FIND IT - DON'T LOSE IT

by TERRY DE VAUX_BALBIRNIE

Locates almost anything in the dark!

A fuse blows and the lights go out. Everything goes dark. You fumble for the torch – you know it's there somewhere – but where?

Let this little gadget show you where!

FIND IT

With the battery-powered *Find It* circuit, you will always be able to locate a torch (flashlight), bunch of keys, door lock – just about anything – in darkness!

While sufficient light reaches a sensor (light dependent resistor – LDR) on the unit, nothing happens. However, when it is dark enough, a light-emitting diode (LED) begins to flash briefly about once every five seconds. This helps to locate the item.

If preferred, you could increase or reduce the flash rate. However, any increase would reduce the life of the battery.

LIGHTING THE WAY

There are many ways of using this circuit and readers will, no doubt, have their own ideas. One method would be to attach the unit to a wall close to the object to be "found". Alternatively, a hook could be fitted to the box so that, say, a bunch of keys or a torch could be hung from it (see photograph).

It would also be possible to attach the unit to a portable item. In some cases, it might even be possible to build the circuit panel inside a piece of equipment but the reader will need to make certain that he or she is totally aware of any safety implications and must be competent at doing the job correctly.

If you are going to use the device to locate a door lock, it may be convenient to have only the LED showing next to the lock and connect it to the unit mounted on the inside of the door.

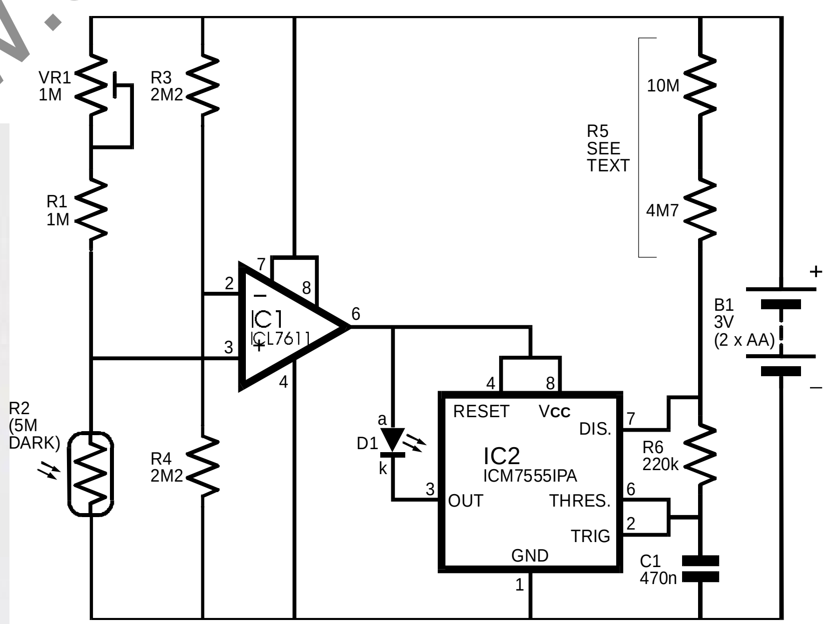

Fig.1. Complete circuit diagram for Find it. Left, Find It being used as an illuminated keyring hook.

As well as household applications, this circuit will be found handy in many outdoor pursuits. Campers and anglers will certainly find uses for it. Note that, in some cases, it will be necessary to waterproof the box and this is left up to the constructor.

The circuit draws power from two AA-size alkaline cells, which should give some one or two years of service. Since it requires more current while the LED is flashing, the actual life of the batteries will depend on the number of hours of darkness in a given 24 hour period. It also depends on what degree of illumination is set for the unit to begin operating.

While sufficient light reaches the sensor (so that the LED is off), the current requirement of the prototype circuit is only 5uA which may be regarded as negligible. While the LED is flashing, this rises to an average 250uA approximately.

This small operating current is achieved by using a short duty cycle – that is, the LED is off for much longer than it is on – about 65 times longer. Thus, in each five second cycle the LED is only actually operating for some 0·08s (80ms).

Although while glowing the LED draws about 10mA, the average requirement is therefore only 150uA approximately. This is added to the 100uA approximately required by the rest of the circuit, giving a total of 250uA. If it is assumed that there are eight hours of operation in a 24 hour period, the average overall current requirement is therefore only 80uA approximately.

While the battery voltage exceeds about 2·5V, the LED will flash brightly. It will become correspondingly dimmer down to about 2V which is the practical end point.

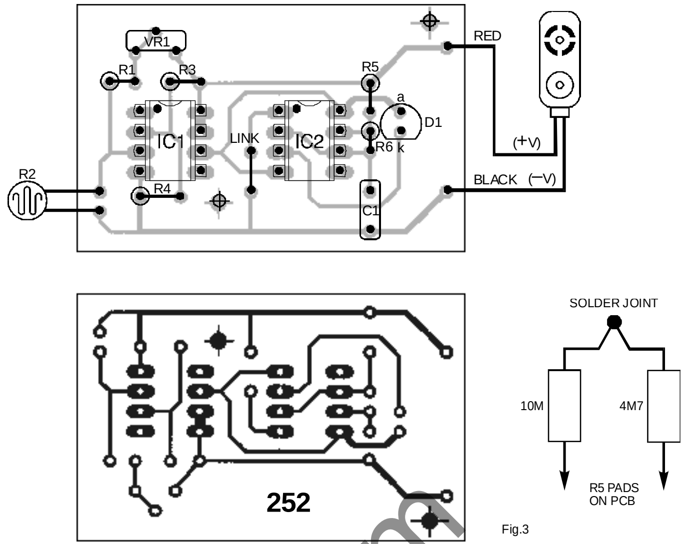

Fig.2. Printed circuit board component layout and (approximately) full size copper foil master pattern. Fig.3 (inset). How to make up R5 by wiring two resistors in series.

CIRCUIT DESCRIPTION

The complete circuit diagram for the *Find It* project is shown in Fig.1. This may be considered to comprise two sections. The first is the light sensing part based on IC1 and associated components and the second, the LED flasher centered on IC2.

Integrated circuit IC1 is an operational amplifier (opamp). This has been specially selected for its ability to operate from a low supply voltage combined with an exceptionally small standby operating current.

Looking at the light sensor stage first, the opamp inverting input (pin 2) is maintained at a voltage equal to one-half that of the supply (nominally 1·5V), due to the effect of equal value resistors R3 and R4 connected as a potential divider across the power supply. Since these have a very high resistance, the continuous current flowing through them is only a fraction of a microamp.

The opamp's non-inverting input, pin 3, is connected to a further potential divider. The top arm of this comprises preset potentiometer VR1 connected in series with fixed resistor R1. The lower one is simply light-dependent resistor (LDR) R2.

As the intensity of light reaching the LDR's sensitive surface falls, its resistance rises and so does the voltage across it and hence at the non-inverting input, pin 3. Depending on the adjustment of VR1, this voltage will exceed that at the inverting input, pin 2, at the operating light level.

A simple rule about opamps is this. When the voltage applied to the non-inverting input exceeds that at the inverting one (as will happen here in dim light), the output (pin 6) will be high. When it is less (bright light), it will be low.

The ICL7611 has an almost

COMPONENTS

Resistors
R1 1M (or as required - see text)
R2 sub-miniature light-dependent resistor (5mm diameter, 5 megohms dark - see text)
R3, R4 2M2 (2 off)
R5 14M7 (10M and 4M7 in series or as required - see text)
R6 220k
All 0.25W 5% carbon film except R2

Potentiometer
VR1 1M miniature enclosed carbon preset, vertical

Capacitor
C1 470n miniature metalized polyester - 5mm pin spacing

Semiconductors
D1 3mm red high-brightness LED (see text)
IC1 ICL7611 micopower opamp
IC2 ICM75551PA low-power CMOS timer

Miscellaneous
B1 3V battery pack (2 x AA cells with holder).

Printed circuit board available from the *EPE Online Store*, code 7000252 (**www.epemag.com**); plastic case, size 102mm x 76mm x 38mm external; 8-pin DIL socket (2 off); PP3-type battery connector (or as appropriate for the holder); connecting wire, solder, etc.

See also the SHOP TALK Page!

Approx. Cost Guidance Only (Excluding Batts) **$16**

full output swing between the supply voltage, and its output will therefore go from 0V to 3V nominal as the light level falls to the required operating point.

LIGHT FLASHER

Now let us look at the LED flasher based on IC2. This consists of an astable (free-running pulse generator). Its frequency is related to the value of resistor R5 (in the prototype, this consisted of two resistors connected in series to make up the required value), resistor R6 and capacitor C1.

The *on* times (during which the output, pin 3, is high) are provided when C1 charges through resistors R5 and R6 to two-thirds of supply voltage (2V approx.). After that, the capacitor discharges via internal circuitry through resistor R6 alone to one-third of supply voltage (1V approx.) and this gives the *off* period during which pin 3 is low.

This cycle repeats indefinitely as long as a supply exists to pin 8 and the reset input at pin 4 is high. With the values of components specified, each cycle takes about five seconds.

Since resistor R5 has a much higher value than R6, capacitor C1 charging time is much longer than the discharge time. Thus, the time during which output pin 3 is high is much greater than when it is low. If a LED was connected between pin 3 and the 0V rail, this would give the opposite effect to that which was required – it would be on for longer than it was off!

To overcome this, the current-sinking capability of IC2 is exploited. That is, current is able to flow from supply positive through the LED and *into* the output.

With the LED connected like this, current will flow through it when pin 3 is *low* rather than when it is high. The result is that the on transitions are much shorter than the off ones. Note that there is no need to use a current-limiting resistor connected in series with the LED, because the operating current is limited to a suitable level by the chip itself.

Referring back to the operation of IC1, its output (pin 6) is connected to IC2 pin 8 (supply positive) and pin 4 (reset) so, while IC1 output is high (that is, when the LDR is sufficiently dark) the criteria are met for the astable to operate and the LED flashes.

In the original version of the circuit, the LED D1 anode (a) was connected direct to supply positive so relieving IC1 of its load. However, even with IC1 pin 6 low (and so apparently no supply existing for IC2), the LED continued to flash dimly!

It seems that current sinking through the LED provided a weak supply for IC2 which allowed it to oscillate. In the final version of the circuit the anode of D1 is connected to IC1 output and this solves the above problem. When the LDR receives sufficient light, there is no power supply for IC2 and nothing happens.

Using IC1 to switch on the power supply for IC2 has a particular advantage in that IC2 draws no current at all while the LDR receives sufficient light, and this greatly reduces the standby current requirement of the circuit as a whole.

CONSTRUCTION

All components, except the cell holder, are mounted on a small single-sided printed circuit board (PCB). The topside component layout and full size underside copper foil track master are shown in Fig.2. This board is available from the *EPE Online Store* (code 7000252) at **www.epemag.com**

Begin construction by drilling the fixing holes then solder the IC sockets and single link wire in position. Do not insert the ICs themselves yet, however. Follow with all other components except the LED D1 and LDR R2.

The suggested value for resistor R5 (14·7MΩ) may be

Completed unit showing positioning of the circuit board and the two-cell holder. Note the light dependent resistor (LDR) mounted in one side panel.

made up using a 10MΩ unit connected in series with a 4·7MΩ one. These are arranged as shown in Fig.3 with the free ends soldered to the "R5" pads on the PCB.

Raising the value of the combination would reduce the flash rate and vice-versa. A 10 megohm, resistor alone would give a rate of about one flash every three seconds.

If you are using the specified miniature LDR having a "dark" resistance of about 5MΩ, then the suggested value of resistor R1 will probably be found to work well. If you use a different LDR having a lower "dark" resistance (say, the common ORP12 type), you may need to reduce the value of R1 to, say, 100kΩ.

FINAL ASSEMBLY

Hold the PCB a small distance above the base of the box and decide how long the LED and LDR leads need to be. The LED should be soldered so that its tip will eventually stand slightly higher than the face of the lid. Take care over its polarity (the slightly shorter lead is the cathode (k).

Note that the specified LED used in the prototype is the *high-brightness* type, and this was found to give better results than the standard variety. However, beware of any LED that has a narrow viewing angle. This could prevent it from being seen if the user is too far off-axis.

The LDR leads should be of such a length that its "window" will take up a position level with either the top face or side of the box depending on the layout decided on. Solder it in place using as little heat as possible to prevent possible damage.

If you wish to mount the LED remotely from the PCB, use a piece of light-duty twin-stranded wire soldered to its copper pads on the PCB. When soldering the LED to the other end, take care over the polarity.

Also, be careful to avoid short-circuits at the joints. Insulate and waterproof them as necessary using heat-shrinkable sleeving. Solder the end wires of the PP3-type battery connector (or as appropriate for the battery holder being used) to the "+V" (red) and "0V" (black) points on the PCB.

Insert the ICs, with the correct orientation, into their sockets. Since they are both CMOS components, they could possibly be damaged by static charge, which might exist on the body. It would therefore be wise to touch something which is earthed (such as a water tap) to remove any such charge before handling the pins.

TESTING

A check may be carried out before mounting the PCB in the box. In that way, any faults will be more easily rectified.

Adjust preset VR1 fully anti-clockwise (as viewed from the top edge of the PCB). This will allow the circuit to respond without having to cover the LDR completely and this will make testing easier. Insert the cells into their holder taking care with the polarity and connect it up.

With the LDR covered with the hand, the LED D1 should flash about once every five seconds. Be patient because you will have to wait longer than this for the first flash. The actual rate is not particularly important but it could be made faster or slower by reducing or increasing the value of R5 respectively.

Now, uncover the LDR so that light falls on it. The LED should stop flashing. If you find difficulty making it work, try again with the LED covered more carefully or take the unit into a dark cupboard.

Adjust VR1 so that the circuit operates at the required degree of illumination. You may find that you need to make further small adjustments when the circuit panel is mounted in position.

BOX IT

If a hook or something similar is to be attached to the case, take account of the PCB position so that any fixings will not cause a short-circuit.

Remove the connector from the cell holder. Position the PCB on the bottom of the box and mark through the fixing holes. Remove the PCB again and drill them through.

Decide where the hole is to be drilled to allow light to reach the LDR. It must not be obscured too much during use or this would result in the LED flashing more than necessary with a consequent increase in the current requirement.

In the prototype, the LDR leads were bent through right-angles (see photograph) and the hole was made in the side of the box. However, the exact arrangements will depend on the application.

Carefully measure the positions of the LED and LDR and drill the holes for these components. The hole for the LED should be of such a diameter that its tip will protrude through it only slightly. That for the LDR should be a little smaller than its window so that this will lie just behind the hole when the PCB is in position.

If required, you could drill a small hole to allow preset VR1 to be adjusted from outside the case using a small screwdriver or trimming tool. However, this was not done in the prototype.

FINISHING OFF

Attach the PCB using plastic spacers on the bolt shanks so that the LED and LDR take up their correct positions. Attach the cell holder to the bottom of the box using a small fixing.

Secure the lid of the case taking care that the LED engages with its hole and test the circuit under real conditions. Make further adjustments to preset VR1 if necessary so that the LED begins to flash at the required light level.

Clockwise rotation of the sliding contact (as viewed from the top edge of the PCB) allows operation with less light. If you would like the LED to start flashing under dimmer conditions and this is not possible with VR1 adjusted fully clockwise, increase the value of resistor R1 – 2·2 megohms would be a good starting point.

Put the *Find It* into service. When the LED begins to flash too dimly to be seen effectively, it is time to replace the batteries.

Go to next section