Constructional Project

AUTOMATIC NIGHTLIGHT

by ROBERT PENFOLD

This latest, low-cost starter project is sure to be a turn-on. Just a gentle tap or clap will trigger it into life.

This simple nightlight starter project is switched on simply by tapping on the case, or gently clapping one's hands close to the unit. The low power bulb then switches on for approximately five minutes, but it can be switched off at any time by operating a Reset button on the top of the case.

The unit was primarily designed with children in mind, but it could obviously be a useful gadget for adults as well, particularly disabled people. It is battery powered and is therefore safe for use by small children. The simple circuit and lack of mains power also makes this project suitable for construction by complete beginners.

SYSTEM OPERATION

The block diagram of Fig.1 helps to explain how the Automatic Nightlight functions. It is based on a monostable, which is simply a circuit that provides an output pulse of a certain duration each time it is triggered. In this case we require the light bulb to be switched on for about five minutes, and the timing components in the monostable are therefore chosen for an output pulse of this duration.

The monostable cannot provide sufficient current to power the bulb, which is therefore controlled by way of a single transistor output stage. Also, an input of the monostable permits the output pulse to be terminated prematurely and the Reset switch controls this input.

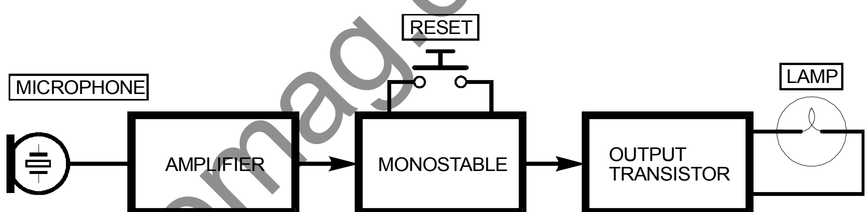


Fig.1. Block diagram for the Automatic Nightlight.

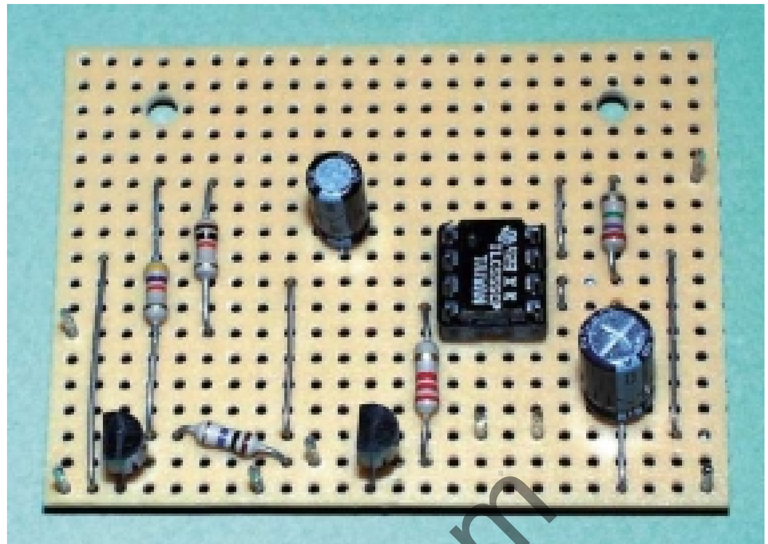
A piezoelectric microphone is used to provide the trigger signal for the monostable, but the output signal from the micro phone is too low to provide reliable triggering. A single stage amplifier is therefore used to boost the signal from the microphone to a level that gives better results.

The sensitivity of the circuit is still quite low, but high sensitivity is not an advantage in this application. It would simply result in frequent spurious triggering of the unit, and operating the Reset switch would produce vibrations that would immediately re-trigger the unit.

CIRCUIT OPERATION

The full circuit diagram for the Automatic Nightlight project appears in Fig.2. It is based on a low power version of the 555 timer (IC1) used in the standard monostable mode. It is important to use a *low power* 555 in this circuit, because it will be left switched on, but in the standby mode, for long periods of time.

The standard 555 has a current consumption of only a few milliamps, but over a period of several nights this would significantly drain the batteries. A low power 555 consumes only a fraction of a milliamp, and should not greatly drain the batteries, even after a few months of use.



Completed circuit board showing the component layout and the use of an IC socket for the low power 555 timer IC.

ON TIME

The timing components in the monostable are resistor R3 and capacitor C2. Under standby conditions an internal transistor of IC1 places a virtual short circuit across C2 that prevents it from charging via R3. This short circuit is removed when IC1 is triggered, and C2 then charges via R3 until the charge potential equals approximately two thirds of the supply potential. The internal transistor then switches on again, and almost instantly discharges capacitor C2.

Under standby conditions the output at pin 3 of IC1 is low, but it goes high while capacitor C2 is charging. The output pulse duration is equal to approximately 1·1 *CR* seconds, with the capacitance value in microfarads and the resistance in megohms.

With the specified values this works out at 297 seconds, or just under five minutes in other words. In practice the pulse duration is likely to be somewhat longer than this due to slight leakage in C2, and it is not possible to set highly accurate output pulse times with a simple circuit of this type.

In the present application highly accurate results are not required, and any slight lack of consistency in the output times is also of little importance. Different output times can be produced by changing the value of resistor R3 and (or) capacitor C2, but times of more than about 20 minutes become increasingly unreliable due to the high values involved. However, longer times are not really needed in this application, and for most purposes the specified values will suffice.

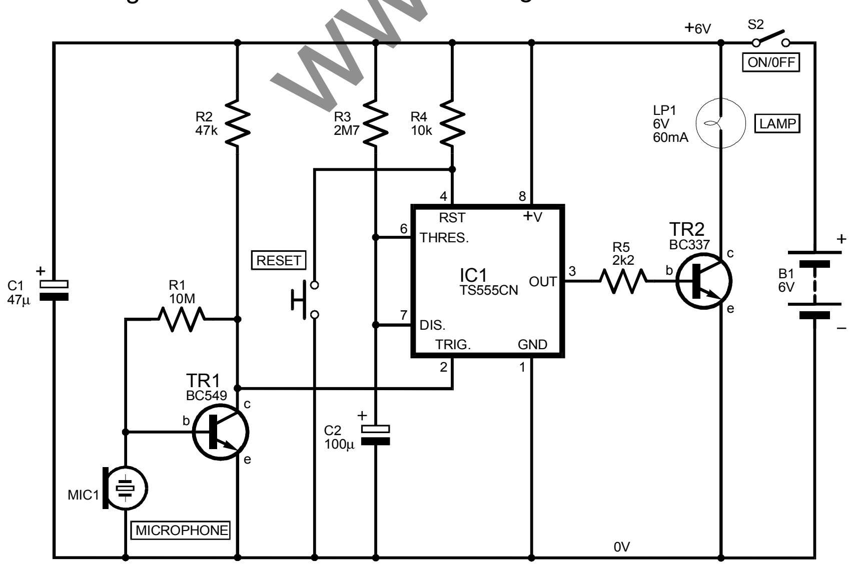


Fig.2. Complete circuit diagram for the Automatic nightlight.

LIGHTING UP TIME

Although light bulb LP1 is a low current (60mA) type, it still requires more current than IC1 can supply. Consequently, it is driven via common emitter switching transistor TR2. When the output of IC1 goes high TR2 is biased into conduction, and LP1 is

COMPONENTS

Resistors
R1 10M
R2 47k
R3 2M7
R4 10k
R5 2k2
All 0.25W 5% carbon film

Capacitors
C1 47u radial electrolytic, 16V
C2 100u radial electrolytic, 10V

Semiconductors
TR1 BC549 *npn* general-purpose transistor
TR2 BC337 *npn* medium-power transistor
IC1 TS555CN low power timer

Miscellaneous
MIC1 cased piezoelectric sounder
LP1 6V 60mA bulb, with holder
S1 push-button switch, push-to-make, release-to-break
S2 s.p.s.t. miniature toggle switch
B1 6V battery pack (4 x AA cells in holder)

Medium size plastic or metal box, style and size to choice; 0.1 inch matrix stripboard, 24 holes by 18 copper strips; 8-pin DIL socket; PP3 type battery connector; multistrand connecting wire; solder pins, solder, etc.

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Approx. Cost Guidance Only (Excluding Batts & Case) **$10**

supplied with virtually the full 6V supply. Resistor R5 prevents an excessive base current from flowing into TR2.

The circuit can handle higher output currents incidentally, but do not use a bulb having a rating of more than about 250mA. Of course, using a bulb having a current rating of more than 60mA will significantly shorten the battery life.

Resistor R4 takes the reset input of IC1 (pin 4) high so that the monostable functions normally. Pressing switch S1 pulls pin 4 low and causes the output pulse to be terminated immediately. Of course, pressing S1 has no effect if LP1 is not switched on.

INPUT TRIGGER

The trigger input at pin 2 of IC1 is driven from the output of a simple common emitter amplifier based on transistor TR1. To trigger the monostable this input must be taken below one third of the supply voltage. The high value of bias resistor R1 ensures that under quiescent conditions the output voltage at the collector (c) of TR1 is half the supply potential or more.

When the microphone MIC1 picks up a sound the collector voltage of TR1 moves either side of its normal level, and if the signal is strong enough the voltage will briefly go below one third of the supply potential and trigger IC1. Microphone MIC1 is actually a piezoelectric sounder and not a proper microphone. In this application audio quality is not a consideration, and a piezo sounder used in reverse as a crude crystal microphone gives good results at low cost.

It is important that the current consumption of the amplifier is very low so that good battery life is obtained. The current drawn by transistor TR1 is typically about 60uA, and the quiescent current consumption of the circuit as a whole is approximately 250uA.

CONSTRUCTION

This battery-powered Automatic Nightlight, the latest in our special series of low-cost starter projects, is built up on a small piece of stripboard. The topside component layout, underside details and interwiring to off-board components is shown in Fig.3. Containing just 24 holes by 18 strips the board is not a standard size and a larger board must be trimmed down to this size using a hacksaw or a junior hacksaw.

The two mounting holes are 3mm diameter and will accept either 6BA or metric M2.5 mounting bolts. Most plastic stand-offs do not work well with stripboard and it is better to use mounting bolts plus spacers to keep the underside of the board clear of the case.

The seven breaks in the copper strips can be made using a special tool, but a handheld twist drill bit of about 5mm diameter will do the job just as well. The circuit board is now ready for the components and link-wires to be added.

Most low power versions of the 555 timer are not static-sensitive, but it is still advisable to mount this component on the board via a holder. Be careful to fit both capacitors with the correct polarity.

Capacitor C2 must be a good quality component if the unit is to function properly. Using a low grade capacitor will either give greatly extended output pulses from the monostable, or once triggered the lamp will simply stay switched on indefinitely. A tantalum capacitor is ideal, but a good quality electrolytic component should give good results.

The five link-wires are made from 22s.w.g. or 24s.w.g. (about 0·6mm diameter) tinned copper wire. Fit single-sided solder pins to the board at the points where connections to the switches, the microphone, etc. will eventually be made.

CASE

A medium size plastic or metal box will comfortably accommodate all the components. It is best to mount Reset switch S1 on the top panel where it will be easy to operate.

The microphone can be mounted behind the front panel, but a large round cutout will then be needed for the body of the component. It is easier to mount it on the front surface of the panel, and only three small holes are then required.

Two of these are for the metric M2 or 8BA mounting bolts, which are not normally supplied with the sounder incidentally. The third hole allows the two flying leads to pass through to the interior of the case. The sounder can be used as a template when marking the positions of the mounting holes.

Piezo sounders usually have one black lead and one red one, which is presumably to indicate their phasing. They are not polarized components though, and can be connected either way round in this case.

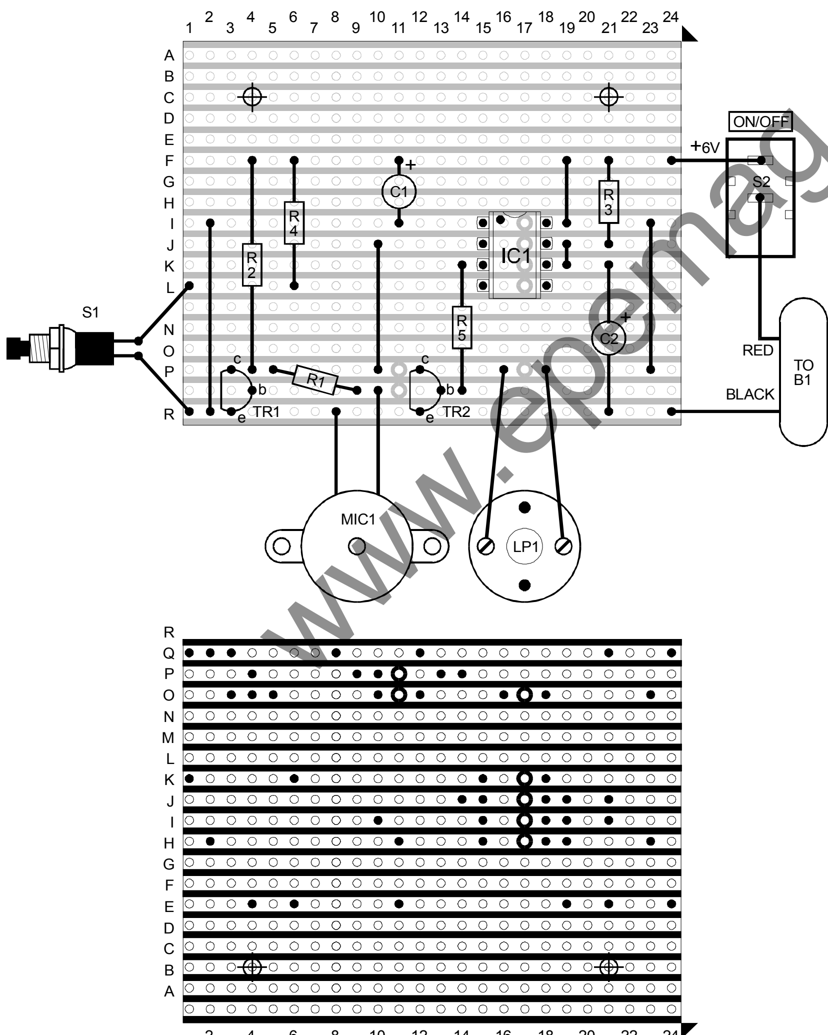


Fig.3. Stripboard topside component layout, details of breaks in the underside copper strips and interwiring to off-board components.

LIGHT WORK

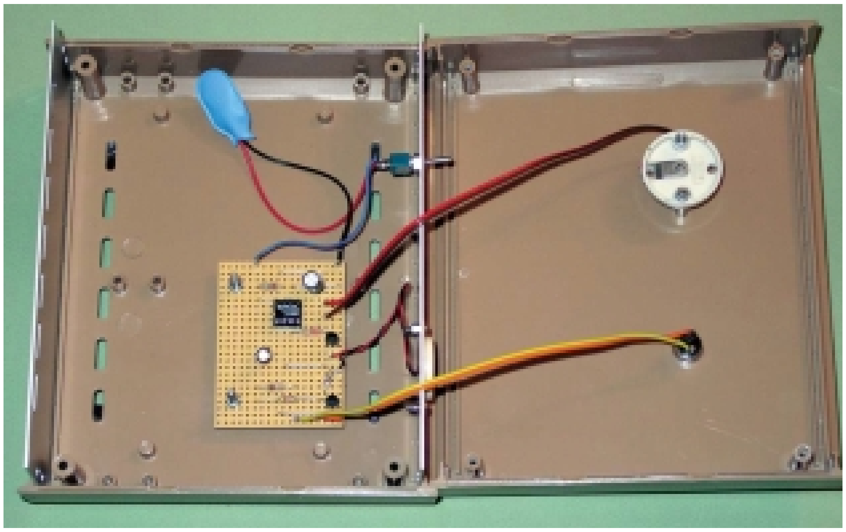
Fitting the light bulb to the case in a reasonably neat fashion is the only awkward aspect of construction. The original intention was to mount the bulb on the top panel using a chassis mounting bulb holder. Some form of transparent plastic cover would then have been fixed over the bulb and holder.

The problem with this method is in finding a suitable cover. The method eventually used was to mount the bulb holder beneath the top panel, with spacers holding it 12·7mm (0·5 inches) beneath the panel. This brings the top of the holder roughly flush with the top panel of the case. A 9mm diameter hole drilled in the top panel enables the bulb to be screwed into the holder.

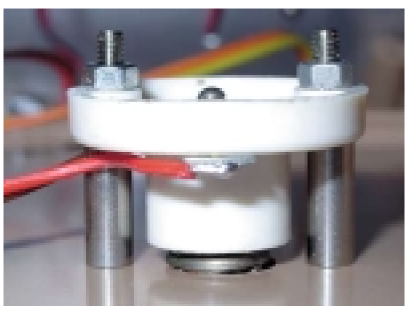
This gives a reasonably neat looking finished article, but it is not very childproof. If small children will have access to the unit it is essential to make access to the bulb more difficult.

One solution is to go for the modern approach, and simply mount everything inside a transparent case. Another possibility is to mount the bulb on top of the main case, but to mount a small transparent case over it. Remember that although access to the bulb must be difficult, it must be possible so that the bulb can be changed.

The small amount of hard wiring is perfectly straightforward. The bulb holder has screw terminals, but you may prefer to remove the screws and make soldered connections to the metal terminal plates. Be careful to connect the battery clip with the polarity shown in Fig.3.



The two halves of the case opened out to reveal the general positioning of the circuit board and the interwiring to the front and top panel mounted components. Don't forget to leave plenty of room for the battery.



Using spacers to mount the bulb holder on the underside of the case lid, above a 9mm diameter hole to allow the bulb to be screwed in from the outside.

TESTING

When the completed unit is first switched on it is likely that it will be triggered and the lamp will switch on. Operating push switch S1 should switch the lamp off again, but avoid making too much vibration when operating S1 or the unit will be triggered again.

With the lamp switched off, try tapping the case or clapping gently near the microphone to check that the unit will trigger properly. If there is any sign of a malfunction, switch off at once and recheck the entire wiring, etc.

If all is well, check that the lamp remains switched on for approximately the correct period. Due to component tolerances and slight leakage in timing capacitor C2 there may be a substantial error in the time that the lamp is switched on. Anything in the region of 4·5 to 7 minutes is acceptable.

If the switch-on time is far too long, or the lamp fails to switch off at all, it is likely that the leakage level of capacitor C2 is too high. It must then be replaced with a higher quality component.

Due to its low standby current consumption the Automatic Nightlight can be left switched on all the time, but it is advisable to switch it off during the daytime. Otherwise there is a risk of it being triggered occasionally, causing the lamp to switch on and run down the batteries unnecessarily.

Finished Automatic Nightlight showing the piezoelectric microphone and on/off switch mounted on the front panel. The bulb should be protected against breakage.