**Light-pulse switch**



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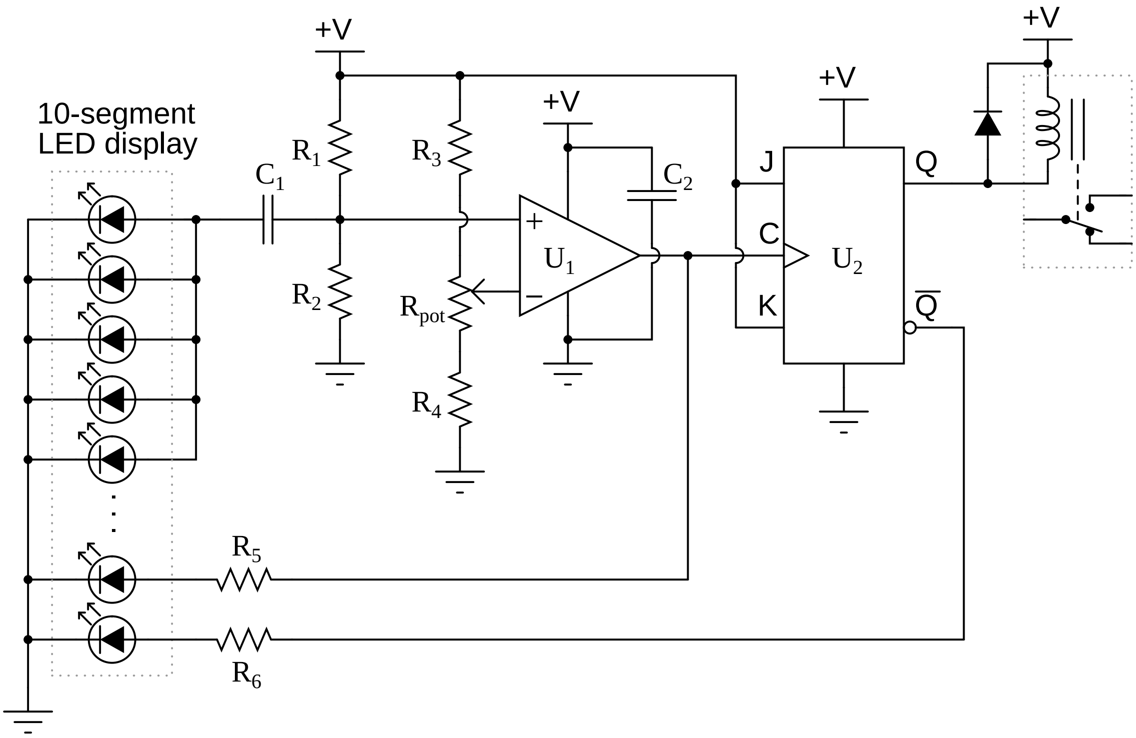
This circuit toggles a J-K flip-flop when it senses a *pulse* of light. Instead of a photocell or a solar cell, paralleled LEDs are used as the photo-detecting component. LEDs are typically much cheaper and more readily available than either photocells or solar cells, which is why I chose to use them here.




Of course, you are not restricted to using this exact design. One variation is to place a monostable 555 timer circuit at the output of the comparator instead of a J-K flip-flop. This would activate the output for a certain time period after detecting a pulse of light, rather than using one light pulse to turn the output on and another light pulse to turn the output off.

The potentiometer should be adjusted for good sensitivity in ambient light conditions. Obviously, the darker the ambient conditions, the more sensitive the circuit is to light pulses.

My original application for this circuit was a means to control an electronic display located inside a glass-fronted display case. By briefly pulsing a bright flashlight at the LED cluster, one could turn the display on and off through the glass with no pushbuttons or other contact-type interface devices.

Deadlines (set by instructor):

- Project design completed:
- Components purchased:
- Working prototype:
- Finished system:
- Full documentation:

Question 1

It is fairly important to use large value resistors (10 MΩ works well) for resistors $R_1$ and $R_2$, as well as a comparator with high input impedance (a TL08x operational amplifier with JFET inputs is fine). Explain why.

file 04027

Answer 1

The (internal) Thévenin equivalent resistance for the LED light sensor is quite high, making it sensitive to loading.

Notes 1

Nothing to note here.

Question 2

Suppose a student builds this circuit, using 10 MΩ resistors for $R_1$ and $R_2$, and a 22 $\mu$F capacitor for $C_1$, and finds that he must frequently adjust the potentiometer to keep the circuit at a reasonable level of sensitivity. A fellow student has encountered and overcome this same problem, and offers to fix the first student's circuit by replacing the 22 $\mu$F capacitor with something much smaller: a 0.001 $\mu$F (1 nF) capacitor.

Now, the modified circuit responds predictably. No longer must the student frequently adjust the potentiometer to achieve the desired sensitivity. Explain why a change in capacitance made such a difference, and what the problem was in the original circuit (with the much larger capacitor).

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Answer 2

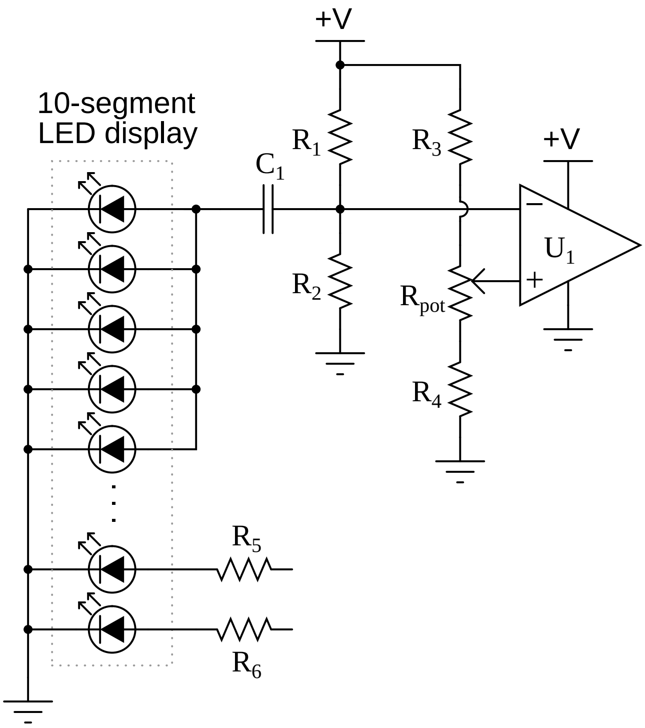
Here's a hint: calculate the time constant ($\tau$) for the RC network formed by $R_1$, $R_2$, and $C_1$.

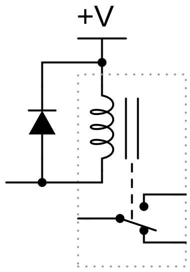
Notes 2

In order to understand the problem, students must recognize the function of this RC network: to filter out the DC bias voltage created by ambient light falling on the LED array, and to replace that changing bias with a fixed bias voltage equal to $\frac{1}{2}$ $V_{supply}$. Once this purpose is grasped, the problem of a slow time constant should be much more apparent.

Question 3

Modify the circuit shown to use a 555 monostable timer instead of a J-K flip-flop at the output of the comparator.




Also, explain the significance of reversing the comparator's input connections (as compared to the schematic shown on the front page of this worksheet). Why is it better to do this, if we are triggering a monostable 555 timer circuit?

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Answer 3

I'll let you and your classmates figure out the answer(s) to this question.

Notes 3

Nothing to note here.