limits the switch-on current through S1 when capacitor C1 is discharged.

(100299-I)

[1] www.ia.omron.com/data_pdf/data_sheet/my_dsheet_gwj111-e1-03.pdf

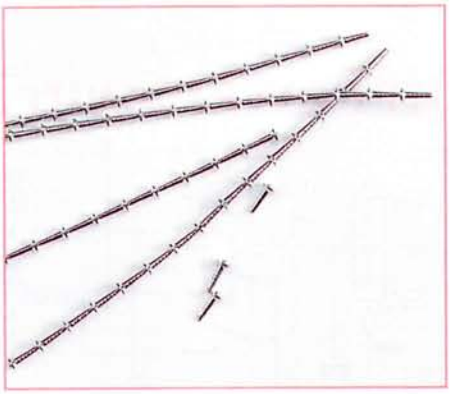
[2] www.vishay.com/docs/28120/mkp3362.pdf

[3] www.vishay.com/docs/28767/28767.pdf

Fast Reliable Vias

Kai Riedel (Germany)

There are several techniques for providing lab-grade contacts from one track side to the other on DIY printed circuit boards. They range from thin wire or solder pins through pressed-in hollow rivets (e.g. from Bungard) and through-contact sleeves (e.g. from ELV) to through-contact rivets (e.g. LPKF 'EasyContac'). These 'vias' can also be produced using electrical techniques or with solder paste. All these methods tend to be time consuming and prone to failure. Some of them also require special tools or employ expensive components.



1

The author prefers the more wallet-friendly track pins made by Harwin in various sizes. Track pins type T1559F46 [1] are available from Farnell for instance (order code 1143874) at a price of £6.96 or €9.85 for a pack of 500). You just drill a hole of 0.8-mm diameter and then insert the pin. Harwin supplies a special insertion tool (Farnell order code 145248, £162.97 or €224.98 ; data sheet at [2]).

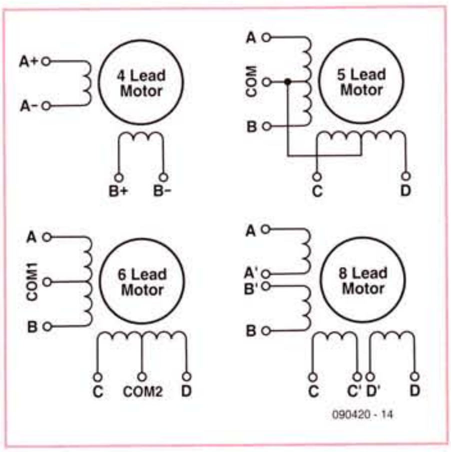
You can also insert these pins without special tools (but not as reliably). A soldering iron with a wide tip will do! Pins heated in this way can be inserted into the PCB with light pressure and then soldered on both sides. The tight fit of the pin in the hole means it will not fall out during or after the insertion and soldering processes, unlike when using pieces of thin wire. Making via connections in this way is quick and easy.

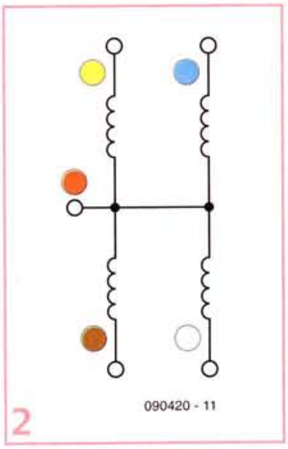
(090425)

[1] www.harwin.com/search/T1559F46?ProductSearch=True

[2] www.harwin.com/include/downloads/tis/ IS-06.PDF

Identifying Stepper Motors





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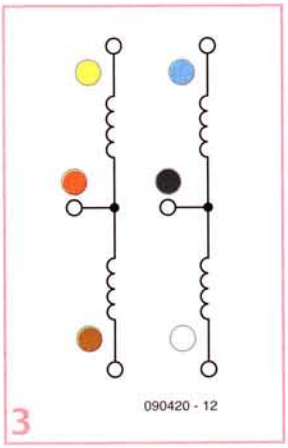

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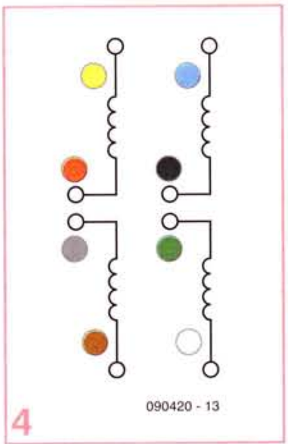


4

W.G. Jansen (The Netherlands)

There are many different types of stepper motor. Because there is no documentation available for stepper motors that have been removed from old equipment you have to carry out some measurements to identify the different wires.

We only need three things for this: an ohmmeter, an AC voltmeter and a transformer with an output voltage between 2 and 6 V. The majority of stepper motors have either two or four stator coils, which are presented to the outside world via 4, 5, 6 or 8 different coloured wires, see **Figure 1**.

For a motor with **4 wires** we have to find two wires that have a resistance between them. We then write down the value of the resistance and the colour of the wires. In this way, we can distinguish between the two stator coils and we know that this is a bipolar motor.

For a motor with **5 wires** (unipolar) it is more *difficult to identify the four individual coils. We start with the measurement of the resist-*ance between all the differently coloured wires and make a note of them in a list (see the example in **Figure 2**). Next, find all pairs of wires that have the lowest resistance between them and call those Rx ...Ω. The resistance values of the other combinations aren't important.

Measurements: yellow/red = Rx ...Ω
blue/red = Rx ...Ω
white/red = Rx ...Ω
brown/red = Rx ...Ω

From this example it appears that the red wire is the common one (COM). Two pairs of coils make up the A-B phase and the C-D phase. To find out which ones belong together we connect a small AC voltage to one of the coils, if need be via a series resistor to limit the current. In this example we chose yellow/red. Now use the AC voltmeter to measure the voltage across the remaining coils. The coil where we measure the largest voltage will be the one that forms one phase in conjunction with the yellow/red coil. It's not important whether we call this the A-B phase or C-D phase.

For a motor with **6 wires** (both bipolar as well *as unipolar devices) it is straightforward to identify the individual coils. Again, we meas-*ure the resistance between all coloured wires and put them in a list.

Measurements: yellow/red = Rx ...Ω
red/brown = Rx ...Ω
blue/black = Rx ...Ω
black/white = Rx ...Ω
yellow/brown = 2Rx ...Ω
blue/white = 2Rx ...Ω

We find a low resistance value (Rx ...Ω) four times and a higher resistance (2Rx ...Ω) twice. There is no connection between the two phases (see **Figure 3**). From this it can be seen that yellow/red/brown is one phase with red as common, and blue/black/white is the second phase with black as common. For bipolar use the 2Rx connections are used and the common wire is left unconnected.

For a motor with **8 wires** (both bipolar as well as unipolar devices) it is quite difficult to determine the correct order of the four coils in the two phases. As for the other motors, we start with the resistance measurements and put them in a list, which will make clear what the individual coils are (see **Figure 4**). In *order to connect the coils in pairs and in the correct phase, the winding direction of each* coil has to be determined. To do this, connect the transformer to one of the coils and measure the voltage across the other coils with the AC voltmeter. The coil that shows the largest voltage will be the one that forms one phase in conjunction with the coil connected to the transformer. To find out if the coils are connected in phase, the coils are connected in series and the transformer is connected across one coil. First measure the voltage across the powered coil and then across both coils in series.

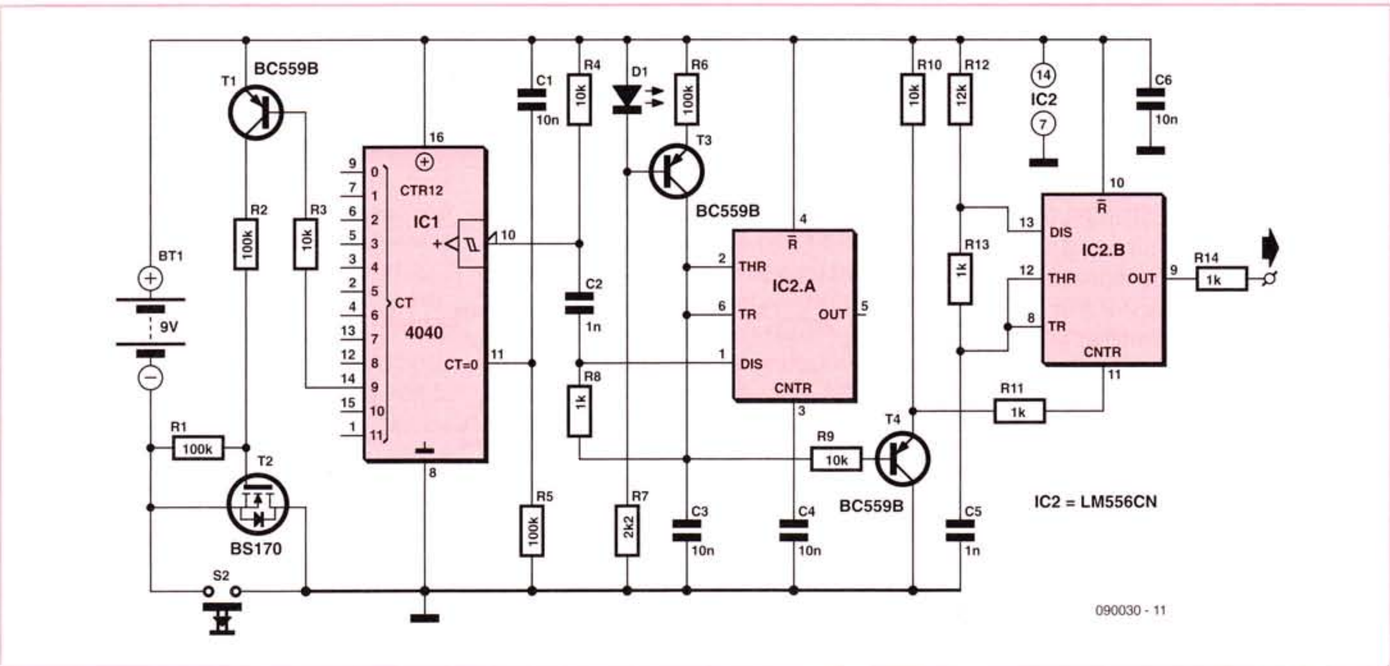
There are two possible outcomes: The voltage across the series connection is about twice that across the single coil, or it's almost zero. The correct series connection is the one where the voltage is highest. For bipolar use you should connect the two coils for each phase in series or parallel, since that results in the maximum torque from the motor.

(090420)

Literature

'Stepper Motors Uncovered',
Elektor November & December 2003

Zapper for Electrotherapy



Jac Hettema (The Netherlands)

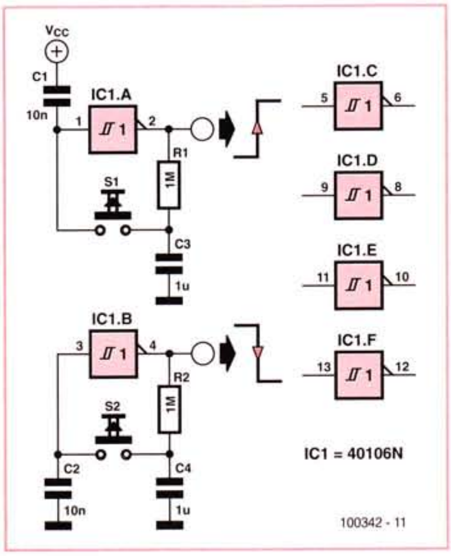
A zapper is a device that is often used in alternative medicine. This device is a so-called electronic bioresonance pulse generator, which generates a square wave at a particular frequency. This signal is applied to the human body via hand or wrist electrodes, causing a minute current to flow through the body. This is claimed to kill bacteria, viruses and other parasites in the body, and to boost the immune system.

After reading the relevant parts in the handbook for self-health by Dr. Hulda Clark and looking at the signal generated by such a device, the author designed a cheap DIY version of such a zapper.

This design is significantly cheaper than the commercially available devices. As far as its effectiveness is concerned, there are various claims and counter-claims put forward, all for what it's worth. At least with this design you can try it for yourself at little cost, in any case a lot less than if you decided to buy a ready-made zapper.

This zapper outputs a square wave signal at the supply voltage of 9 V in series with a resistor of 1 kΩ. This means that the maximum output current can never exceed 9 mA (when short-circuited), which keeps it safe to use. The frequency varies between about 28 kHz and 75 kHz. C3 is charged up via a constant current source so that the change in frequency is fairly linear. The LED used in the constant current circuit doubles as the 'on' indicator for the device. After about eight minutes the zapper turns itself off, since output Q9 (pin 14) of IC2 then goes high. This stops the base current in T1, which turns off the supply voltage to the circuit via T2.
The ground and output connection (R14) of the circuit are connected to the body via two hand or wrist electrodes (in the simplest case these could be two pieces of bare wire). For safety reasons the circuit should only be powered from a 9 V battery.

(090030)



Six-way Switch

Kees van het Hoff (The Netherlands)

The 40106 is a versatile CMOS IC containing six Schmitt trigger inverters. It can be used to implement a set of alternating-action switches with hardware contact bounce suppression.

Aside from one gate of the IC, all you need for each switch is a pushbutton, a resistor and two capacitors. It works as follows. The 1 µF capacitor at the output is charged or discharged via a 1 MΩ resistor, depending on the output level of the inverter.
Pressing the button causes the input level of the gate to change, which in turn causes the output level to toggle. The 10 nF capacitor determines the output state after the supply voltage is switched on. You can connect it to the supply voltage rail or the ground rail as required. If you hold the button pressed, the output signal will be a square wave with a frequency determined by the RC time constant, which is approximately 1 second.

You may experiment with the component values if you wish.

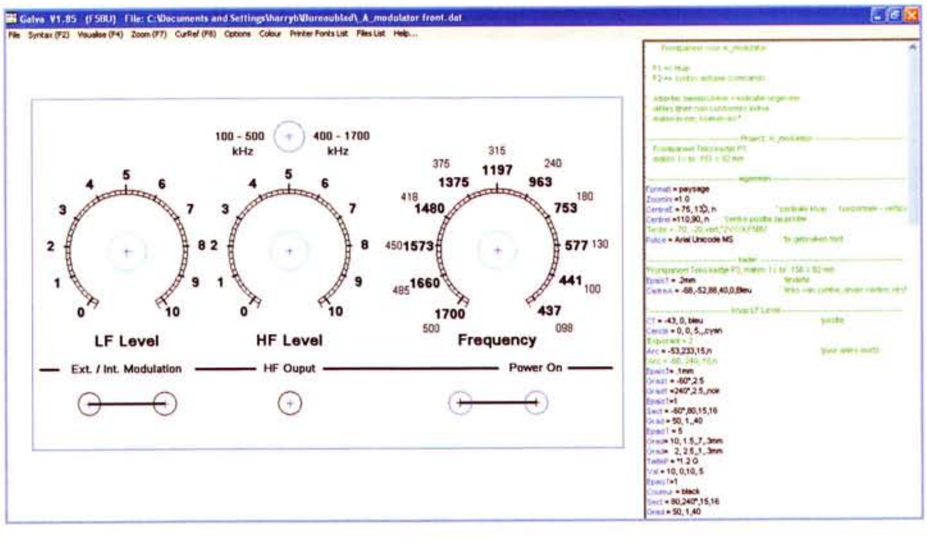
(100342-I)

Front Panel Design Program

Henk van Zwam (The Netherlands)

Everybody who builds their own equipment will come across this problem at some stage: How can I create the layout for a decent front panel? Plain text can be positioned in the right place using a word processor, but scales for potentiometers, rotary switches and variable capacitors are a different matter.

For several years there has been a great program that can solve these problems: Galva (version 1.85). It is freeware and originates from France, but also offers an English language user interface. It also has an extensive help section. The design can be printed on any printer, using paper or a transparency, depending on the printer used.



The program is really a type of programming environment: The user writes a number of commands with parameters that result in the drawing when the F4 key is pressed. The program has two windows: a graphical window for the drawing and a text window where the commands are typed in. It doesn't have the usual graphical interface that we expect with most drawing programs. However, it doesn't take long to learn how to use this program because you know the reasons for issuing a specific command. Logos (signs) etc can be imported and all fonts and symbols present in Windows can be used. It almost goes without saying that colours can be used.

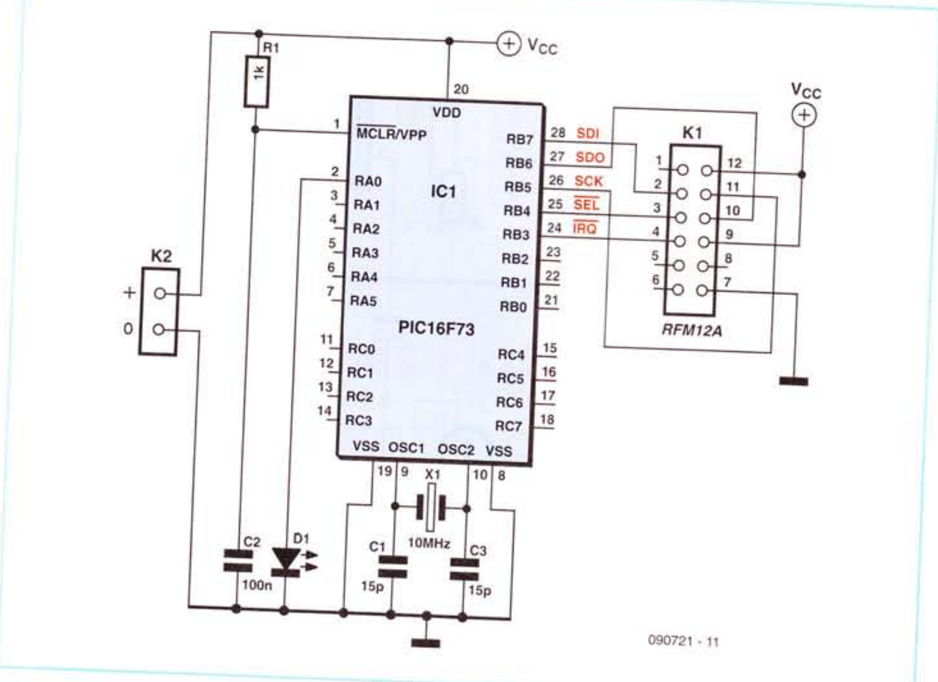
The results are amazing: scale division lines can be positioned to within a fraction of a degree, positioning of components can be done to a tenth of a millimetre. The learning curve is quite short because you can study the included examples and use them as the basis for your own designs. You can quickly see what the possibilities are when you change some of the parameters in the examples. The program is suitable for use in a large number of projects to create scales and front panels, but it can also be used to create millimetre paper, logarithmic paper, nomograms, logarithmic tables and such like.

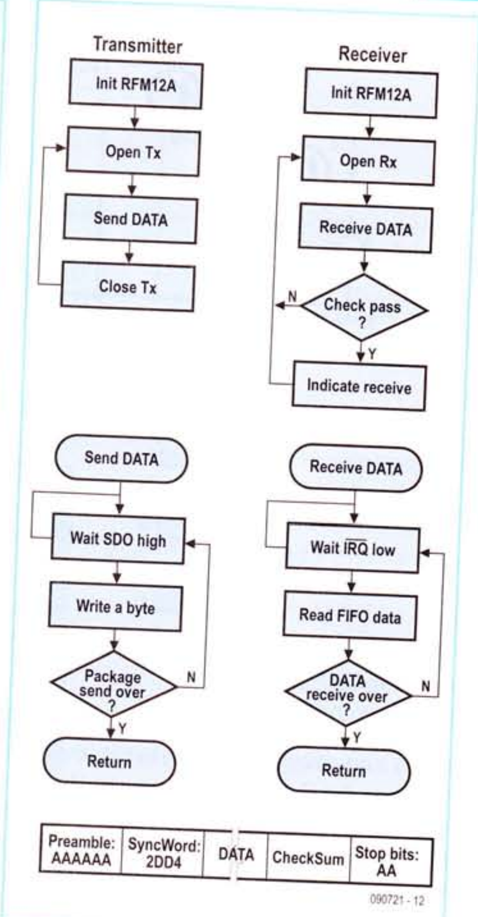
Galva can be downloaded from the (French) website at [1]. You'll find the program in the 'Electronique' section.

(100287)

[1] www.radioamateur.org/download/

PIC/C or VHDL/FPGA for RFM12 TX/RX





By Bojan Jovanovic and Milun Jevtic (Serbia)

The use of the low-cost RFM12 868 MHz (US: 915 MHz) ISM (licence-free) radio module with microcontrollers like the ATmega and the R8C13 is straightforward once you've read some relevant Elektor publications [1],[2],[3].

Here, the use of the RFM12-434-D DIP type transceiver module for 434 MHz (US: 315 MHz) [4] is proposed instead of the RFM12-868-S, which is an SMD type. Of course, the antenna length has to be changed to 17 cm to suit the lower frequency.

The authors used a PIC16F73A to control the RFM12A transceiver module. The firmware for the micro was written in C using an EasyPIC4 development board and mikro C PRO for PIC, both from Mikroelektronika. As a quasi parallel activity, software was developed in VHDL for the FPGA Cyclone II family. For this, the Altera DE2 board and QuartusII software were used.

The communication protocol governing the transmitter and receiver algorithms for the C-coded PIC16F73 are shown here. The supply voltage and logic '1' voltage are both + 5 V. In the PIC application, the serial SPI communication interface is realized in software. Data rate and frequency deviation are 4.8 kbps and ±90 kHz respectively. During data transmission, the microcontroller monitors the SDO pin to check whether the Tx register is ready (SDO high) or not to receive the next byte. This byte is transferred serially, MSB first. When receiving data, the receiver generates an interrupt request by pulling the nIRQ pin low when the FIFO register has received data. These data bits are transferred serially, again MSB first, to the microcontroller.

Slightly different algorithms and communication protocols were applied for the CycloneII FPGA to make it talk to the RFM12 transceiver module. In this case the supply voltage and logic '1' voltage are both defined as +3.3 V. All source code files and executables developed by the authors for both 'branches' of the project (i.e. C/PIC or VHDL/FPGA) are available free of charge from the Elektor website [5]. The RFM12-868-S is available through the Elektor Shop as item # 071125-71.

(090721)

[1] ATM18 on the Air, Elektor January 2009, www.elektor.com/080852.

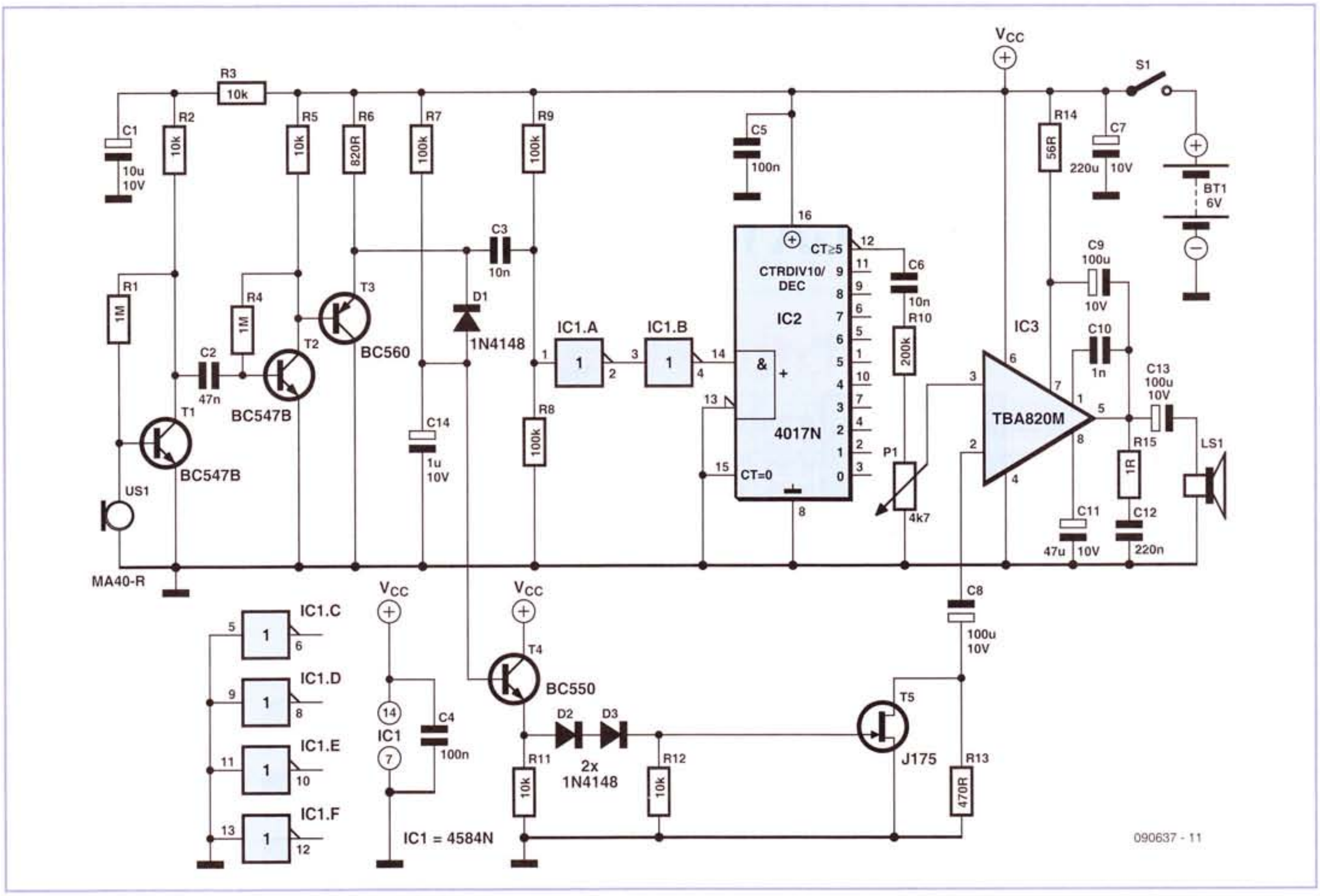
[2] Radio for Microcontrollers, Elektor January 2009, www.elektor.com/071125.

[3] USB Radio Terminal, Elektor July & August 2009, www.elektor.com/090372.

[4] www.hoperf.com

[5] www.elektor.com/090721

Bat



Guy Boniface and
Jean Rowenczyn (France)

Here's a novel way of listening to bats over the Summer. Put the receiver — powered by four AA (R6) cells — on a window-ledge, for example, preferably aiming the ultrasonic detector towards an outdoor light or some trees. Run out a few metres of cable so as to install the small loudspeaker inside the house. Wait for nightfall and, if there are bats around, you'll hear a sound like bursts of crackling from the loudspeaker. Do note that bats won't fly about under some weather condition (rain, strong winds, etc.)

The detector receives the ultrasonic signals, which are amplified by T1, T2, and T3, then sent to IC1 which is wired as a threshold detector. It converts the analogue signal into digital pulses which it sends to IC2, which divides the signal by ten so as to make it audible to the human ear. The gain of the LF amplifier IC3 is adjusted automatically by transistor T4 and T5 depending on the amplification of the signal by T3, filtered by R7 and C14. The impedance between IC3 pin 2 and ground is what determines the amplifier gain.

The 40 kHz ultrasonic receiver used (MA40-R or SQ40-R) is available from Conrad Electronics (# 182281-62) or Farnell (# 213226).

(090637-I)

Flashing Lights for Planes and Helicopters

Jean-Louis Roche (France)

There are two sorts of lights on aircraft: red or white flashing lights, which are called 'anti-collision lights', and steady lights, red on the tip of the left wing, green on the tip of the right wing, and white at the tail, called 'position lights', which enable an observer to see if the aircraft is approaching or going away. On the tip of each wing, in addition to the steady lights, there may also be flashing white strobe lights. The position light simulator given here takes a few liberties with the real position lights, making them flash (it's more fun!) and using a little trick to simulate the strobe effect.

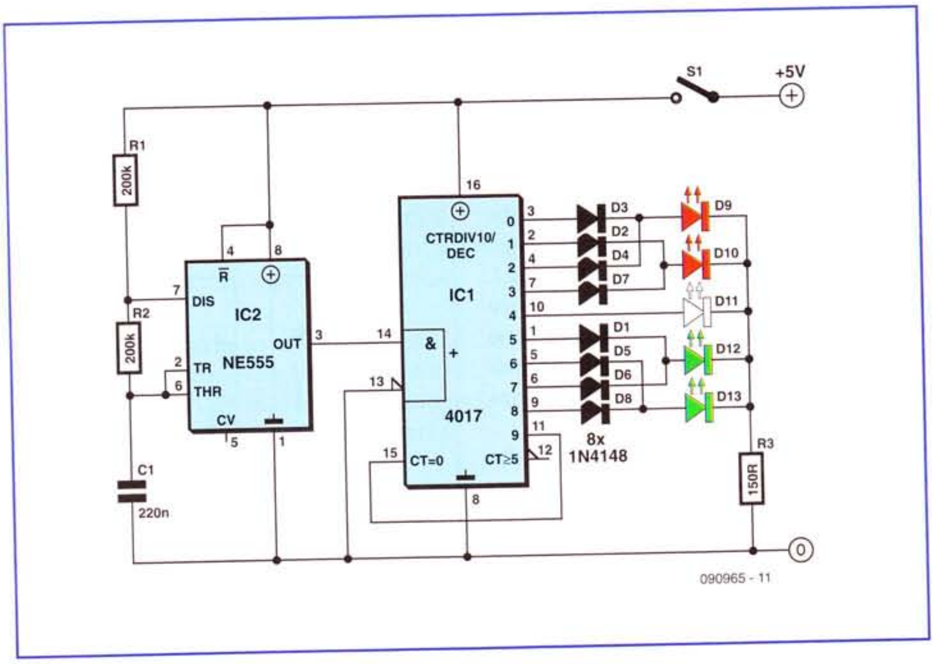
The well-known NE555 is found in its SMD version for the timebase, combined with a 4017 decade counter with ten decoded outputs, also in SMD version. Normally, each output is used independently. In this circuit, two outputs are coupled with a one-output gap: Q0 and Q2 (front left, red LED), Q1 and Q3 (rear left, red LED), Q5 and Q7 (front right, green LED), Q6 and Q8 (rear right, green LED). To avoid the low output's shorting the High output, a diode is used in series with each output.

In this way, we get 'double flashing' of each LED, giving the strobe effect.
Output Q4 is used for the tail of the plane (white LED) or helicopter (red LED) with a single flash, without the strobe effect. Output Q9 is used for the reset.
Only one LED is lit at any given moment, so the consumption is kept low so as not to reduce battery life in flight. The 150 Ω resistor limits the supply voltage/current to each LED.
The circuit's power rail (4.5 V) can be taken from an unused output on the model's decoder. A sub-miniature switch could be fitted if necessary, but since a plane or helicopter is required to have its lights on at all times...

(090965-I)

Internet links

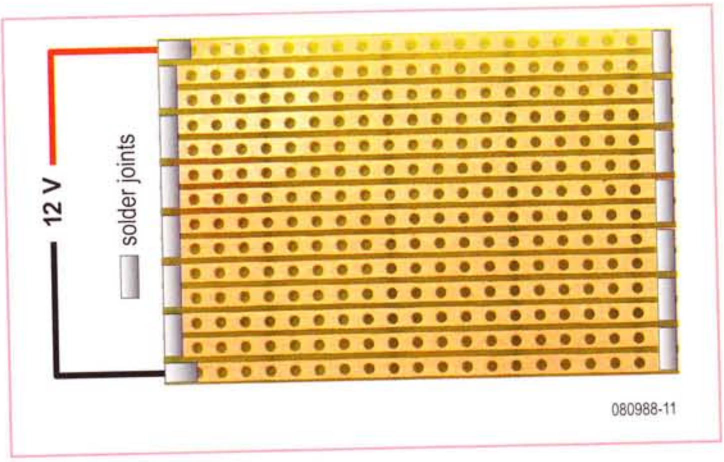
[1] www.elektor.com/090965



Breadboard as Hotplate

Klaus Berthholdt (Germany)

A standard 60 mm x 100 mm piece of prototyping strip board (breadboard) can very simply be used as a 12 V warming plate. All that's necessary is to connect the copper tracks in series. At 12 V the board will pass around 4 A giving a power dissipation of almost 50 watts. Power can be supplied by a standard car battery or 12 V battery charger. The temperature on the epoxy side of the board can reach around 100 °C!



The simplest method to make the plate is first to solder all the tracks together at both ends of the tracks. Now take a small hobby drill like a Dremel fitted with a cutting or grinding wheel and use it to cut through alternate soldered ends so that all the strips are connected in series. The two connections to the plate are made at the end of the strips as shown in the picture.
A 15 cm length of track at 20 °C has a resistance of around 70 mΩ. With the hotplate connected to 12 V a current of around 4 A was measured indicating a total resistance of 3 Ω i.e. approximately 83 mΩ per strip. The average temperature of the copper strips was measured at 65 °C.

Make sure that the connecting wire to the hotplate is of sufficiently heavy gauge to handle the expected current. Any wiring to a car battery should also include an in-line fuse, a short-circuit can be hazardous.

As well as making a good hotplate the strips can also be used to make a precise low impedance voltage divider network.

(080988)

Water Alarm

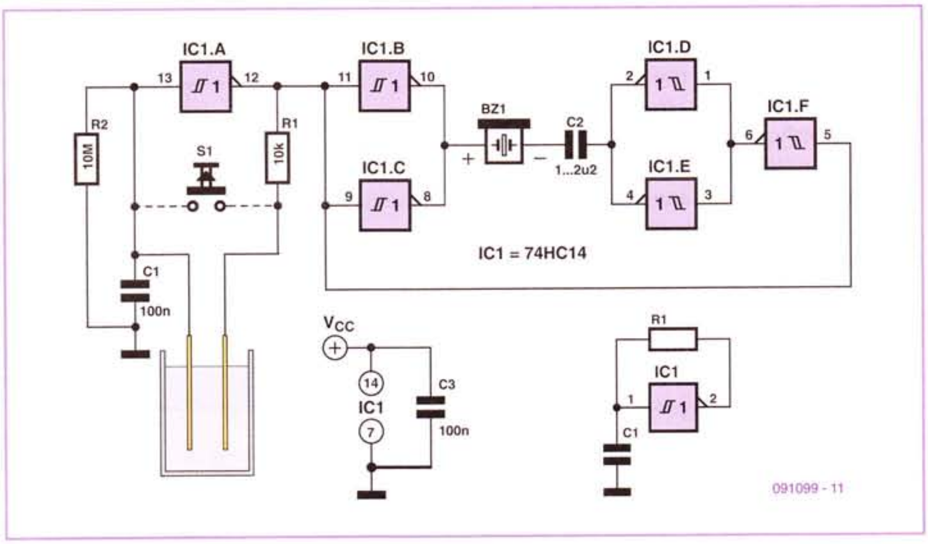
Roland Heimann (Germany)

The LM1830 fluid detector IC from National Semiconductor is designed to be able to detect the presence of fluids using a probe. This chip requires a relatively high supply voltage and is not the most frugal power consumer. It is also quite specialised so unless you are buying in bulk the one-off price is not cheap.

An alternative circuit shown here uses a standard CMOS IC type 74HC14. It has the advantage of operating with a 3 V supply and consumes less than 1 µA when the alarm is not sounding, this makes it ideal for use with batteries.
The 74HC14 has six inverters with hysteresis on their input switching thresholds. A capacitor (C1) and a feedback resistor (R1) is all that's necessary to make an inverter into a square wave signal generator.

In the water alarm circuit the feedback resistor consists of R1 and the water sensor in series. R1 prevents any possibility of short-circuit between the inverter's input and output. Resistor R2 defines the inverter's input signal level when the sensor is not in water. Any open-circuit (floating) input can cause the inverter to oscillate and draw more current. The remaining inverters in the package (IC1.B to IC1.F) drive the piezo buzzer to produce an alarm signal. Capacitor C2 ensures that no DC current flows when the circuit is in monitoring mode (with the alarm silent) this helps reduce the supply current.
A micro-switch can also be substituted for the water sensor to make the circuit a more general purpose alarm generator.

(091099)

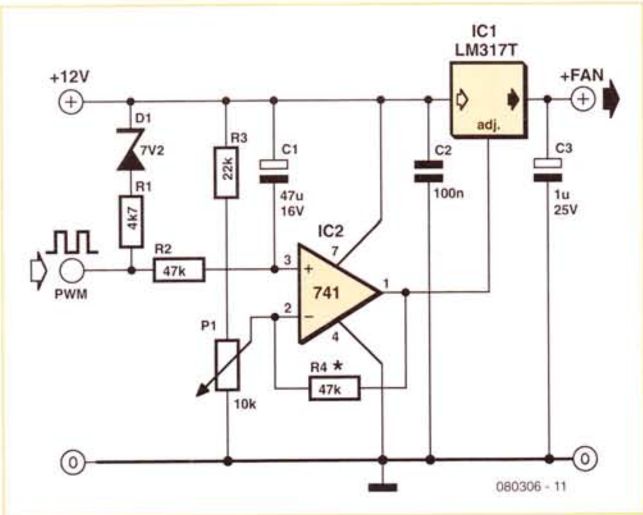


3-Pin Fan in 4-Pin Socket

Joachim Berg (Germany)

The most recent PC motherboards provide four pin connectors for cooling fans especially for the CPU fan. The older three pin fans are controlled by varying their DC voltage. The fourth pin on the newer connectors supplies a PWM signal to control fan speed. A three pin fan can be plugged into the four pin connector but with its fixed 12 V supply it runs at full speed all the time the PC is switched on. This is not an ideal situation if only for the noise levels.

During a recent motherboard upgrade the author was reluctant to replace his existing copper-finned CPU cooler which still had plenty of life left in it. An electronic solution was the only way ahead. A circuit was needed to convert the PWM signals from the fourth connector pin into a variable DC supply for the three pin fan. The PWM signal originates from an open collector output which can only be pulled up to a maximum of 5.5 V. For this reason R1 is connected in series with a zener diode to limit the pull up voltage to 4.8 V. The PWM signal is integrated by the network formed by R2 and C1. The resulting signal is amplified by an opamp (almost any type that can work at 12 V will do here). The opamp output signal controls an adjustable voltage regulator which supplies sufficient current even for the most powerful fan.



P1 adjusts the fan's minimum rotational speed (with a cold CPU). Capacitor C1 is connected to V_{CC} so that when the PC switches on it transfers almost the full 12 V to the opamp input to run the fan at full speed momentarily. This ensures the fan gets a small kick to get it going from rest. The regulation sensitivity can be adjusted by changing the value of R4. Incidentally the plug from an old floppy disk drive power connector can be used (after a little trimming) to connect to the 4-pin motherboard fan plug.

(080306)

Mobile Phone TX Demo

Jonathan Hare (UK)

This is a very simple and cheap device that demonstrates mobile phones (US: 'cell phones') generate RF energy (radio waves) strong enough to light an LED.

We have a 30 cm (7.5 cm per side) full-wavelength loop antenna (a 'Quad' to radio amateurs) connected to a germanium diode and a hyper-bright LED. The loop can be made of copper wire, thin sheet metal or a track on a PCB. The diodes need to be wired correctly. A germanium diode is preferable as the LED probably has too great a self-capacitance to perform at the very high frequencies generated by the phone (approx. 800/900 MHz or 1800 MHz) but will work well with the DC(-ish) pulses from the germanium diode (which has a small capacitance as well as low forward drop). In the junkbox or granddad's electronics drawer, look for fossils like the OA91, OA95, OA79 or AA119. The common or garden silicon 1N914 or 1N4148 will also work to degree and Schottky's like the BAT85 are

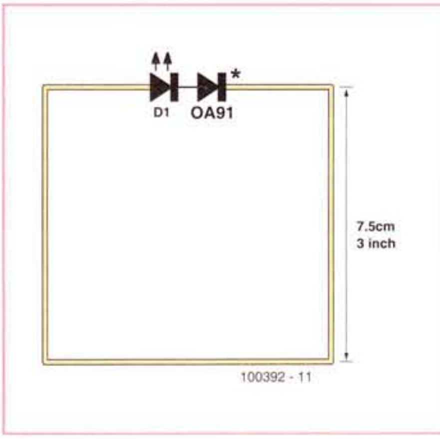
worth a try but eventually you'll find good old germanium rules.

To show the mobile's transmitter (TX) generates radio waves put it near to the loop and dial a number (use a freephone number, e.g. your voice mail) or text. The radio waves will induce a voltage into the loop, large enough to light the LED. The LED will flash indicating packets of digital data being sent by the mobile phone transmitter. You may need to set your phone to 'GSM 900/1800' (US: 'Cellphone 800') rather than the '3G' network in the settings menu. This may not apply to all mobile phones.

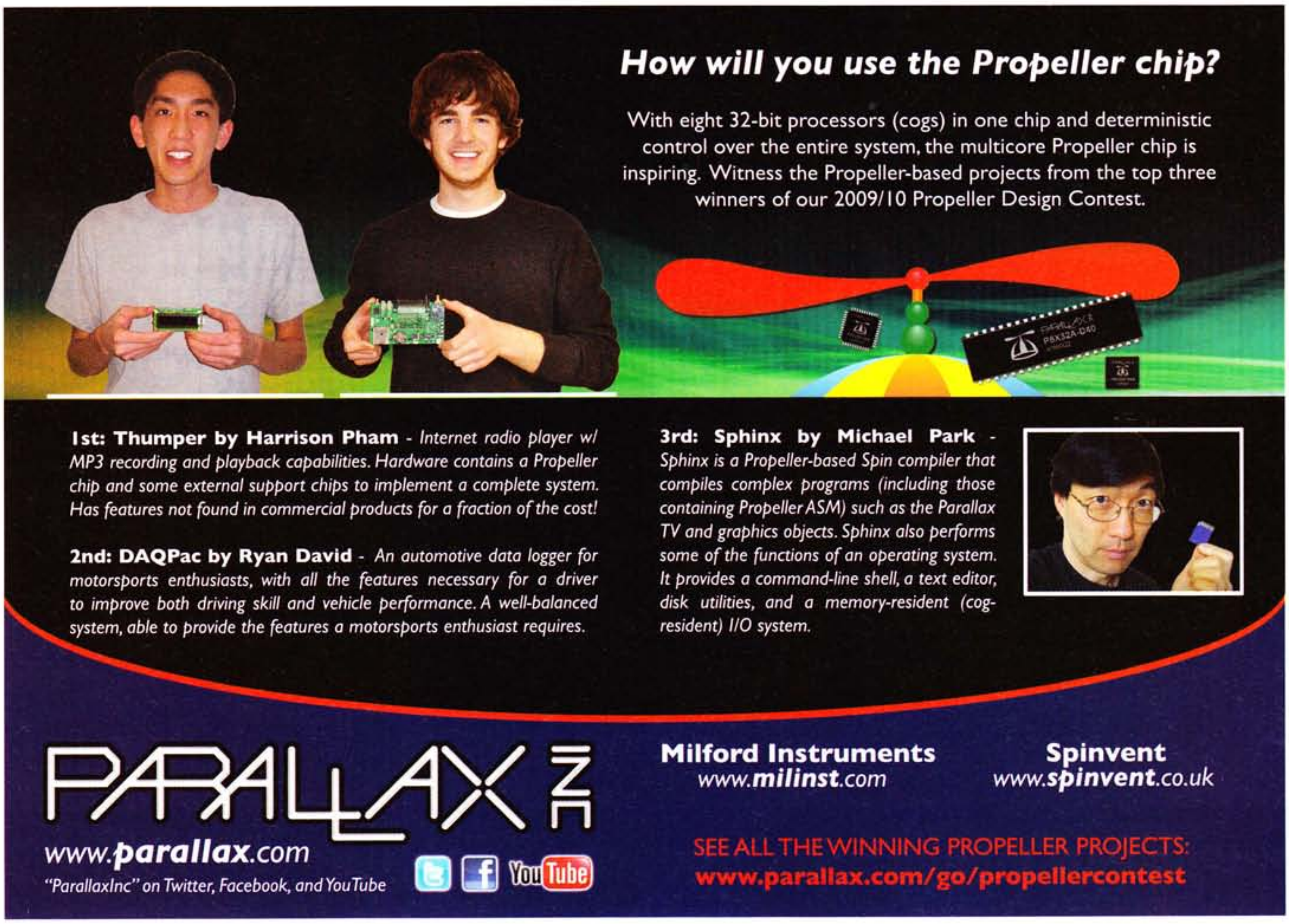
The circuit can also be used to prove that a mobile phone transmits well before producing a ring tone, as well as at intervals (using various power levels) to report its presence to the network.

For other experiments with this device please see the author's website [1].

(100392)



[1] www.creative-science.org.uk/mobile_LED.html

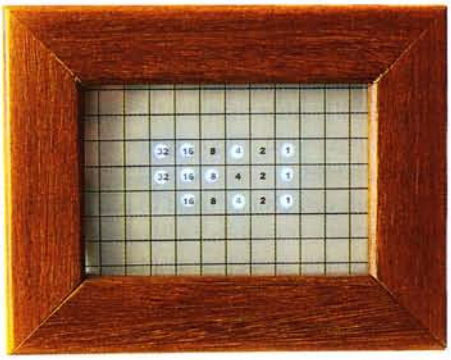


Binary Clock

Sanne-Martijn Kessel (NL)

This clock displays the time in binary using discrete LEDs. The use of Flowcode [1] makes it very easy to program the PIC controller in this project.

The circuit is very simple and can be constructed with individual parts on a piece of experimenter's board or using the relevant E-blocks modules: EB006 (1x PIC Multi-programmer), EB004 (3x LEDs), EB005 (1x LCD) en EB007 (1x switches). The firmware, which can be downloaded from the website for this article [2], determines how this circuit functions. Port B drives six LEDs for indicating the seconds, Port C drives six LEDs for indicating the minutes and port D takes care of driving the five LEDs for indicating the hours. Two pushbuttons on port E let you adjust the time (S1 for the hours and S2 for the minutes). This leaves port A available to drive the LCD display in 4-bit mode. For completeness, this display also shows the time, as well as the day of week (1 to 7).



S3 is used to reset the processor, which also results in the seconds being set to zero. The current through the (white) LEDs is about 11 mA, which means that the total current supplied by the PIC will always remain below 200 mA. The LEDs project their light onto white opaque glass, which is covered by a transparent sheet with numbers printed on it. On top of this is a clear pane of glass. The LEDs are mounted in a frame with holes, so they will always remain neatly in place.

For the power supply you can use a mains adapter with a stabilised 5 volt/400 mA output. Goldcap C4 is optional and can be added if you want to stop the circuit from losing the time when there is a brief power cut.

At midnight the time jumps forwards by 54 seconds in order to keep the exact time (if required, this can be changed in the Flowcode). This is necessary because increasing or decreasing the internal counter is either just too much or too little to keep perfect time.

In the photo the time is:
16+4+1= 21 hours (bottom row)
32+16+8+1=57 minutes (middle row) and
32+16+4+1=53 seconds (top row).

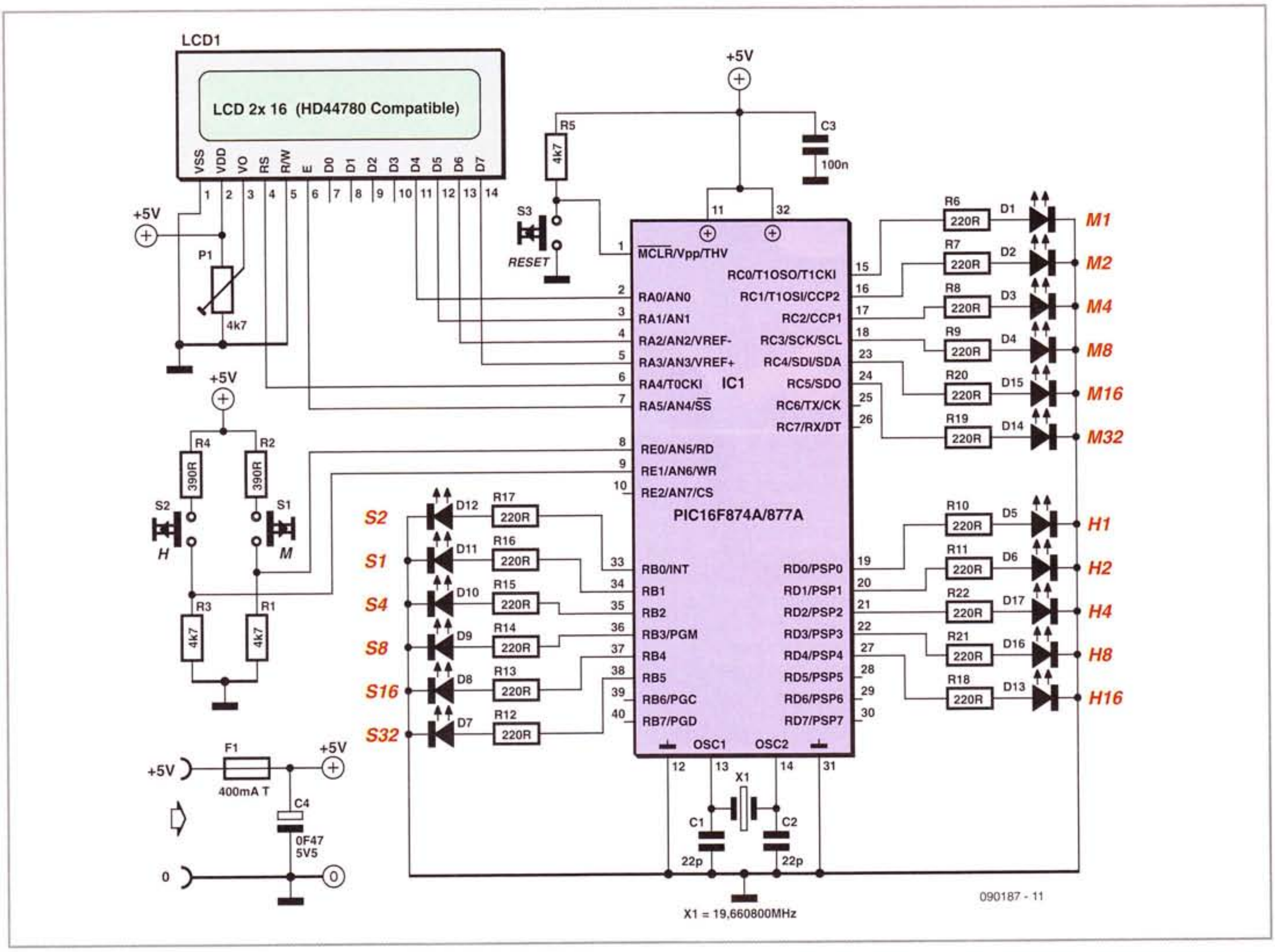
With the circuit housed in a suitable enclosure, you end up with a nice looking designer-clock, which is guaranteed to be noticed by any visitors!

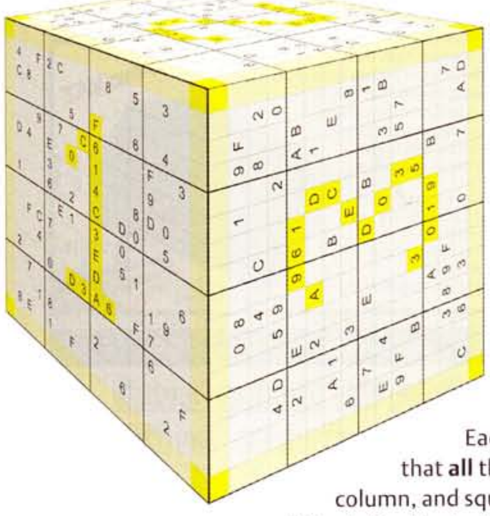
(090187)

Web links:

[1] www.matrixmultimedia.com

[2] www.elektor.com/090187





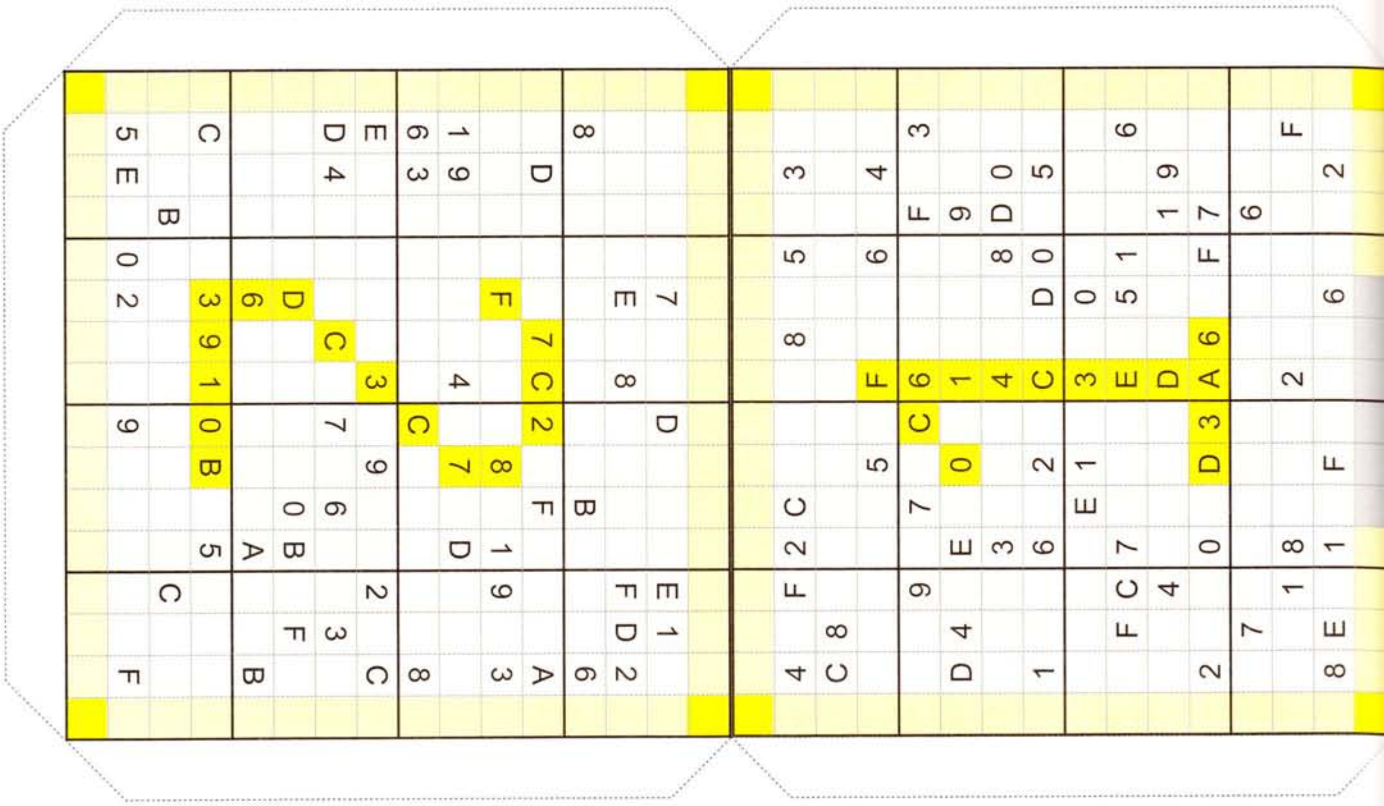
Hexadocube

Claude Ghyselen (France)

The Hexadocube is a cube or die where each face is occupied by a Hexadoku. The problem to be solved (the six linked grids) is just a flat 2D representation (referred to as the development) Note that the face numbers that appear in the background are arranged in such a way that the numbers on opposite faces always add up to 7, just like on a die.

Each grid uses figures from the hexadecimal system, i.e. from 0 to F. Fill in each grid in such a way that **all** the hexadecimal figures from 0 to F (0 to 9 plus A to F) are used **once and once** only in each row, column, and square of four boxes (marked by a bolder outline). Certain figures have already been entered in the grid to define its starting situation.

Attempting to solve each grid individually is impossible, as each grid is linked with its four 'neighbours' by the boxes lying along the edges of the cube (boundaries) that separate them. These boxes are coloured yellow, and are deliberately left empty in



Where to send your entry?

Send your answer (the figures in the greyed-out section, from bottom to top) with your address by e-mail, fax, or post before **September 1, 2010** to:

Elektor Hexadoku - 1000, Great West Road
Brentford TW8 9HH - United Kingdom.
Fax (+44) 208 2614447 Email: hexadoku@elektor.com

Join in and win!

Send us the six hex figures in the greyed-out area (from bottom to top). We'll hold a draw of all the correct international responses we receive; the winner will receive **a complete Sceptre-Intersceptre kit** worth £236 We're also giving away three Elektor gift vouchers worth £40 each. So get those grey cells working!

No correspondence will be entered into, and Elektor International Media staff and their families may not enter. One winner only per household.

Prize winners

The solution of the May 2010 Hexadoku is: **C81BA**.

The £80.00 voucher has been awarded to: Olivier Heurtel (France).

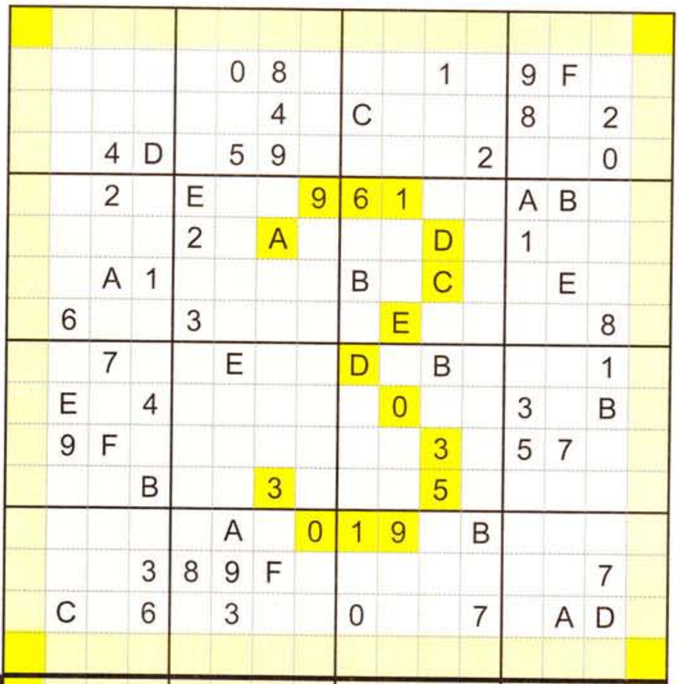
The £40.00 vouchers have been awarded to: Darjo Brlec (Slovenia), Recep Alaca (France) and Werner Stumpf (Germany).

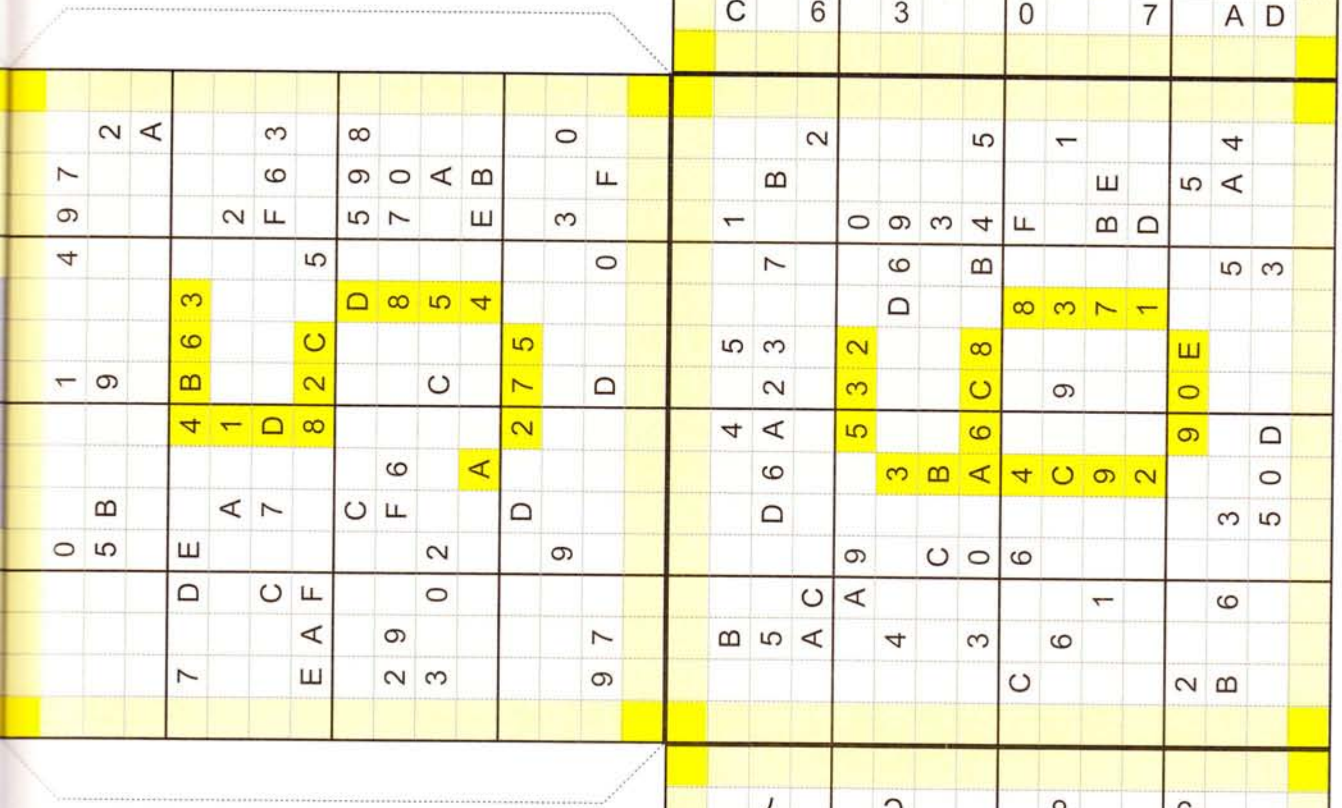
Congratulations everyone!

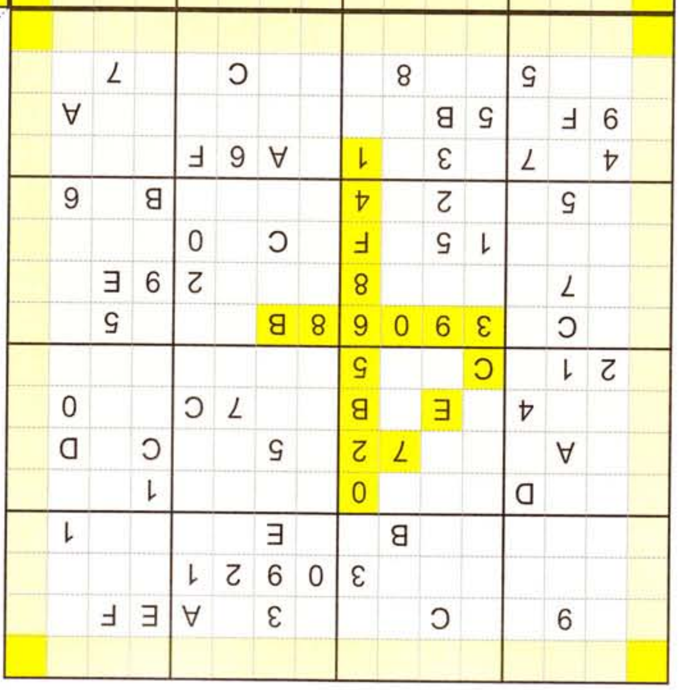
the opening situation.

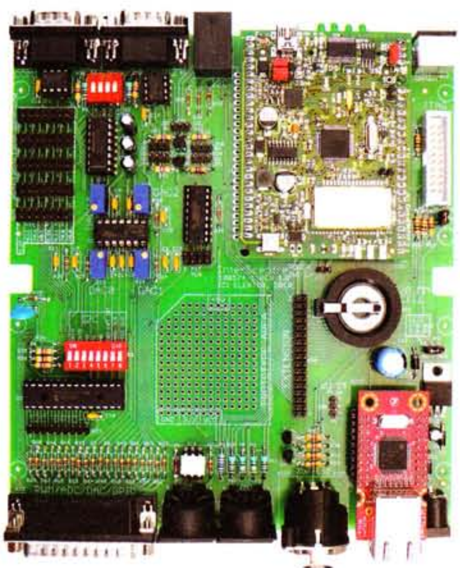
The values that fit in a back-to-back pair of these boxes (either side of an edge, hence belonging to two different faces) must be the same. For example, a character A found on face 1 along the edge with face 2 will have to be copied across into the box on face 2 on the other side of the boundary. In the same way, the corners of the cube (there are eight of them, coloured orange) which belong to three faces must have the same values on all three faces.

(090724-I)



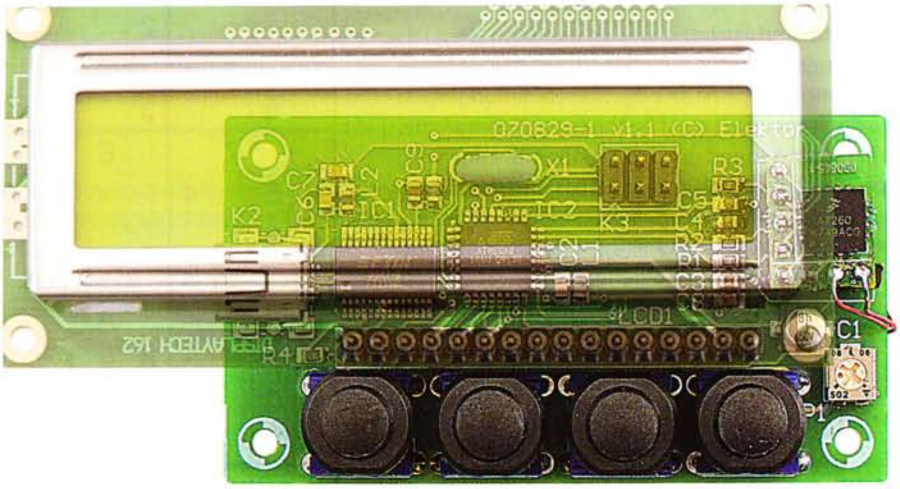






USB Tilt Sensor

Wilfried Waetzig (Germany)

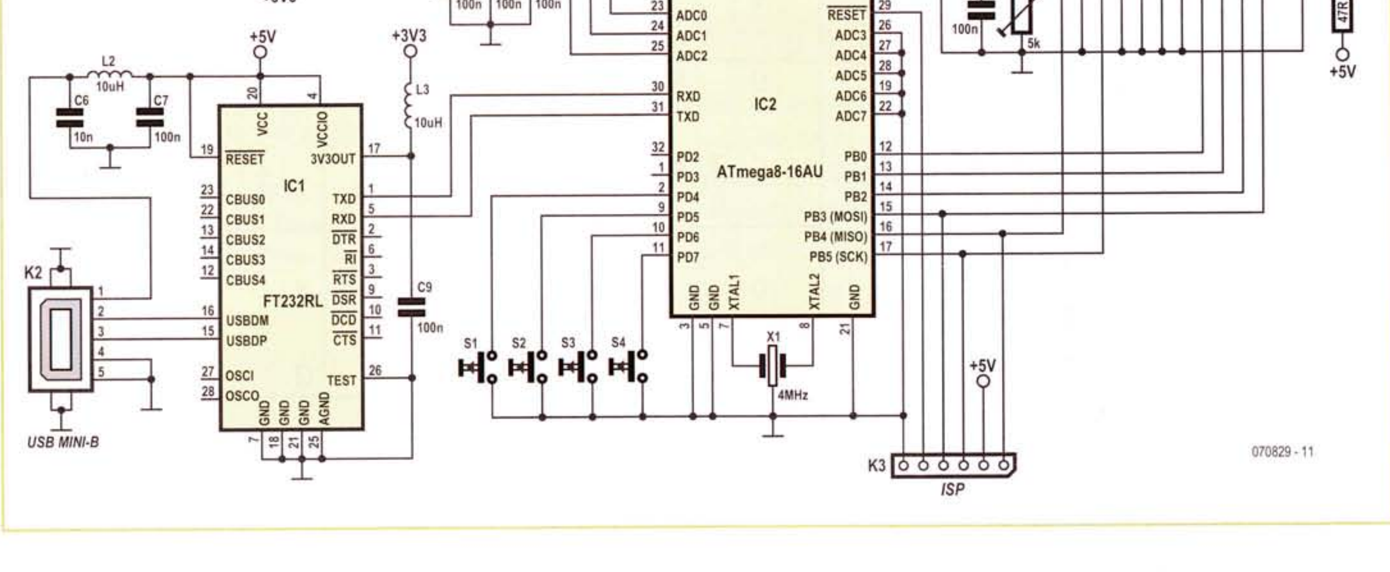


A tilt sensor is a very versatile device: for example, it can be used as a (game) controller or as an alarm sensor to protect valuables. The circuit described here uses the same sensor as we used in our two-axis accelerometer project [1]. The Freescale MMA7260Q can measure accelerations along three spatial axes, producing three proportional analogue output voltages [2]. The sensitivity of the device is adjustable in four steps. For the purposes of this project we use the 800 mV/*g* setting, giving a full-scale range of –1.5 *g* to +1.5 *g* on each of the three axes. The IC comes in a tricky-to-solder QFN package, and so to make life easier we have made available a small carrier board with the device already mounted ('MMA7260 on carrier board', order code 090645-91: see [3]).

The carrier board is simply plugged into the main board via two 4-way pinheaders. If the main board is now tilted about its main horizontal axis (or about the perpendicular horizontal axis), the sensor will record an acceleration in the X (respectively Y) direction equal to some fraction of 1 *g*, the acceleration due to the earth's gravity. From this value we can determine the tilt angle. In practice the sensor is not tilted about just one of its axes, and this is where the Z-axis acceleration measurement comes into play: we can use this value to help determine the deviation from vertical of the axis perpendicular to the main board. In general we can use the three acceleration values to compute a tilt angle in the X and Y directions, assuming that it is held steady and not subjected to any translational accelerations.

Based on the author's suggestions, Elektor lab trainee Jerry Jacobs designed a compact printed circuit board, which can be ordered via the Elektor website [3]. As usual, a pre-programmed microcontroller is also available, or, if you prefer, you can download the software as a hex file or as source code and program it yourself.

The circuit is relatively simple. The central component is an ATmega8-16 microcontroller, which drives an LCD panel via port B and which is controlled by pushbuttons connected to port D. The analogue signals from the acceleration sensor are connected to the analogue inputs ADC0 to ADC2.
Practically all the passive components are concerned with decoupling and smoothing,



with the aim of making the analogue measurements as accurate as possible. Particular attention is paid to smoothing the analogue supply to the microcontroller (AV_{CC}).

Power is provided over a USB connection, which also provides a means to transfer the measured angular values to a PC or other host. The well-known FT232RL device is used as a UART-to-USB bridge. The 3.3 V power supply for the sensor, which also forms the reference voltage for the ADC, is provided by the FT232RL, which obviates the need for a separate 3.3 V regulator.

Now we turn to the mathematics involved, which are essential to understanding the software. The ADC resolution is 10 bits and so the analogue voltages at ADC0, ADC1, ADC2 are converted to digital values as follows:

val = U*1024/V_{ref},

where V_{ref}=3.3 V. A value of $V = V_{ref}/2$ = 1.65 V corresponds, according to the device datasheet, to an acceleration of 0 *g*; *V* = 2.45 V corresponds to +1 *g* and 0.85 V to –1 *g*. For tilt angle measurements these are the maximum and minimum values that should be encountered, corresponding to inclinations of +90 ° and –90 °. Call the corresponding ADC conversion results (760 and 264, obtained from the formula above) ADCmax and ADCmin.

In practice the system must be calibrated before making measurements, which in this case means determining the values of ADCmin and ADCmax for each of the three axes. Each axis is calibrated separately, by holding the board vertical in all possible orientations: it is easiest to hold it against a solid vertical surface. At the end of the process we have determined all the ADCkmax and ADCkmin values (where *k*=0 for the X axis, 1 for the Y axis and 2 for the Z axis).

Button S4 then starts the measurement process. The readings are smoothed by averaging 16 consecutive conversion results, which helps to reduce the effect of small vibrations.

Given the current averaged readings for ADCkvalue (where *k* runs from 0 to 2) the software calculates:

(X/Y/Z)gval = (ADCkvalue – ADCkmid) / ADCkdif

where ADCkmid = (ADCkmax + ADCkmin)/2 and ADCkdif = (ADCkmax – ADCkmin)/2.

Xgval, Ygval and Zgval are then the measure accelerations (as a fraction of 1 *g*) along each axis. Freescale Application Note AN3461 [4] describes a method for deriving the values xangle, yangle and zangle:

tan (xangle) = Xgval / sqrt (Ygval^2 + Zgval^2)
tan (yangle) = Ygval / sqrt (Xgval^2 + Zgval^2)
tan (zangle) = sqrt (Xgval^2 + Ygval^2) / Zgval

Here xangle is the pitch (the angle the X axis of the acceleration sensor makes with the horizontal, positive for a clockwise tilt viewed from in front of the board), yangle is the roll (the angle the Y axis of the acceleration sensor makes with the horizontal, positive when the board is tilted towards you) and zangle is the overall tilt (the angle the Z axis of the acceleration sensor makes with the vertical, positive for any tilt). When the board is horizontal, all angles are zero.

The web page accompanying this article [3] links to a free extra document for download covering initialisation, calibration and more. There is also a brief description of the communication protocol used with the PC, and details of fuse bit settings in the microcontroller. The web page also includes the parts list and software downloads, and links for ordering the microcontroller and circuit board.

(070829)

[1] www.elektor.com/060297

[2] www.freescale.com/files/sensors/doc/data_sheet/MMA7260QT.pdf

[3] www.elektor.com/070829

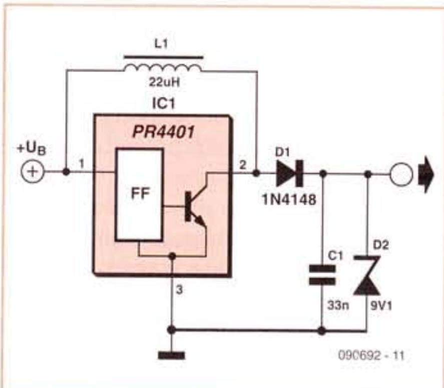
[4] http://cache.freescale.com/files/sensors/doc/app_note/AN3461.pdf

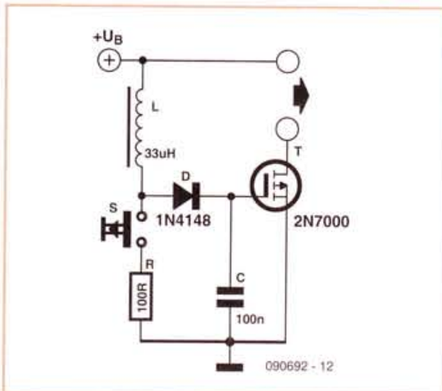
Virtual 9 V Battery

Jakob Trefz (Germany)

PP3-size 9 V batteries (IEC: 6LR22) have a considerably poorer price/energy ratio than 1.5 V AA (IEC: LR6) cells. This makes it all the more unfortunate when you accidentally leave a device switched on!

The author uses a number of such devices and so started looking for a solution to this problem. His first thought was to use a DC/DC converter to allow the use of 1.5 V cells in 9 V equipment. A perfect device for this application is the Prema PR4401 LED driver. The IC is small, with just three connections, and the required external circuitry consists of just a coil, a diode and a smoothing capacitor. The device can convert input voltages of between 0.9 V and 1.9 V to 9 V with acceptable efficiency. The maximum load is around 3 mA.





However, this is only half the story. Even when there is no load at the output the IC still draws current, and so the battery will eventually run flat even if the equipment is switched off. This means that some kind of automatic shutdown circuit is needed. How can we make a timer that runs on less than 1 volt and which consumes only a negligible current? The answer was found in the form of a MOSFET with a very low on resistance and a threshold voltage of just over 3 volts. This voltage is still more than twice the terminal voltage of an AA cell, however; we need to generate a sufficiently high voltage (greater than 3 V) briefly and store it on a capacitor. The capacitor will discharge very slowly into the gate of the MOSFET to which it is connected, which will then cause the connected device to be powered for a few minutes before being turned off.

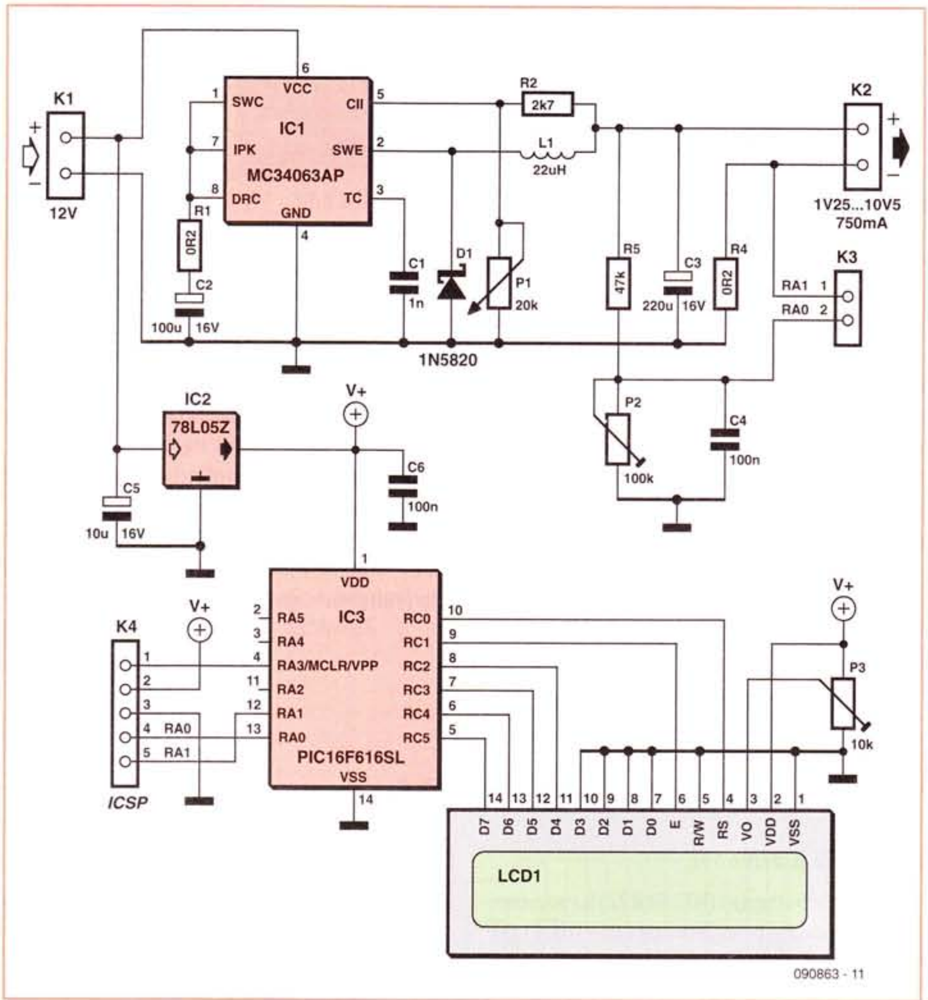
The self-inductance of coil L is used to generate the higher voltage. When switch S is briefly closed a current flows in the coil. We need to check that the maximum gate voltage of the MOSFET (20 V) will not be exceeded: from the maximum input voltage (approximately 1.6 V), the current that briefly flows through R (approximately 1.5 mA) and the inductance of L we can calculate how much energy can be stored in the coil. When S is opened C is charged via D, and we can then work out the resulting voltage across C. With the component values given, this comes to about 5 V. The author's prototype gave a power-on period of 15 to 20 minutes.

(090692)

Bench PSU for PC

Ludovic Voltz (France)

Given that every PC has a powerful, well-regulated PSU that supplies, among other things, a 12 V rail, why not make use of it to produce a PSU variable from 1.25 to 10 V? Well, that's just what we're proposing to do here. This power supply can also be used as an addition to a conventional bench supply in order to simulate an analogue voltage, if the bench supply has only one output.



The conversion part is entrusted to the cheap and very popular MC34063 DC-DC converter, arranged as a step-down. Using a switching solution makes it possible to limit losses due to the Joule effect. The MC34063 is associated with a microcontroller, aided by an LCD display (1×16 characters) which lets you display the output voltage along with the current being supplied by the PSU (connect K3 to pins 4 an5 of K4). Under ideal conditions, 700 mA may be drawn, but don't worry, the IC includes a current limiter which will come into action as soon as you go over the limit.

Program the microcontroller using the software available from [1] and adjust P2 to make the displayed output voltage correspond with the actual value. Note that certain single-line 16-character displays behave like a display with two lines of eight characters. The download contains two HEX files for dealing with both eventualities.

Once the PSU has been assembled, you will be able to house it in one of your computer's spare slots for a 5¼-inch floppy disk drive.

One last little detail: to allow more accurate setting of the output voltage, you can include a second 1 kΩ potentiometer in series with P1.

(090863-I)

[1] www.elektor.com/090863

Green/Red Multiflasher

Ken Barry (UK)

This circuit can be made to produce interesting and attractive light effects using just a cluster of red LEDs and one of green LEDs. One effect is first alternating between red and green, and then lighting red and green together. With the exception of the triple LED devices (Rapid Electronics # 56-0205 for green, # 56-0200 for red) all parts are cheap and easy to find, possibly even in your junkbox.

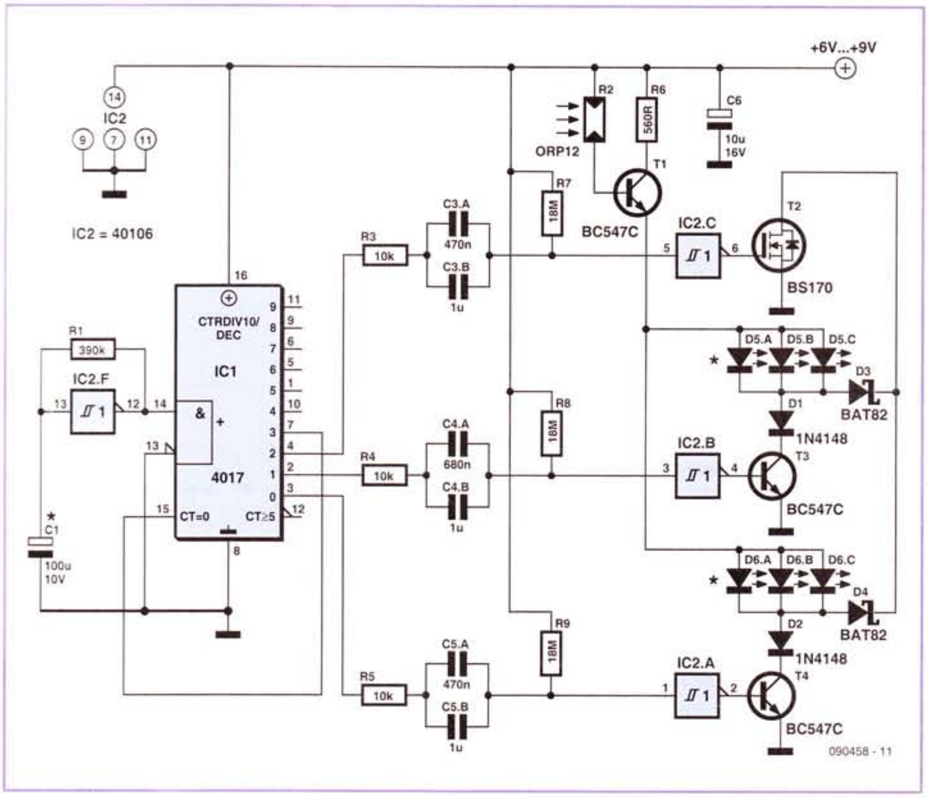
The values of networks R3/C3, R4/C4 and R5/C5 govern the length of the flashes. Using the indicated values, these are about 18 seconds with a 0.5 second interval.

Because the colours used do not have equal luminous intensity (expressed in millicandelas) D1 and D2 are silicon diodes and D3 and D4, germanium, with Schottky devices (BAT82) as an alterative because they also exhibit a low forward drop of about 0.3 V. As germanium devices, look for the OA91, OA85 or AA119. If D1 and D2 are omitted, Green and Red are brighter by themselves than when on simultaneously.

MOSFET T2 switches both LED devices on simultaneously arranging for roughly equal luminous output.

The display has an integrated LDR that causes the LEDs brightness to adapt automatically to darkness and bright light conditions.

The circuit has lots of openings for experimentation and adaptation, for example, the flash rate is determined by the value of C1, while the link between the counter's R (reset) input and O3 output determines if a space is inserted after the last flash, or not. Colourful and lively effects may also be obtained by using tri-colour LEDs with a common anode. The power consumption of the circuit depends largely on the LEDs used. With the Rapid LED types shown, about 70 mA may be expected at a 6 volts supply voltage.



(090458)

Electret Mic Booster

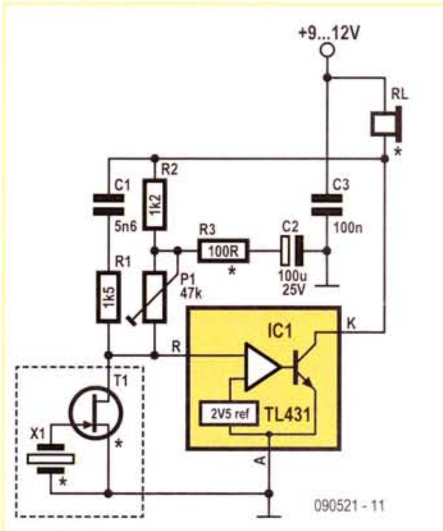
Ian Field (UK)

Anyone who's spent much time searching the web for interesting circuits is likely to have found at least one TL431 based audio amplifier, the circuit being based on the principle that any comparator can be used in linear mode if it's rolled off with enough negative feedback. Although the TL431 is often referred to as a programmable or adjustable zener, it is in fact a comparator with it's own 2.5 V reference all neatly wrapped up in a TO92 package.

The problem with the TL431 amplifiers to be found on the web is that they simply roll it back with large nfb and leave it at that, which results in very low gain, to make matters worse some such circuits make a bit of a hash of biasing the control input.

The circuit presented here takes care of the low gain by adding an AC shunt to the feedback path and using an electret mic for the input — the 2.5 V set on the control input at stable operating condition suits an electret mic perfectly. The first prototype had a 35 ohms loudspeaker as a load (R_L), this gave good results although the TL431 ran a bit warm with a V_{cc} of 12 V. An old 130 ohm telephone earpiece is likely to present a less stressful load. AC shunt C2 (100 µF) has to be a quality component in terms of its ESR specification — don't just use a scruffy capacitor lying about as you may experience RF sensitivity. It was necessary to add a series resistor (R3; about 100 ohms) or in extreme cases an inductor (L1; 100 – 220 µH). Components C1 & R1 are entirely optional to selectively feed some un-shunted feedback to reduce noise; 1.5 kΩ & 5.6 nF are as good a place as any to start off with.

Initial set-up depends on the current drawn by the electret mic and the value for R_L — anywhere between 200 and 2,000 ohms is good. R2 allows the TL431 cathode to swing despite the AC shunt, 1.2 kΩ was found to be satisfactory, P1 can be a 47 kΩ trimpot and is used to set the voltage drop on R_L. In the case of moving-coil speakers a compromise between voltage swing and pre-biasing the cone should be sought, with a resistive load adjust for 0.5 V_{cc}, once the operating point is determined P1 can be measured and replaced by an equivalent fixed resistor.



The circuit has a couple of handy features, firstly it works very well on the end of a twisted-pair — the output can be tapped off at the wiper if R_L is a pot at the power supply end, secondly by salvaging the JFET from an old electret mic (some common types of JFET will work but not quite as well), just about any piezo electric element can be used as the transducer. Brass disc sounders give a good output (handy as vibration sensors if glued to a structure); even the quartz discs from clock crystals give some output, a phono crystal cartridge gives a high output and the piezo-ceramic pellet from a flintless cigarette lighter gives a huge output... the range of possible applications is awesome!

A surprising application is the ability to test the microphonic sensitivity of ordinary capacitors! Disc ceramic types don't need to be tapped very hard to produce an output but rolled metalised foil types produce some output too.

(090521)

LED Tester

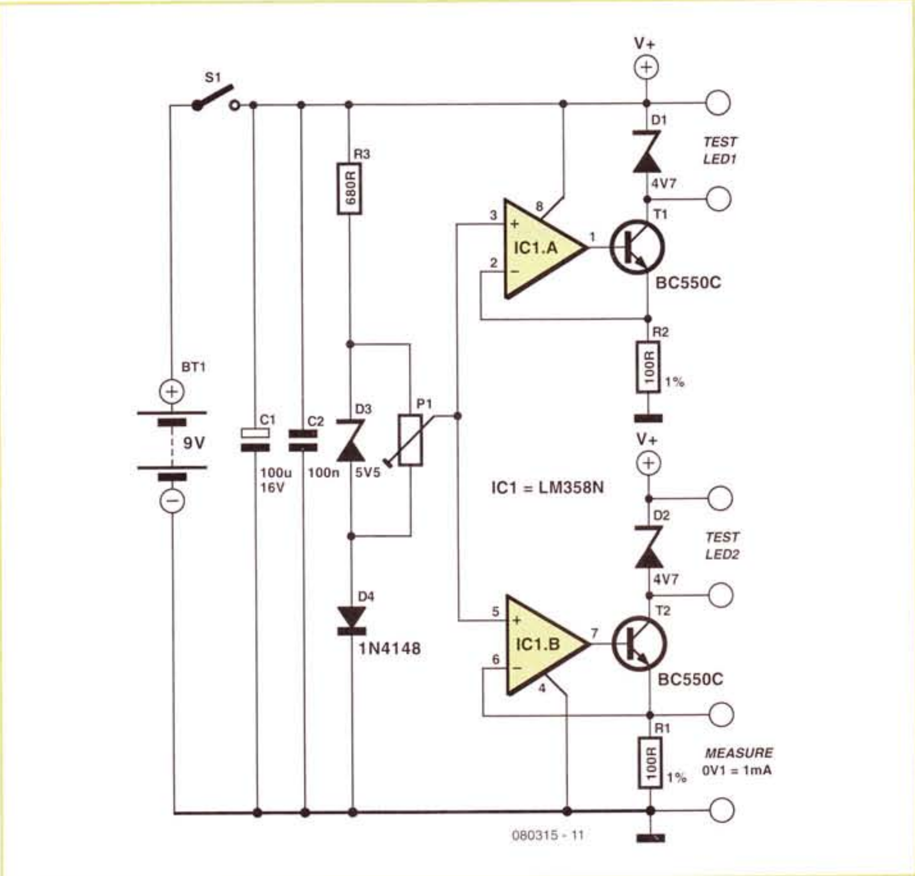
Herbert Musser (Austria)

In some circumstances it may be necessary to select LEDs with closely matched characteristics. This design makes the job a whole lot easier. It uses two tracking current sources to allow the comparison of the two LEDs under test. LED current is adjustable by potentiometer P1 giving a range from 1 to 50 mA. Zener diodes D1 and D2 ensure that the voltage across the LEDs cannot rise above 4.7 V. This prevents the LEDs from being destroyed if they are accidentally connected to the tester the wrong way round.

Each of the two opamps together with a transistor builds a voltage controlled current source (more accurately a current sink). Each of the 100 Ω emitter resistors act as a current sense, the voltage developed across them is proportional to the LED current. A voltage of 100 mV per mA of LED current can be measured across the emitter resistor using either a DVM or panel meter. This allows precise control and display of the LED current.

Current through both LEDs track together with very good accuracy and makes it a simple job to identify matching LEDs.

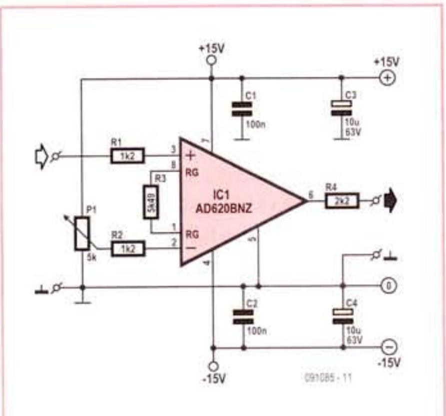
(080315)



Voltage Difference Magnifier

Egbert Wolters (The Netherlands)

This circuit was designed for monitoring the charge- and discharge process of a 6-V lead-acid battery. This process takes place between 6.2 V and 6.8 V. The author used a measuring instrument that has several measuring ranges (0–1 V, 0–10 V, etc.). The 10 V range, however, is too coarse for this measurement. A better measurement result could be obtained if 6 V were subtracted from the measured voltage. The measuring range would then be from 6 to 7 V.



A single opamp such as the LF351 suffered from mutual dependency of the measured and offset voltages and was therefore not suitable. The AD620 from Analog Devices, however, has been especially designed for this type of application and works well. In this opamp each of the input signals has its own opamp, so that they do not interfere with each other.

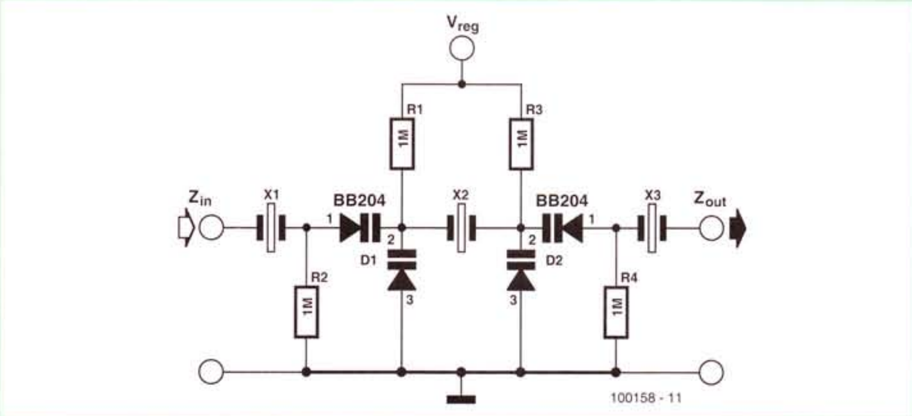
The schematic is simple. The offset voltage can be set accurately with a 10-turn potentiometer. The resistor of 5.49 kΩ (1%) can be connected or removed from the circuit with a jumper; without the resistor the gain

is one, with resistor the difference voltage will be amplified 10 times (9.998 times, to be more accurate).
The AD620 draws slightly more than 1 mA (idle current is 1.3 mA max.), so that battery power is also an option. The IC can be used with power supply voltages ranging from ±2.3 V to ±18 V. Small button cells could even be considered when doing only brief measurements. The maximum differential voltage is 25 V, something that you will have to take into account, particularly if you are going to measure an unknown voltage.

The greatest DC-accuracy is obtained with the version of opamp shown in the circuit. There is also a cheaper version, the AD620ANZ (the Z stands for lead-free). For a good application note about the AD620 we can recommend the document that describes the evaluation board made by Analog Devices (EVAL-INAMP-62RZ_82RZ_82_RMZ.pdf at [1]), in addition to the data sheet, of course.

(091085-I)

Variable Crystal Filter



U_r (V)	bandwidth (kHz)		
	–3 dB	–20 dB	–40 dB
0	2	6.2	17.9
0.5	2.7	7.0	20.6
1	3.2	7.7	22.0
2	4.0	8.5	24.4
4	4.6	9.6	29.9
8	5.5	10.7	33.2
16	6.4	12.1	38.5
30	7.3	13.6	40.2
Measured at $Z_{in} = Z_{out} = 330\ \Omega$			

Gert Baars (The Netherlands)

Crystal filters are often used for IF filters in receivers, where the bandwidth of this filter largely determines the selectivity of the receiver. The unique feature of the filter described here is that the bandwidth has been made adjustable.
The configuration is a so-called ladder filter with three crystals of the same frequency. Because the crystals should actually be identical, we recommend that you buy three from the same production batch, which is generally the case of you order/buy them all at the same time.
Varicap diodes are usually specified from U_r= 0.5 V. The measuring result for 0 V is shown nevertheless. With a range in U_r = 0 to 12 V, the bandwidth is adjustable from 2 to 6 kHz, which is suitable for the range of CW/SSB to standard AM.

The ripple of the filter is determined by the input and output impedances Z_{in} and Z_{out}.

With smaller values of Z_{in} and Z_{out} the ripple will increase, but the roll-off will be steeper. A compromise is $Z_{in} = Z_{out} = 330\ \Omega$ resulting in a ripple of <3 dB. It is expected that the characteristics at other IFs such as 10.7 or 9 MHz will be much the same.

(100158-I)

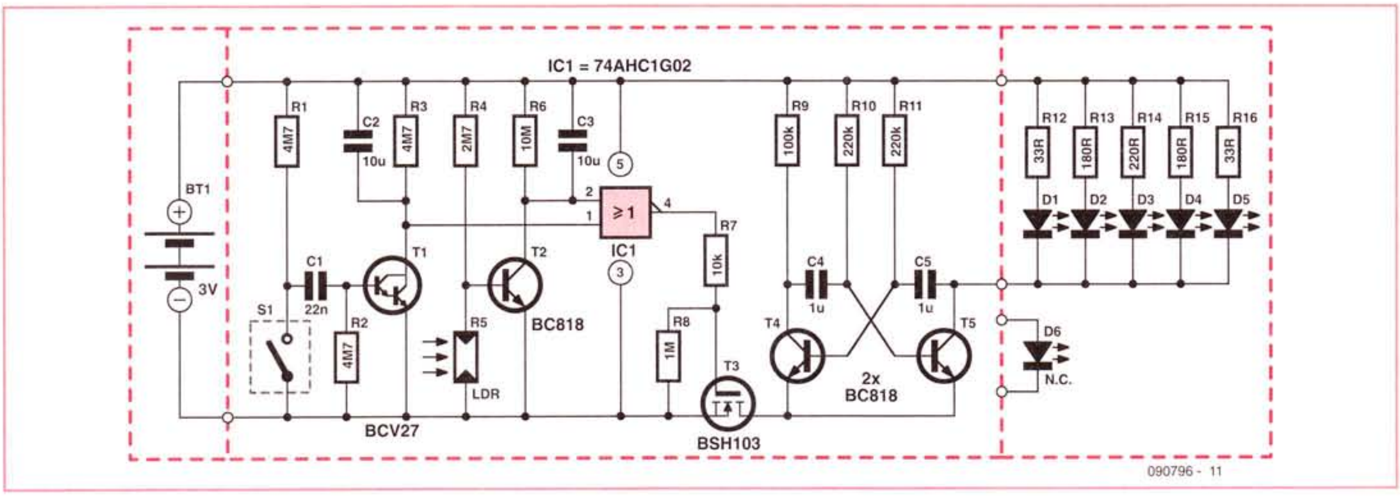
Automatic Rear Bicycle Light

Ludwig Libertin (Austria)

This is a design for a rear bicycle light that automatically switches on and off according to ambient lighting conditions. The red LEDs flash with a 50 % duty cycle to save energy; you can modify the circuit to light the LEDs continuously if local laws require it. The circuit can of course also be used as a safety light by pedestrians.

The author bought a commercially-available rear bicycle light and replaced the printed circuit board inside with his own design: the circuit is shown here. Space was rather tight, and so surface-mount devices were used in the construction of the prototype. Leaded devices would of course work just as well, and the 10 µF SMD film capacitors can be replaced by electrolytics.

The five high brightness red LEDs shown to the right of the circuit diagram were already present in the original unit, on their own circuit board along with their series resistors. This part of the unit was re-used. This explains the variation in value of the series resistors, which can be changed according to the brightness desired and the characteristics of the LEDs used. The original light also included a green LED (D6), which we do not use in this design.
The circuit has two sensors: a vibration switch (S1) in a TO18-like package (for example, RS Components order code 455-3671) and an LDR (R5, a standard type with a resistance when illuminated of around 250 Ω and a dark resistance of at least 10 MΩ). When the bicycle is moved the vibration switch will open and close its contact, generating pulses at the base of Darlington T1 via C1, causing it to turn on. C2 is thus charged and the input to gate IC1.A (pin 1) goes low. If it is sufficiently dark the voltage produced by the voltage divider formed by R4 and LDR R5 will be greater than 0.6 V, causing transistor T2 to conduct and C3 to charge. When C3 is charged a low level will appear at the second input (pin 2) to gate IC1.A.



If both inputs are at logic zero the output of the NOR gate will go high, causing FET T3 to conduct. As a result power is supplied to the astable multivibrator comprising R9, R10, R11, C4, C5, T4 and T5, and the LEDs will flash at 5 Hz. They will continue to flash for as long as pulses continue to be supplied by the vibration sensor S1 and as long as it remains sufficiently dark.

If the vibration sensor stops providing pulses (because the bicycle is stationary) C2 will no longer be charged and will gradually discharge over a period of 25 seconds or so through parallel resistor R3. The output of the gate will go low and T3 will block; hence after the expiry of the 25 second delay the LEDs will go out.
If the bicycle is moving and S1 is delivering pulses, but the LDR is illuminated (perhaps by passing cars or by street lighting) the LEDs will continue to operate for about 70 seconds, with C3 keeping its input to the gate low.

The circuit is designed to run on 3 V (two AAA cells). The quiescent current consumption is less than 2 µA and the batteries should last for over 300 hours of operation.

In practice the vibration sensor was found to be so sensitive that it delivers pulses even when the cyclist is waiting at a traffic light, and so the LEDs continue to flash. The LEDs only go out when the bicycle is perfectly still.
The ambient light threshold can be set by adjusting R4 to suit the characteristics of the LDR.

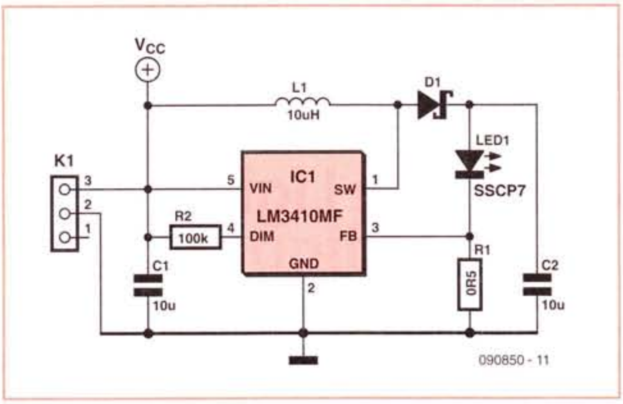
To modify the circuit so that the light is steady rather than flashing, remove T4, T5, C4, C5, R9, R10 and R11 and connect the cathodes of LEDs D1 to D5 directly to the drain of FET T3.

(090796)

The LM3410 LED Driver

Steffen Graf (Germany)

The LM3410 IC is a constant current LED driver useful in either boost converter or SEPIC design applications. A SEPIC (Single Ended Primary Inductance Converter) design allows the power supply's output voltage to be set above, below or equal to its input voltage. In this application the chip is configured as a boost-converter (i.e. the output voltage is greater than the input voltage).
The LM3410 is available in two fixed-frequency variants. Using either the 525 kHz or 1.6 MHz clock version it is possible to build a very compact LED driver. The output stage can supply up to 2.8 A, allowing several high-power LEDs to be driven from a rechargeable Lithium cell or several 1.5 V batteries. The chip also features a dimmer input giving simple PWM brightness control.
Output current is defined by an external shunt resistor. To keep losses low the LM3410 uses an internal voltage reference of just 190 mV.



Power dissipation in the shunt resistor is therefore low. Using the desired value of LED current the value and power dissipation of the shunt resistor is given by:

R_Shunt = 0.19 V/I_LED
P_Shunt = 0.19 V*I_LED

A 10 µH coil (L1) will be sufficient for most applications providing it has a suitable saturation current rating. The Input and output capacitors should be 10 µF ceramic types with a low value of ESR. Many distributors including Farnell stock these components. The Diode should be a Schottky type (as in all switching regulators). The author has developed a PCB for this design; the corresponding Eagle files can be freely downloaded from www.elektor.com/090850. In summary the most important features of the LM3410 are:

- Integrated 2.8 A MOSFET driver.
- Input voltage range from 2.7 V to 5.5 V.
- Capability to drive up to six series connected LEDs (maximum output 24 V).
- Up to 88 % efficiency.
- Available is 525 kHz and 1.6 MHz versions.
- Allows both boost and SEPIC designs.
- Available in 5 pin SOT23 or 6 pin LLP outline.

(090850)

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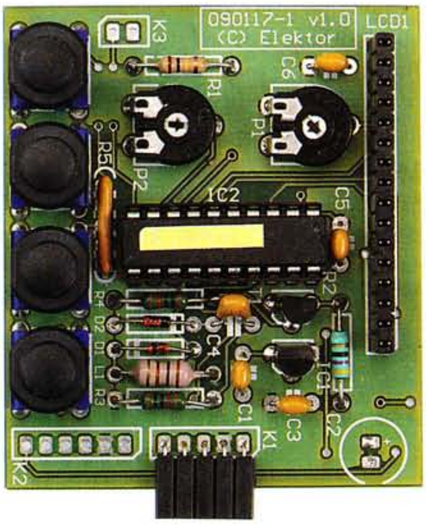
Sailor's Battery Meter

Anders Gustafsson (Finland)

On a sailboat, the condition of the battery is a major concern for obvious reasons. On the author's boat, a 120 Ah lead-acid battery is charged from a 25 watts solar panel. The battery monitor described here was designed to give peace of mind. It consists of two sub circuits: a sensor and a control/readout.

Lead-acid batteries are subject to self-discharge, usually expressed as a percentage of the total capacity per month, at 25 °C. A figure of 5% for a 100 Ah battery means that you will have 95% left after one month at 25 °C. Self-discharge is temperature-dependent, doubling for every 10 °C above 25 °C and halving for every 10°C below 25 °C. This is incidentally why batteries last longer if stored cold (but not freezing).

To accurately monitor a battery you need to measure the current into the battery and out of the battery. You also need to monitor temperature to be able to calculate self-discharge accurately. To make things more difficult, neither a photovoltaic panel, nor a fridge compressor represent constant sources or loads, instead they vary with time. Another problem is that you need to accurately measure

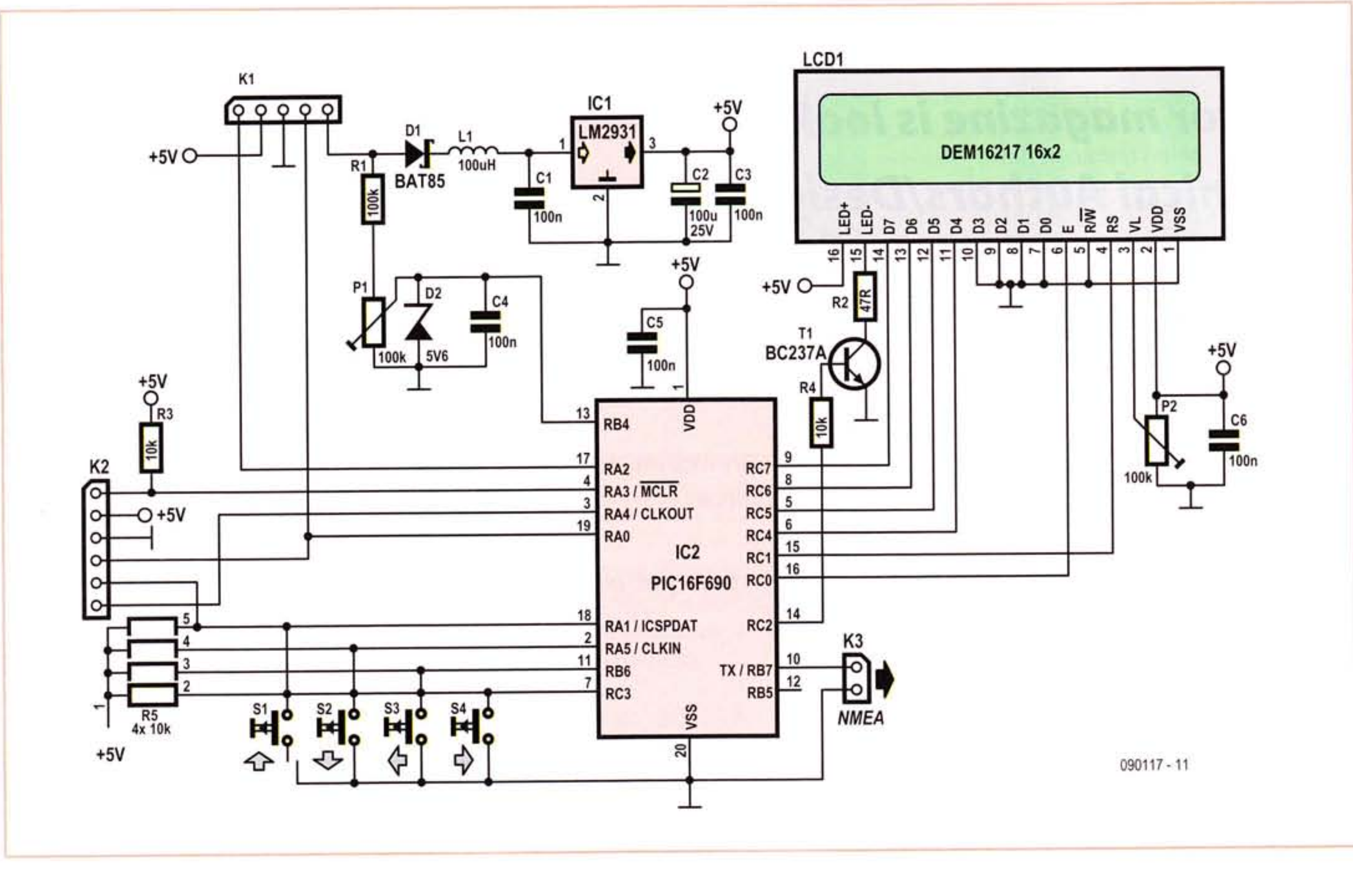


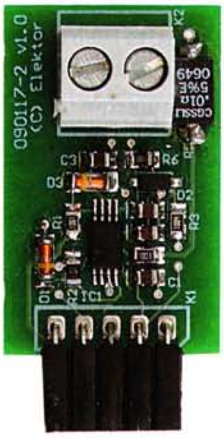
currents as low as tens of mA up to tens of ampères in our case and do so with reasonable accuracy over time.

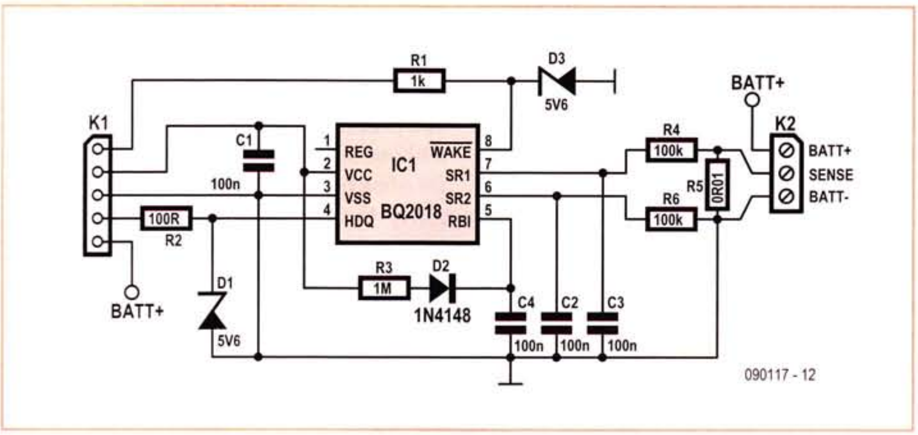
The process to measure charge is called coulomb-counting and is basically an integration of current over time. Having measured the current, usually with a small shunt, the result is integrated to form a value representing the charge. To do this, you can either sample the current and integrate numerically, or you can feed the current (or voltage) into a current (or voltage) to frequency converter and count the resulting pulses. Both methods have their advantages and disadvantages The pulse-counting approach eliminates the quantisation error from the measurement, leading to better accuracy over time. This was the approach chosen for this project.

Here the BQ2018 from Benchmarq (now incorporated into TI) is used as a charge counter. The BQ2018 is a tiny chip originally designed to be embedded into a battery pack. It is completely self-contained, needs only a handful of discrete components and communicates with the outside world through a serial link.

The BQ2018 and associated components can be mounted on a small PCB and located close to the battery in order for the built-in thermometer to read the battery temperature.







The same PCB contains shunt resistor R5 (Welwyn, 0.01 Ω, 1 W, SMD, 20 ppm/K). Since the maximum input to the BQ2018 is 200 mV this gives a full-scale of 20 A. A maximum of 200 A or 400 A might be appropriate for larger vessels, in which case you will use a lower value shunt. Metal-film resistors are recommended for R4 and R6 to keep noise and thermal drift to a minimum. R4, R5 and R6 should be connected in 'Kelvin' arrangement with heavy duty wires on the R5 terminals.
The sensor board communicates with, and is powered by, the control/display board via connector K1.

The control/display with its PIC16F690, LCD display and pushbuttons can poll the BQ2018 at a leisurely pace of once every 30s, allowing plenty of time for the PIC to calculate and display average current. Since the counters in the BQ2018 are 'only' 16-bits, care must be taken to read and zero them before they have a chance to roll over. In our case this happens every 6 hours, but the design has circuitry so that you can put the PIC to sleep and let the BQ2018 wake it when current rises above a predefined value. To implement that in software is left as an exercise for the reader.
Serial data from the BQ2018 is according to a protocol called 'hdq' defined as 'single-wire, open-drain interface asynchronous return-to-one referenced to Vss'. While it is possible to use the UART in the PIC16F690 to read this, you need additional components to make it work and besides, the UART is needed for the NMEA output. The problem is solved by the software using 'bit-bang' communication routines to talk to the BQ2018. Basically the PIC sends a command and immediately changes the output pin to input to receive data — this has to happen quickly as the first data bit may begin as soon as the command R/W bit time ends.
If you define NMEA in the source file the monitor will output NMEA data in the form:

```
;        $IIXDR,U,vvvvvv*CS
;        $IIXDR,A,aaaaaa*CS
;        $IIXDR,G,hhhhhh*CS
```

That's, volts, amps and charge. If you additionally define IDEBUG then it will instead dump out data for logging:

```
; ctc;ccr;dtc;dcr;ctc0;ccr0;dtc0;d
   cr0;charge;amps;volts
```

This is great for debugging and troubleshooting. The source code file for the project is available free from the Elektor website [1]. The same applies for the PCB artwork. Readers without access to a suitable programmer may obtain a ready-programmed PIC16F690 device from Elektor under order # 090117-41.

To connect the sensor, you remove the negative terminal from the battery, connect the negative pole of the battery to the + terminal on the sensor and connect the cable that used to go to the negative battery terminal to the – terminal on the sensor. Connect a wire from + on the battery to BATT+ on the sensor board and connect the headers K1 and K2 through a 5-wire cable.
To calibrate offset, short the shunt and hold down the Up key, whilst powering on. The unit will enter calibration mode and show a running counter on the display. After approximately one hour, the unit will show the measured offset and store it in EEPROM. Next, to calibrate voltage, measure the battery voltage with a DVM and adjust P1 for the same voltage on the display.

To set the unit according to your battery parameters, press → (Right) until you reach 'Maintenance', then press ↓ (Down). This will take you to a menu where you navigate with the Right and Left keys; Down on a value lets you adjust that value with the Left and Right keys. Down accepts and Up aborts without saving.

The left and right keys scroll through a series of display modes where the default of zero is probably the most interesting. Please see the source code for an explanation of the rest.
Finally, the author runs a dedicated website on the battery monitor at [2]. Software updates will be posted there.

(090117)

[1] www.elektor.com/090117

[2] www.dalton.ax/battmeter

Timer for Battery-Powered Tools

Piet Germing (The Netherlands)

Most hobbyists will have some tools that are battery-powered, such as a drill, screwdriver or power scissors. Unfortunately (and especially with cheaper devices) the batteries often seem to be empty when you need to use such a tool. This is usually caused by the self-discharge of the batteries. However, it's not a good idea to continually keep the batteries on charge because the cheap chargers would ruin the batteries in the long term due to their constant charging current. On top of that, it is wasteful of energy.
A simple method for charging cheap battery-powered tools in an environmentally friendly

and battery friendly way is to limit the charging period. The charging current from a simple charger is such that an empty battery-pack can be charged in about 5 hours ('fast' charger) to 15 hours (normal charger). Assuming a charging efficiency of 70% it means that the charging current is between 0.35 to 0.1 times the battery capacity in Ah. To compensate for the self-discharge of a fully charged battery of a maximum of 5% the charger has to operate at a duty-cycle of 1% and 3% respectively. In other words, charge the battery for a quarter of an hour or three-quarters of an hour per day using the original charger. In this calculation we haven't taken account of the discharging of batteries due to the actual usage of the tools.

The practical solution is very simple: use a 24-hour time switch, which can be picked up for a few pounds from a DIY store. The time-slots in the mechanical versions are usually for quarter-hour periods. When pins are used to select the period the minimum time is often half an hour. When you add a 4-way AC power adapter you can charge multiple devices at the same time.

It is recommended to keep the charging periods as short as possible and to spread them out through the whole day, so that if the battery becomes over-charged it won't have enough time to heat up too much internally, which is the most common cause of damage. With this method it won't do any harm if you add one or two extra quarter-hour periods in the day, so that partially discharged batteries can be fully charged again.

(100263)

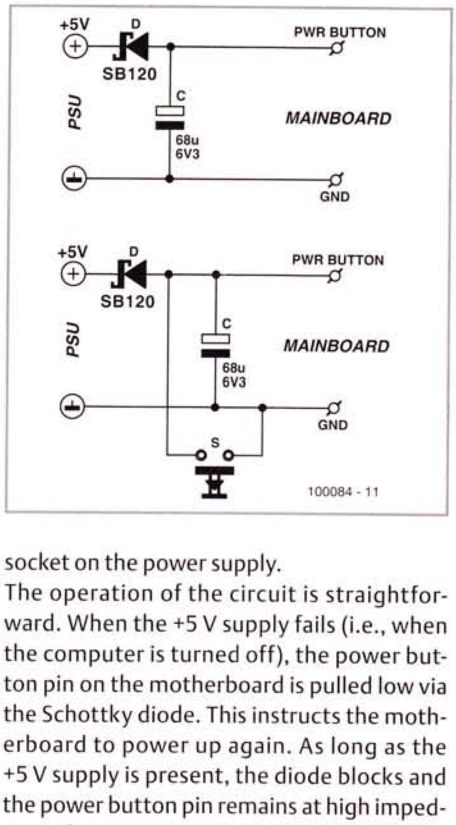
'Always on' for PCs

Dr Rolf Freitag (Germany)

Many enthusiasts will be using their PCs as data loggers, controllers or as web servers. In these cases it is important that the machine is kept powered up for as great a fraction of the time as possible, even if there has been a power cut or if the power button is inadvertently pressed by another member of the household. Today's operating systems offer a range of automation options and it is perfectly possible to arrange things so that the computer starts itself up automatically.

The 'always on' circuit shown here automatically restarts an ATX PC in the above situations. There are just two components: a Schottky diode connecting the power button pin on the motherboard to the +5 V line on the power supply, and a capacitor from the power button pin to ground. The capacitor is a 68 µF tantalum type rated at 6.3 V, and the diode is a type SB 120, rated at 20 V and 1 A. The total component cost is in the sub-one-beer range!

The most convenient arrangement is to mount the circuit directly on a 4-way Molex disk drive power plug, insulating the capacitor and diode using heatshrink tubing. The assembly can then be plugged into a spare socket on the power supply.



The operation of the circuit is straightforward. When the +5 V supply fails (i.e., when the computer is turned off), the power button pin on the motherboard is pulled low via the Schottky diode. This instructs the motherboard to power up again. As long as the +5 V supply is present, the diode blocks and the power button pin remains at high impedance, floating typically at around 3.3 V. The capacitor serves to filter out spikes and brief dropouts.

In its simpler version the circuit replaces the power button on the case, and the computer can now only be switched on and off at the mains.

The author has tested the circuit on modern SuperMicro X8SAX and X8DTH-6F motherboards as well as on an older Tyan Tiger MPX. He found that the capacitor value should be reduced in some cases: the SuperMicro motherboards have a high internal pull-up resistance which only charges the capacitor rather slowly.

Note that some PC keyboards have a 'Sleep' button which puts the computer into a low-power mode. In this case the circuit will not work, and you should either use a keyboard without such a button or disable sleep modes from within the operating system.

In its more advanced version the existing power button is retained in parallel with the circuit (see circuit diagram). The power button then causes a 'graceful shutdown' whereby the operating system can bring the computer to a halt in an orderly manner.

(100084)

Car Radio Booster

Christian Tavernier (France)

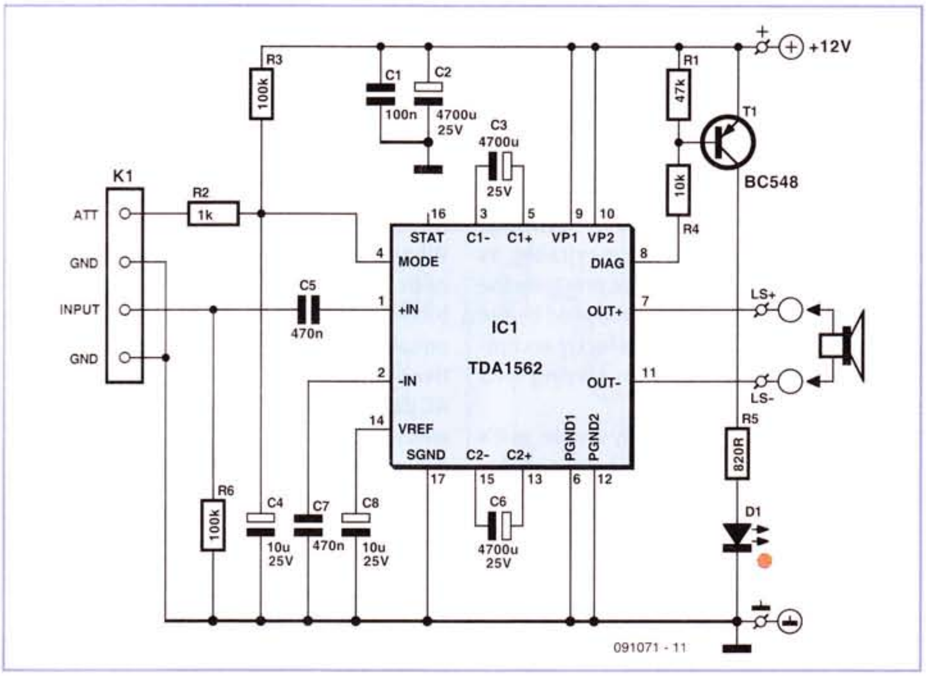
One solution for increasing the power of an amplifier running on a low-voltage supply, like a car radio powered from at best 14 V, is to use a 'bridge' configuration, i.e. to connect the loudspeakers between the outputs of two identical amplifiers whose inputs receive the same signals, but in opposite phases. This doubles the apparent voltage applied to the loudspeaker, which in theory quadruples the maximum power available. In practice, because of the various losses in the power transistors, we can only triple it. The peak-to-peak voltage applied to the loudspeakers in the car radio example is 28 V, less the losses in the power transistors, i.e. around 24 V. So we have an rms voltage of around 8.5 V (24 V / 2$\sqrt{2}$), which gives an rms power — the only one we hear — of 18 watts (8.5 V² / 4 Ω).

The booster described here does noticeably better, as it can deliver up to 55 watts rms into 4 Ω with distortion of less than 0.5 % — and it's capable of 70 watts rms if you can put up with 10 % distortion. To achieve this, it does not break the laws of physics, but it does use a very original system for boosting the supply voltage, using integrated power switches and high-value electrolytic capacitors.

It uses just a single IC per channel, a TDA1562Q from NXP which handles both the power amplification in class H and the voltage boosting. Since our circuit is intended to be fitted 'behind' a car radio, it has no volume control and its high-impedance input allows it to be connected to either the radio's loudspeaker output, or, preferably, to the line output that some car radios have these days.

Capacitors C3 and C6 are used for the voltage boosting mentioned above. Via the TDA1562Q's integrated electronic power switches, these are alternately charged up to the circuit's supply voltage, then put in series with the supply, thereby doubling it to supply the power output stages. Given the very high currents drawn by such a process when C3 and C6 are being suddenly charged, the supply voltage needs to be very heavily decoupled so as to ensure that it doesn't collapse momentarily when C3 and C6 are connected across it. This is the role of C2.

Transistor T1 drives a 'diagnostic' LED from information provided on IC1 pin 8. This LED, off in normal operation, flashes when the IC detects output distortion (in fact clipping, i.e. distortion of 10% or more) and lights steadily when the IC detects a short-circuited output, in the absence of an output load, or when its thermal protection comes into operation.
The ATT input can be left floating if you don't



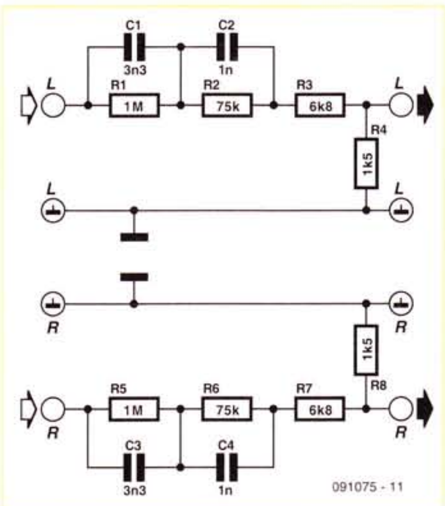
need it. This is a mute control that puts the circuit into stand-by when grounded. No output signal is produced and the consumption is reduced to a minimum.
The PCB [1] carries all of the components and two of them will need to be built for a stereo application. Given the heavy currents involved, the wiring for the supply and the connections to the loudspeakers will need conductors with a minimum cross sectional area (c.s.a.) of 2.5 mm^2.

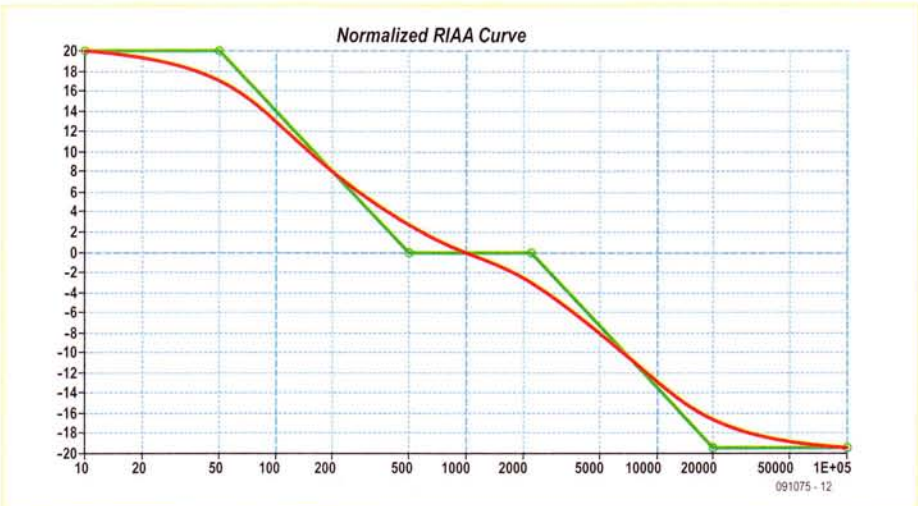
Obviously, the TDA1562Q must be bolted to a heatsink, the efficiency of which will govern the maximum possible time it can work at full power.

(091071-I)

[1] www.elektor.com/091071

Reverse RIAA Adaptor





Christian Tavernier (France)

If you're short of inputs on your amplifier, but it has an input for a magnetic pickup with RIAA correction, this very simple project will let you convert this into a high-level linear input, making it compatible with the outputs from all current audio sources. It won't have quite such perfect quality as a real line input, for two reasons.

Firstly, our circuit is bound to introduce a slight reduction in the signal-to-noise ratio (SNR), as it attenuates a high-level signal and then amplifies it back up again. Secondly, minor linearity 'hiccups' are inevitable, as the correction it produces is not precisely the reverse of the RIAA correction applied by the preamplifier — but it is still perfectly acceptable, especially if it is only for playing MP3 signals!
Our circuit diagram is extremely simple, as it's just a simple passive filter whose components have been calculated to reproduce the inverse RIAA curve to that in the preamplifier, i.e. the same as that used when cutting discs. It's perfectly simple to build, but to avoid degrading the signal-to-noise ratio too much, we recommend using metal film resistors, which are less noisy than their carbon counterparts.

What's more, since the preamplifier magnetic pick-up input applies a great deal of bass amplification, because of the RIAA equalization, the circuit is extremely sensitive to induced interference, especially from AC powerlines, and so it will need to be very well screened. We built it 'in the air' and fitted it into a salvaged metal tube (a medicine container) which acts as both case and screen.

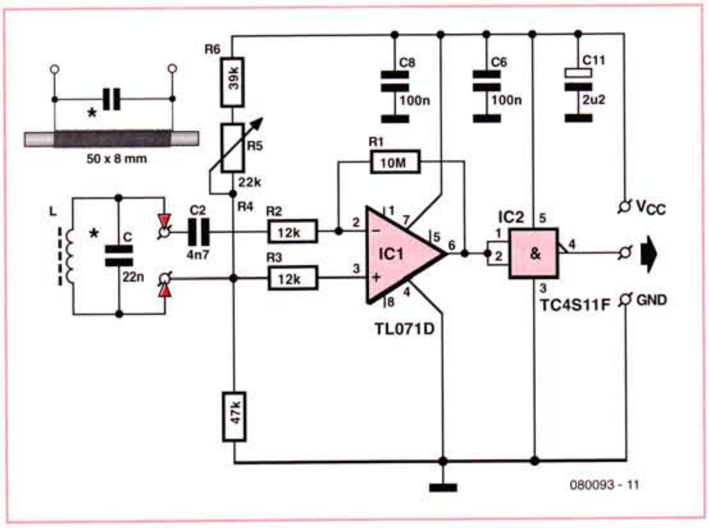
Given the components used, and although it does of course depend somewhat on the sensitivity of the magnetic pick-up input of the amplifier with which it is used, signals with an amplitude of 200–600 mV_{rms} can be applied to this circuit without fear of overloading the preamplifier.

(091075-I)

Pulse Receiver

Siegfried Borst (Germany)

The compact circuit presented here is perfect for receiving the signals from pulsed fixed-frequency transmitters. Chest straps from several well-known brands (Polar, Huger, Kettler, Crane, Outbreaker, ...) transmit a short signal burst with a frequency of 5.3 kHz. These signals can be received and used in your own projects, as the author shows on his website [1].



The circuit uses a ferrite rod with 1000 turns of 0.2 mm enamelled copper wire and a (tuning) capacitor to receive the signals. The value of the capacitor (22 nF) has been selected for use at a frequency of about 5.3 kHz, but this can of course be adapted for use at different frequencies. The received signals are amplified by opamp (IC1), after which a NAND gate (IC2) turns them into a nice waveform with straight edges. For the supply you can use any DC voltage source in the range of 9 to 18 V. There is a board layout available [2], which can be ordered via ThePCBShop [3].

(080093)

Web links

[1] http://peterborst.gmxhome.de/sigiborst

[2] http://www.elektor.com/080093

[3] www.thepcbshop.com

AC Power Indicator

Jacob Gestman Geradts (France)

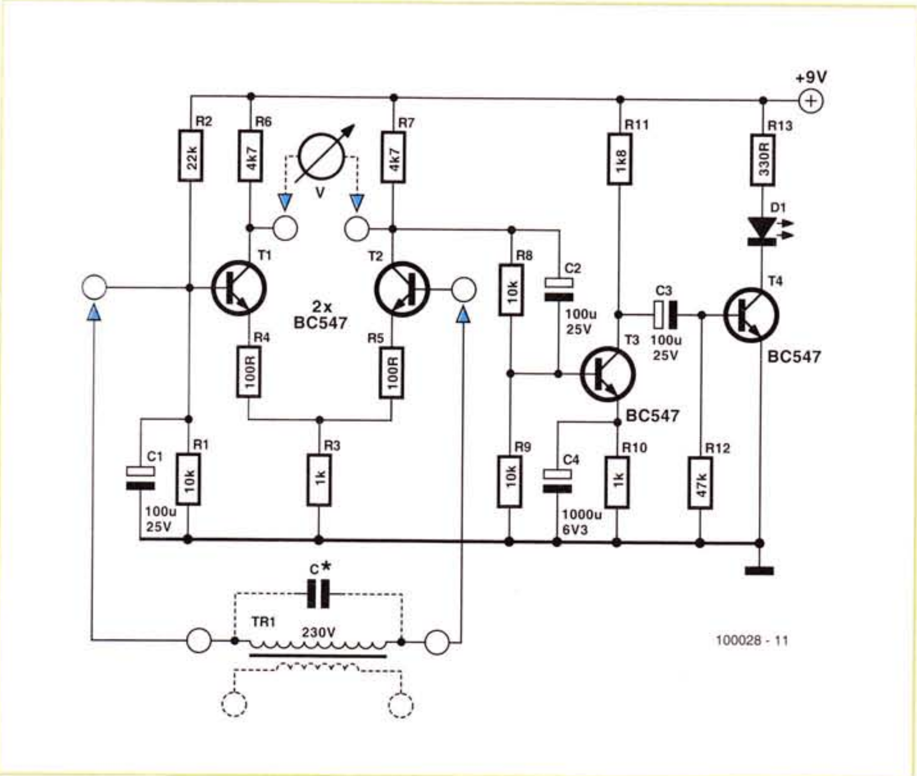
The AC powerline indicator presented here has a complete galvanic isolation from the grid. The indicator is an LED that lights up when a current flows, although the current can be measured more accurately with an AC voltmeter set to its mV range. The detector is a transformer taken from an old mobile phone charger. The value of the secondary isn't important because we only make use of the primary 230 V (115 V) winding. The (extension) cable through which the current has to be detected should have an as short as possible section of its outer insulation removed. The wires should then be moved apart. The blue wire should be placed on top of the transformer and the brown wire underneath, or the other way round. The brown and blue isolation shouldn't be removed, so there is no danger of the AC line voltage becoming exposed. If there is a green/yellow wire as well, this can be placed on either side of the transformer. The brown and blue wires should be in parallel with the windings on the transformer. The secondary winding(s) should be left open circuit so that they don't attenuate the measured signal.

In our prototype we found that an alternating 50 Hz voltage of about 2 mV was induced when a 30 watt soldering iron was connected to the extension lead. With higher-powered devices the measured voltage rises proportionally. Since it is unlikely that the iron core of the transformer will ever become saturated, the relationship between the measured voltage and the current flow should be fairly linear.

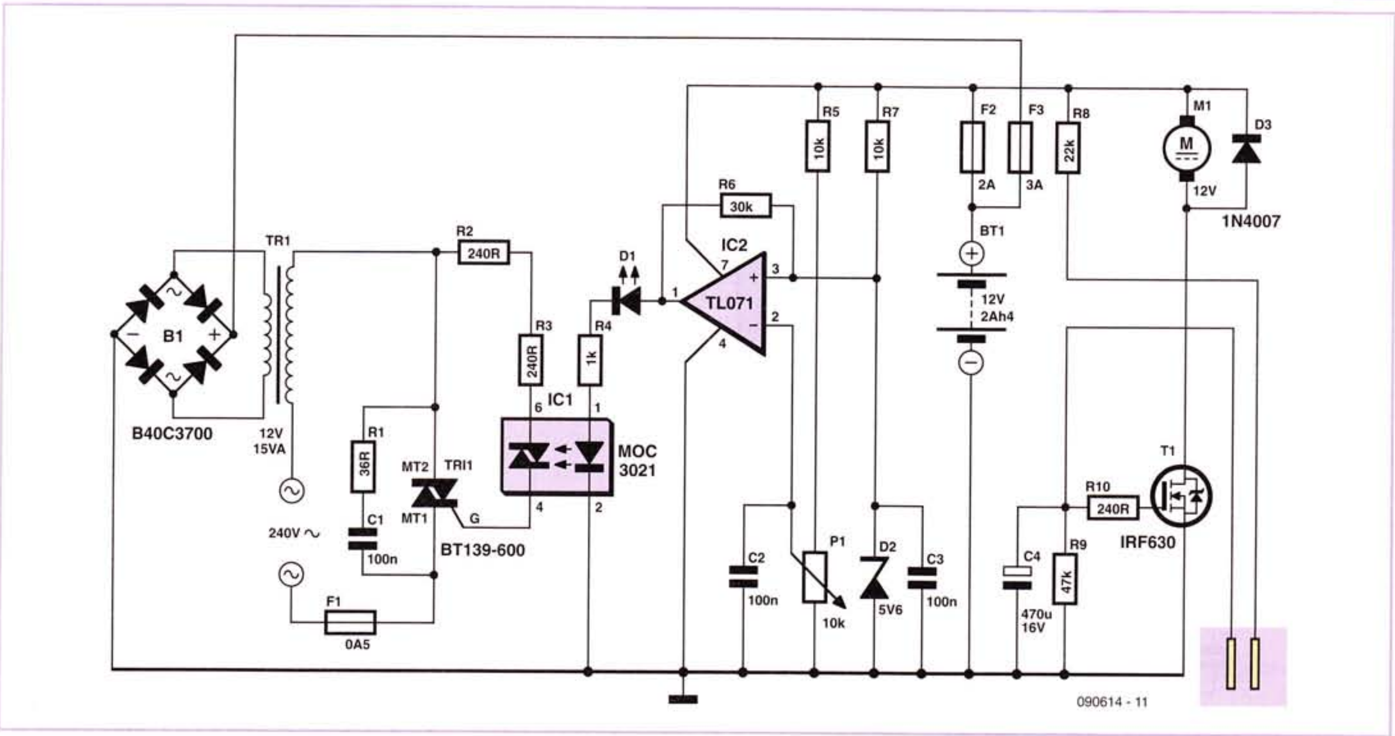
The transformer output signal is amplified by a differential amplifier built around T1 and T2. If you wish, you can connect an AC voltmeter across the collectors of T1 and T2 to get an indication of the size of the current. The rest of the circuit takes care of lighting up the LED when a current flows through the (extension) cable. The measured signal is amplified again by T3 and then T4 is used to drive the LED with a 50Hz square wave. A 9 V battery is suitable for the power supply.

When a capacitor is connected in parallel with the primary winding of the transformer it can make the circuit less sensitive to frequencies other than 50 Hz. Ideally, the circuit should resonate at exactly 50 Hz. This will make the circuit most sensitive. The capacitor should be chosen such that the measured signal across the collectors of T1 and T2 is at a maximum for a certain current flow. However, the capacitor isn't vital and the circuit still works well when just the transformer is used. When a low-current type is used for the LED, R13 can be increased to 1.2 kΩ (≈ 5 mA max. for D1).

(100028)



12-volt Cellar Drain Pump



Gustave Bolkaerts (Belgium)

This circuit lets you control a pump, to keep the level of water in a cellar below a certain threshold, for example. Power is supplied to the pump by a battery that is recharged automatically when the AC powerline voltage is present.

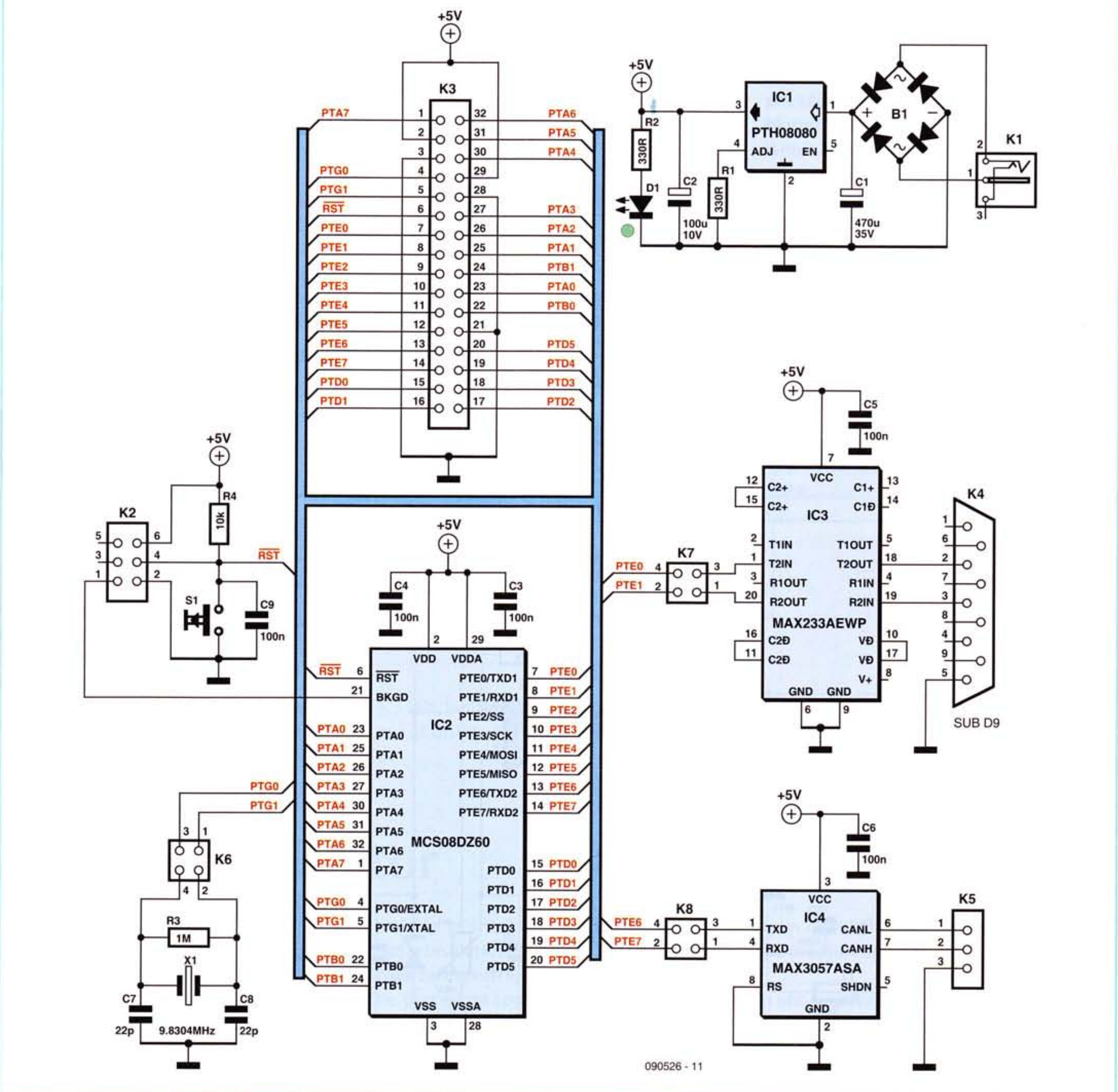
If the water level rises, the electrodes touch the liquid and a current begins to flow. The transistor then conducts and the pump runs. The pump stops when the water level has dropped sufficiently for the electrodes to no longer be in contact with it — but not straight away, as the voltage on the transistor gate is maintained for a few seconds more by the 470 µF capacitor. This makes it possible to ensure the electrodes are completely clear of the water.

The battery is constantly tested by the comparator circuit around the TL071 IC. Its output drives the gate of the triac in the transformer primary circuit via the opto-isolator.

The transformer secondary charges the battery via the rectifier, using as little power as possible, and in this way keeps the battery at 13.2 V.

(090642-I)

MCS08DZ60 Evaluation Board



Joël Guittet (France)

This development board around a 68HCS08DZ60 microcontroller from Freescale aims initially to be a platform for experimenting with the CAN bus. So it's equipped with a CAN driver and the bus is available on a 3-way connector. The board also carries an RS-232 driver. Hence the microcontroller's SCI1 port is available on a standard 9-pin female D connector. The CAN driver and the RS-232 driver can be disconnected from the microcontroller via jumpers.

The 5 V power supply (with LED indicator) is based around IC1. This is a switching module from Texas Instruments, but can be replaced without modifying the PCB by a conventional 7805 (in this case, there is no need for R1, which should not be fitted).

The clock circuit can be disconnected from the microcontroller via two jumpers, as the microcontroller is actually capable of running on an internal clock.
Connector K2 enables the microcontroller to be programmed, while K3 gives access to all its pins (except for BKGD, which is only used for programming) for a piggy-back module, for example.

The tools needed for programming are the 'CodeWarrior For Microcontrollers' software available for free download from the Freescale website and a 68HCS08 programmer. Here, there are several possible solutions, like the Multilink programmer from PEMicro or the OSBDM [2,3].

Some programming examples, along with lots of other information about Freescale microcontrollers, are available from the author's website [4].

The PCB design is available from [1]. The PCB gives you an opportunity to have a go at a double-sided board, as there are not many tracks on the back of the board and none of the holes need to be through-plated.

(090526-I)

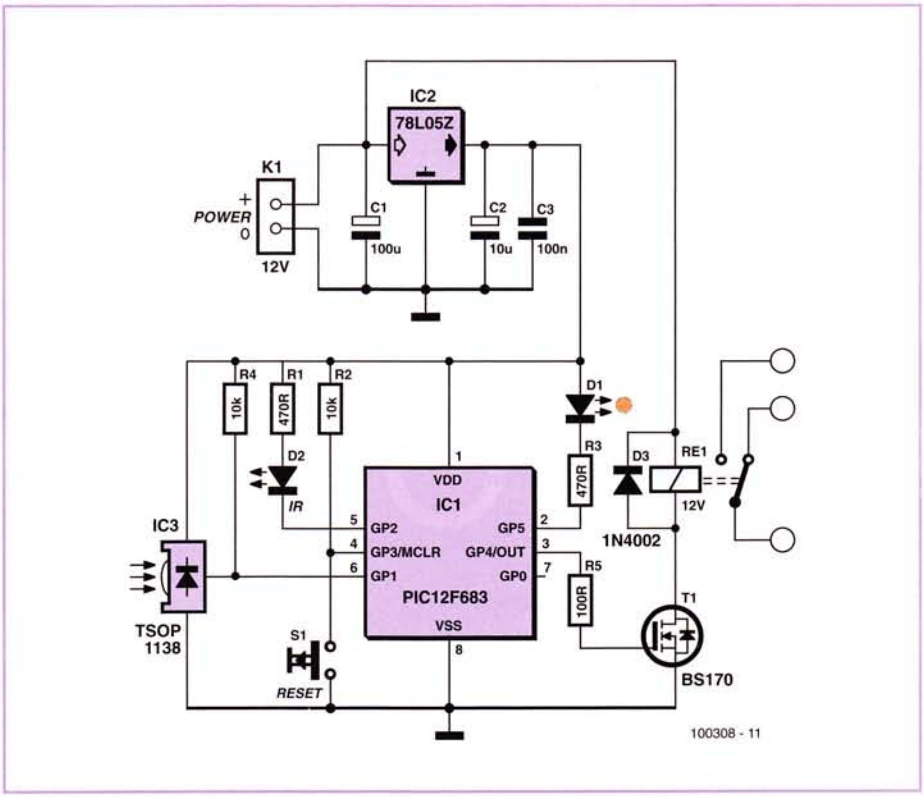
[1] www.elektor.com/090526

[2] forums.freescale.com/freescale/

[3] www.68hc08.net

[4] myfreescalewebpage.free.fr

Animal-friendly Mousetrap



Kees Reedijk (The Netherlands)

This mousetrap is built around a PIC12F683 and uses an infrared transmissive optical sensor that is modulated at a frequency of 38 kHz, so that it isn't affected by the ambient light. The modulation is carried out by the PIC, which generates a 38 kHz signal at port GP2, which is connected to the IR LED. The IR receiver is a type that is usually found for use with remote controls. It reacts only to 38 kHz signals. It reports the presence of an IR signal to the PIC via port GP1. When the IR lightbeam is broken the PIC turns of the relay via port GP4 and FET T1, which causes the door of the mousetrap to close.
The transmissive optical sensor is housed inside a small wooden box. A small amount of food is placed inside this box. When a mouse walks through the light beam on its way to the food it causes the door to shut behind it and an LED starts flashing. The door is normally kept open by the coil of a relay that has been taken apart. When the coil is no longer powered the tin door is pushed shut by means of a spring. A piece of glass or transparent plastic should be put on top of the box, so that the mouse doesn't have to enter a dark space. When a mouse has been caught it can be let free again somewhere outside, some distance away from the house.
The reset button has to be pressed to ready the trap for its next victim. The author has managed to catch a few dozen mice with this device.
The program is written in PICBASIC Pro and can be freely downloaded from the Elektor website, it is found in archive file # 100308-11.zip.

(100308)

Tiny Pulser

Wilfried Wätzig (Germany)

The author repeatedly needed several different digital signals for testing his circuits, and a simple function generator did not provide a satisfactory solution. He quickly developed a design for a pulse generator with three outputs, as described here, which can generate a variety of pulse trains with adjustable frequency.

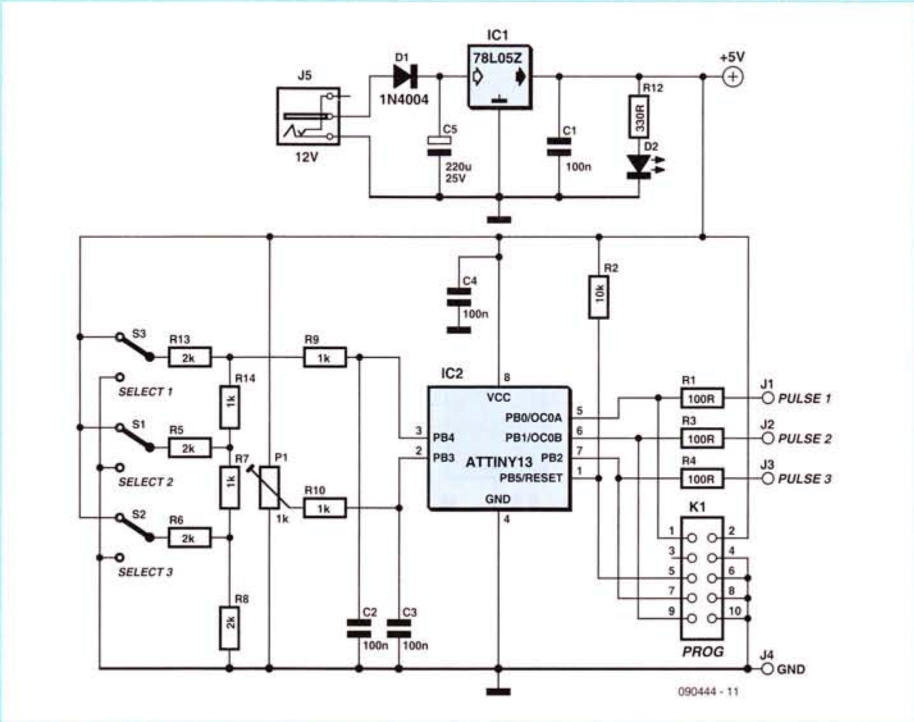
The heart of the circuit is an ATtiny13. This compact AVR microcontroller has five external I/O pins, of which three (PB0, PB1 and PB2) are used for the pulse outputs and two (PB3 and PB4) are used as inputs for the A/D converter. Switches Select 1 to Select 3 and the R/2R network (R5, R6, R7, R8, R13 and R14) are used to set a voltage on PB4 that selects the pulse mode (0–7) in the software. The pulse rate is controlled by the voltage on PB3, which can be adjusted with potentiometer R11 to cover the range from 290 Hz to approximately 8 kHz. The timing diagrams illustrate the pulse sequences generated in modes 0 to 6:

Modes 1 & 2: non-overlapping pulses with adjustable frequency (normal or inverted)
Modes 2 & 3: fully overlapping pulses with adjustable frequency (normal or inverted)
Modes 4 & 5: partially overlapping pulses with adjustable frequency (normal or inverted)
Mode 6: three-bit binary counter with adjustable frequency

Mode 7 is a special mode in which PWM signals at a frequency of 2300 Hz are output on the PB0 and PB1 pins. PB1 provides a PWM signal that periodically ramps up from 0 to 100% (0–255) and back down again, with a repetition rate of approximately 0.5 Hz. The PWM signal on PB0 can be controlled via the ADC3 input. The pulses from Timer0 are output on PB2. We have more to say about Timer0 further on.

The firmware for the Tiny Pulser was written in assembly language using Atmel AVR Studio 4. Fast execution is especially important here because the output pulses are generated by software in the Timer0 interrupt routine. The pulse sequence is generated using a cyclic counter with a range of 0 to 7, and the values of the three output signals are stored in an array indexed by mode (0 to 7) and cycle state. Each time an interrupt occurs, the appropriate values are read from the PULSE[MODE, CYCLE] array and fed to the outputs.

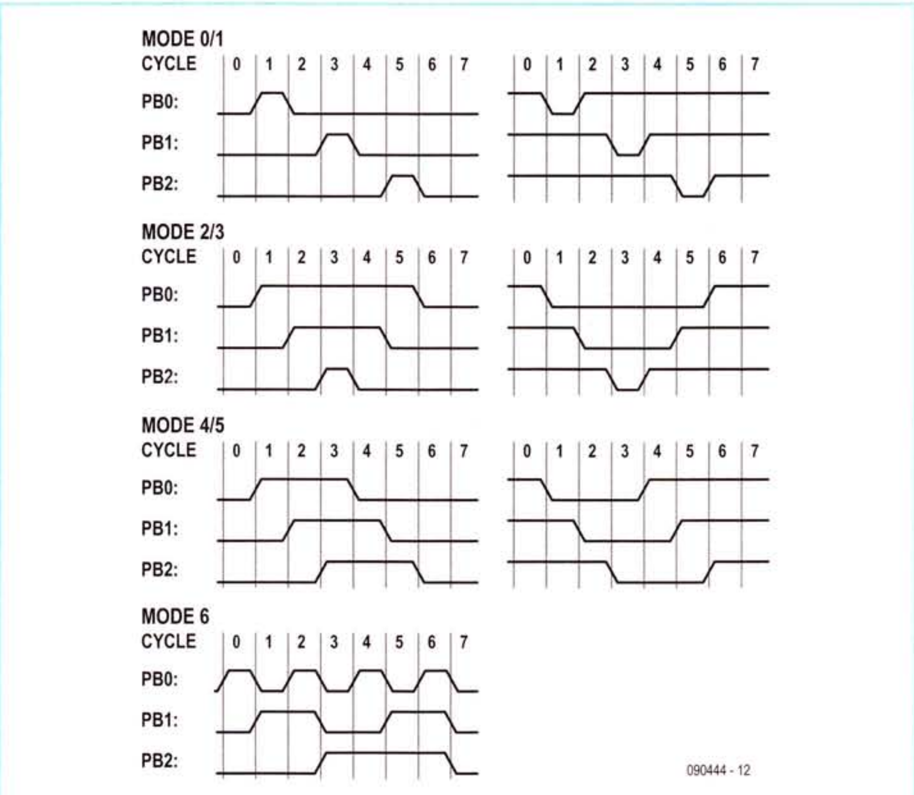
The ATtiny13 microcontroller is clocked by its internal RC oscillator at 4.8 MHz, and the fuse bits must be configured accordingly:



Fuses: CKSEL = 0,1 → 4.8 MHz
CKDIV8 = 0 → no divide by 8
SUT = 1,0 → slow rising power

The source code and a hex file can be downloaded from the Elektor website (www.elektor.com/090444), along with a ReadMe file with information about programming. If you don't want to program the microcontroller yourself, you can order a pre-programmed device from the Elektor Shop at www.elektor.com/090444 (order number 090444-41).

(090444-I)



MicroMinimal Thermometer

Vladimir Mitrovic (Croatia)

The thermometer shown here is "micro" not only because it is built around the ATtiny13 microcontroller, but also because it can be built as a miniature device when built from SMD components.

The temperature is measured by a DS18S20 high precision 1-Wire® digital thermometer from Maxim. The program inside the ATtiny13A microcontroller initiates a single temperature conversion, waits until the conversion has finished, then reads and displays the result. the temperature can be read by counting red and green blinks from a two-colour LED. For example, 2 red and 3 green blinks will be produced if the temperature is 23°C. Blinks are easily readable because each blink lasts approximately 135 ms and is followed by a 400 ms pause.

The same LED pair is used to display other events, too:

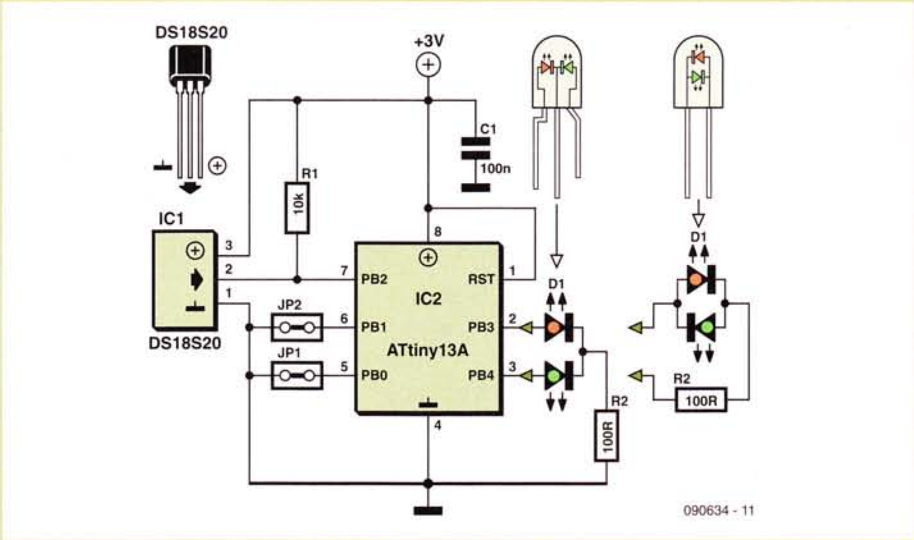
1. When the temperature is negative (centigrade value), an R-G-R-G sequence with no intermediate pauses stands for the "–" sign (red and green blinks are clearly visible);
2. 0°C is displayed as a 1 second long sequence of short red and green blinks (red and green light blend together);
3. A communication error is displayed as a 1-second long red light.

As indicated in the circuit diagram, two different two-colour (red + green) LED types may be used: 3-terminal (with common cathode) or 2-terminal (with red and green LEDs in anti-parallel connection). The ATtiny program is the same for both versions. Since LEDs consume most of the power, choose an appropriate value for R2 to suit your own needs. A 100 Ω resistor results in an 8 mA current flow through the LED that's switched on.

During the display period the LEDs are on at a 25% duty cycle, with 1 second conversion periods between two display sequences to reduce the average LED consumption to roughly 1.5 mA. This may be considerably lowered if two separate red and green low-current LEDs are used for display. But even with 20-mA LEDs, the circuit may be powered by a small 3 V Lithium cell for a good period.

Although in theory the instrument can measure temperatures between –55°C and +125°C, in practice it seems prudent to stay within the –15°C to +50°C range.

The DS1820 can be detached from the rest of the circuit for as far as the 1-wire protocol allows; a 3-m (10 ft.) connecting cable was tested and everything worked well. If the sensor is properly insulated, you can measure the temperature of water or other non-aggressive liquids. But the most common use of the proposed circuit is to build a small and simple thermometer with low power consumption, which will be at hand and functional whenever you need it.




```
Do
   Config Clockdiv = 8                 'Set clock=1.2MHz
   1wreset                             'Start 1-Wire communication
   1wwrite &HCC                        'Skip ROM
   1wwrite &H44                        'Convert T
   Config Clockdiv = 64                'Set clock=150kHz
   Counter0 = 109                      'Wait 1s
   Gosub Wait
   Config Clockdiv = 8                 'Set clock=1.2MHz
   Gosub Read_t                        'Read T
   Config Clockdiv = 64                'Set clock=150kHz
   Gosub Disp_t                        'Display T
   Portb.1 = 1                         'Prepare to read JP2 (Powerdown)
   Counter0 = 255                      'Wait 7ms
   Gosub Wait
   If Pinb.1 = 0 Then Exit Do          'JP2 closed? Exit&Powerdown!
   Portb.1 = 0
Loop

Portb.0 = 0
Portb.1 = 0
Powerdown

End
```

With JP1 closed the readout is in 'modulo 5' mode: each blink of the red LED now equals 5, while the green blinks are still unity. Thus 4 red and 3 green blinks will occur if the temperature is 23°C.

If JP2 is closed, the microcontroller goes into power-down mode if the temperature is measured and displayed for the first time. This option consumes minimum power. To repeat the measurement, switch off the thermometer, wait for 1 to 2 seconds and switch it on again.

The program developed for the project is called 'EE_micro_T.bas' and was written in BascomAVR for compiling and turning into object code. A small extract is shown here. The complete program is a free download [1]. Those without access to an ATtiny13A programmer or BascomAVR may buy their ready-programmed IC through the same web page.

Readers preferring Fahrenheit readout should modify the BascomAVR program accordingly.

(090634)

[1] www.elektor.com/090634

Waterproof Bathroom Switch

Ludovic Mézière (France)

The object of this circuit is turn the domestic lighting on and off in complete safety in a room with very high humidity. A detector, flush-mounted into the wall, detects the magnetic field variations caused by the proximity of a hand and controls an AC power switching system. Hence lighting control is achieved through the wall covering, with no exposed electrical equipment.

Operation is based around a specialized IC (IC3): the QT113A from Quantum (bought out a few months ago by Atmel). This IC generates a pulsed magnetic field while a capacitive measuring system detects the variations. Any variation in the magnetic field results in toggling of its output. A series of filters avoids errors, and detection has to be confirmed three times before the processor will toggle the output, which avoids unwanted triggering. IC3 has a self-calibration feature that enables it to adapt itself to variations in external conditions. The pulsed operation limits RF emissions as well as consumption.

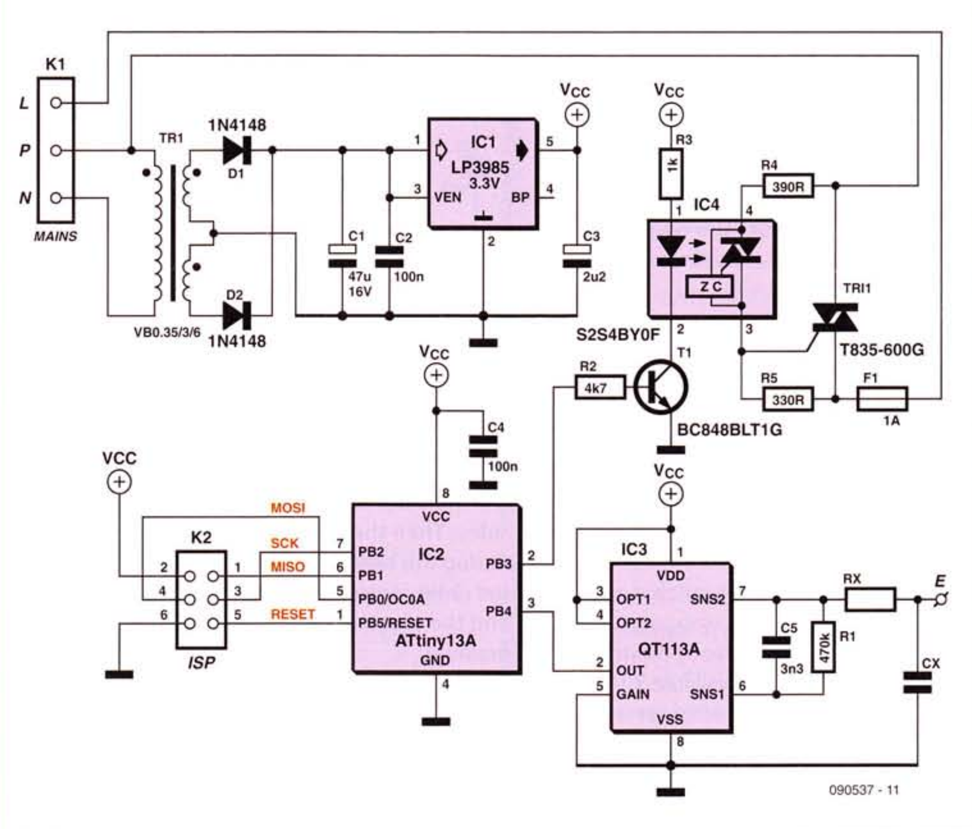
The electrode is formed from a piece of copper-clad PCB board of around 5 × 5 cm, which has had the photosensitive film removed to allow a wire to be soldered on for connecting it to the electronics board. The electrode must be kept a few centimetres away from the electronics board, otherwise it won't work; this prevents you from being able to use a double-sided PCB with one side carrying SMD components and the other side acting as the electrode. The value of capacitor C1 will determine the sensitivity of the detector, and its value will need to be adjusted depending on the environment and the sensitivity required.

IC3's output provides an oscillating signal that enables it to prove it is working, which means we have to use a small controller which will register the information provided by the detector and handle the load switching via an opto-triac and a triac. A standard ISP connector is available for programming the microcontroller. A miniature transformer makes it possible to include a small 5 V PSU on the board and isolate the circuit from the mains. Isolation between the output and the mains is ensured by an opto-triac, but it's important to remember that one part of the circuit is connected to mains voltage.

All the components are SMD types, but are still easy enough to solder using a conventional iron. The PCB can be fitted into an electrical back-box (e.g. Legrand Batibox) in the bathroom, for example, behind a tile. All you have to do to turn the light on or off is touch this tile with your finger.

(090537-I)

[1] www.elektor.com/090537



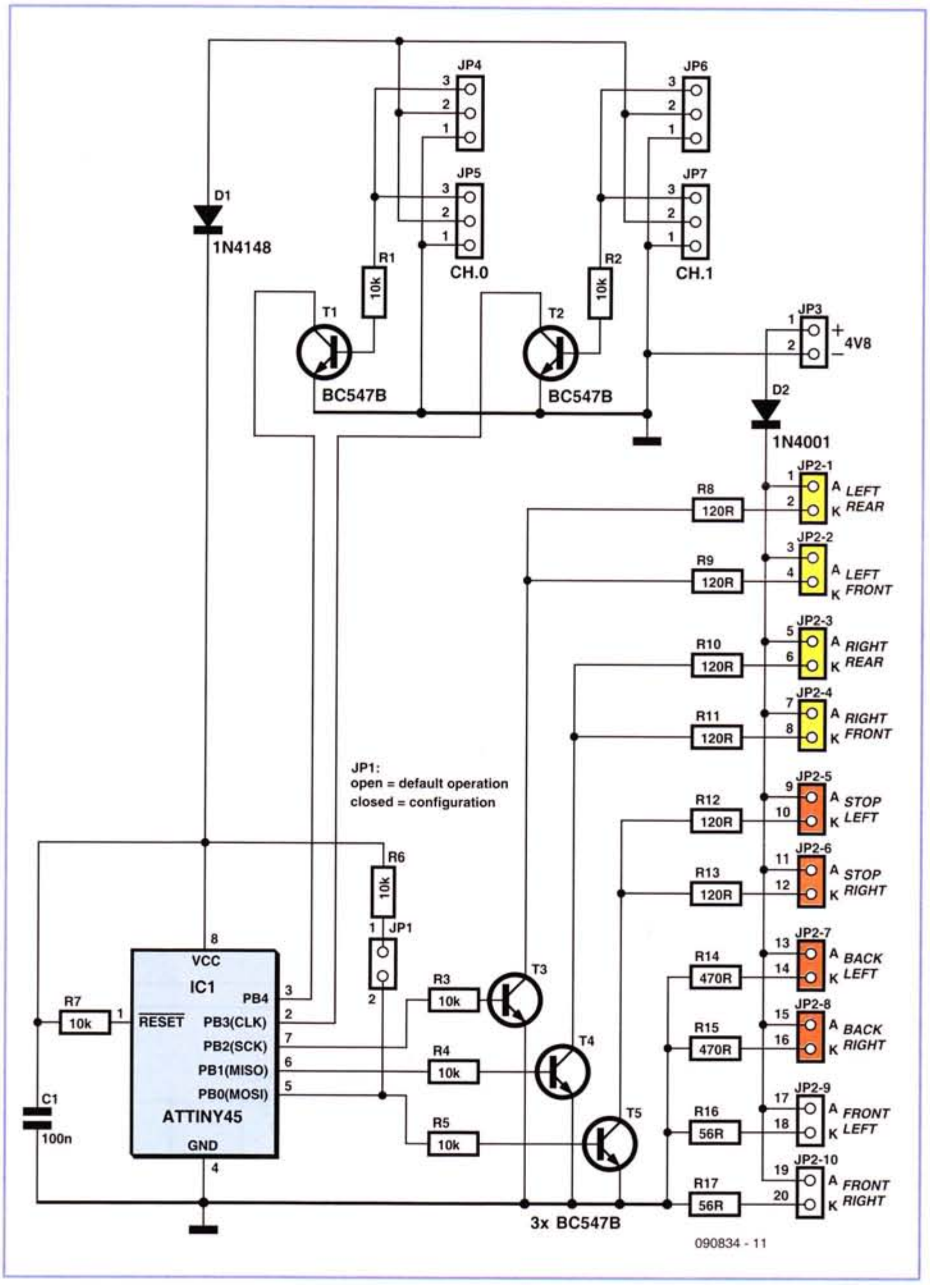
Lights Control for Model Cars

Manfred Stratmann (Germany)

The author gave his partner a radio-controlled (RC) model car as a gift. She found it a lot of fun, but thought that adding realistic lights would be a definite improvement. So the author went back to his shed, plugged in his soldering iron, and set to work equipping the car with realistic indicators, headlights, tail lights and brake lights.

The basic idea was to tap into the signal from the radio control receiver and, with a bit of help from a microcontroller, simulate indicators using flashing yellow LEDs and brake lights using red LEDs. Further red LEDs are used for the tail lights, and white LEDs for the headlights. Connectors JP4 and JP5 (channel 0) are wired in parallel, as are JP6 and JP7 (channel 1), allowing the circuit to be inserted into the servo control cables for the steering and drive motor respectively. The ATtiny45 microcontroller takes power from the radio receiver via diode D1. T1 and T2 buffer the servo signals to protect IC1's inputs from damage.

IC1 analyses the PWM servo signals and generates suitable outputs to switch the LEDs via the driver transistors. T3 drives the two left indicators (yellow), T4 the two right indicators, and T5 the brake LEDs (red). The red tail lights (JP2-8 and JP2-8) and the white headlights (JP2-9 and JP2-10) are lit continuously. The brake lights are driven with a full 20 mA, so that they are noticeably brighter than the tail lights, which only receive 5 mA. If you wish to combine the functions of tail light and brake light, saving two red LEDs, simply connect pin 10 of JP2 to pin 14 and pin 12 to pin 16. Then connect the two combined brake/tail LEDs either at JP2-5 and JP2-6 or at JP2-7 and JP2-8.



JP3 is provided to allow the use of a separate lighting supply. This can either be connected to an additional four-cell battery pack or to the main supply for the drive motor. The values given for resistors R8 to R17 are suitable for use with a 4.8 V supply. JP2 can take the form of a 2x10 header.

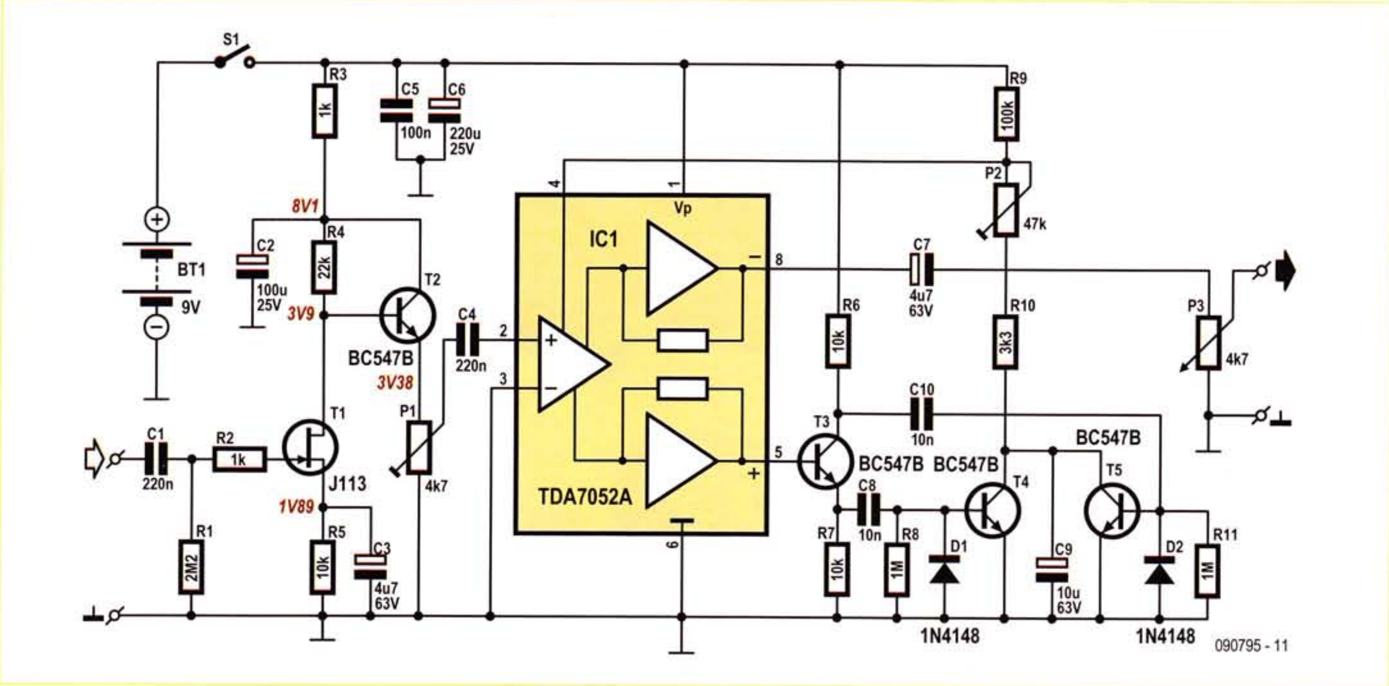
As usual the software is available as a free download from the Elektor web pages accompanying this article [1], and ready-programmed microcontrollers are also available. The microcontroller must be taught what servo signals correspond to left and right turns, and to full throttle and full braking. First connect the finished circuit to the radio control electronics in the car, making sure everything is switched off. Fit jumper JP1 to enable configuration mode, switch on the radio control transmitter, set all proportional controls to their centre positions, and then switch on the receiver. The indicator LEDs should first flash on both sides. Then the car will indicate left for 3 s: during this time quickly turn the steering on the radio control transmitter fully to the left and the throttle to full reverse (maximum braking).

Hold the controls in this position until the car starts to indicate right. Then set the controls to their opposite extremes and hold them there until both sides flash again. Now, if the car has an internal combustion engine (and so cannot go in reverse), keep the throttle control on full; if the car has an electric motor, set the throttle to full reverse. Hold this position while both sides are flashing. Configuration is now complete and JP1 can be removed. If you make a mistake during the configuration process, start again from the beginning.

(090834)

[1] www.elektor.com/090834

No-CA3080 Guitar Compressor



Ian Field (UK)

The TDA7052A is a readily available amplifier chip (Farnell # 526198) that has a DC controlled volume input. Here, the IC is used as the variable gain amplifier in a guitar compressor, so the effect can be accomplished without the hard to obtain CA3080 operational transconductance amplifier (OTA). Note that the suffix-less TDA7052 does not have DC volume control.

The TDA7052A has a relatively low input sensitivity and also a relatively low input impedance, so common source JFET amplifier T1 provides some pre-gain while emitter follower T2 provides low impedance drive for IC1's input. Advantage is taken of IC1's dual outputs to keep the diode pump and output loads apart, although distortion from this probably wouldn't happen as IC1 has very low output impedance (about 0.2 ohms). The output on pin 8 is fed via DC blocking cap C7 to the level pot P3.The output on pin 5 drives phase splitter T3 whose outputs drive T4 and T5 on alternate half cycles. Both of these transistors in parallel discharge C9 which effectively holds the control voltage for pin 4 of IC1.

The input stage has a number of design aspects worthy of mentioning. The JFET stage will clip if the I_{dss} is too high. For T1, a 2N3819 can be got away with if selected for I_{dss} less than 5 mA otherwise the input amplifier won't work. This may not be possible with all brands of 2N3819. The J113 shown here is spec'ed at 2 mA min. and no upper limit given on the data sheet.

Source resistor R5 may be determined empirically by temporary insertion of a trimpot to set the drain to 0.5 V_{BATT}, obviously centring the drain operating point optimises the headroom for output swing. With lower values of drain resistor it may be possible to use unsorted examples of the 3819.

It is made abundantly clear in the TDA7052A appnote and data sheet that good supply decoupling is important, hence it is recommended that C6 be a good quality electrolytic. C5 is specified as 0.1 µF in accordance with data sheet advice, although if a miniature 0.22 µF that will fit in the available space is ready to hand – every little helps. C5 should be fitted as close as possible to the IC1 supply pins.

It is assumed that anyone who gets as far as building a board for a guitar pedal will know how to wire a bypass stomp switch, however there are some notes that concern the placement of the pots. Ideally only one pole of the two pole changeover stomp switch is needed, to switch the output jack between the compressed output and an additional pot on the pre-gain buffer.

It is likely that P1 (pre-gain) would be useful as a front panel control, and this is a good place to connect the bypass stomp switch. The best option is to use 2x 10 kΩ pot in parallel instead of P1 on its own, one wiper feeding IC1 pin 2 (pre-gain), the other feeding the stomp switch bypass (bypass gain). P2 (sustain) varies how much effect the voltage on C9 affects the voltage on IC1 pin 4 and therefore controls the range of gain control.

The circuit is supplied by the usual PP3 9 V battery, a slide switch can be wired in series with the positive lead from the battery clip if preferred, but it is common practice in the FX industry to use stereo jack sockets with the tip of the plug carrying the signal as normal, the ring contact of the jack socket is shorted to ground when a mono plug is inserted. Provided skeleton style jack sockets are mounted in a metal case, inserting a mono plug connects the ring contact to the case. In this way if the battery negative lead is connected to the ring contact of one socket and the PCB negative lead is connected to the ring contact of the other jack socket, removing either jack plug will break the circuit between the battery negative and PCB negative.

The circuit from C1 to P1 is useful in it's own right as a 'clean boost' pedal, within reason the input impedance can be pretty much as high as you want to make it, and emitter follower T2 gives it a very low output impedance capable of driving long cables without losing the high notes and also overdriving the input stage of valve amplifiers (not so worth while with transistor amps!). However, depending on the JFET choice and biasing it is just possible that a good quality guitar with *ditto* pickups might overload the input stage to a degree.

(090795)

Mini Sixties Plus

Joseph Kreutz (Germany)

This circuit is inspired by an amplifier published in the '60s that produced 8 watts a channel into 8 Ω and was based on AD161 and AD162 germanium (not 'geranium') power transistors. These at last made it possible to build complementary-symmetry power stages with performance similar to that obtained with the standard at the time: a class AB 'push-pull' using with two EL84 (6BQ5) pentodes. Modest as it is, the power of the 'Mini Sixties' is still more than enough to drive high-quality speakers and provide comfortable listening for a signal from a computer or MP3 player. It goes without saying that for a stereo project, you'll need to build two channels.

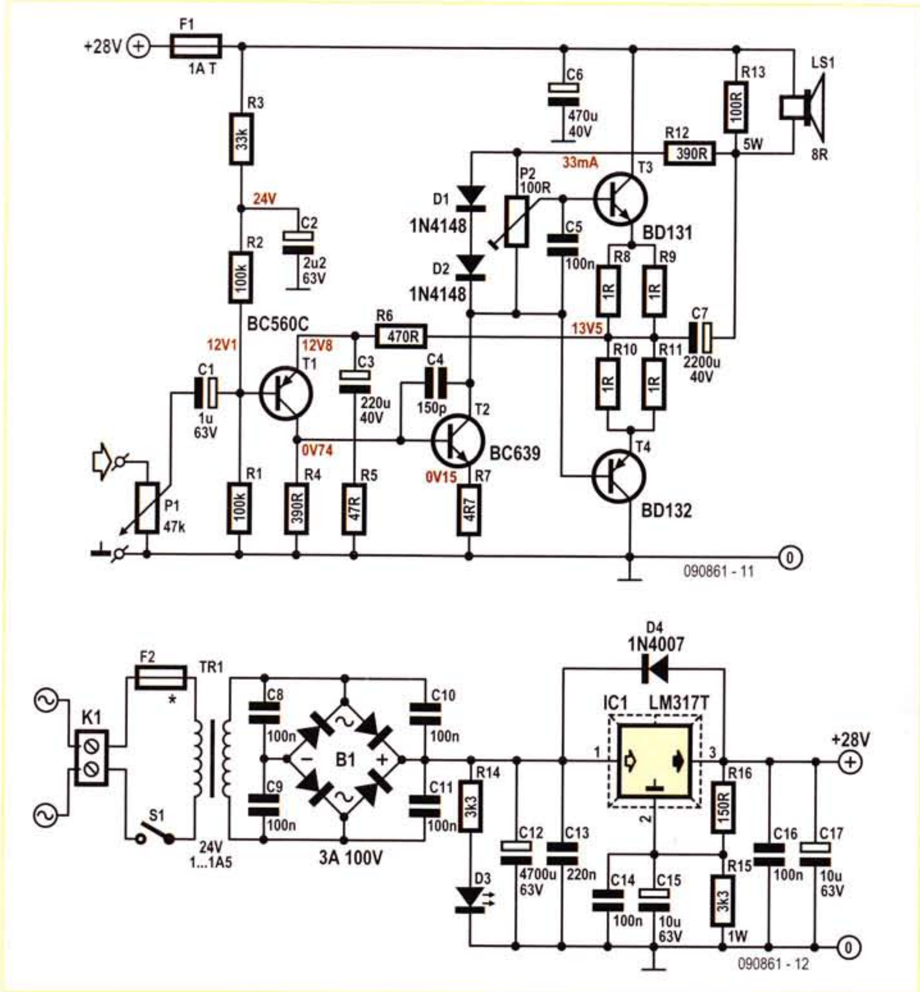
The input signal is applied to the base of T1, which is biased via the divider formed by R1, R2, and R3, decoupled by C2. T1's emitter receives the negative feedback signal tapped off the output by R6. As T1's collector current is determined by the difference between the input and negative feedback signals, this transistor forms an error amplifier.

Series network R5 and R6 determines the voltage gain of the 'Mini Sixties' in the audio band. In the configuration shown here, the gain is 11 (1+R6/R5). Selecting a value of 22 Ω for R5 (and 470 µF for C3) enables you to increase the gain to 22 if this proves necessary. The values for R5 and C3 have been chosen to obtain a low-frequency cut-off of about 15 Hz.

The amplifier's voltage gain stage is formed by transistor T2, with resistor R12 as its load. The latter is connected to the loudspeaker output and not to the supply rail, in such a way that the voltage across it virtually doesn't vary at all: this is the 'bootstrap' effect. The current through it then stays constant and is enough to drive the power transistor, even when the output voltage nears its maximum. The disadvantage is that this current also passes through the load, resulting in a small DC voltage across the terminals of the load (26 mV @ 33 mA).

Resistor R13 avoids T2 finding itself open collector when there is no load connected to the amplifier, in such a way that the quiescent voltage at the junction of R8||R9 and R10||R11 maintains its value which is half the supply voltage. Emitter resistor R7 linearizes the voltage gain stage and capacitor C4 establishes the dominant pole, which ensures the stability of the amplifier.

The power stage is formed by T3 and T4 wired as a very classic complementary-symmetry 'push-pull' stage. Diode D1 and D2 stabilize the power stage quiescent current, which will need to be set to 20 mA by adjusting preset P2. A multi-turn type is highly recommended for P2. The quiescent current is measured using a voltmeter between the emitters of T3 and T4: the voltage measured in mV corresponds to the current in mA. If necessary, the quiescent current setting may need to be tweaked once the amplifier has reached its normal operating temperature.



Specifications:

Sensitivity: 820 mV (9.1 W)
Gain: 10.4
Max. power: 9.1 W (THD = 1 %)
Frequency response: 21 Hz - 1 MHz (1 W)
21 Hz - 400 kHz (8 W)
THD+N: 0,.4 % (1 kHz, 1 W, BW = 80 kHz)
S/N: 78 dB (BW = 22 kHz lin.)
86 dBA

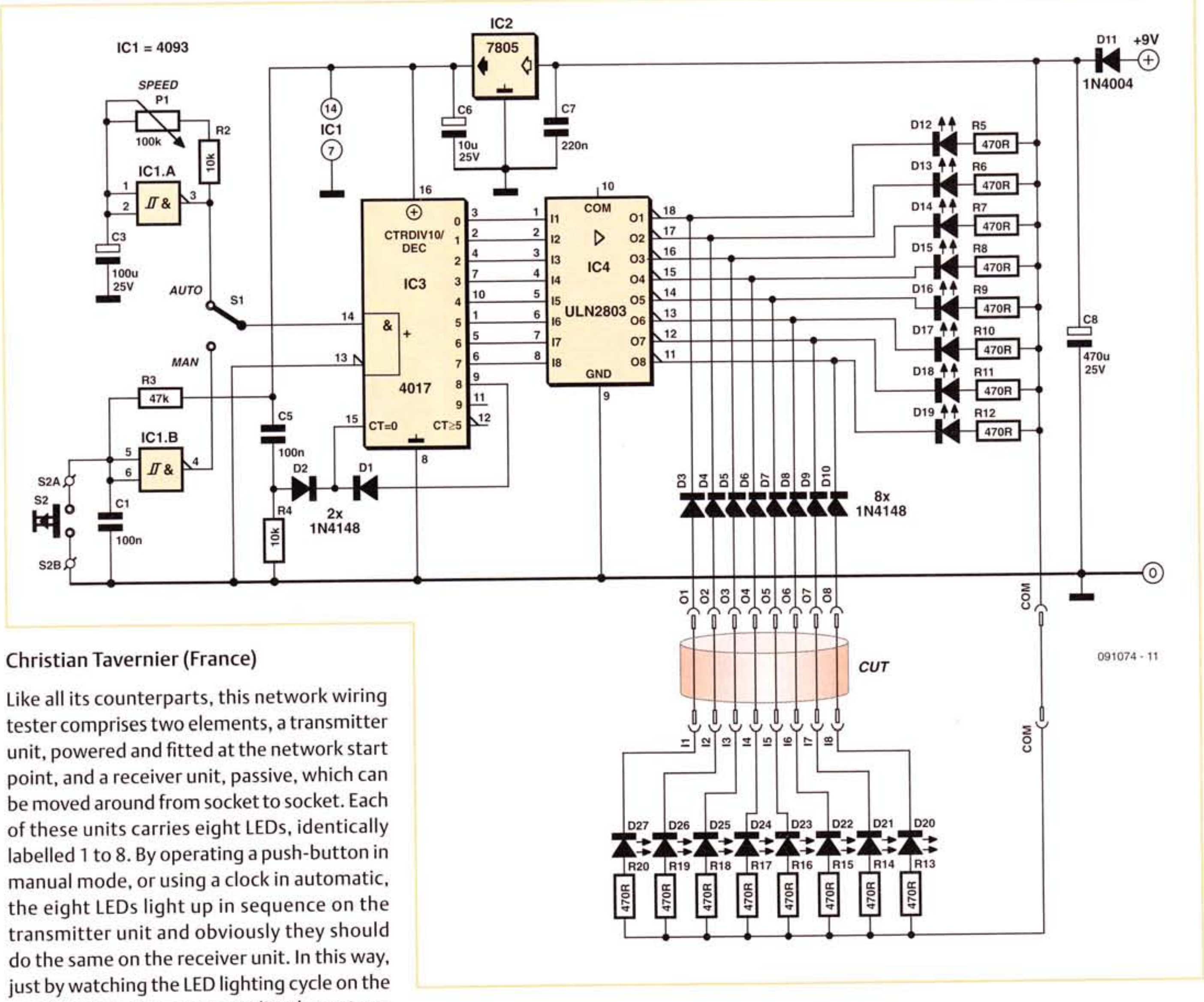
The power transistor will need to be fitted to a heatsink with a thermal resistance of less than 4 °C/W, using insulating spacers and heatsink compound. It will also be necessary to make sure that D1 and D2 are in good thermal contact with T3 and T4.

The amplifier does not use a symmetrical power supply, which is why the load is connected via capacitor C7. Since the amplifier is not protected against short-circuits on the load, a 1 A slo-blow fuse lets us limit the damage in the event of a problem. The 28 V power supply is taken care of by an LM317 regulator, whose current limiter offers an additional degree of protection. The regulator will also need to be mounted on a heatsink with a thermal resistance of less than 2 °C/W. Where applicable, you may also need to provide insulation. The supply transformer TR1 must be capable of supplying 24 V @ 1–1.5 A. The fuse F2 should have the value recommended by the transformer manufacturer.

The voltages and currents shown on the circuit were measured on our prototype. We measured the distortion as 0.14 % (1 kHz, 1 W) – not all that bad for an experimental project using just four transistors.

(090861-I)

Network Wiring Tester



Christian Tavernier (France)

Like all its counterparts, this network wiring tester comprises two elements, a transmitter unit, powered and fitted at the network start point, and a receiver unit, passive, which can be moved around from socket to socket. Each of these units carries eight LEDs, identically labelled 1 to 8. By operating a push-button in manual mode, or using a clock in automatic, the eight LEDs light up in sequence on the transmitter unit and obviously they should do the same on the receiver unit. In this way, just by watching the LED lighting cycle on the receiver unit, you can immediately spot any crossed wires, as well as any open circuits (the relevant LED never lights up) or shorts (two or more LEDs light at the same time).

The transmitter unit circuit is simple. The Schmitt-input NAND gate IC1.A is wired as a multivibrator, whose speed can be adjusted using P1, while IC1.B is wired as a simple debounce circuit for button S2, used in manual mode. Switch S1 lets you apply the output of one or the other of these to the input of IC3, a decade counter IC, which here we force to count up to eight by connecting its Q8 output back to its reset input. Its outputs are not capable of driving LEDs, especially over wiring that be 'dangerous' for them (a short, for example), so a ULN2803 is used to drive the outputs. This integrated network of eight Darlington transistors, each capable of switching up to 500 mA, drives the eight LEDs fitted to the transmitter unit (D12–D19) and feeds its signals to the socket comprising contacts O1–O8, to which the wiring to be tested must be connected. At the other end of the cable, via the socket comprising contacts I1–I8, is the receiver unit which contains just eight LEDs (D20–D27) and their current limiting resistors. For the latter to work, there obviously needs to be a common connection between transmitter and receiver. In the case of screened network wiring, the screen can be used for this purpose. Another solution consists of using the earth wire of the electrical installation to fulfil the same function. But if neither of these solutions is feasible, then you'll have to resign yourself to running a flying lead for this purpose.

The transmitter unit power supply is obtained from a 'plugtop' adapter supplying around 9 V at around 10 mA or so. The supply to IC1 and IC3 is regulated at 5 V, even though it's not strictly necessary. For occasional short use, a 9 V battery could be used.

If the project is intended solely for testing network wiring, O1–O8 and I1–I8 will be in the form of RJ45 sockets and COM will be connected to their screening contact. Take care to stick to the same numbering for the LEDs on the transmitter and receiver units, and if the project is going to be used in automatic mode, that the LEDs are in the correct order.

(091074-I)

Glass Blower

Merlin Blencowe (UK)

Most guitar pedals obtain a high input impedance simply by using a large resistor at the input of the first opamp, but this generates a good deal of noise due to the input bias current.

The Glass Blower avoids this by using a smaller resistance (R2) which is bootstrapped by C2 to an effective value of tens of megohms. The total input impedance of the circuit is then set mainly by R1, which does not carry any DC bias current.

Because most guitar pedals use a 9 V supply as standard, their output swing is limited to about 6 V_{pp} with ordinary opamps, and this is barely enough to cause clipping in the first stage of a tube amp. The Glass Blower doubles these figures without requiring a greater supply voltage, and so can produce 'early Jesus & Mary Chain' i.e. **very** high levels of additional tube overdrive. This is achieved by driving T1 and T2 with the output signal, which forces pins 4 and 7 of IC2 to follow the audio signal, effectively bootstrapping the power rails. With a rail-to-rail opamp for IC2, an output of 16 V_{pp} (!) can be obtained with an ordinary 9 V battery. The voltage **across** the opamp remains constant, however, so there are no worries about damaging the opamp even with supply voltages up to 30 V. To avoid instability at high gain and input levels, individual opamps should be used, not dual opamps.

R7 sets the maximum gain to

1 + R6 / R7

or 22 (27 dB) using the component values shown. For use with humbucker pickups a value of about 1 kΩ for R7 may be more appropriate, to avoid clipping at maximum settings. Switch S1 is an ordinary, latching footswitch (e.g., Maplin # N84AR).

The power supply is of the conventional type used in guitar pedals. Either a 9 V PP3 battery or mains power adapter can be used, and the pedal is only switched on when a mono guitar plug is inserted into the **stereo** input jack.

The author's prototype was built in a 116 × 64 × 30 mm aluminium enclosure (suggest Maplin LH71N and Rapid 303540, or Maplin GU62S and Rapid 303539 for the more experienced constructor!)

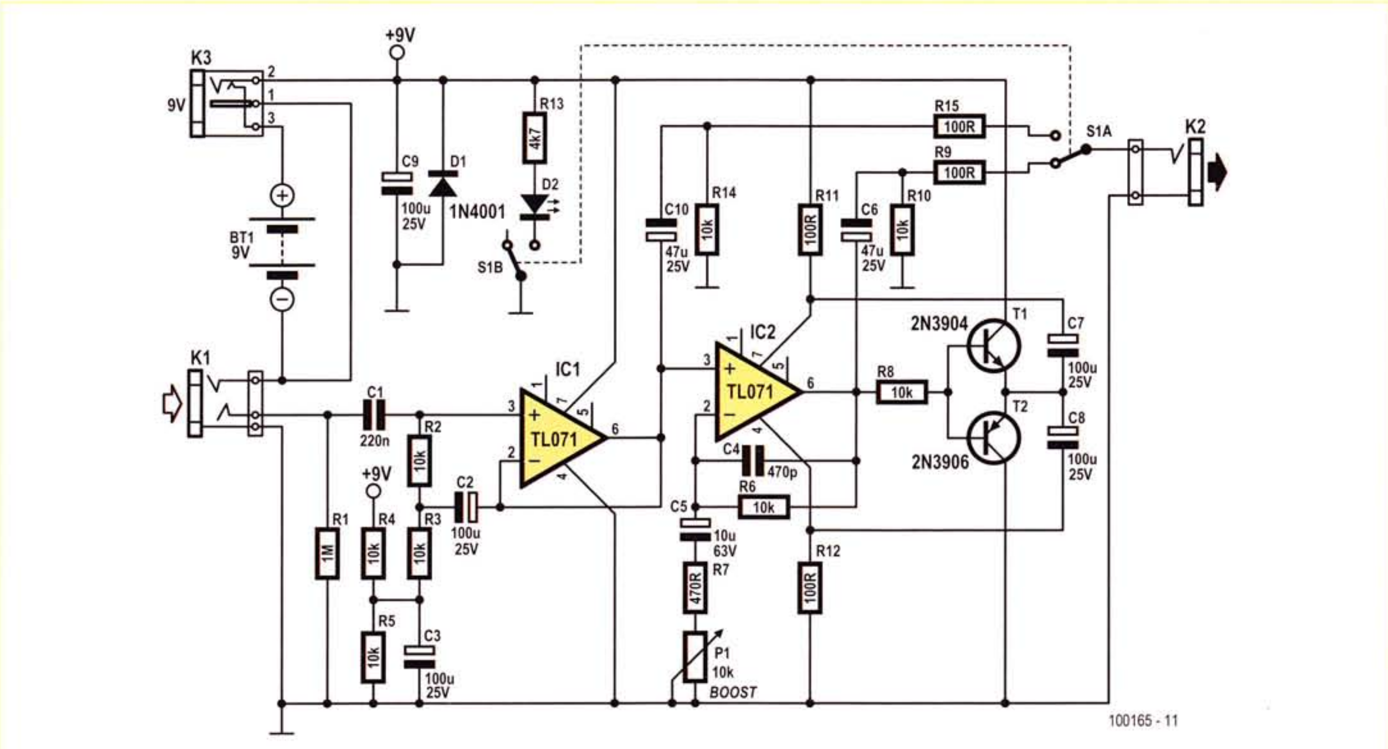
The 2.1 mm DC socket must be an insulated type since the centre pin is grounded (e.g., Rapid 200980, Farnell 1137744, Maplin FT96E). The input / output jack sockets (6.35 mm) should ideally be of the insulated type, but non-insulated ones will do (e.g., Maplin HF92A or HF93B).

For guitar pedals it is inconvenient to have all the sockets / controls on a single circuit board they are panel mounted and wired to the PCB by hand.

The author's design for a PCB and the associated wiring diagram may be downloaded from [1]. Compared to the schematic shown here, small differences exist in respect of component reference numbers.

(100165)

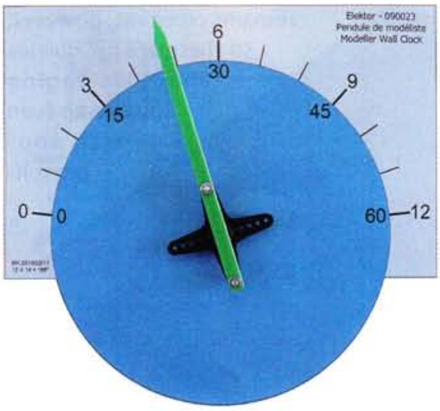
[1] www.elektor.com/100165



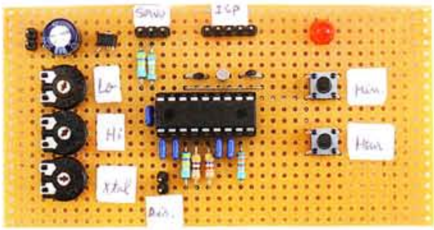
Modeller's Clock

Michel Kuenemann (France)

The special feature of this analogue wall clock is that it uses a standard model servo to tell the time. The display principle is the same as for an ordinary wall clock, but with two important differences. A standard model servo is unable to cover a travel of 360°, so we'll need to adapt the clock face to this situation. What's more, it's not possible to show the hours and minutes at the same time using just a single servo – so the clock will show the hours during the first part of each minute, and then the minutes for the rest of the current minute.



The circuit is arranged around a PIC18LF1320 microcontroller with a 32.768 kHz clock crystal to generate the 'seconds'. The controller core and the peripherals are clocked by the internal RC oscillator running at 8 MHz Test point TP1 delivers one pulse per second.



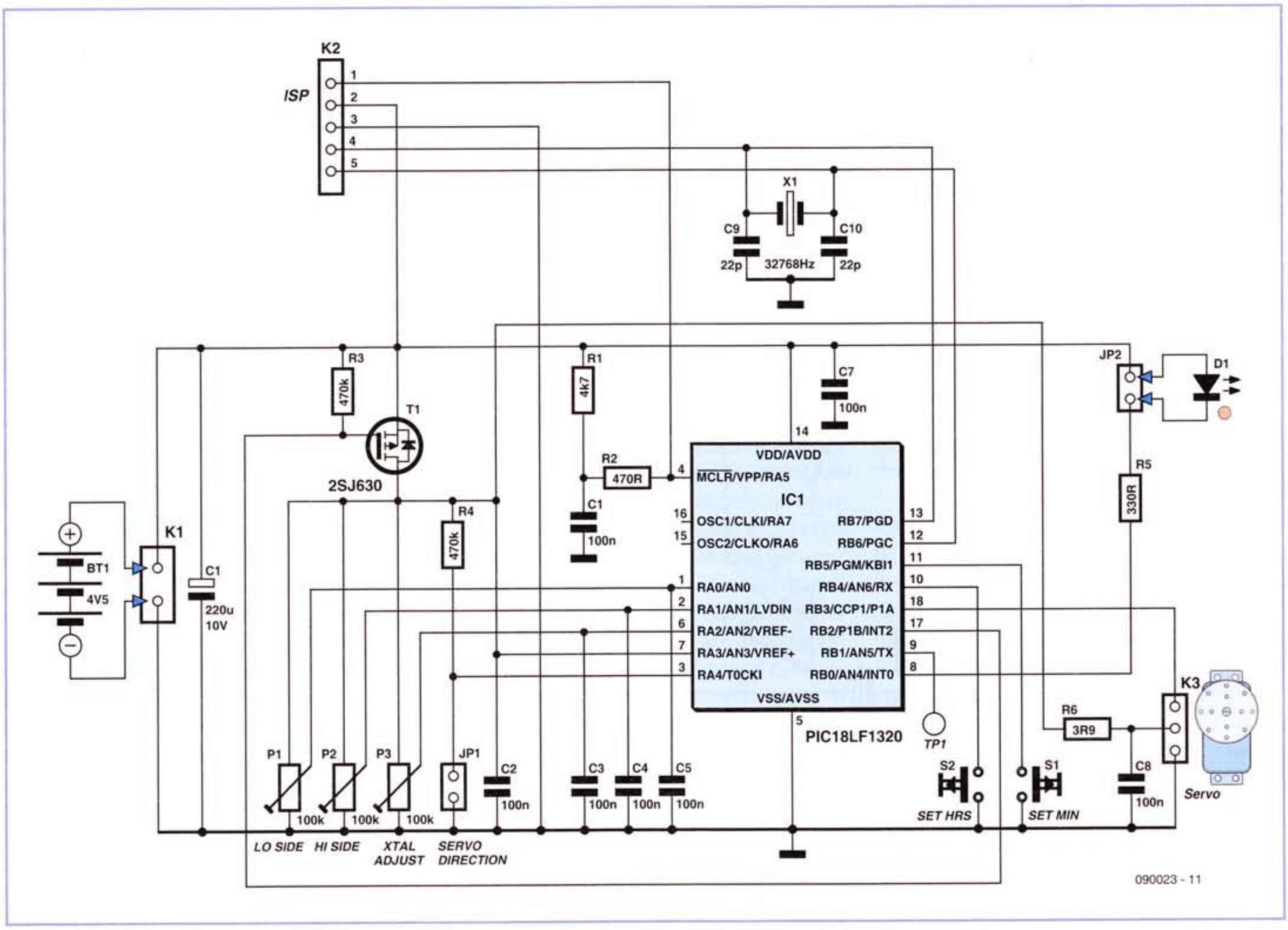
Two push-buttons are used to adjust the time, one for setting the minutes and the other for setting the hours. These buttons are also used to select the mechanical adjustment mode for the clock, as we shall see later.

The LED connected to the microcontroller flashes once per second while the servo is indicating the hours, but is out while the minutes are being displayed. The hand indicates the minutes during the first 50 seconds of each minute and shows the hours during the remaining 10 s.

Two potentiometers allow us to adapt the clock's operation to the mechanical travel of the servo used. A third potentiometer is used to compensate for any drift in the clock crystal. This adjustment makes it possible to compensate for an error of ±100 ppm, corresponding to a drift of over 4 mins per month.

Jumper JP1 is to be fitted if the servo turns anti-clockwise while the clock is being set.

Transistor T1 is used to turn off the servo power between two movements. Even when it's not rotating, a standard servo consumes around 15 mA or so, which is too much for a battery-powered clock.



The circuit is powered by three 1.5 V cells. Depending on the size of the servo used, it may be better to replace the batteries by a small plugtop adaptor supplying 5 V. You can also use three NiMH rechargeable cells, well known to model enthusiasts. The microcontroller's 'brown out' facility, set at 2.7 V, will avoid deep discharging the batteries by maintaining the microcontroller in reset if the threshold is reached.

This little circuit can easily be built on 2.54 mm-pitch perforated board. The potentiometers should be wired in such a way that they are at maximum voltage at the clockwise end. Do not fit jumper JP1 and set the three potentiometers to mid travel.

Connect up the servo and the supply. The servo goes briefly to neutral (mid travel) then turns anticlockwise to the 0 o'c position. If the servo turns the other way (towards 12 o'c), fit jumper JP1 and reboot the microcontroller. That should sort everything out.
Now it's time to make the face for the clock. You will be able to draw inspiration from the "universal" face available to download [1]. This 120° face can in principle be used with any type of servo that has a travel between 120° and 180°. To adjust the servo travel, proceed as follows.

Set the clock running while pressing one of the setting buttons and wait for the servo to turn in the direction of 0 o'c. Adjust P1 so that the hand is on the 0 o'c mark on the face. Now press one of the buttons to set the servo to the other end of its travel, and adjust P2 so that the hand is on the 12 o'c mark on the face. Repeat this operation until the adjustment is perfect at both ends. Turn the clock off, then back on again, and check that the hand moves to exactly opposite the 0 o'c mark.
Setting the time is easy. Press the 'set hours' button one or more times to set the hours. Keeping the button pressed makes the hours advance fast. Setting the minutes is done in the same way, only pressing the 'set minutes' button.

If after about a fortnight you notice the clock is gaining or losing time, adjust potentiometer P3. If the clock loses, turn P3 slightly clockwise; if the clock gains, turn P3 slightly the other way. After an adjustment, you must wait at least 12 days before touching the adjustment again. The adjustment lets you compensate for several minutes a month, so you'll need to adjust P3 very carefully. What's more, it's important to note that P3 does not affect the frequency supplied by test point TP1.

(090023-I)

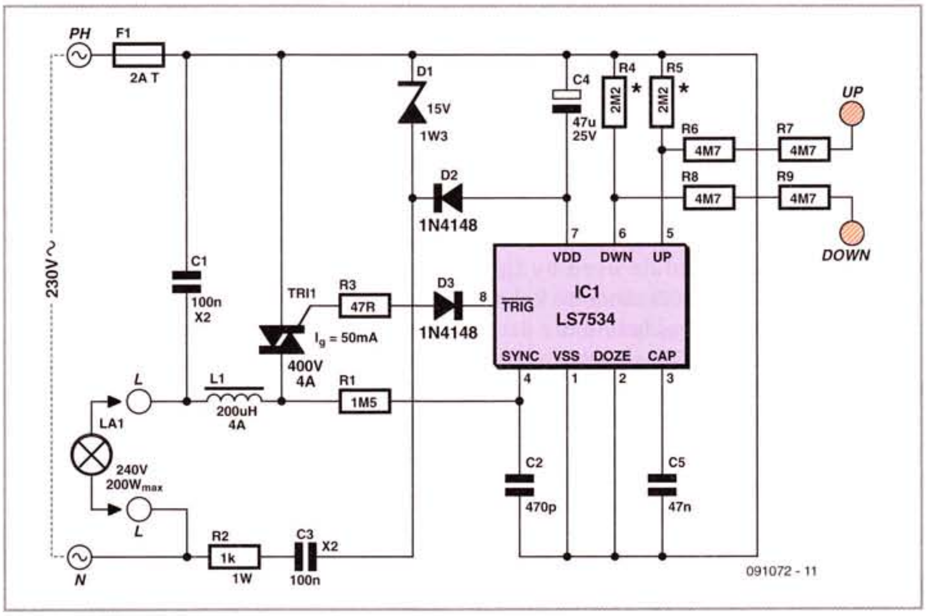
[1] www.elektor.com/090023

Touch-controlled Dimmer

Christian Tavernier (France)

Here's a dimmer that, besides being touch-controlled, also has a setting memory that enables it, for example, to turn the lighting on at the level you had set last time it was turned off. The project uses a specialized IC, an LS7534 from LSI Computer Systems, available from Farnell, among others. This IC is powered directly from the domestic AC powerline, which is dropped using capacitor C3 in order to avoid any thermal dissipation.

The power switching element is a triac, turned on at the zero crossing of the mains via the synchronization information conveyed to the LS7534 via R1 and C2, and turned off after a larger or smaller part of the sinewave so as to be able to adjust the brightness to the required level.



The touch pads are connected to the UP and DOWN inputs via two high-value series resistors, which for safety reasons must not be either reduced in value or replaced by a single resistor of equivalent value. Note here that the values of pull-up resistors R4 and R5 can be adjusted between 1 MΩ and 4.7 MΩ in order to adjust the sensitivity of the touch control.

Choke L1 is a conventional toroidal type intended to reduce the interference radiated when the triac turns off, in conjunction with capacitor C1. For safety reasons, it is vital that the latter, along with C3, should be class X2 types, intended for direct mains operation.
The triac can be any 400 V, 2–4 A type. You just need to take care to pick a type that is fairly sensitive, with a trigger current of no more than 50 mA, otherwise the LS7534 won't be able to trigger it properly. Although on the circuit diagram we have shown the maximum lamp power as 200 watts, it's possible to go above that, but in this case the triac will need to be fitted with a heatsink, which

will make the project bulkier.

If the project is not built in to an electrical wall box, you must be sure to choose an insulating case, since in the absence of a transformer, the whole of the circuit is at AC line potential and any accidental contact with it could be fatal.

Using the dimmer is very easy, but requires you to make the distinction between long or short contact with the touch pads. When the light is off, a short touch (typically 34–325 ms, according to the data sheet) on UP makes the lamp light gradually up to the maximum value reached last time it was turned off. When the light is on, a short touch on DOWN makes the lamp slowly go out.

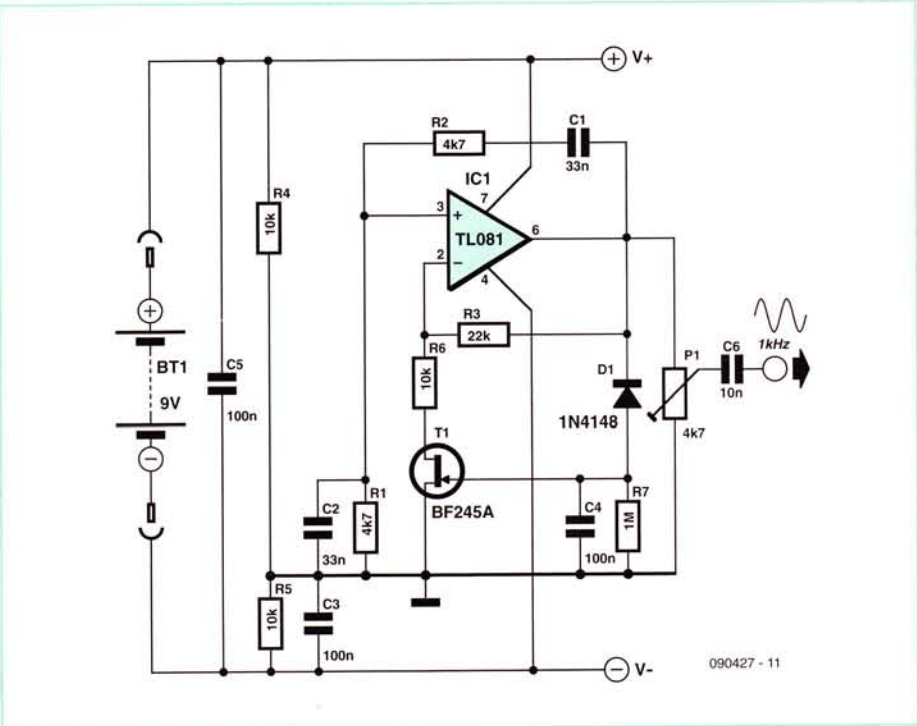
A long touch on UP (typically longer than 334 ms) gradually increases the brightness up to maximum, beyond which it has no further effect. A long touch on DOWN reduces this same brightness down to minimum.

(091072-I)

Vest Pocket VHF FM Test Generator

Kai Riedel (Germany)

After licensing restrictions were relaxed in many countries for VHF FM band transmitters with 50 nW transmit power, several small, inexpensive FM transmitter modules appeared on the market. In the author's view, such a module forms a good basis for a small FM-band test generator. This only requires a sine-wave modulation signal, which can come from an existing audio generator. If you don't have a suitable audio generator available, you can build the Wien bridge oscillator described here.



FET T1 provides amplitude stabilisation in order to keep the distortion low. The generated signal is fed to the transmitter module via a 3.5-mm stereo headset socket, which mates with the usual 3.5-mm stereo plug of the FM transmitter (the left and right terminals of the socket are wired together). Adjust the output level of the audio oscillator with potentiometer P1 to avoid overdriving the transmitter.

In the transmitter module used by the author, the HF stage is built around a Rohm BH1418FV IC. You can easily find the data sheet for this IC with a Google search, and it can help you identify the HF output on the transmitter circuit board. You can then use a length of coax cable to tap off the FM signal and feed it to the antenna connector of the receiver under test. Here you must pay attention to the maximum rated input level of the receiver and impedance matching, and if necessary you should use an attenuator at the receiver input. You can use an oscilloscope to trace the signal in the receiver and analyse the receiver output signal.

(090427-I)

Astrolamp

Martin Dümig (Germany)

It takes up to an hour for our eyes to fully adapt to the dark and achieve maximum light sensitivity with the iris fully open. Astronomers use red light to avoid interfering with this adaptation process. A lamp for stargazing should also have several other features. Some of the features of the lamp described here are:

- Red light for observation
- Dimmable
- Easy operation (including with gloves if necessary)
- White light for erecting and dismantling the telescope
- Reliable protection against operator errors (no accidental white light)
- Existing lamps can be remodelled

The lamp is controlled by a single button and responds to button presses as follows:

- With the lamp off, pressing the button for less than 5 seconds switches on the red light
- With the lamp off, pressing the button

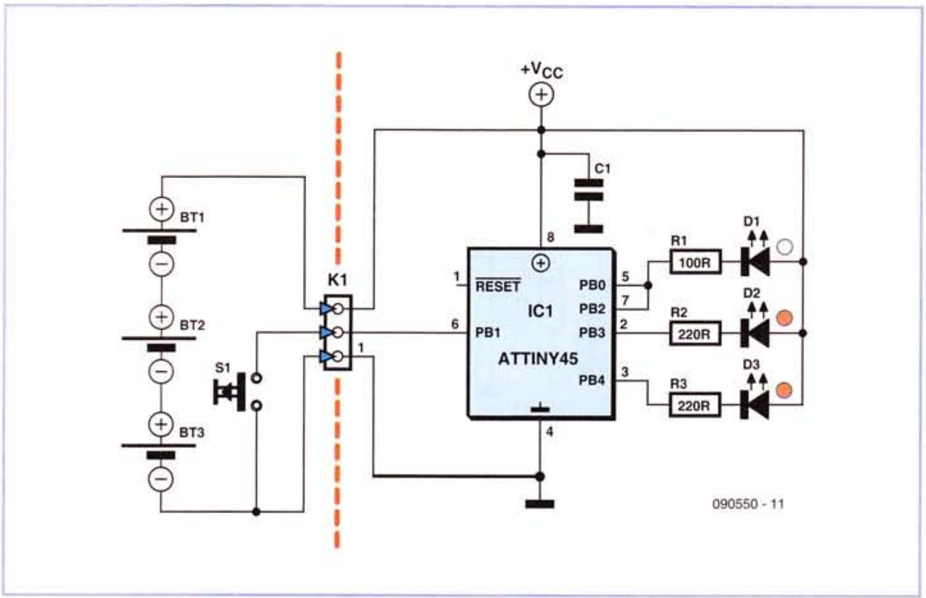
for more than 5 seconds switches on the white light

- With the red light on, pressing the button for less than 1 second switches off the lamp
- With the red light on, pressing the button for more than 1 second alternately brightens or dims the lamp
- With the white light on, pressing the button switches off the lamp

The lamp also remembers the red light setting.

The starting point for the remodelled lamp is an inexpensive headlamp from a DIY shop, which has seven white LEDs and a splash-proof button. The lamp has a battery module that holds three AAA cells (4.5 V), with two spring contacts that press against contact surfaces on the built-in PCB. This board holds the control button for lamp. Three wires lead from this board to another PCB with the LEDS and the LED driver IC. They are: ground (GND), +4.5 V (VCC), and Button (contact closure to ground).

In the remodelling process, the original PCB with the LEDs and LED driver was replaced by a PCB with the author's circuitry. The original portion of the lamp circuit (battery holder and button) appears at the left in the schematic diagram. The new LED board is fitted with an ATtiny45 microcontroller and three LEDs with series resistors, consisting of two diffuse red LEDs and a white LED. The latter LED can be salvaged from the original LED board (maximum LED current around 50 mA). As the microcontroller's rated output current is only 20 mA per pin, the white LED is connected to two pins. Buffer capacitor C1 may be omitted if space is tight.



The firmware (including the source code in assembly language) may be downloaded from the web page for this project [1], where you may also order a pre-programmed ATtiny45 microcontroller. If you wish to program the microcontroller yourself, you can select various ATtiny microcontrollers or the AT90S2343 (the type originally used by the author) in the software. The firmware occupies only a small part of the microcontroller's program memory, so there's plenty of room for extensions.

The values of resistors R1 to R3 can be adjusted to match the forward voltages of the LEDs actually used. The voltage drop across the microcontroller is practically negligible.

The remodelled lamp is switched off exclusively by the microcontroller, which according to the data sheet draws less than 1 µA in sleep mode, nearly the same as the self-discharge rate of the batteries. The microcontroller is awakened by pulling PB2 to ground (when the button is pressed).

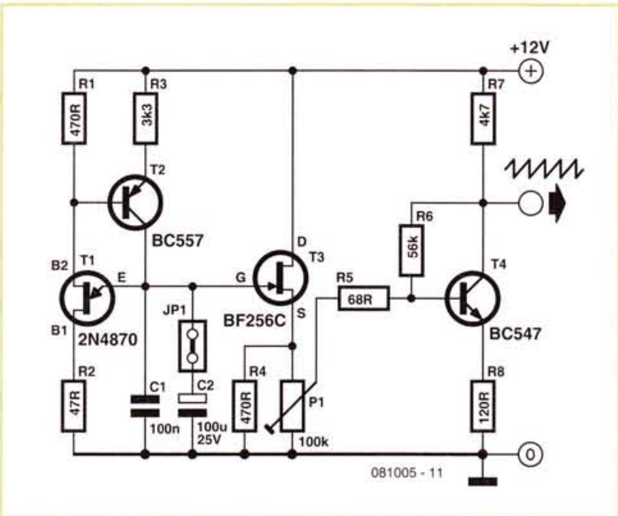
(090550-I)

[1] www.elektor.com/090550

Sweep your Function Generator

Holger Bruns (Germany)

Function generators built around the XR2206 have always had an excellent price/performance ratio, and the IC although 'obsolescent' is still available. If your generator does not have built-in sweep ('wobbulator') capability, a small external circuit is all you need. You can fit the circuit in place of the frequency adjustment potentiometer if you don't already have a sweep input.



The circuit is a classic sawtooth oscillator based on a unijunction transistor (UJT), which switches when its base voltage reaches the trigger level. This allows the capacitor connected to the base to discharge rapidly. To obtain a linear charging characteristic and thus a linear sawtooth ramp, the capacitor is charged by a constant current source built around a BC557. The output signal is buffered by a FET (BF256C) to minimise the load on the oscillator.

The output stage built around the BC547 provides the interface to the XR2206 function generator, with trimpot P1 serving to adjust the sweep amplitude.

To make it easier to see the signal on an oscilloscope during alignment, it's a good idea to remove jumper JP1 near capacitor C2 in order to increase the sawtooth frequency. Fit the jumper again after completing the alignment. With the 100 µF electrolytic capacitor (C2) back in the circuit, the sweep frequency will be significantly lower. If necessary, you can use a different value to obtain a different sweep rate.

You can probably find all the necessary components in your parts bin, but if not, the UJT is still available (for little money from RS Components), and the FET can be replaced by most other small-signal N-channel JFETs.

For the UJT, you can also use a 2N2646 or a 2N2647. If you also want to put together an XR2206 function generator, check reference [1] for free instructions for assembling a tried and tested Elektor circuit.

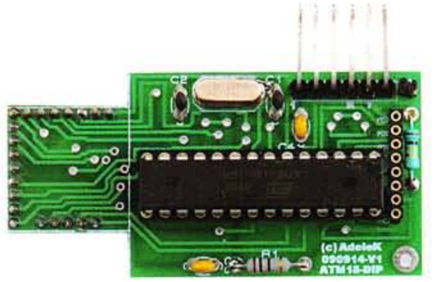
(081005-I)

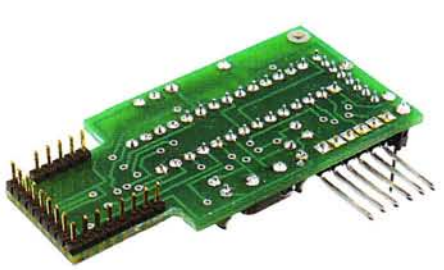
[1] www.elektor.com/060312

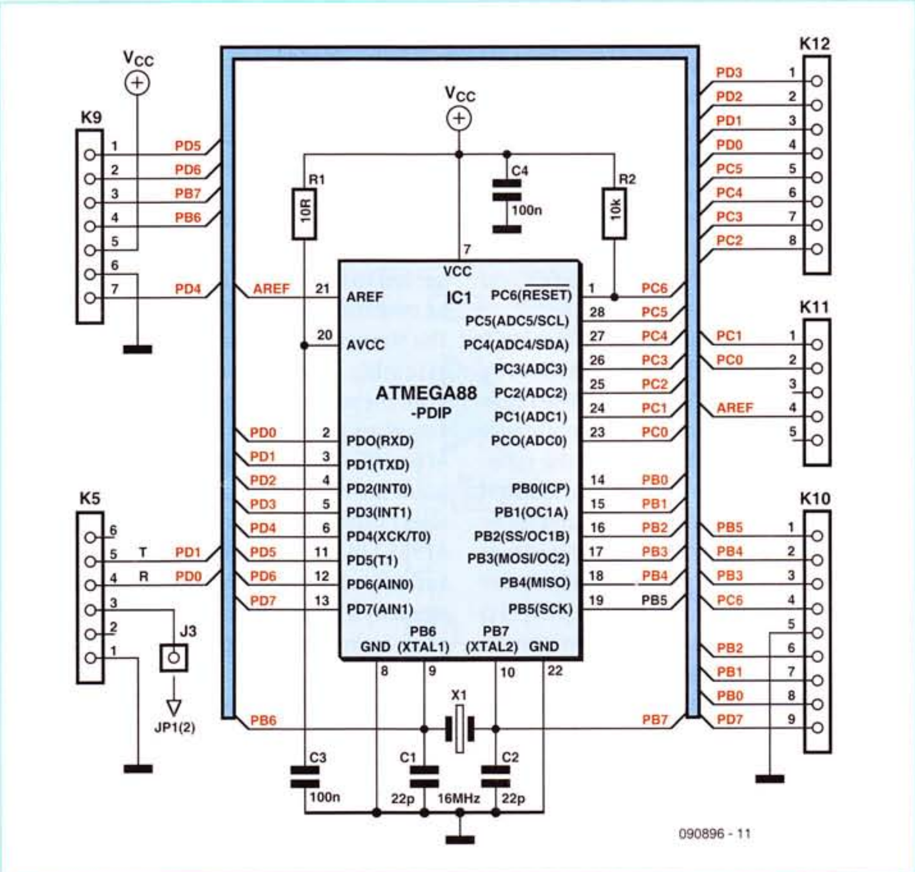
ATM18-DIP

Grégory Ester (France)

Even though you can't actually damage the microcontroller in the ATM18 project by the configuration of its fuse bits, setting them wrongly can however disable it. There are actually several different ways of cutting off







the branch you're sitting comfortably on. Thus it is possible to accidentally change, for example, the programmer access mode or the clock source. In both the aforementioned cases, bringing your microcontroller back to life can take some time and may even need equipment you don't have to hand.

Rather than replacing the whole controller board # 071035-91, how about just removing the ATmega88? This substitution operation will only cost you an ATmega88-20PU DIP 28 at just a couple of pounds, which compares favourably with the price of the complete board sold by Elektor.

We should point out that the DIP version offers a 6-channel ADC, as against eight for the TQFP version. Apart from this subtle difference, the ATM18-DIP board is similar to its smaller sister in virtually every respect. Virtually, since we must note the following niceties all the same:

- connector K12 is moved to the top;
- if you opt for powering via the USB port, you'll need to connect the USB/RS-232 (TTL) cable to the ATM18-DIP PCB in the same way as you did for the piggy-back board PCB. Then, if you want to use USB powering, connect a wire from J3 (ATM18-DIP) to pin 2 of JP1 (piggy-back board PCB).

So the ATM18-DIP will be used in the development stages, while once the system has been finalized and debugged, it'll be preferable to use the TQFP version, which takes up less space.

The parts list and PCB artwork for this project may be found at [1]. 'ATM18' is a project series featured in Elektor, starting April 2008.

(090896-I)

1] www.elektor.com/090896

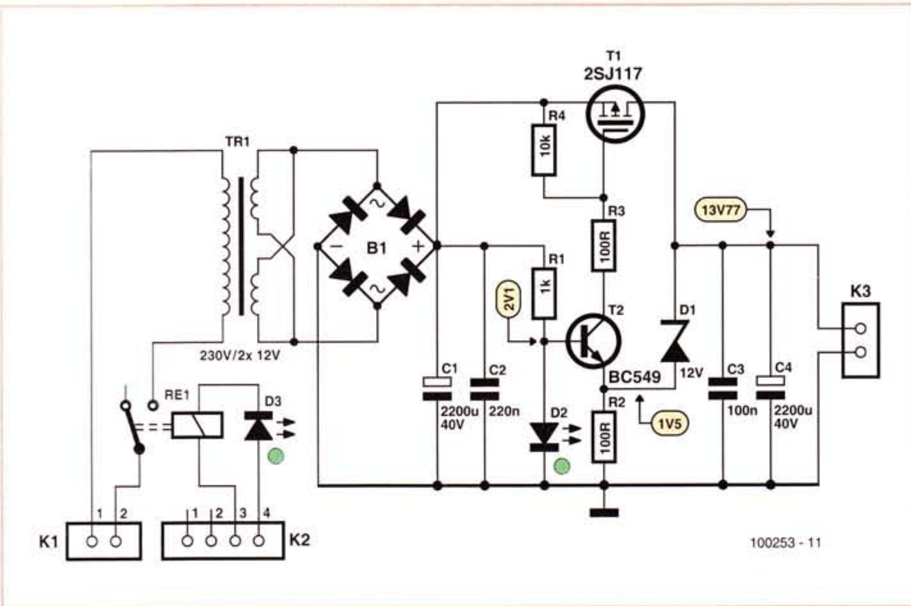
Discrete Low-drop Regulator

Jac Hettema (The Netherlands)

This circuit was designed to ensure that an amplifier circuit containing a TDA1516Q would not exceed its maximum supply voltage when the load is small. This amplifier is used in a PC to increase the audio power somewhat. The

PC power supply, however, created so much interference that an additional power supply was required.

The power supply has its own power transformer with a secondary voltage of 12 V AC. After rectification and filtering this results in a DC voltage of about 16 V. The regulator consists of a P-channel MOSFET SJ117, the gate of which is driven via a voltage divider connected to T2. The base of T2 is held at a constant voltage by LED D2, so that the voltage across emitter resistor R2 is also constant and therefore carries a constant current. When the output voltage is higher than about 13.5 V, zener diode D1 will start to conduct and supply part of the current through R2 — as a result the MOSFET will be turned on a little less. In this way there is a balance point, where the output voltage will be a little over 13.5 V (1.5 V across R2 plus the 12 V zener voltage). The regulator is capable of delivering up to about 2 A — in any case it is a good idea to fit the MOSFET with a heatsink.
It is possible to add an optional potentiometer in series with the 12-V zener diode, which will allow a small amount of adjustment of the output voltage.



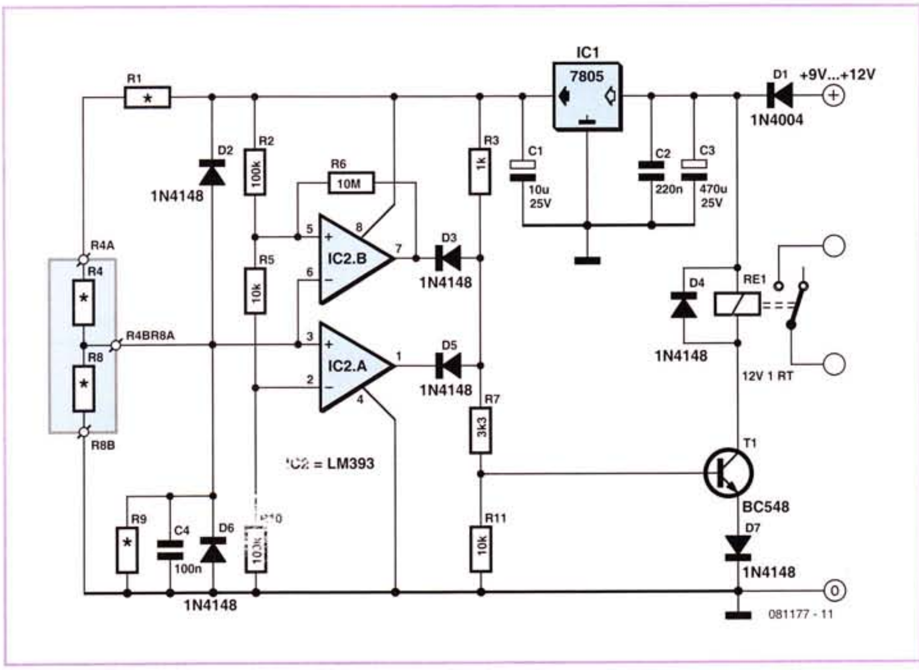
The relay at the AC powerline input ensures that the power supply is only turned on when the PC is turned on. This relay is driven from a 4-way power supply connector from the PC.

(100253-I)

Analogue Electronic Key

Christian Tavernier (France)

This circuit uses two comparator that are combined in what is called a window comparator, i.e. resistors R2, R5, and R10 determine a voltage window within which the voltage applied to the junction of D2 and D6 must lie in order for the outputs of IC2.A and IC2.B to both be high at the same time. Given the value used for these resistors, this window is from 10/21 to 11/21 of the comparator supply rail (5 V). If IC2.A and IC2.B outputs are both high at the same time, transistor T1 is saturated via the AND gate formed by D3 and D4, and relay RE1 is energized to operate the electric latch or any other locking device.



The key is defined by the generation of the specific voltage at the junction of D2 and D6, formed, for example, by a simple stereo jack containing the two resistors R4 and R8. Together with R1 and R9, they form a potential divider that needs to be suitably calculated in conjunction with the values of R2, R5, and R10 so that the key can open the lock.

Clearly, all this will only work correctly is the supply voltage to these two dividers is stable, which is ensured by IC1, regulating it to 5 V.
If we had set the values for R1 and R9, all the readers of this edition of Elektor would have had the same key, which is clearly not a good idea! So you need to decide for yourself not only R4 and R8, which form the key, but also R1 and R9 which let you customize the 'lock'.

Here are the relationships between the values of resistors R1, R4, R8, and R9 for the key to be able to open the lock:

$$10 \cdot R8 \cdot R9 < 11 \cdot (R1 + R4) \cdot (R8 + R9)$$
$$10 \cdot (R1 + R4) \cdot (R8 + R9) < 11 \cdot R8 \cdot R9$$

Given the size of the window formed by R2, R5, and R10, 5 % tolerance resistors are adequate.

Note too that, as the relationships consist of inequalities, and that there are only two (un)equations for four unknowns, this leaves quite a wide choice for the resistor values. We advise you to set at least two of them to preferred values, which will then let you work out the others. If, as is more than likely, this does not result in other preferred values, you'll then need to use series/parallel combinations to obtain the calculated values — or else choose different starting values in order to arrive at a better compromise.

(081177-I)

[1] www.elektor.com/081177

DIY SMD Adapter

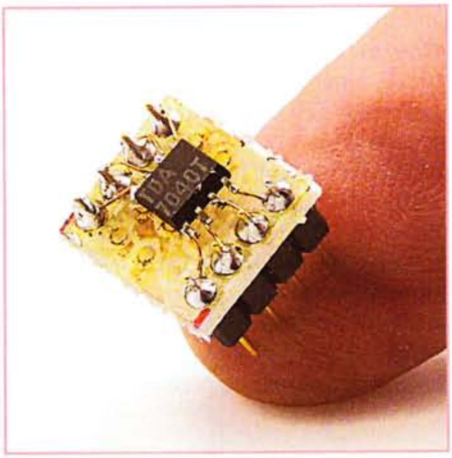
Michael Hölzl (Germany)

In order to use an SMD device on a standard prototyping or perf board (breadboard) you will first need to fit it into some sort of carrier or (expensive) professional adapter board with pins at the same raster as the perf board. Such an adapter can also be made quite cheaply; we will take you through the steps using an SO-8 narrow package as an example.

Firstly cut a small rectangle of perf board to act as a chip carrier. It must be long enough to have one pad per IC pin down each side of the IC (in our case 4 pads long). Its width should allow two rows of unused pads either side of the chip with the chip in the centre. The next step is to carefully remove all the unused copper pads with a knife so that there is no possibility of any of IC leads shorting with a pad. Once the small piece of board has been cleaned up the IC can be glued centrally onto the board.

The carrier can now be fitted with the connecting pins so that when complete, the whole assembly can be used in the same way as a standard DIP or DIL chip. Solder pins are used here; firstly push the pins into a solderless plug-in breadboard to hold them in position. Place the carrier board over the pins then carefully solder each pin in position on the carrier board.

Now connect each pin to the corresponding IC lead using thin enamelled copper wire (ECW). If you are lucky enough to have the self-fluxing type then this job will be much easier. Normal ECW can also be used but it will be necessary to scrape the enamel from the ends and tin them.



Any recommended supply decoupling capacitors can be mounted directly on the carrier board across the supply pins.

The method works well with SO packaged chips. SO-8 devices do not need any enamelled wire; the chip leads can be soldered directly to the solder pins. Before powering up the chip make a careful inspection of all the solder joints to ensure there are no unintentional short circuits.

(090614)

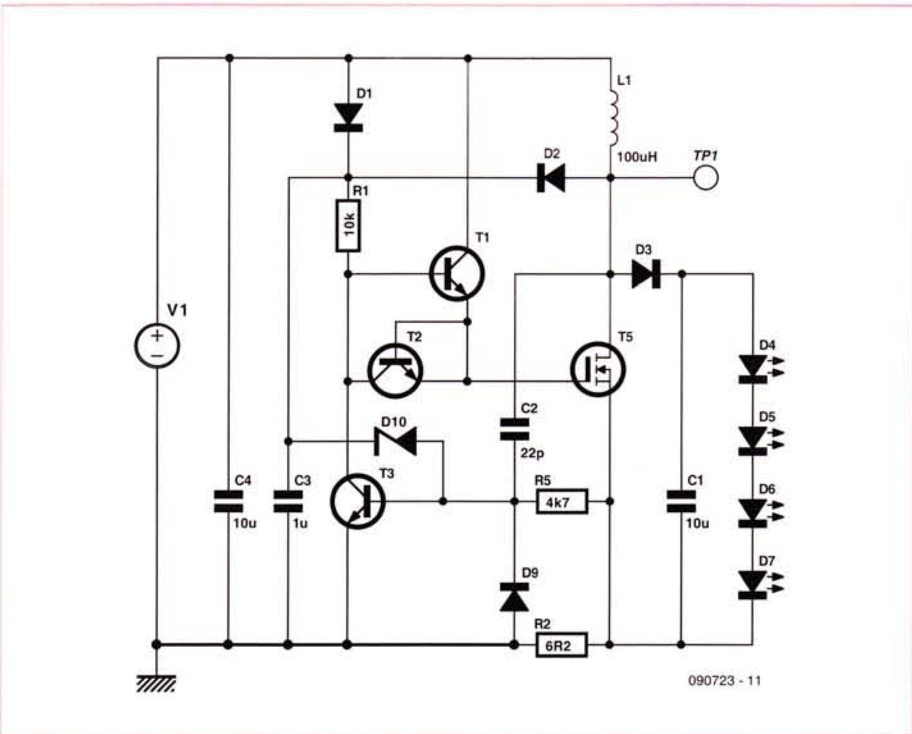
LED Bicycle Light Revisited

Bernd Schulte-Eversum (Germany)

The LED bicycle light that we described in the July/August 2009 edition of Elektor has proved very popular. The author was particularly struck by the basic design, but as always, there is room for a little improvement! Below we describe two enhanced variations on the original theme.

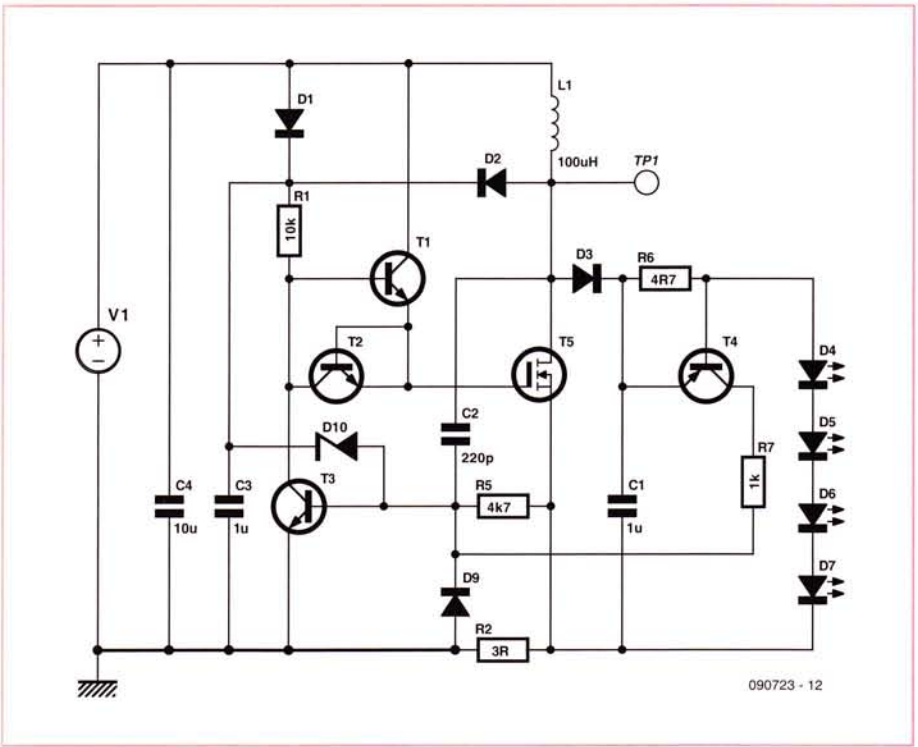
Both circuits are, like the 2009 original, powered from a 6 V (rechargeable) battery, shown here as V1. The simpler of the two circuits, which consists of four transistors, is in function essentially the same as the original version. It takes the form of a boost converter with feedback provided by the voltage drop across a current sensing resistor, in this case R2. A value of 6.2 Ω for R2 is suitable for use with four white LEDs at D4 to D7, and gives an LED current of approximately 20 mA. The 250 mW Zener diode D10 is provided to limit the output voltage in the case that the LED chain should go open-circuit, pulling the gate of the MOSFET to ground via T3, T1 and T2 if the output voltage exceeds the breakdown voltage of the Zener. A breakdown voltage of between 15 V and 24 V is recommended. L1 is a 100 µH coil with a current rating of at least 0.5 A and should have a very low DC resistance.

Transistor T1 provides a low-impedance source to charge the gate of MOSFET T5. Transistor T2 (the author used an SMD BC846S dual transistor) is wired as a diode, and is responsible for discharging the gate of T5 via T3. This extension to the original circuit means that MOSFET T5 switches more quickly, which improves overall efficiency. As a side-effect the switching frequency also rises significantly. With a switching frequency of over 150 kHz ceramic or film capacitors must be used at the input and output, as electrolytics will gradually fall off in effectiveness. In the original circuit a type NTD4815N MOSFET with an on resistance $R_{DS(on)}$ of 15 mΩ (at V_{GS}=10 V) was recommended, although almost any N-channel MOSFET with similar on-resistance characteristics will be equally suitable.



The second circuit employs five transistors, and differs from the first in that it uses a secondary current regulation loop based around transistor T4. This makes the design more suitable for use at higher LED currents, giving greater current stability in the presence of power supply voltage fluctuations. The voltage drop across resistor R6 due to the current flowing through the LEDs turns transistor T4 on. Via T3 this in turns modulates the switching of T5, hence keeping the output current constant. Transistor T4 is a type BC856B; an alternative device in a leaded package is the BC556B. T3 is a BC546B. The BC846S dual SMD transistor used for T1 and T2 can be replaced by a BC546B (for T1) and a type 1N4148 diode (for T2).

(090723)



Dynamic Limiter

Ton Giesberts (Elektor Labs)

This circuit is a revised version of the Audio Limiter published in the 2002 Summer Circuits edition, which is intended to limit the (possibly excessive) dynamic range of the audio signal from a TV set or DVD player (for example). The original circuit is based on attenuating an excessively strong source signal. Here we take the opposite approach of amplifying the quieter passages. To minimise the typical 'breathing' effect of compressors, the control range is limited to only 24 dB. The gain is adjusted in discrete (non-audible) steps, which avoids non-linearity and thus avoids distortion.

With the component values shown on the schematic diagram, the circuit can boost the gain in 15 steps of 1.6 dB each, yielding 16 levels from 0 to 24 dB. The voltage divider used in the original circuit has been replaced here by negative feedback circuitry using two non-inverting amplifiers. This reduces the number of resistors and allows smaller multiplexers to be used — in this case consisting of two halves of a 4052 IC per channel (the 4052 is a dual 1-of-4 analogue multiplexer/demultiplexer).

The entire control logic is the same as before. Although there are two stages per channel, fewer resistors are necessary than with the original design. To allow the overall gain to be controlled in equal steps, the individual amplifiers (IC1A/IC3 and IC1B/IC4) have different step sizes. The gain steps of the first stage are relatively small (0, 1.6, 3.2 and 4.8 dB), while the gain steps of the second stage are relatively large (0, 6.4, 12.8 and 19.2 dB). The total gain can thus be controlled over a range of 0 to 24 dB in 16 equal steps. The individual resistor values are easy to calculate with this approach: $(10\ \text{k}\Omega)/(10^{A/20} - 1)$, where *A* is the desired gain and 10 kΩ is the value of R5, R10, R14 or R18. Other gain ranges can also be implemented in this manner (see **table**), but you should bear in mind that steps larger than 1.6 dB may be audible.

The control circuitry is largely made up of simple discrete logic. The multiplexers are driven by an up/down counter (IC8). Window comparators are used to determine the signal level at the output. They are built around two comparators of an LM399 (quad comparator) for each channel. The same reference voltage (across P1), at approximately 1 V, can be used for both channels. The reference voltage can be modified by changing the value of P1 — for instance, 10 kΩ yields around 1.7 V. The con-

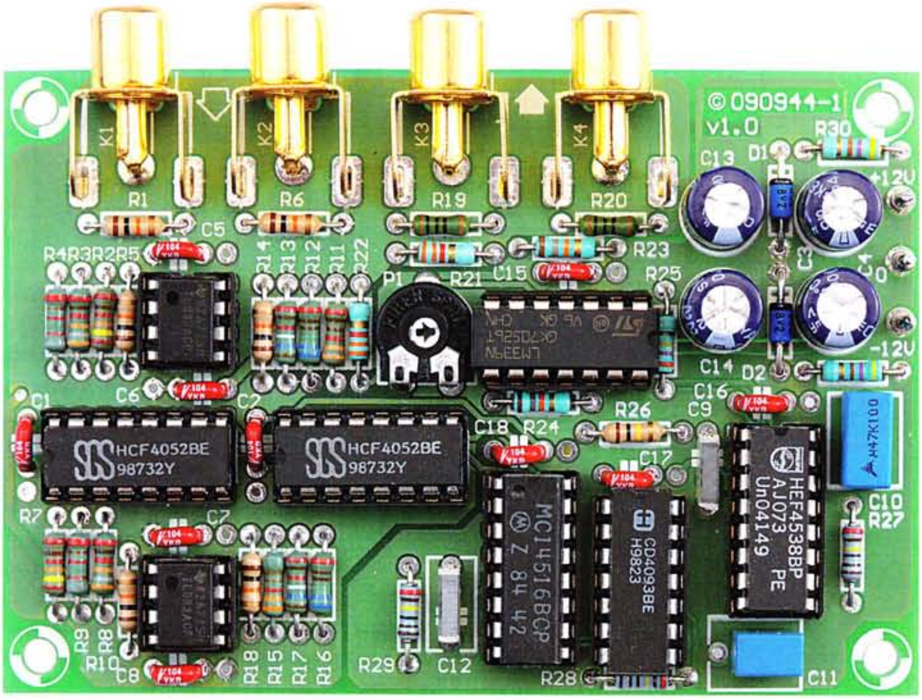
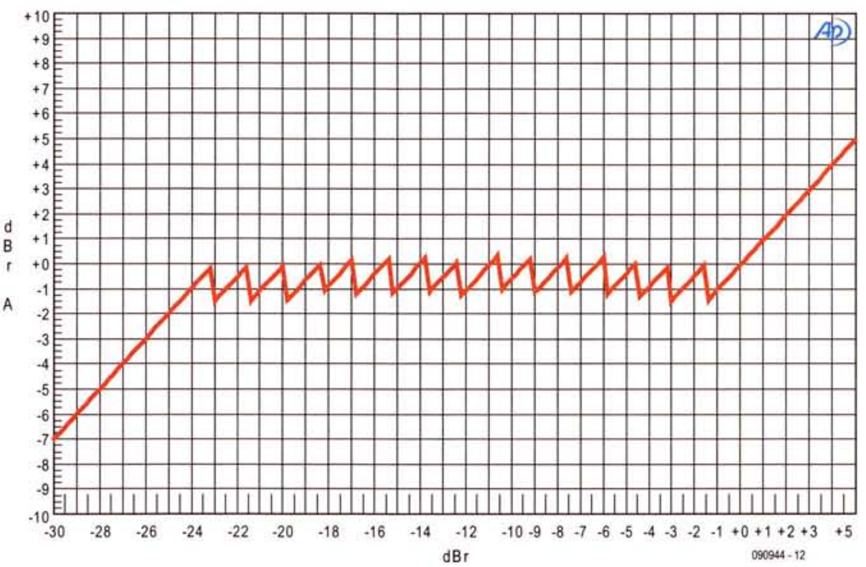
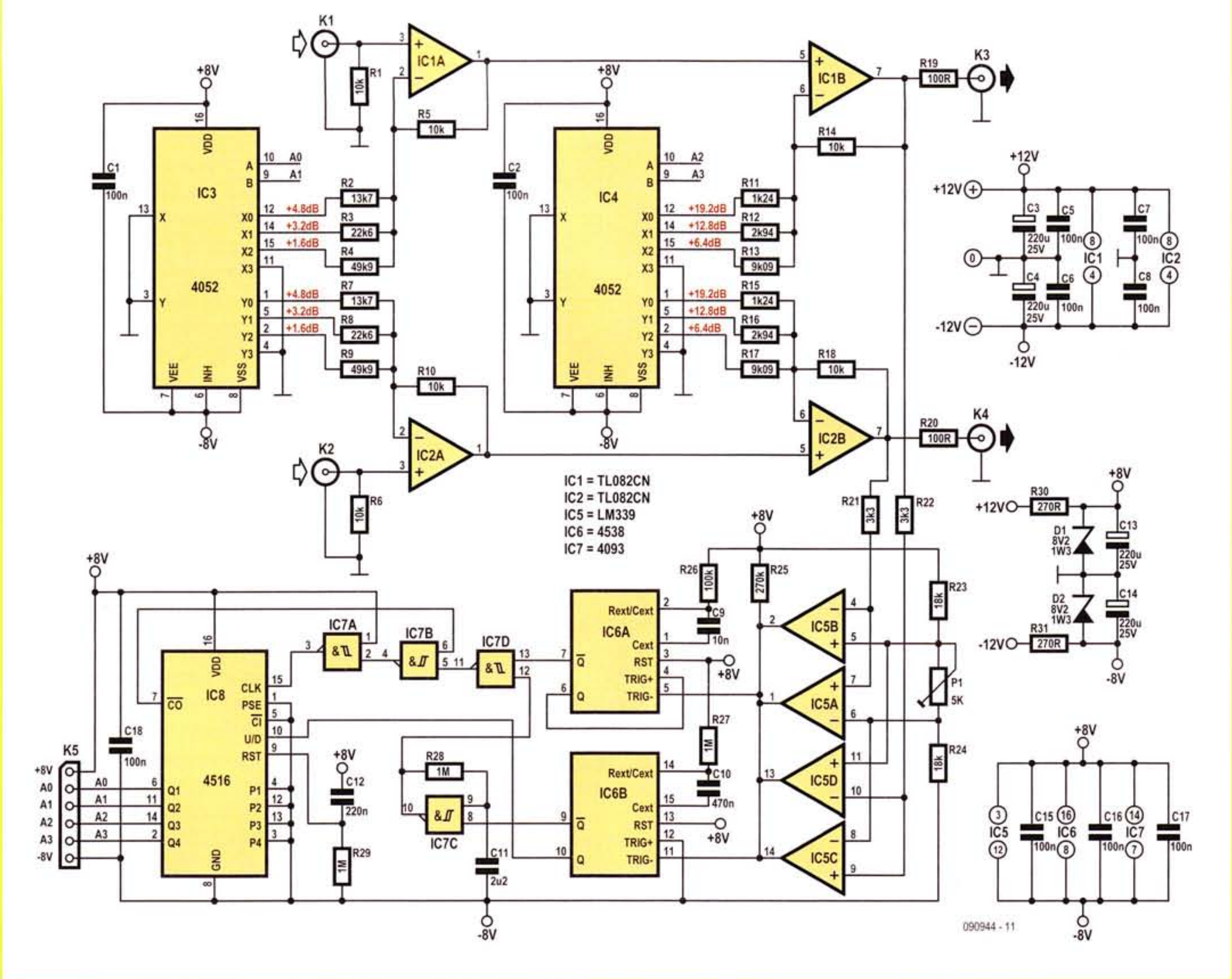


Table. Alternative control ranges (R5 = R10 = R14 = R18 = 10 k)

	15 dB			20 dB		
	Theoretical	**E24**	**E96**	**Theoretical**	**E24**	**E96**
R2 & R7	24.24 kΩ	24 kΩ	24.3 kΩ	17.10 kΩ	18 kΩ	16.9 kΩ
R3 & R8	38.62 kΩ	39 kΩ	38.3 kΩ	27.83 kΩ	27 kΩ	28.0 kΩ
R4 & R9	81.95 kΩ	82 kΩ	82.5 kΩ	60.27 kΩ	62 kΩ	60.4 kΩ
R11 & R15	3.354 kΩ	3kΩ3	3.32 kΩ	1.883 kΩ	1.8 kΩ	1.87 kΩ
R12 & R16	6.614 kΩ	6kΩ8	6.65 kΩ	4.142 kΩ	4.3 kΩ	4.12 kΩ
R13 & R17	17.10 kΩ	18 kΩ	16.9 kΩ	11.80 kΩ	12 kΩ	11.8 kΩ





trol circuit responds to the peak level of the output signal. As long as the output signal level is lower than the reference level, oscillator IC7c is enabled by monostable multivibrator IC6b. This causes IC8 to count down slowly (pen 10 of IC6 is low) until the lowest count is reached. The counter is then blocked by IC7b, and the gain is set to the maximum (the X0 outputs of IC3 and IC4 are at ground level). IC6b is triggered when the window comparators generate pulses. The outputs of IC6b remain asserted as long as this occurs (the 4528 is retriggerable), and oscillator IC7c is blocked. IC6a is now triggered by the comparators. The Q output of IC6a is connected to the positive trigger input to prevent retriggering of IC6a. In this situation the counter is clocked by pulses from IC6a (pin 7).

The pulse width is set to 1 ms to prevent the multiplexers from going a few steps too far at high frequencies. If you find the recovery time too long, you can make it shorter by reducing the value of R26. The time delay provided by IC6b ensures that the circuit does not start amplifying the audio signal right away, but instead waits for half a second. This gives the circuit a calmer control characteristic.

The circuit is designed for a minimum gain of 1. Signals larger than the set reference level are passed through unchanged. As the quieter passages in the audio signal are amplified, you can set the volume control of your sound system to match the loudest sound level. A circuit that simplifies the optimal adjustment of P1 is described elsewhere in this Summer Circuits edition.

The logic circuitry operates from symmetrical 8-V supply voltages. They are derived from the symmetrical 12-V supply rails with the aid of two resistors and two Zener diodes. The values of these components as shown on the schematic diagram are dimensioned for the external indicator circuit, which can be connected to K5. The current consumption is approximately 20 mA. If you don't use the indicator, the current consumption can be reduced by 5 mA by increasing the values of R30 and R31 to 470 Ω. The distortion is very low – only 0.001% at 1 kHz with 500 mV input and output levels.

The measured characteristic curve shows the behaviour of the circuit. The X axis represents the input signal, while the Y axis represents the output signal. Here 0 dB corresponds to the reference level. The 24 steps of controlled gain adjustment as the input signal level increases are clearly visible here.

A PCB layout for the circuit and the accompanying components list may be downloaded from the Elektor website [1].

(090944-I)

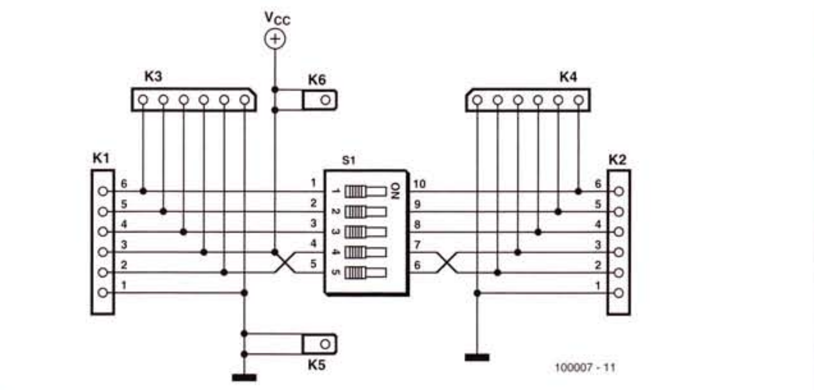
[1] www.elektor.com/090944

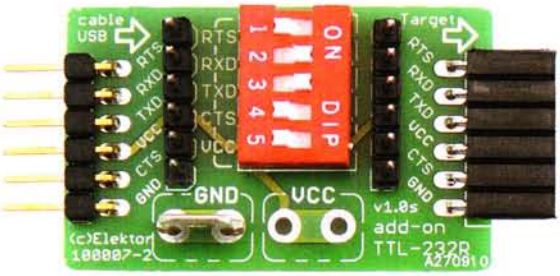
USB/TTL Serial Cable: Extension & Supplement

Antoine Authier (Elektor Labs)

Two years ago, I presented here the USB/TTL serial conversion cables from FTDI [1][2] — wonderful communication and debugging tools. The increasingly frequent use of ARM CPUs in our projects like Sceptre, the battery monitor, the engine test bench, etc. has led us to use the 3.3 V version in order to protect the ARM's input/output ports intended for 3.3 V (unless otherwise stated; the data sheets are unclear about this... but better safe than sorry!)

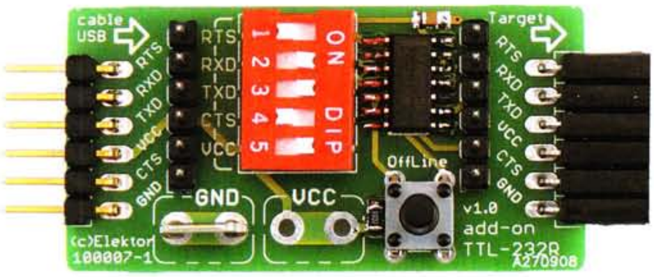
1





From now on, the 3.3 V version of the USB TTL-232R cable will be available in the Elektor online shop with the reference 080213-72. The 5 V version is still available with the reference 080213-71.

While working on various projects, and especially when debugging onboard software



using these cables, I found it was useful to be able to interrupt certain of the signals or to be able to look at them on an oscilloscope. It was then I came up with the modest circuit given in Figure 1. Connectors K3 and K4 make it easy to look at each signal. The miniature 5-way DIP switch S1 lets you interrupt any of the TX, RX, CTS, RTS signals available at the end of the cable. It also lets you cut the 5 V rail coming from the USB cable. By isolating your circuit like this from this voltage, which in certain cases might end up connected directly across some batteries, you will avoid damaging them or even making them explode.

The grounds remain connected. This 0 V reference is present on the FASTON terminal, which is very handy for clipping on multimeter and oscilloscope probe 'croc clips'. A second FASTON terminal offers the USB 5 V rail in case it comes in useful, though I didn't actually fit it.

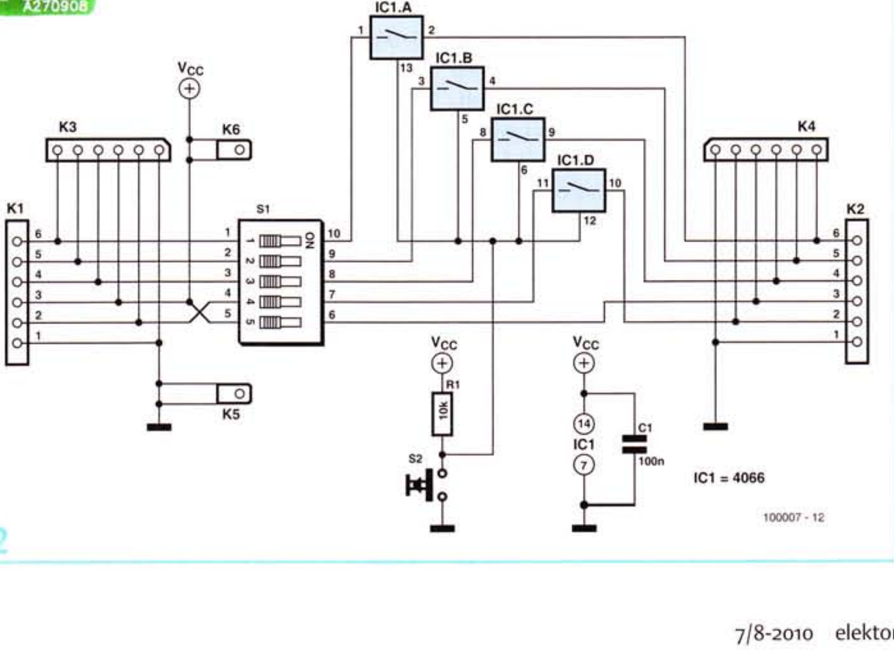
Note that the order of the signals is changed at the DIP-switch so that the 5 V rail comes at one end, where the switch will be easier to operate with your fingernail.

On the 'deluxe' version circuit shown in Figure 2, you'll see we've added a 4066 CMOS analogue switch, IC1. This makes it possible to disconnect all the serial link's logic signals in one go simply by pressing pushbutton S2. I noticed in fact that the voltage present on the cable's TX pin is enough to power an ATmega324PA (low-voltage) and prevents hot rebooting of the microcontroller, even if its power is momentarily interrupted. So this button comes to the rescue and makes debugging easier, without having to either unplug the cable or operate the DIP-switches for such a short time.

(100007-I)

[1] 080213-I USB → serial TTL cable: www.elektor.com/usb-ttl

[2] 080470-I USB → RS6232 cable: www.elektor.com/080470



2

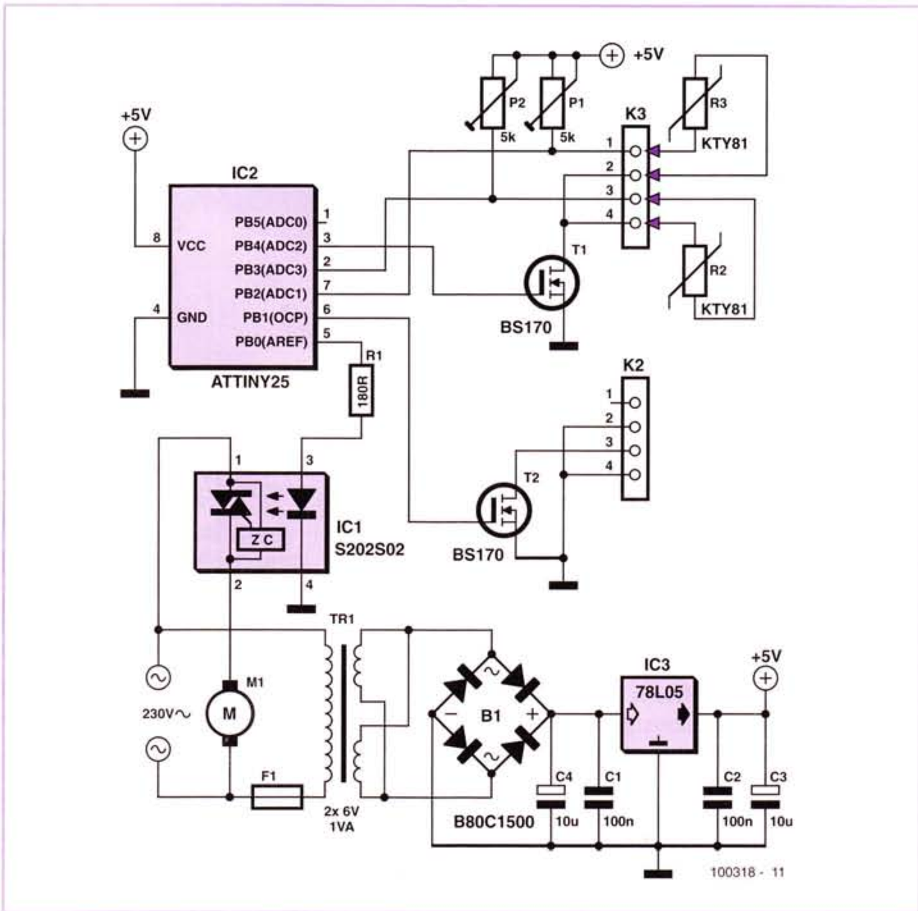
Underfloor Heating Controller

Marc Dirix (NL)

Central heating systems that include underfloor heating often leave the extra pump used to pump the water through the underfloor pipes running continuously. The reason for this is that the central heating controller doesn't have a separate control circuit and output for the underfloor heating pump.
This circuit was designed to control the underfloor heating pump independently or via the switch in the living room thermostat. The design has been made very flexible and can be connected in four different ways:

1) Temperature sensor 1 is connected to the inlet pipe of the underfloor heating, Temperature sensor 2 is shorted. The pump is turned on when the inlet pipe becomes warm enough. When the temperature of the inlet pipe drops below the trigger temperature the pump will continue to run for 20 minutes.

2) Temperature sensor 1 is connected to the inlet pipe of the underfloor heating, Temperature sensor 2 is connected to the outlet pipe. This works in a similar way to that in the previous configuration, but also: as long as the inlet pipe is warm the pump will be stopped (temporarily) when the outlet pipe rises above the trigger temperature.



3) Switch input connected to the living room thermostat. As long as the switch (connected to the same input as for Temperature sensor 1) is closed, the pump will run. When the switch opens the pump stops after 20 minutes.

4) Switch input connected to the living room thermostat, Temperature sensor 2 is connected to the outlet pipe of the underfloor heating. This works in a similar way to that in the previous configuration, but also: as long as the inlet pipe is warm the pump will be stopped (temporarily) when the outlet pipe rises above the trigger temperature.

Temperature sensor 2 can also be used to protect the underfloor heating from over-heating. In this case, set the trigger temperature to about 50 degrees and connect the sensor to the inlet pipe of the pump.

The circuit is built around an ATtiny25. Two ADC inputs of the controller measure the voltage across both PTCs. The voltage across the first temperature sensor is compared by the software to a trigger value and zero. When the trigger value is exceeded or the value is zero (due to an external switch), the Motor-power pin (pin 5) is pulled high and the pump is started via the opto-triac. When the pump is started, another output (pin 6) is pulled low at the same time. You can connect external components to this output, such as an indicator lamp.

To prevent a continuous current from flowing through the presets and temperature sensors, the PTCs are connected to ground via a software-controlled FET only when a measurement is made.

A configuration fuse inside the microcontroller is blown so that the internal clock runs at 128 kHz. This is fast enough to run the program and this frequency is divided by 1024 in the prescaler of timer1. Timer1 then counts to 125 and generates an interrupt. This interrupt will occur approximately once per second.
During the interrupt routine the state for the pump is determined. When Temperature sensor 1 exceeds the trigger value or equals zero (switch input), the pump timer will be set to 20 minutes. These 20 minutes are to make sure that the pump remains on for another 20 minutes after the temperature has fallen below the trigger level. If the second temperature sensor goes above the trigger level the pump will be stopped immediately.

At the end of the interrupt routine a measurement is started by first making the FET conduct so the PTCs are connected to ground. An ADC routine is then run to read in the value. The temperature sensors are measured alternately, so that the measurement interval for each sensor is 2 seconds.

The circuit will turn on the pump for a minimum of 5 minutes during any 18-hour period. For this there is a Summer-timer, which keeps track of how long ago the pump was last on. When the pump is turned on the Summer-timer is reset to zero. If the Summer-timer hasn't been reset for 18 hours (16-bit integer = 65,536 s = 18.2 hours), the pump timer will be set to 5 minutes. As long as this is active, the pump will be on.

(100318)

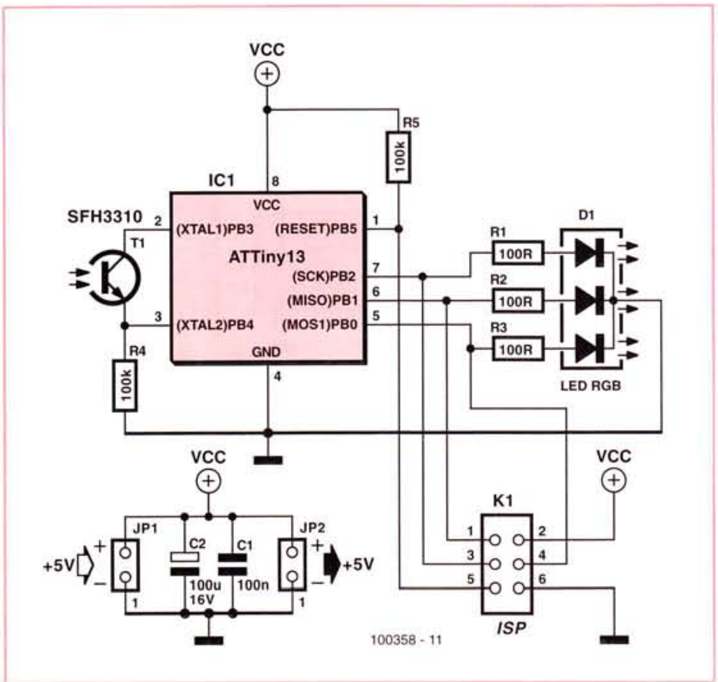
RGB Synchronizing Fireflies



Alexander Weber (Germany)

If you like the emergence of visual patterns, be it natural or man made, one you're bound to be impressed by is the 'synchronization' of hundreds or thousands of fireflies. First they flash randomly but after some time and influencing each other, they flash in sync (kind of).

The author was triggered to propose this circuit to Elektor following the publication of "Fun with Fireflies" in the April 2010 edition [1]. The version shown here employs an ATtiny13 microcontroller and just one RGB LED and should be cheap and easy to build in large numbers.

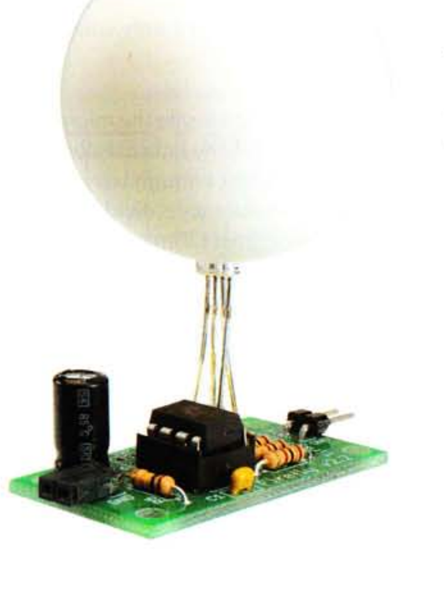


The RGB firefly does not move around, and uses colour to express its mood. If all is in sync, it will flash in relaxed and cool blue. If it detects flashes that are not in sync, it will get a bit uncomfortable and the colour will slightly change to green, yellow and red.

Note that every firefly acts completely autonomously, i.e. not 'obeying' or trying to achieve, a pre-programmed pattern. As you build more fireflies and allow them to interact, they become increasingly a self organizing system — strength and fun are indeed in numbers!

The firmware running in each firefly determines its behaviour, based upon light levels measured by an SFH3310 phototransistor. Talking software now, each firefly has a value that represents the power to flash. This value rises over time. If the power reaches a certain limit, the firefly flashes and the power is reset to zero. If the firefly detects another flash nearby, it increases the power by a small boost value. That way it will flash slightly earlier than last time. Doing so over and over again may lead to all fireflies flashing in sync — and prove the concept of robotic swarming [2].

The main parts in the circuit are the microcontroller, the light sensor and the RGB LED. The sensor and R4 form a potential divider, whose voltage level is read by the ATtiny13 microcontroller through an ADC channel at pin 3. The circuit is designed for a 5 V power supply and has no integrated power regulator. The supply voltage is taken from a 'rail' created by plugging firefly boards to form a row using plug/socket pairs JP1 and JP2 (i.e. these are not jumper positions).



Various types of photoresistors exist. Two different versions were tried and found to work well. Only resistor R4 has to be adjusted in a way that gives a good range of voltage and still limits the current through the photoresistor. Recent experiments showed that a phototransistor outperforms both photoresistors and LDRs. Compared to the LDR, it does not have a memory effect and reacts faster (~5 ms compared to ~50 ms). Eventually the SFH3310 was chosen and 100 kΩ for R4.

One thing to remember while choosing a light sensor, is that the spectral sensitivity of the sensor has to match the human eye sensitivity (~400 nm – ~700 nm).

The software developed for the RGB Synchonizing Fireflies may be downloaded free from the Elektor website [3], compiled and blown into the ATtiny chip via ISP header K1. Readers without access to a suitable programmer may order the ready-programmed ATtiny13(V) chip from Elektor as item # 100358-41.

The construction and use of clusters of these little electronic creatures is copiously illustrated by pictures and a video on the author's website [4],[5], which also provides leads to obtaining kits for this 'embedded-in-biology' project, or is the other way around?

(100358)

[1] www.elektor.com/100014

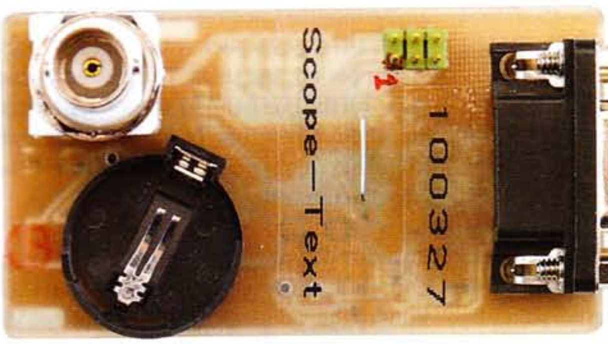
[2] www.elektor.com/100013

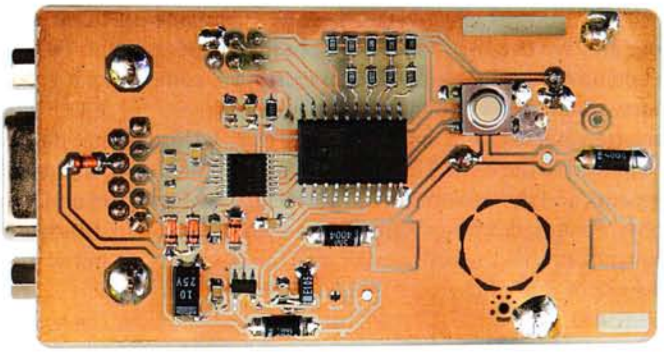
[3] www.elektor.com/100358

[4] http://tinkerlog.com/2009/06/25/64-synchronizing-fireflies/

[5] http://tinkerlog.com/howto/synchronizing-firefly-how-to/

Scope Text





Emile Steenbeeke (The Netherlands)

Scope Text is a small circuit based on the ATTiny2313 microprocessor, which can be used to display text on a CRT oscilloscope. The text is shown on the screen as a scrolling message display.

Apart from the ATTiny, you'll find an RS-232 interface chip (MAX3221) and a 3 V voltage regulator in the circuit. The functionality is mainly determined by the firmware, which can be downloaded from the website for this article [1].

The firmware is written in C using WINAVR. A terminal program can be used to enter some text, which is stored in the EEPROM of the processor. A maximum of 100 characters can be stored, with ASCII values ranging from 32 to 128. Each character that is displayed is also sent out via the RS232 port, so you can check what text is stored even if you don't have a scope to hand.

The terminal program is written in Delphi6 PE along with an extra installed component (CPORT310) [2]. The terminal program also makes sure that all RS232 outputs are logic High, so that the circuit can be powered via these signals.

The circuit can therefore be powered from the COM port of the PC, but you could also use a DC power supply or a CR2032 battery. The battery supply is very useful when, for example, you want to surprise a colleague with a 'Happy Birthday!' that scrolls across their scope screen.

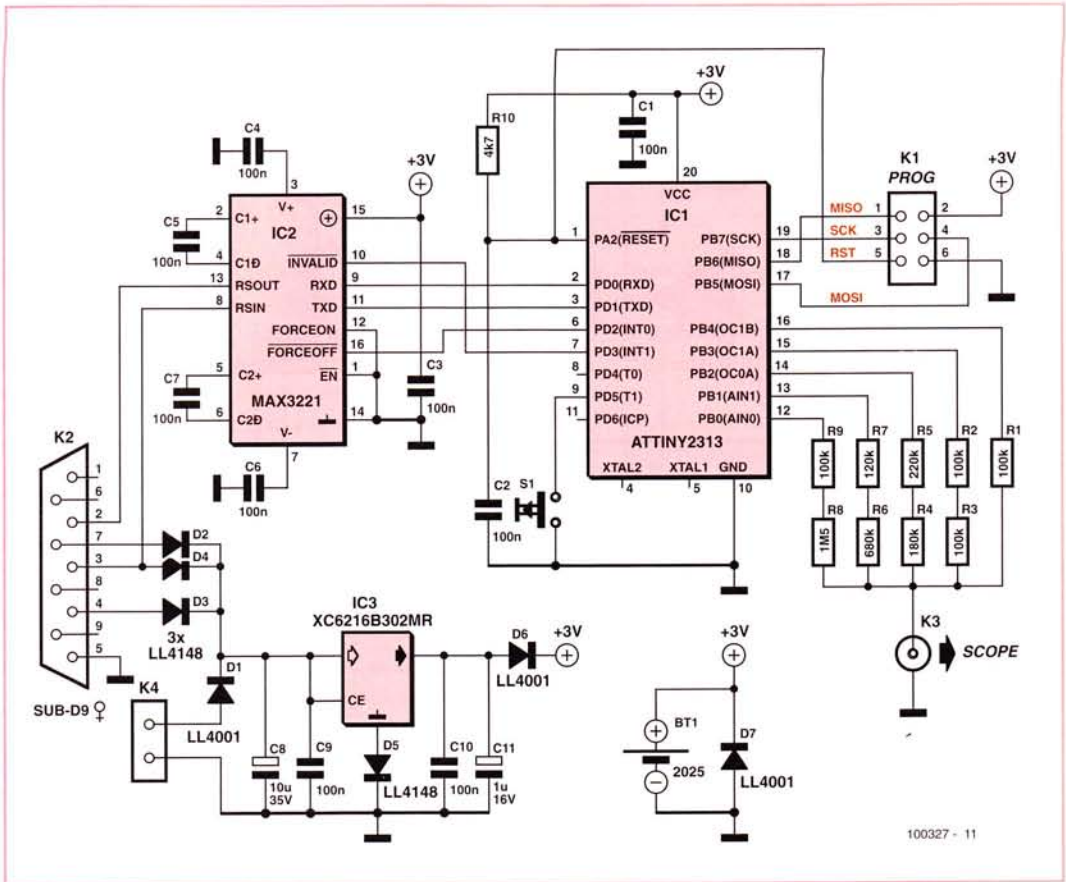
When the circuit is turned on the word 'ELEKTOR' appears once on the screen before the text from the EEPROM is shown. When the circuit is battery-powered and an RS232 connection is made, 'RS232 ON' is shown on the screen. This stays on for a while before it scrolls off the screen and is followed by the stored text. When the connection is cut off 'RS232 OFF' appears on the screen. The RS232 chip goes into an auto power-off mode when there isn't an RS232 connection and draws only 1 µA or so, which is good for the battery life.

Each frame is preceded by a short pulse, which can be used to trigger the scope. A clear stable picture is obtained when the scope is set to 1 V/1 ms. Unfortunately, the circuit doesn't work with a digital oscilloscope. There is a switch that can stop the movement of the text. The INI file contains the COM port number used and is automatically generated. If an error message appears that states that the port is not available, this file can be edited so it stores the correct port number.

(100327)

[1] www.elektor.com/100327

[2] http://svn.isysbus.org/misc/delphi/components



Wireless Alarm Transmitter and Receiver

Christian Tavernier (France)

Here are two circuits that make it possible to add up to eight detectors to an existing alarm system without running a single cable. Each transmitter has a unique number that is reported to the central unit in the event of an alarm, and the transmitter battery condition is monitored. Transmissions between the transmitters and the central unit are coded and are in one of the two ISM frequency bands: 433.92 MHz (US: 315 MHz) or 868 MHz (US: 915 MHz).

The transmitter circuit (**Figure 1**) does not include the actual radio transmitter, as it is compatible with any UHF radio transmitter module with a binary input.

The heart of the circuit (IC1) is a digital data coder. It outputs from its DOUT pin a binary sequence containing an address, coming from inputs A1–A5, and data reflecting the state of inputs D6–D9. The addresses are used here for the 'house' code, while data lines D7,D8,D9 code the transmitter number from 0–7. Line D6 transmits the battery status, measured by comparator IC2.

The detector is a **normally closed** type connected to inputs E1 and E2. In the absence of an alarm and if the battery is OK, IC3.A is inhibited, which also inhibits IC3.B. This prevents IC1 from operating, via its TE input, and also turns off T2, cutting the power to the RF module. The transmitter is then in stand-by and uses very little current.

In the event of an alarm, i.e. opening of the detector contacts, or if the battery is low, IC3.A goes high and enables multivibrator IC3.B, which then generates a rectangular signal with a low duty cycle, owing to the large difference in the values of R9 and R10. When this is high, IC1 is enabled via its TE input and T2 is saturated via T1. The radio transmitter module is then powered and transmits the information supplied by IC1. This state continues as long as the alarm has not been cancelled or the battery replaced.

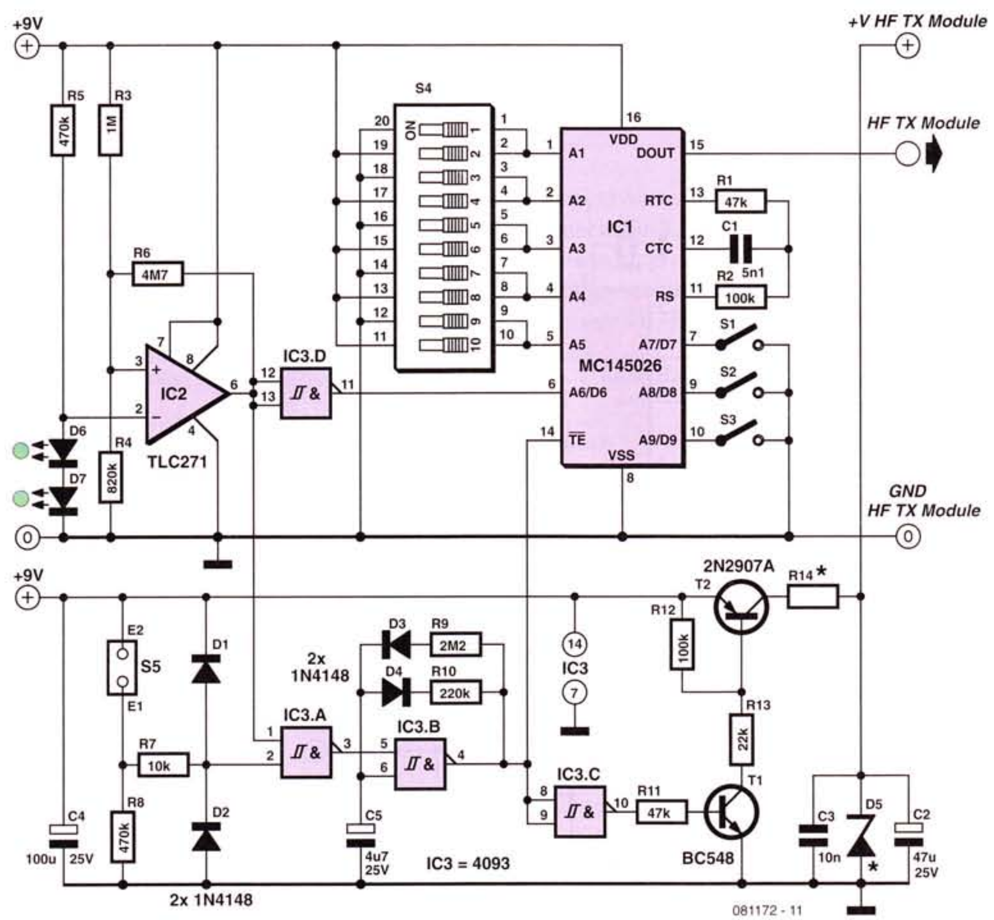
So the module transmits its status for a short time, then goes back into stand-by for a longer period, and so on. This makes it possible to on the one hand to economize battery life, and on the other, to minimize the collisions that might occur if other transmitters were to come on at the same time.

Resistor R14 and zener diode D5 must be chosen according to the supply specifications of the radio module used (usually 5 V at a few tens of mA). It is essential that IC2 be a TLC271, which is the only one able to guarantee very low stand-by power consumption.

The address coding inputs are 3-state inputs. So each input can be connected to ground, to V+, or left floating. Obviously, you need to set the same code on all the transmitter modules and the receiver. The data inputs D7–D9 are binary, and you need to choose a different combination for each transmitter.

The receiver (**Figure 2**) does not include the

1



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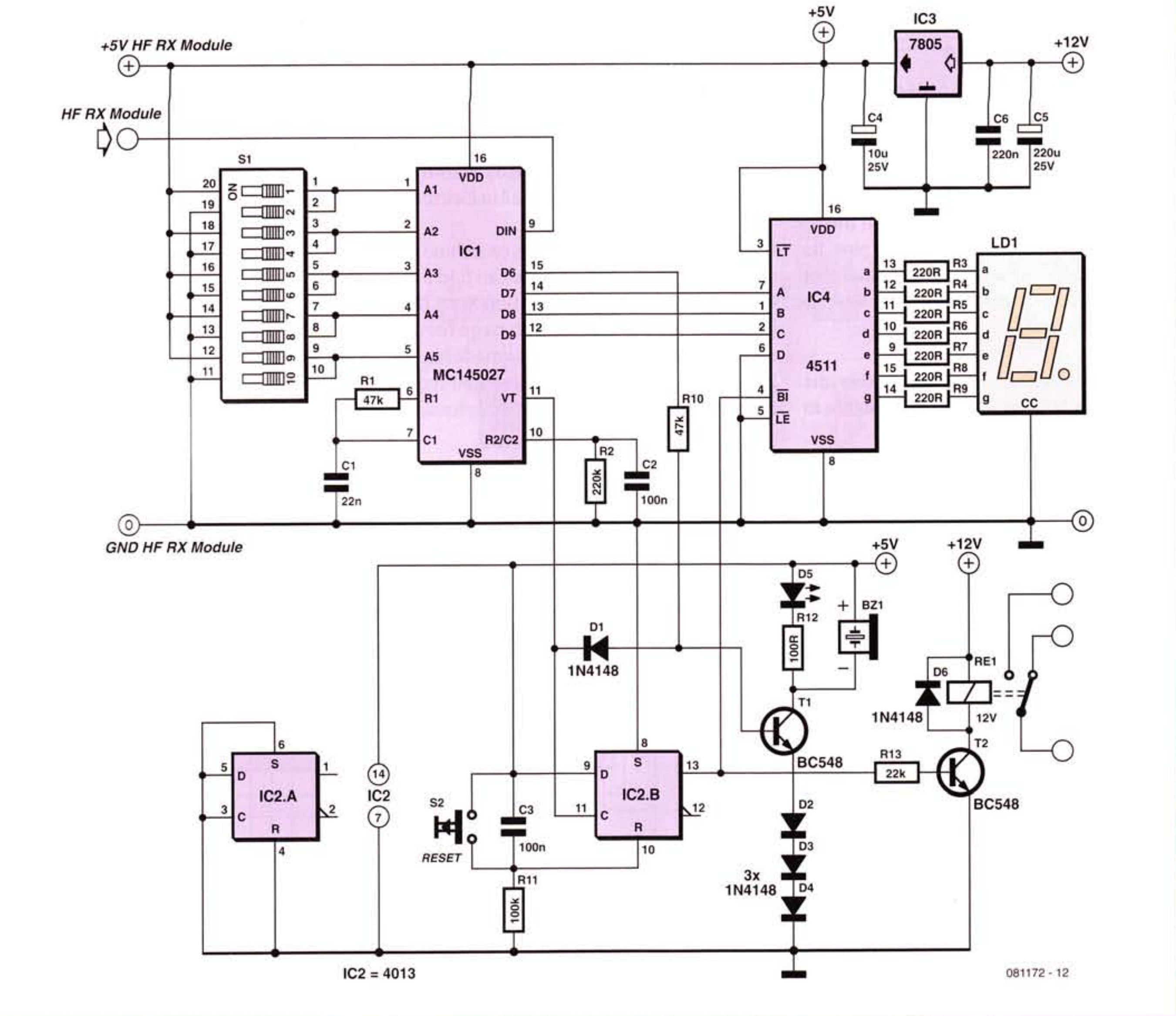


UHF receiver, it's up to you to choose which one to use.

The binary signal from the UHF receiver's output is applied to the input of IC1, which is the natural companion to IC1 used in the transmitters. If there is a clash of addresses, the transmitter's D6–D9 data appear on the same outputs of IC1. In addition, the VT signal goes high each time IC1 receives a valid data sequence.

The three data bits corresponding to the transmitter number are decoded by IC4, a BCD–7 segment decoder. If its BI input is high, display LD1 shows the number of the transmitter that has triggered the alarm. The BI signal comes from a D-type flip-flop (IC2.B) that memorizes the alarm status, as it is triggered by IC1's VT output. It is reset automatically at power-up via C3 and R11, or manually using push-button S2. In an alarm state, the flip-flop also energizes relay RE1 via T2.

When the transmitter battery is exhausted, IC1's D6 output goes high, setting off the audible alarm and lighting LED D5. Looking now at the receiver, we can tell if we have a 'normal' alarm (RE1 energized, no audible warning, LED not lit) or a low battery warning (RE1 energized, audible warning active, LED lit). In both cases, the display indicates the number of the transmitter concerned.

Note that in the event of alarms from several modules, the display indicates the numbers of the modules concerned in turn, but this may be difficult to read if more than two transmitters are operating at the same time.

The power supply is stabilized at 5 V, except for the relay supply. This can be provided by a 'wallwart' adaptor or, better still, be tapped off the associated central unit supply, which usually has battery back-up in the event of a mains failure.

Remember to code A1–A5 as for the associated transmitters. Note too that, given the circuit used, the audible warning device must be a model with built-in electronics. The relay output should be connected to one of the inputs of the associated alarm system.

(081172-I)

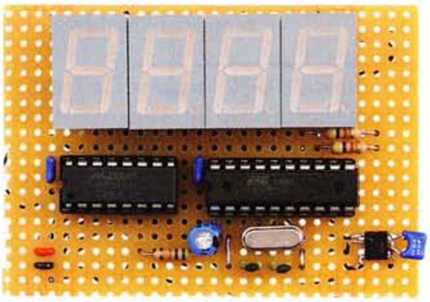
[1] www.elektor.com/081172

Thermometer with Four-Digit LED Display

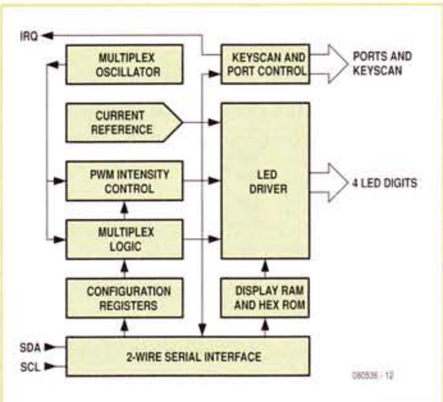
Andreas Köhler (Germany)

Until recently, the Philips SAA1064 LED driver IC has been a sort of unofficial standard for driving seven-segment LED displays. It can be used to implement four-digit displays that can be driven over an I²C bus. However, no matter how it's packaged (DIL24 or SO24) this IC is simply on the large side with its 24 pins. Its minimum supply voltage of 5 V and quiescent current of nearly 10 mA are also not exactly state of the art now.

An attractive alternative for tasks of this sort is the Maxim MAX6958 IC. It is available in



the smaller QSO package with only 16 pins, can operate at 3.3 V, and has a shutdown mode with a current consumption of only 20 μA. Inspired by this progress, the author resolved to design a digital thermometer circuit using this IC. Aside from the MAX6958, four common-cathode LED display modules (Toshiba TLR 324) and an Atmel AT89C2051



microcontroller (other types could conceivably be used), all that's necessary is a suitable temperature sensor. The selected device, a National Semiconductor LM75, fits well with the rest of the electronics because it is also I²C compatible. The microcontroller clock signal for this simple application can be generated by any crystal with a frequency in the range of 4 to 12 MHz.

While writing the assembly language firmware, the author had to battle with the complexity of the display driver, a consequence of the restricted number of pins. The type of multiplexing used here by Maxim has already been described in detail in Elektor [1].

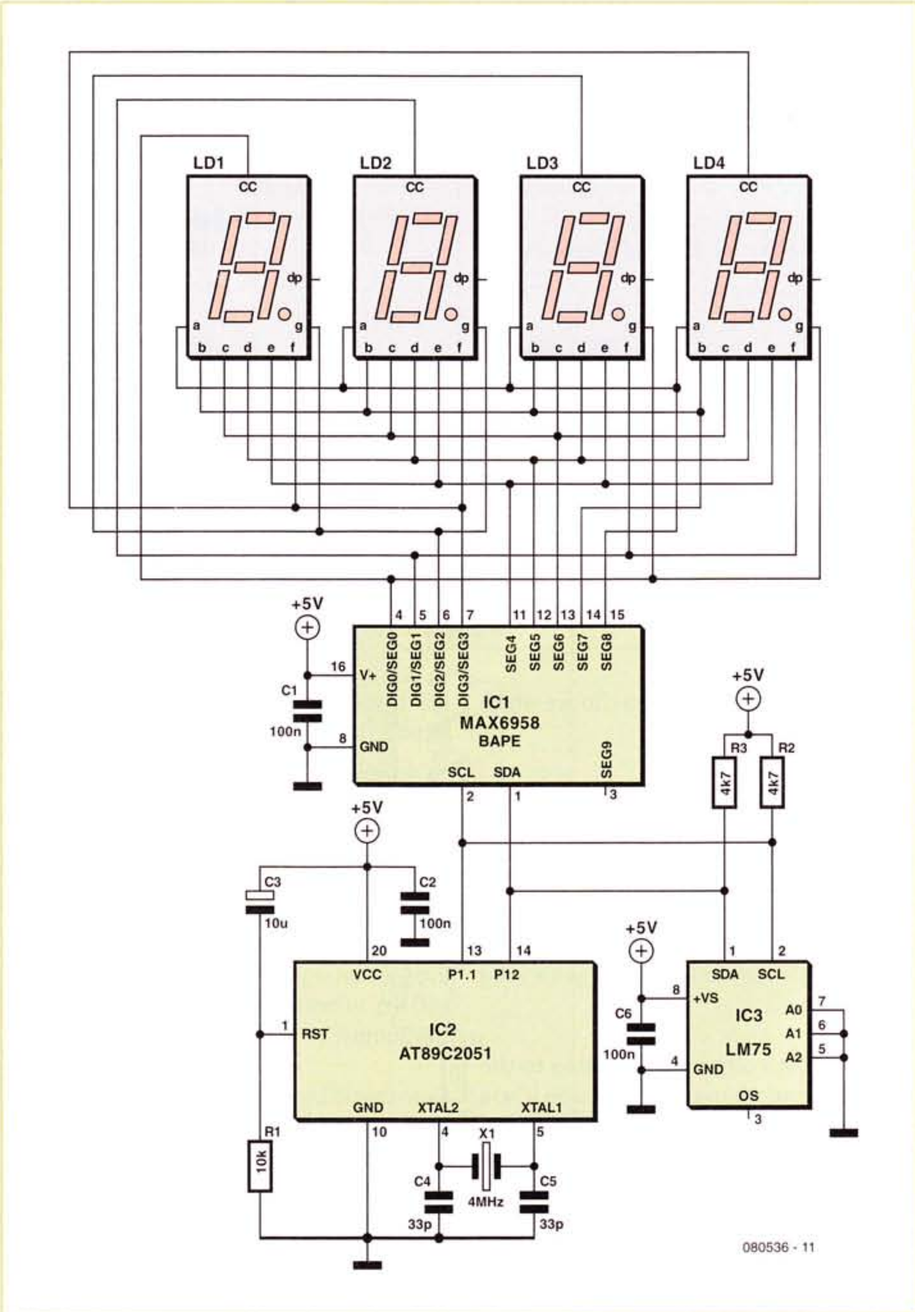
If you want to know what goes on behind the scenes with this driver IC, you can find a full explanation in Maxim Application Note 1880 [2]. Naturally, the Elektor web page for this article [3] offers not only a ready-made hex file but also the author's fully commented source code file, so you can modify the software if you so desire. If you simply want to build the circuit and aren't interested in programming the microcontroller, you can order a pre-programmed device from the Elektor Shop [3].

(080536-I)

[1] Charlieplexing, Elektor July & August 2006; www.elektor.com/060124

[2] www.maxim-ic.com/app-notes/index.mvp/id/1880

[3] www.elektor.com/080536

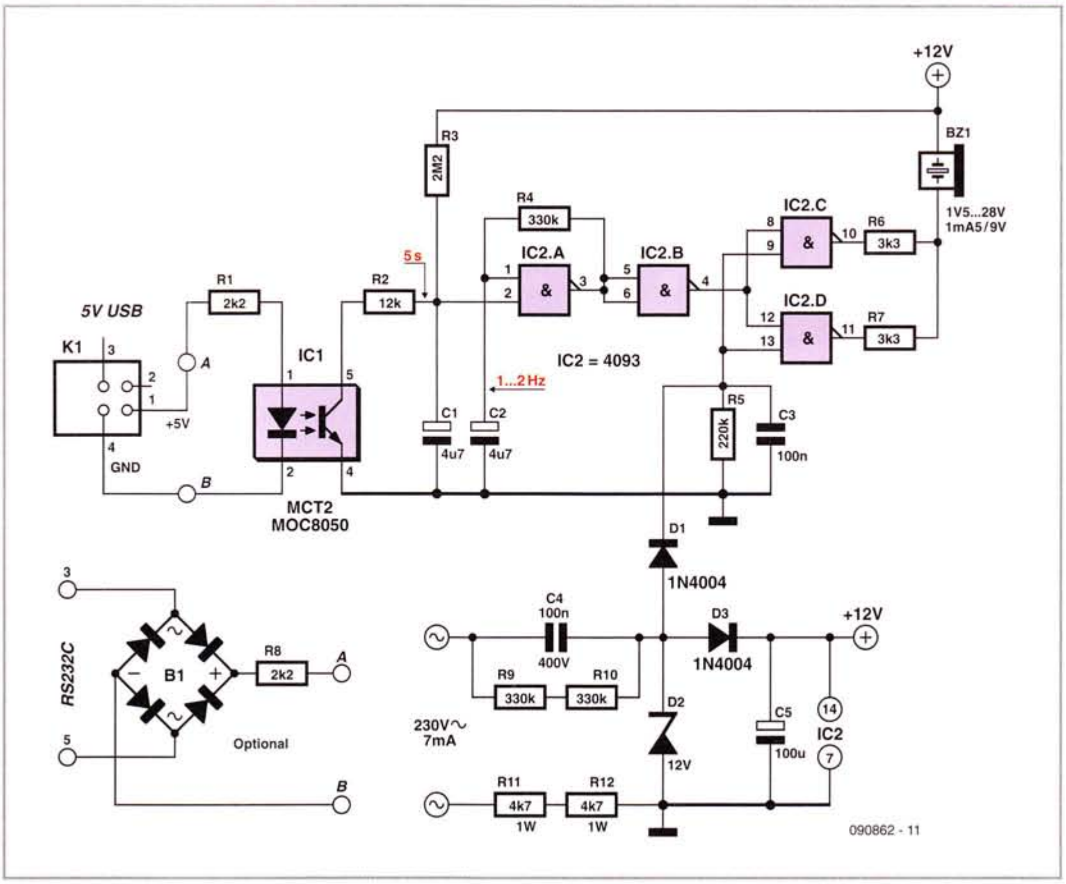


Power Saver

Géry Szczepanski (France)

When a switched multiway is used to power a PC, printer, scanner, modem, and so on, all these devices often stay powered, in stand-by, simply out of habit or by oversight. The circuit described here lets you avoid this problem.

When the switch on the multiway is turned 'on', you have around 5–10 s to turn the computer on. Turning the computer on powers the circuit's opto-isolator, via its USB socket, which disables the sounder. When the computer is turned off, you again have around 5–10 s to turn 'off' the switch on the multiway. After this delay, the sounder operates to remind you.



The circuit uses just a single IC (CD4093), a quad Schmitt input NAND, along with an opto-isolator for mains isolation. Gate 1 forms a very low frequency oscillator at 1–2 Hz, enabled via pin 2, whose rise-time to logic 1 is of the order of 5 s.

When the opto-isolator diode is powered, the resistor discharges the capacitor and keeps pin 2 of gate 1 at 0. Thus the oscillator is disabled and the sounder (a type with built-in oscillator) stays silent. The 220 kΩ resistor, 100 nF capacitor, and diode ensure the sounder cuts off straight away when the AC power is turned off and the 100 µF capacitor is discharging.

The circuit was built on a 42 × 35 mm piece of prototyping board, fitted into a case salvaged from an old modem plugtop AC line adaptor. In this way, it can be plugged directly into one of the sockets on the multiway. A 2-core cable is used to connect it to the computer's USB socket (pins 1 and 4), PS/2 socket (pins 4 and 3), or the 15-pin sub-D joystick connector (pins 8 and 5). An RS-232 socket can also be used, with a slight modification (see circuit).

Warning: the circuit is at AC line potential!

(090862-I)

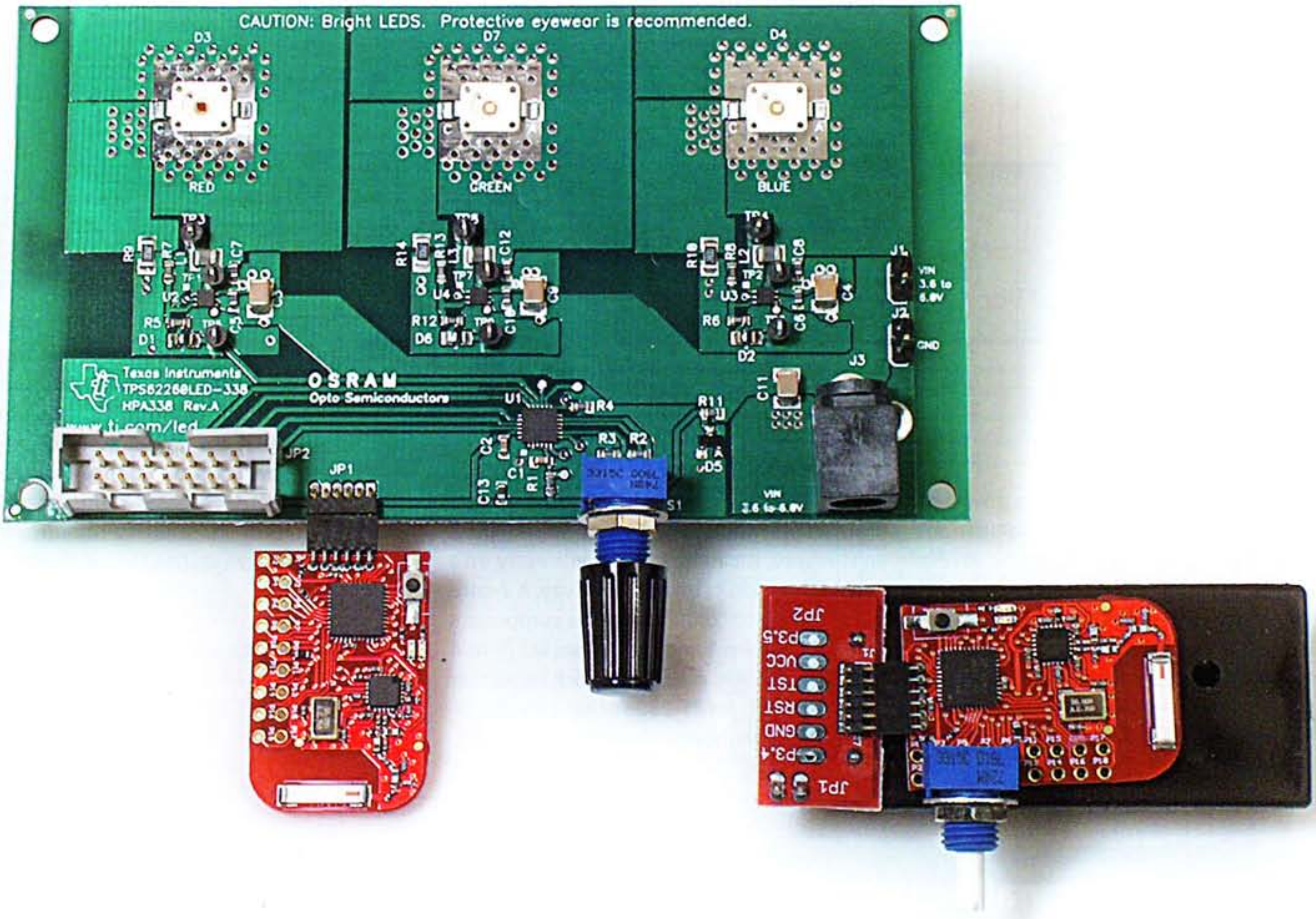
[1] www.elektor.com/090862

Remote Control
for RGB LED Mood Lighting

a TI development tool example application

By Dirk Gehrke and Christian Hernitscheck (Texas Instruments, Germany)

In the article 'RGB LED Mood Lighting' (*Elektor*, February 2008) we mentioned that a remote control could be added to the unit. Here we describe how it is done, connecting an eZ430-RF2500 to the MSP430 microcontroller. The ideas presented can be adapted to a wide range of other applications.



The eZ430-RF2500 is a development tool that includes two tiny eZ430-RF2500T radio module boards and a USB debugging interface board. Each board is provided with a six-way header connector. The USB debugging interface board can be used to help debug the MSP430 software as well as to program the two eZ430-RF2500T boards. As **Figure 1** shows, the main components on the eZ430-RF2500T boards are an MSP430F2274 microcontroller, a CC2500 2.4 GHz transceiver device, a crystal and a chip antenna.

eZ430-RF2500 used as a radio remote control

To simplify implementing the data communications functions we use the 'MSP430 interface to CC1100/2500' library, which can be downloaded free of charge from the TI website [1]. The advantage of using this library is that it includes all the functions we need to communicate between the MSP430 device and the CC2500 transceiver used in this project. In particular, it makes it simple to initialise the CC2500 and to initiate transmission and reception of data.

As already indicated, the eZ430-RF2500 kit includes two eZ430-RF2500T boards; in this application we use one as a transmitter module and the other as a receiver module.

Figure 2 shows the remote control unit fitted with a battery holder for two AAA-size alkaline cells. The rotary encoder is not yet connected. The battery expansion board is equipped with a six-way header and is also included in the eZ430-RF2500 development kit.
The eZ430-RF2500T printed circuit board shown in Figure 1 is used as a receiver module, mounted on the prototyping area of the RGB LED mood light board. The connections provide the receiver with power and carry the decoded signals back from the receiver to the mood light board.

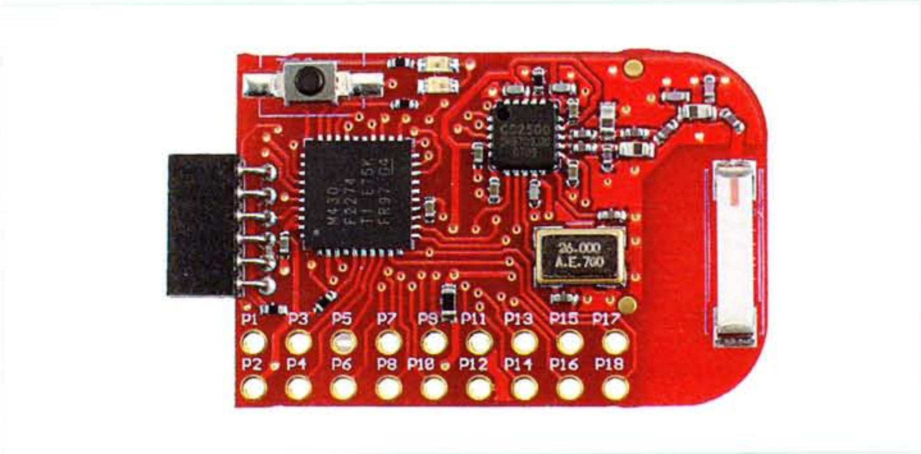


Figure 1. eZ430-RF2500T board used as a receiver module.

Transmitter board with rotary encoder

The transmitter board is fitted with a rotary encoder. For each movement of the encoder's shaft to the left or right a signal is sent to the receiver module on the RGB LED mood light board. This keeps the quantity of data transmitted to a minimum. Furthermore, the transmitter is only activated when the encoder is moved; otherwise, it remains in a power-down mode.
The connections to each of the two printed circuit boards are laid out with a 2.54 mm (0.1 in.) spacing and so it is very easy to connect the rotary encoder to the board. The pins of the encoder should be wired to pins 3, 5 and 7 of the eZ430-RF2500T board, which correspond to I/O pins P2.0, P2.2 and P2.4 of the MSP430F2274. Pin P2.2 is configured as a digital output switched to ground, and pins P2.0 and P2.4 are configured as digital inputs that can generate interrupts. Internal pull-up resistors in the MSP430 are enabled to ensure that these inputs carry well-defined logic levels.

Connecting the receiver board

In order that the eZ430-RF2500T board used as a receiver module can be provided with a 3.3 V supply from the RGB LED board, the Zener diode circuit on that board must be modified. The modification involves replacing the 330 Ω series resistor (R2) with a 68 Ω resistor. This ensures that sufficient spare current will be available to power the receiver module.

As noted above, the eZ430-RF2500T board can be connected directly to the main board using connector JP1. However, first we must program both the eZ430-RF2500T boards and the RGB LED mood light board with the most up-to-date version of the software, implementing the necessary functions to allow remote control of the light.

The signals originating from the rotary encoder are taken from pin 1 (RXD0) and pin 6 (TXD0) of the eZ430-RF2500T board directly to I/O pins P2.1 and P2.0 of the MSP430F2131IRGE on the RGB LED mood light board. The same connector (JP1) provides the 3.3 V power supply to the receiver module on pin 2 (VCC) and pin 5 (GND).

Radio module software

In the interests of simplicity the software has been designed so that the same code can be used on both the eZ430-RF2500T boards. The board that is fitted with a rotary encoder will behave as a transmitter and the other board will behave as a receiver.

When power is applied both eZ430-RF2500T boards start up behaving as receivers. The MSP430 software indicates this state by lighting the green LED on the eZ430-RF2500T board.
If the rotary encoder connected to the transmitter board is operated, the software will leave receiver mode and start to behave exclusively as a transmitter. This reduces the current consumption of the transmitter board, extending its battery life. The total current consumption of the remote control transmitter in idle mode is determined by the following:

- the current consumption of the MSP430F2274 in LPM4 mode (typically 100 nA);
- the current consumption of the CC2500 in sleep mode (typically 400 nA);
- a current through the two pull-up resistors dependent on the rotary encoder position (typically 0 μA to 189 μA).

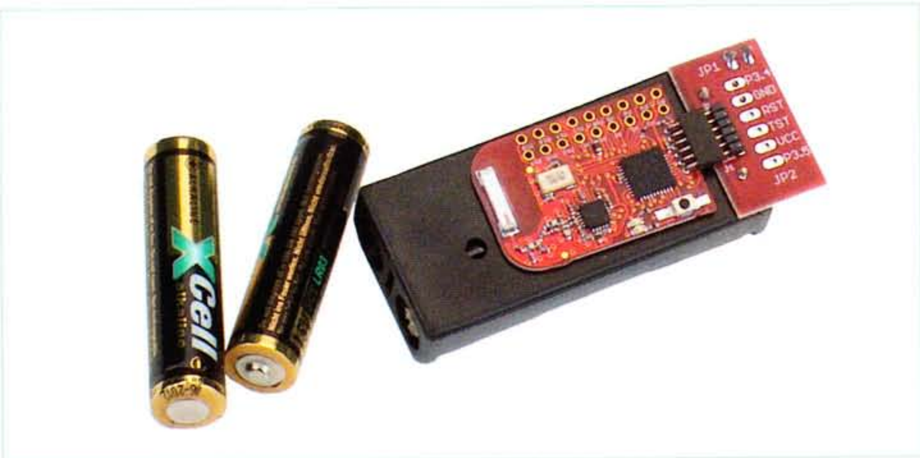


Figure 2. eZ430-RF2500T board used as a remote control module.

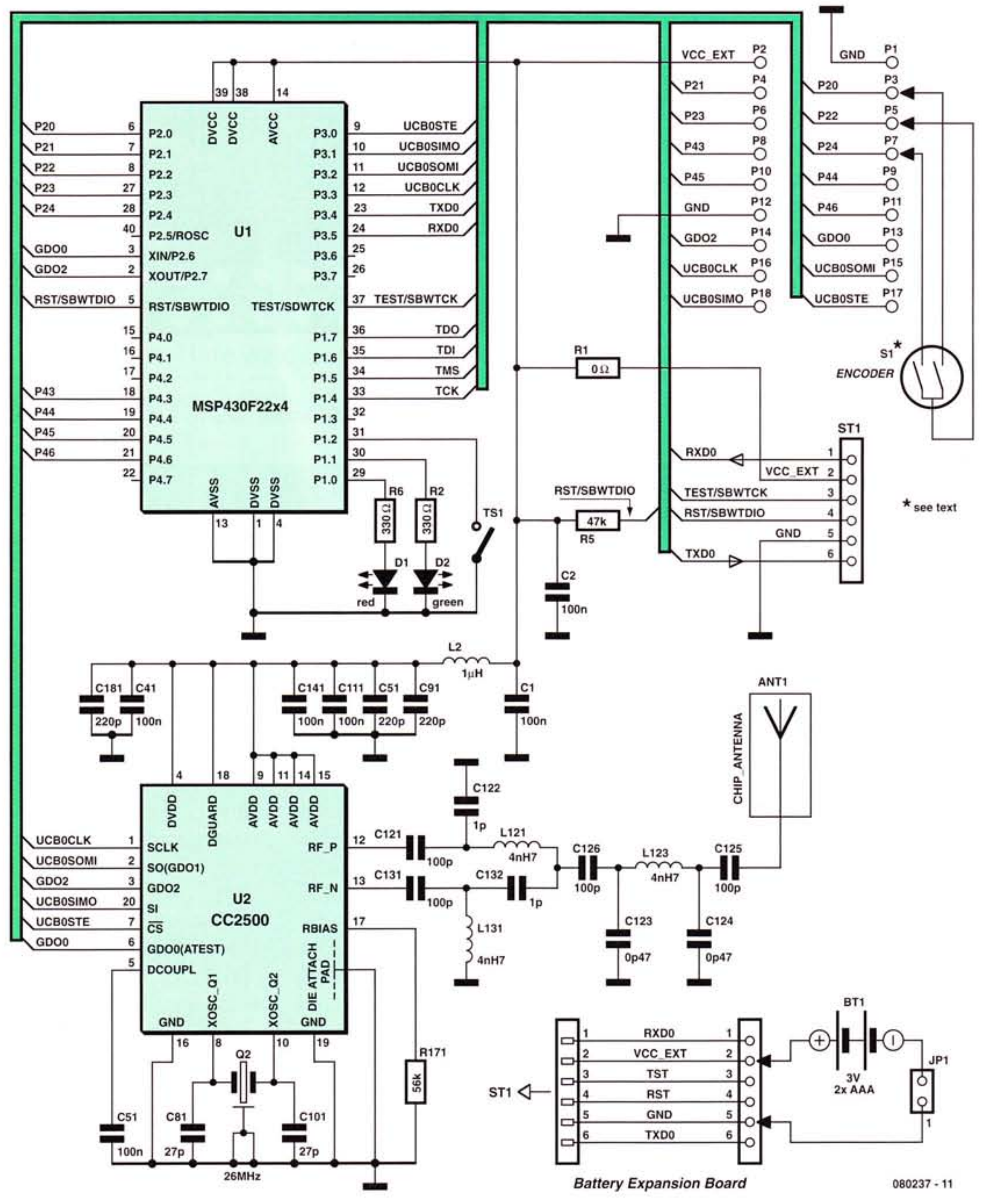


Figure 3. Circuit diagram of the eZ430-RF2500T board.

The typical current consumption of the transmitter board in idle mode therefore principally depends on the position of the rotary encoder, and varies between around 0.5 µA and 189.5 µA. To these figures must be added a factor to account for chip-to-chip parameter variations. The current consumption can be reduced further by using external high-value pull-up resistors at the encoder inputs rather than the internal pull-ups. Both LEDs are extinguished in transmit mode, lighting briefly when motion of the rotary encoder is detected.

In the original article on the RGB LED mood light in February 2008 we described a very simple way to process the signals from the rotary encoder. For the remote control version we have improved the design. A glance at the new software will reveal that the processing is now done using look-up tables. Behind the data in the tables is a state machine whose pattern of execution is shown in **Figure 4**. The state diagram includes, for example, the ability to resynchronise when power is applied and the state of the encoder is not known. A significant problem when processing signals from a rotary encoder is switch contact bounce, which is taken into account in the state diagram. The decoder function is called when a change of state has been detected. An interrupt is only generated when an edge is detected on one of the two inputs P2.0 and P2.4, generating an interrupt, which means that the remote control spends most of its time in idle mode, minimising power consumption.

Software extensions for the RGB LED mood light

The extensions to the software for the RGB LED mood light to allow its remote control are relatively straightforward. The initialisation is extended to set up port pins P2.0 and P2.1, and an interrupt service routine is added for port P2 to process the levels on inputs P2.0 and P2.1, which originate from the eZ430-RF2500T receiver board.

Each rising edge on pin P2.0 generates a port P2 interrupt to the MSP430F2131, and the service routine increments pointer LEDptr. Remember that pointer LEDptr is used to access the table which contains the settings for the three high-power LEDs (red, green and blue). Similarly, when a rising edge is detected on port pin P2.1, a port P2 interrupt is triggered and the service routine decrements pointer LEDptr.

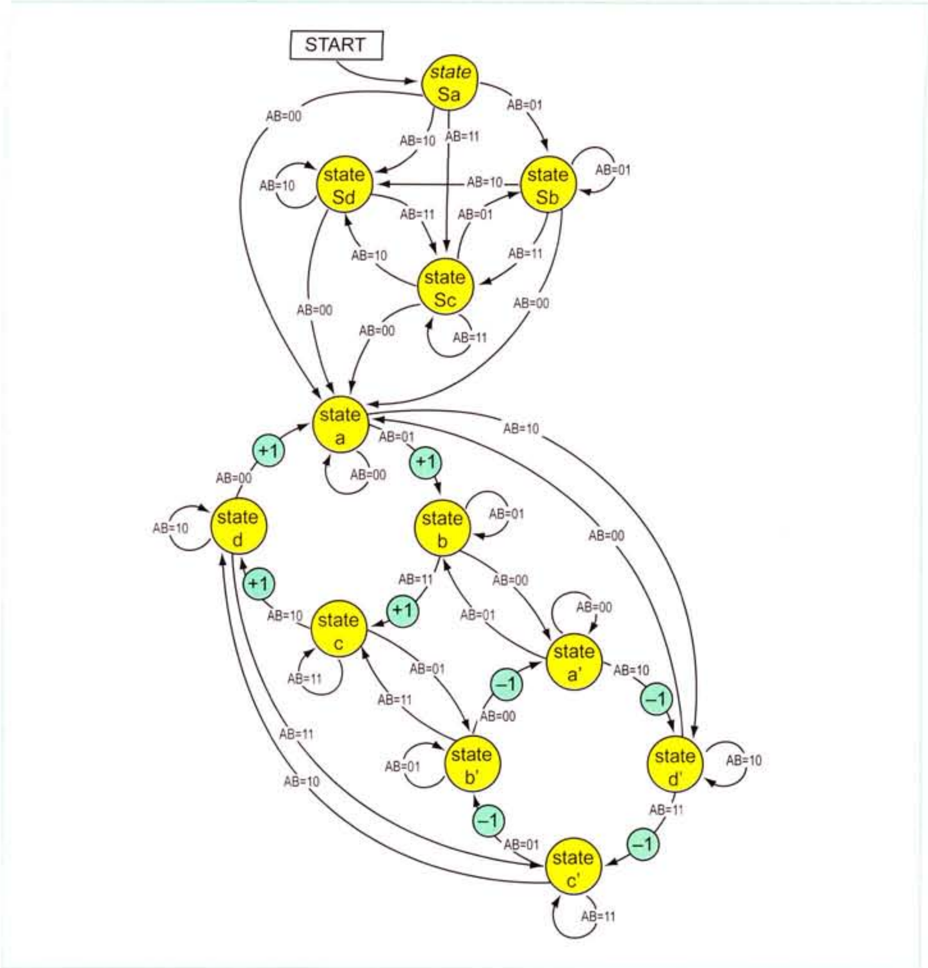


Figure 4. State diagram of rotary encoder signal processing.

Reprogramming the RGB LED mood light

The MSP430F2131IRGE on the RGB LED mood light board must be reprogrammed with the most up-to-date software. A full guide to the installation of the IAR Embedded Workbench KickStart software and programming the device using either the MSP-FET430UIF or MSP-FET430PIF is given in the description of the TPS62260LED-338 evaluation module, available on the internet [2].

Conclusion

Thanks to the use of the low-cost eZ430-RF2500 kit the remote control can be constructed without heroic SMD soldering skills or tedious tracking down of obscure components. Programming the software into the devices is simplified by the USB UART board provided. Project source code for the transmitter and receiver boards, as well as the new software for the RGB LED mood light board, are of course available for download from the *Elektor* website at www.elektor.com.

We hope that this article will spur you into developing your own applications and wish you many happy hours of experimenting!

(080237-I)

Web Links

[1] http://focus.ti.com/mcu/docs/mcusupporttechdocsc.tsp?sectionId=96&tabId=1502&abstractName=slaa325

[2] http://focus.ti.com/docs/toolsw/folders/print/tps62260led-338.html

Literature

eZ430-RF2500 Development Tool User's Guide
(literature number SLAU227A)

MSP430 Interface to CC1100/2500 Code Library
(documentation slaa325.pdf, code files slaa325.zip)

CC2500 Low-Cost Low-Power 2.4 GHz RF Transceiver
(literature number SWRS040B)

MSP430x22x2 Mixed Signal Microcontroller
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Sources of supply

eZ430-RF2500: www.ti.com/ez430-rf

RGB EVM board ('LED mood light'): www.ti.com/

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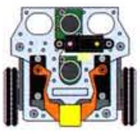

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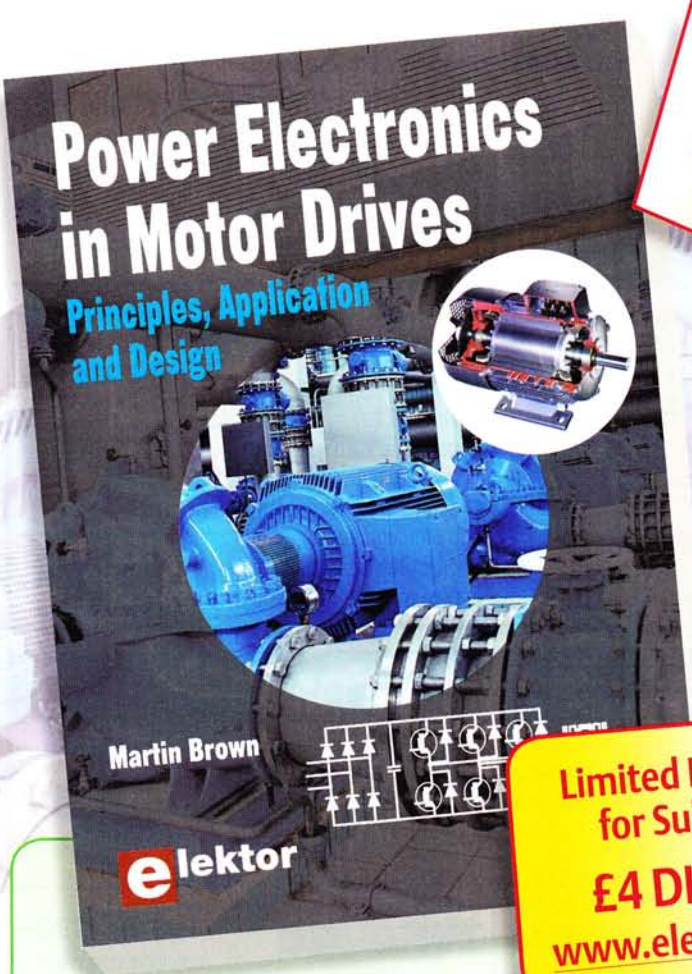

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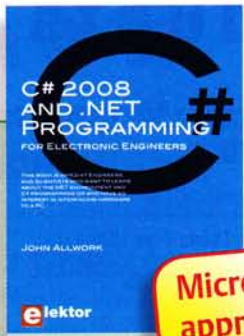

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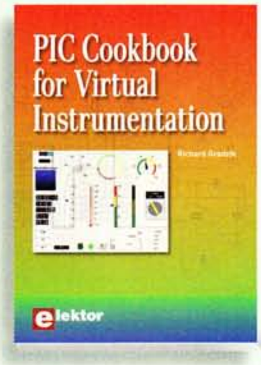

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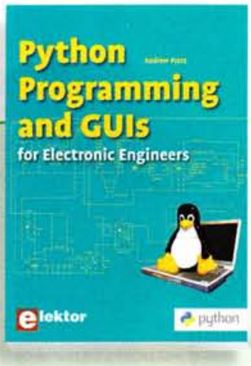

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(June 2010)

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(March 2010)

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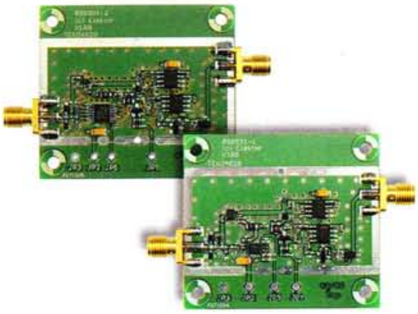
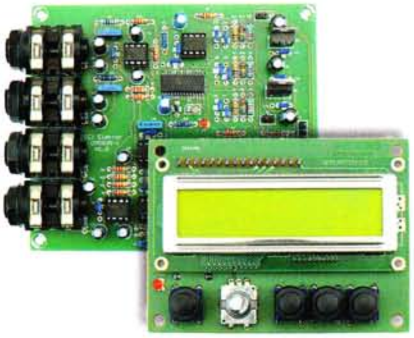


2.5 GHz Frequency Meter

This modular design offers a wide frequency range from 40 MHz to 2.5 GHz and even the ability to perform level measurements (dBm/mW/mV). For the operation and display of data use is made of the display module for the True-RMS voltmeter published in our May 2009 edition.
Two different versions can be built, which differ in terms of accuracy and input voltage range.

Image Detection System

In this system the powerful yet inexpensive PIC16F690 micro is employed to process images from a small black and white camera (1916 x 1918 pixels) by way of its analogue input. This image can be compared to a reference stored in EEPROM. The PIC can detect movements in the image and even the coordinates of a light source 'seen' in the image. The image can also be sent to a PC.



Digital Multi-Effect Processor

Each musical performance sounds much better right away with some appropriate sound effects. This little circuit offers many options, thanks to the use of a special IC from Spin Semiconductors. This little 'effects miracle' includes high performance D/A and A/D converters, a RAM-based memory delay, four LFOs, three additional analogue inputs and a 24-bit ALU. Eight standard effect algorithms have already been programmed in the chip by the manufacturer.

Article titles and magazine contents subject to change; please check the Magazine tab on www.elektor.com

Elektor UK/European edition: on sale August 19, 2010. Elektor USA edition: published August 12, 2010.

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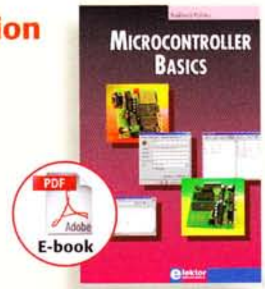

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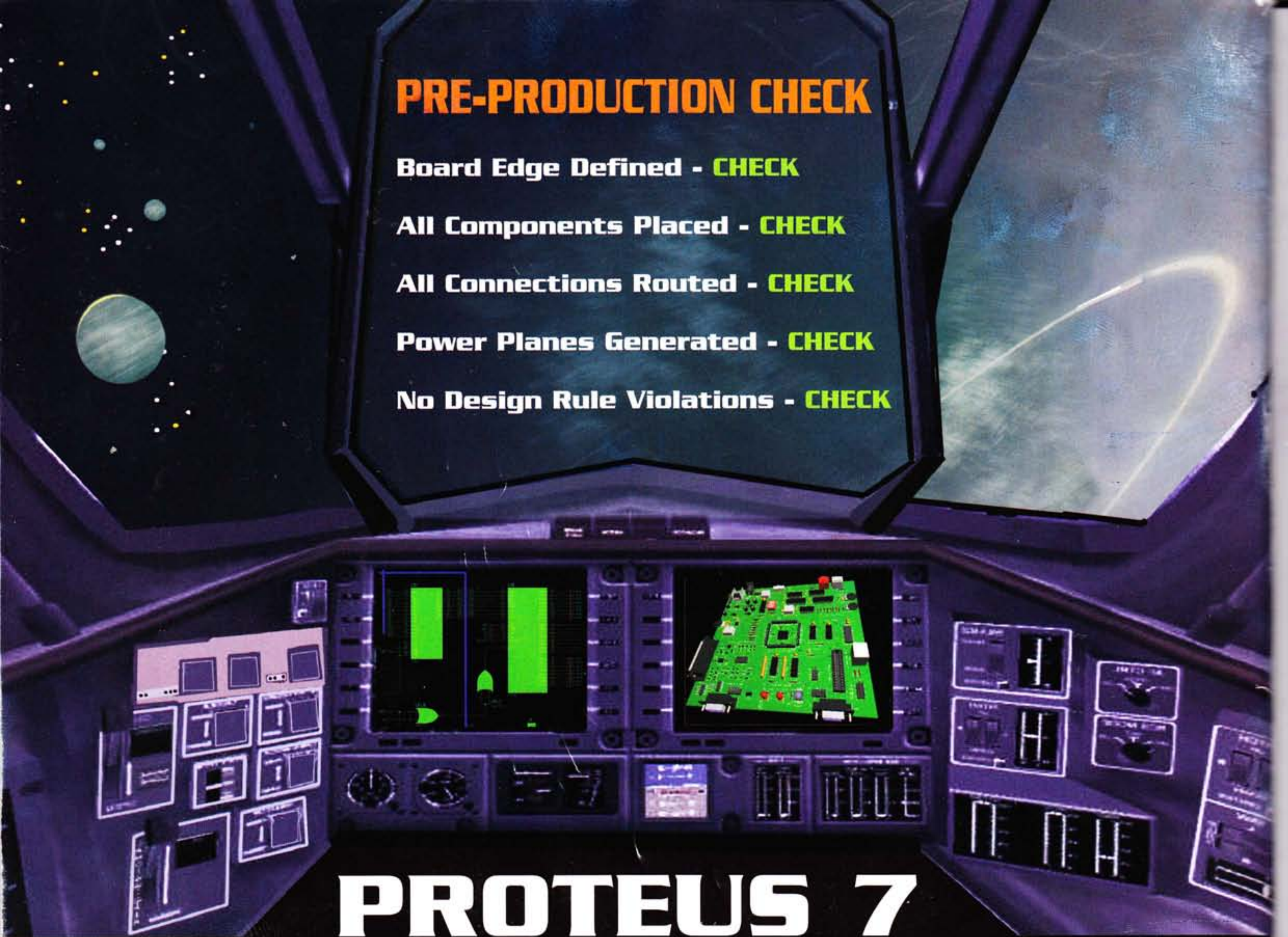
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