

Passive-Optical Person Detector

responds to changes in ambient lighting

Design by B. Kainka

Ordinary proximity detectors use infrared sensors which respond to the warmth of the human body. But there's a simpler way: we can use ambient lighting and detect changes in illumination.



Any move a person makes causes a change in the ambient lighting. This circuit uses an ordinary phototransistor as its 'eyes' to detect these changes. The circuit can detect even the smallest change in illumination: it is not even necessary for a shadow to fall directly on the detector. It is enough if just a part of the sky is occluded. The sensitivity

of the sensor can be set using a potentiometer.

The circuit will work over a wide range of ambient lighting conditions. A control loop with a logarithmic characteristic ensures that any given percentage change in light level is equally well detected, whatever the

ambient level may be. The circuit will therefore even work in a darkened room. Gradual changes in illumination are ignored, while rapid changes are greeted with an acoustic alarm. However, direct sunlight is not good for the sensitivity of the circuit: it is better to use indirect lighting, reflected from other objects in the environment.

Component selection is not particularly critical. Any ordinary phototransistor can be used for T1. For T2, as well as the type BC547B suggested in the parts list, any similar NPN transistor such as the BC548, BC549 or BC550 will do fine. The transistor's current gain should not be too small, however, and so it's important to check the identifying letter ('suffix') after the part number, which indicates the gain group. Type A transistors are not suitable: types B or C should be used instead.

For the opamp (IC1.A and IC1.B), other dual opamp devices such as the TL072 or TL082 can be used.

The LEDs used should be low current types, able to operate at their rated intensity with a current of 2 mA. In comparison, conventional (generally older) LEDs need considerably more current, being specified to reach their rated intensity at 10 mA or even 20 mA. It's not surpris-

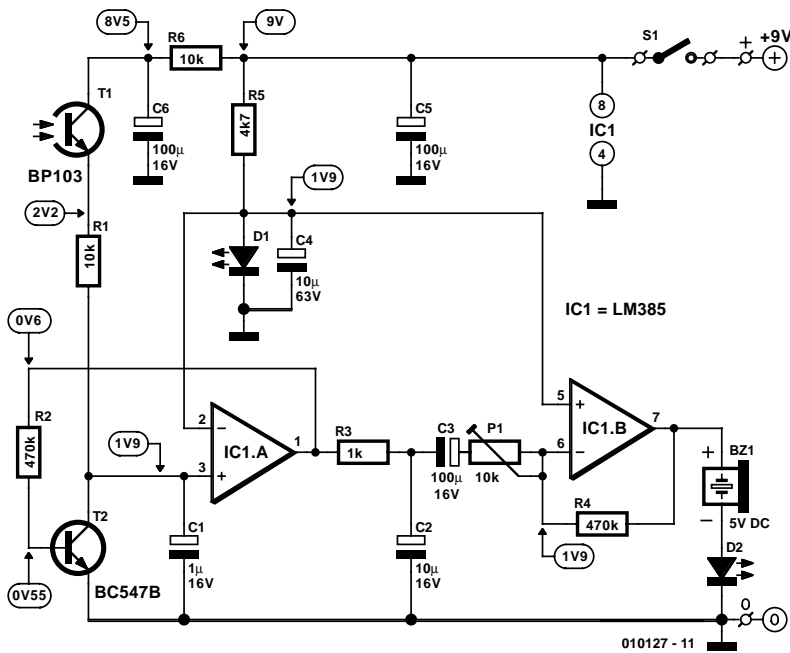


Figure 1. The control circuit around T2 provides automatic compensation for different intensities of ambient illumination.

ing that low current LEDs have been so widely successful.

We should also remark on the buzzer, which is a DC (or 'active') type rated for operation at 5 V. The output of opamp IC1.B will be 1 V or 2 V less than the battery voltage of 9 V, and we also need to take into account the voltage drop of about 2 V across LED D2, which is in series with the buzzer and which lights when the opamp drives the buzzer.

The battery should last for a reasonably long time. Although LED D1 is continuously illuminated, it only draws about 2.5 mA in the quiescent condition. In the alarm condition, extra current flows through the buzzer

How does it work?

The circuit uses two operational amplifiers, or opamps, contained in a single package. The first stage, around IC1.A, forms a control loop. The further the output voltage rises (above about 0.6 V) the more transistor T2 conducts. T2 thus forms a variable load for phototransistor T1. As the illumination increases, more current flows through the phototransistor. T2 then also turns more fully on, keeping the voltage at the output of the opamp more-or-less constant. In this way the circuit can work over a very wide range of illumination levels.

The transfer characteristic curve of a transistor is very close to exponential over a wide range. Each increase in base voltage of about 20 mV gives rise to a doubling in the collector current. This is used in reverse in this circuit, where a doubling of the ambient illumination intensity will lead to a rise of about 20 mV in the output voltage of IC1.A. If the ambient illumination changes by only 10%, the output voltage will change by just a couple of millivolts, essentially independent of the absolute level at which this relative change occurs.

The second sensor amplifier stage is coupled via a high-pass and a low-pass filter. In the quiescent state, with constant illumination,

the output voltage of IC1.B will be at about 1.9 V. Changes in the input voltage will be greatly amplified. Very rapid changes in intensity will be filtered out by the low-pass filter formed by R3 and C2. This reduces the sensitivity of the circuit to the 100 Hz flicker from mains-powered lighting. Very slow variations, on the other hand, are filtered out by the high-pass filter formed by C3 and P1. This ensures that the alarm is not triggered by clouds or by changes in the level of sunlight over the day. However, in the middle frequency range, between about 0.1 Hz and 10 Hz, the circuit is very sensitive, and detects the normal rapid movements of people. The gain, and hence the sensitivity, of the circuit can be set using P1.

IC1.B operates as an inverting amplifier. This means that a sudden fall in light intensity will cause a rise in the output voltage. As soon as this voltage rises above about 2.5 V, and so more than 0.5 V appears across the buzzer, it will start to sound. Thus a shadow crossing the sensor will result in a brief tone. At the same time, current flows through LED D2, which will therefore light briefly. The first LED (D1) not only shows when the circuit is operating, but is also used to generate a stable auxiliary voltage of about 1.9 V.

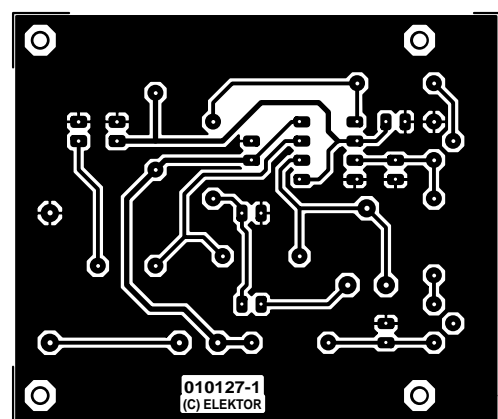
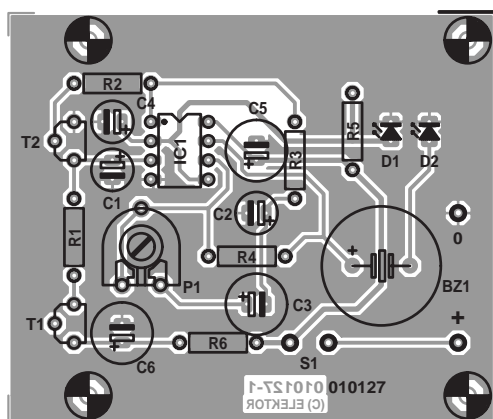


Figure 2. The printed circuit board makes constructing the person detector straightforward (board available via The PCB Shop).

and the other LED, and the total current consumption rises to about 10 mA.

Assuming that the circuit board has been correctly populated (and that the battery is connected with the right polarity!), the buzzer should emit a brief sound and LED D2 should briefly light as soon as the circuit is switched on by closing S1. D1 should light continuously as long as S1 is closed. If D1 does not light, either the diode or the battery is connected the wrong way around. Or the battery is flat — which you can always check with a meter.

The sensitivity of the circuit can be adjusted using trimmer potentiometer P1. The further P1 is turned to the right, the more sensitive the circuit. At high sensitivity even the flickering of fluorescent tubes (including so-called 'energy saving bulbs'), although invisible to the naked eye, will be amplified by the circuit. In electrical terms this is like a 100 Hz AC hum signal and so it is not surprising that it interferes with the circuit's operation, and in some cases can cause the buzzer to sound continuously. The sensitivity control must be backed off until the circuit no longer responds to the fluorescent light, but only to changes in the ambient illumination.

COMPONENTS LIST

Resistors:

R1, R6 = 10k Ω

R2 = 470k Ω

R3 = 1k Ω

R4 = 470k Ω

R5 = 4k Ω 7

P1 = 10k Ω preset

Capacitors:

C1 = 1 μ F 16V radial

C2, C4 = 10 μ F 16V radial

C3, C5, C6 = 100 μ F 16 V radial

Semiconductors:

D1 = LED, green, low-current

D2 = LED, red, low-current

T1 = BP103

T2 = BC547B

IC1 = LM358P

Miscellaneous:

S1 = switch, on/off, 1 contact

BZ1 = 5V DC (active) buzzer

9V PP3 (6LR22) battery with clip-on lead

Enclosure with battery compartment, size 101 x 60 x 26 mm

PCB, available from The PCB Shop, see www.elektor-electronics.co.uk

The DC voltage measurements shown in the diagram were made under normal room lighting using a digital multimeter with a 10 M Ω input impedance.

The printed circuit board shown here is unfortunately not available ready-made through the Publishers'

Readers Services. However, it may be obtained as a one-off from **The PCB Shop** — for more details see the PCBs & Software page on our website.