

Project – Door Knock Indicator

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Smart systems engineering

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1. Purpose:

The simple system detects a knock on the door for a person that has difficulty in hearing. The system contains a 555 timer to provide monostable multivibrator and a lamp to notify knocking. There are two kinds of system, one is used with batteries and the other one is used with barrel jack connector.

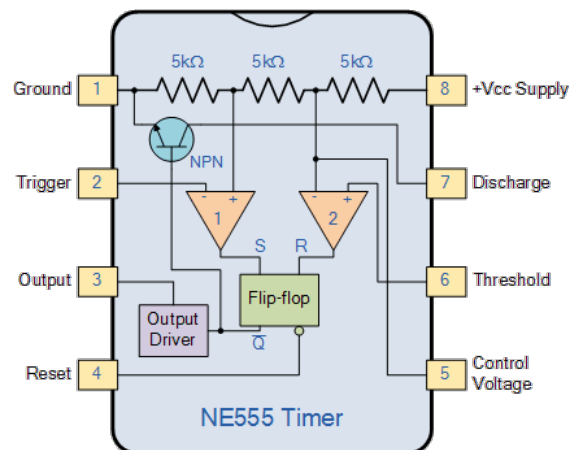
2. Overview:

The first model is powered by 5 x CR2032 3-V batteries to prevent using more cables near the door and also ensure the power supply. The main benefit of batteries is that they increase the convenience for users since they enable portability of devices. Their biggest disadvantage is that they can only be used for a limited time, even rechargeable batteries eventually die.

The second model is powered by the wall socket through AC to DC convertor and barrel jack connector to prevent the disadvantage of the first model.

3. Monostable 555 Timer:

A monostable multivibrator has only one stable state, also called a one shot, and produce a single output pulse when it is triggered externally. When triggered, a pulse of pre-defined duration is produced. The circuit then returns to its stable state and produces no more output until triggered again.



Pin 1 - Ground (GND) This pin is connected to the circuit ground.

Pin 2 - Trigger (TRI)

A low voltage (less than $\frac{1}{3}$ the supply voltage) applied momentarily to the Trigger input causes the output (pin 3) to go high. The output will remain high until a high voltage is applied to the Threshold input (pin 6).

Pin 3 – Output (OUT)

In output low state, the voltage will be close to 0V. In output high state, the voltage will be 1.7V lower than the supply voltage. For example, if the supply voltage is 15V, output high voltage will be 13.3 volts. The output can source or sink up to 200 mA (maximum depends on supply voltage).

Pin 4 – Reset (RES)

A low voltage (less than 0.7V) applied to the reset pin will cause the output (pin 3) to go low. This input should connect to Vcc to prevent electrical noise which causing a reset.

Pin 5 – Control voltage (CON)

It can control the threshold voltage (pin 6) through the control input (which is internally set to 2/3 the supply voltage). When not in use, it is recommended that this input be connected to circuit ground via a 0.01uF capacitor to prevent noise.

Pin 6 – Threshold (TRE)

In monostable mode, the voltage across the timing capacitor is monitored through the Threshold input. When the voltage at this input rises above the threshold, value the output will go from high to low.

Pin 7 – Discharge (DIS)

When the voltage across the timing capacitor exceeds the threshold value, the timing capacitor is discharged through this input.

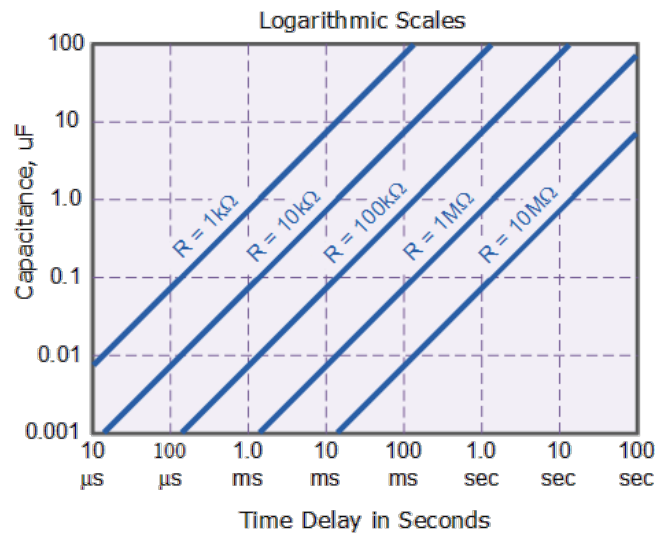
Pin 8 – Supply voltage (VCC)

This is the positive supply voltage terminal. The supply voltage range is usually between +4.5V and +18V.

The amount of time that the output voltage remains “HIGH” or at a logic “1” level, is given by the following time constant equation.

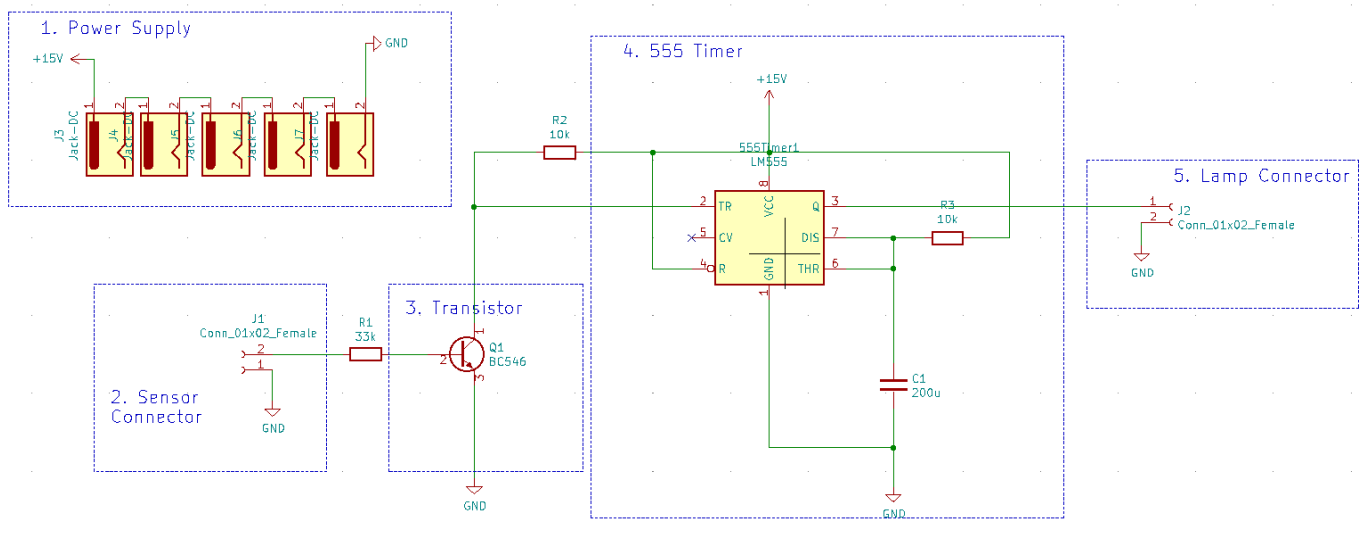
$$t = 1.1 * R * C$$

Where, t is in seconds, R is in Ω and C in Farads.

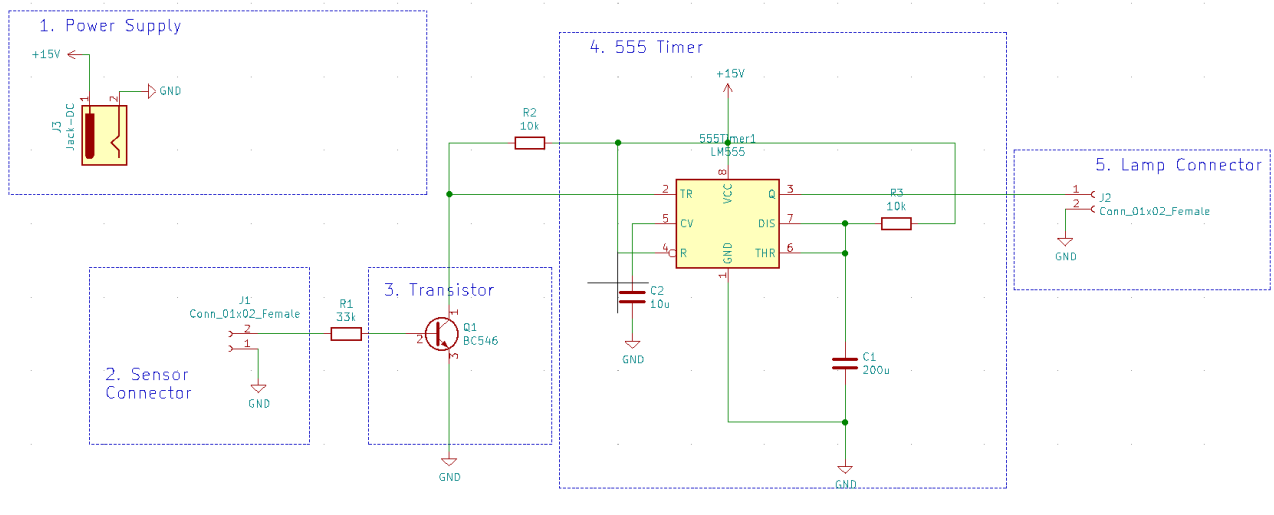


4. Structure:

First model:



Second model:



5. The System Operation:

When [Piezo sensor](#) (1) detects any knock on the door, it will drive voltage larger than 700mv which is larger than V_{be_on} to trigger the current go through emitter region in [transistor](#) (2). The suitable voltage is applied to the pin 2 of [555 timer](#) (3) to activate the high state of pin 3. As $R1 = 33k\Omega$ and $R2 = 10k\Omega$ in the schematic, the piezo sensor will provide enough current in both base and emitter region to drive the transistor to active or saturation mode. In calculation, if the piezo sensor provides the voltage exceeding 0.9V, the transistor is driven into saturation mode. Thus, h_{fe} or beta is no longer 110 and reducing. As the potential between $R2$ cannot exceed 15V, it will leave the V_{ce} around 50mV depending on the current through emitter region I_c . Therefore, it is enough to trigger output to high state periodically ($t = 1,1 * 10000\Omega * 200 * 10^{-6}F = 2,2$ seconds).

[12-24 LED light bulb](#) (4) is using to notify the hearing-impaired people in the room. The ideal working voltage for this lamp is from 12V to 24V, 15V power supply need to be used to drive around 13.3 V in output to light up the lamp.

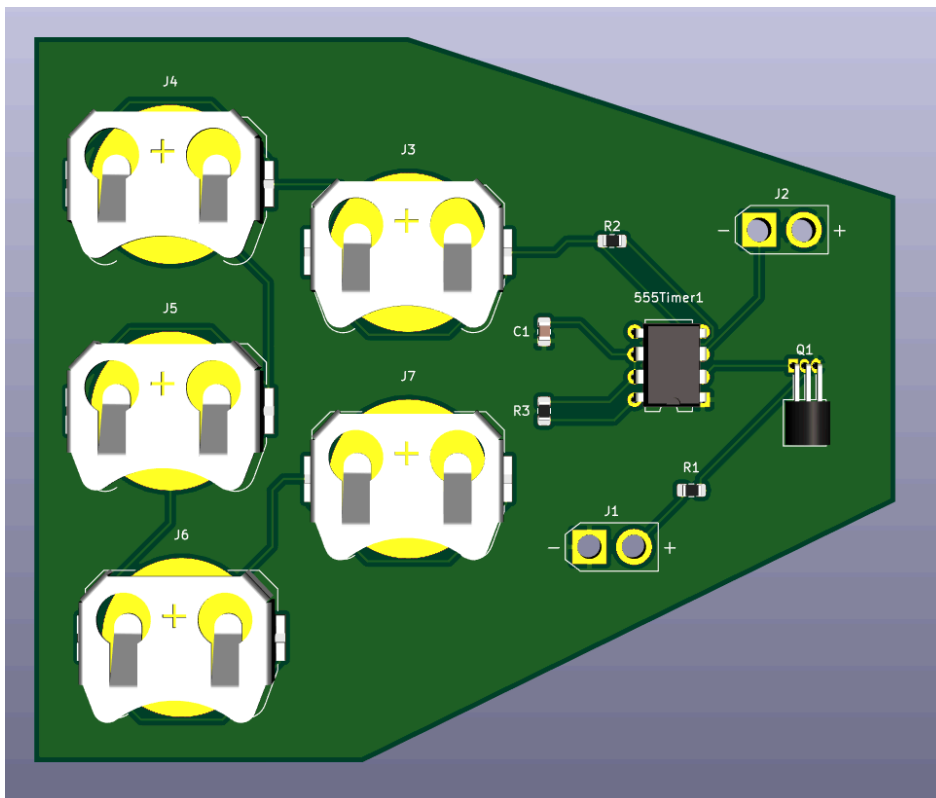
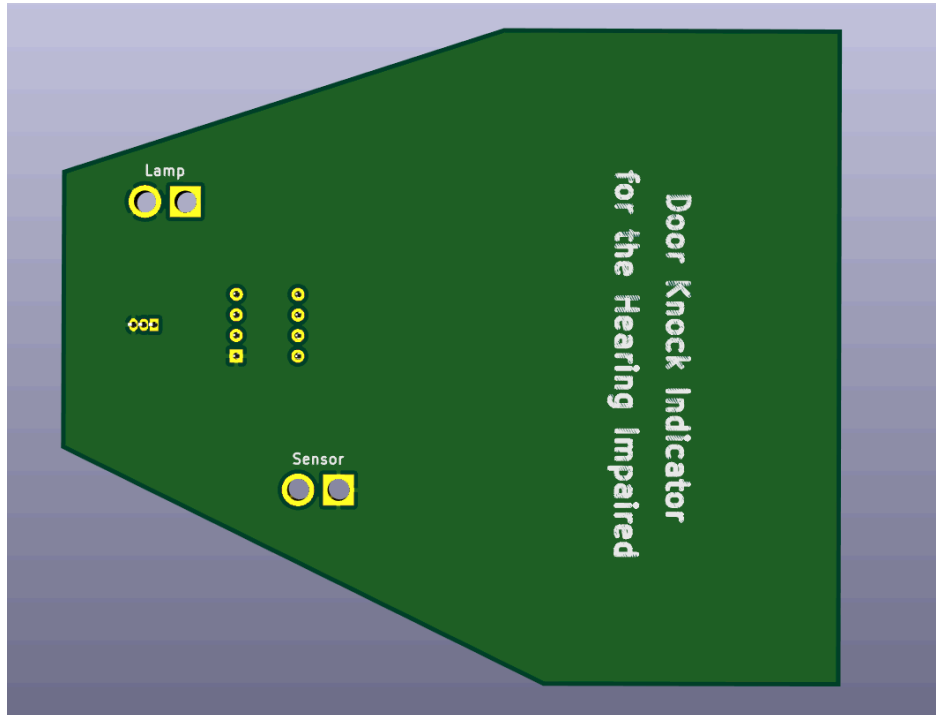
For the first model, 5x [CR2032 3-V batteries](#) (5) is using to supply the voltage. In the second model, it must be more complicated with the combination of [AC 100-240V AC to DC 15V switching power converter](#) (6) and [DC barrel power jack](#) (7).

After notifying time, if the piezo sensor does not receive any knock on the door or just receive slight touch or little wind blowing across the door, it probably provides the voltage less than 600mV to drive the transistor to cut-off mode. The trigger will receive 15V from Vcc as the op-amp inside 555 timer neglects the R2-10kΩ.

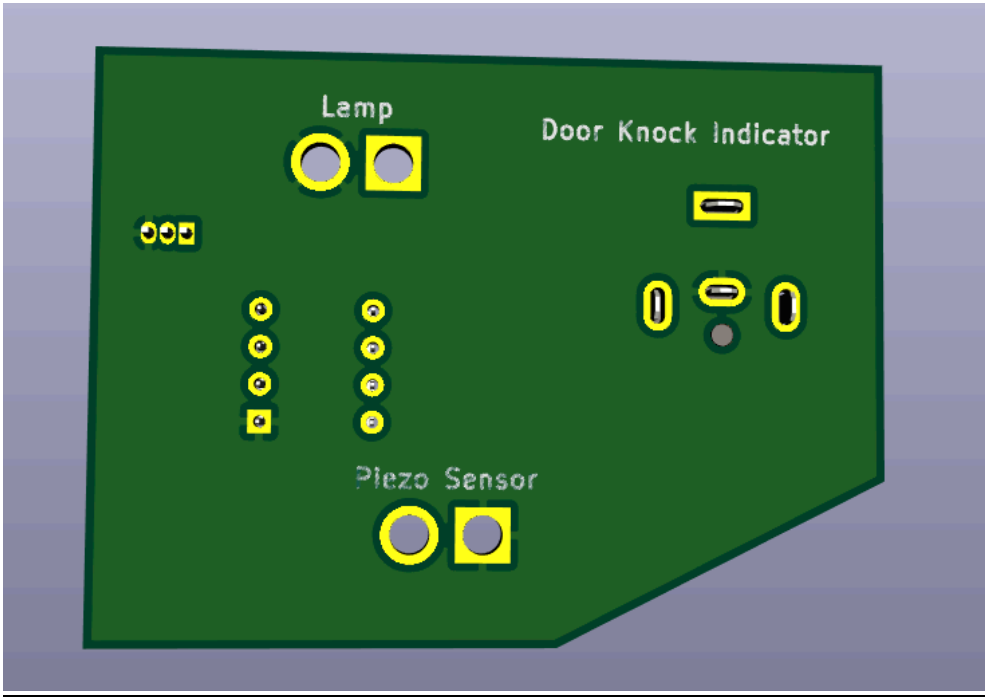
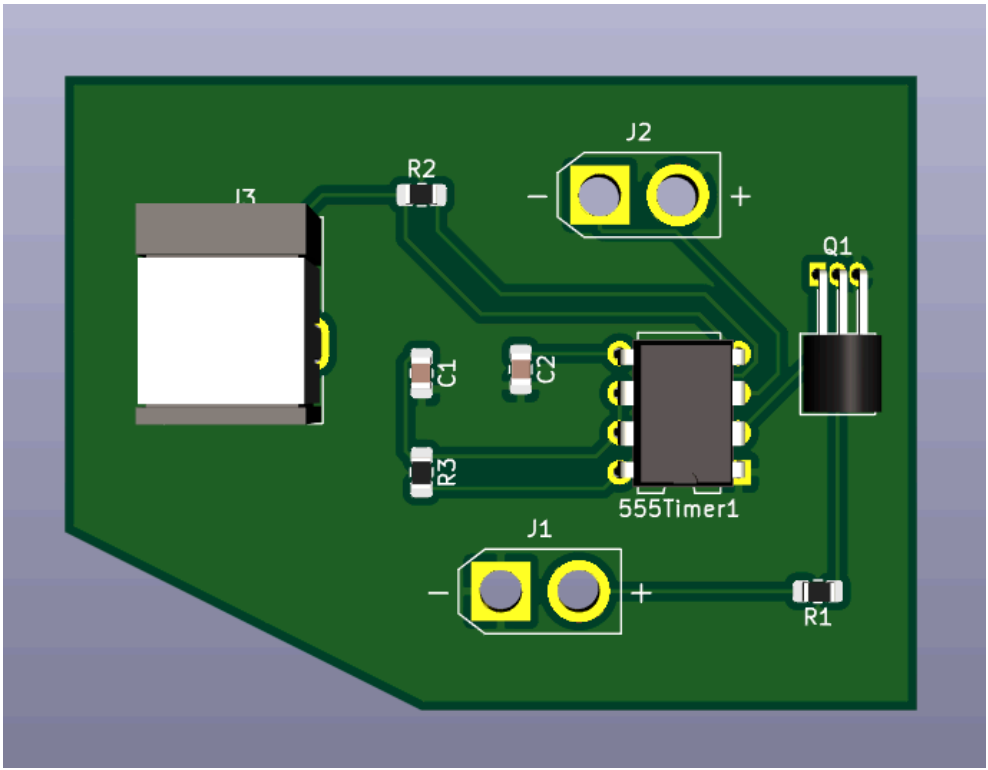
The red-LED lamp is highly recommended because the red color is used for danger signals. The primary reason is that the red light is scattered the least by air molecules. The effect of scattering is inversely related to the fourth power of the wavelength of a color. Red light has the largest wavelength amongst the visible spectrum, and thus is scattered the least, and therefore it can travel longer distances without losing significant amount of intensity. Hence, it is easily recognized by hearing-impaired people in the room.

6. PCB model:

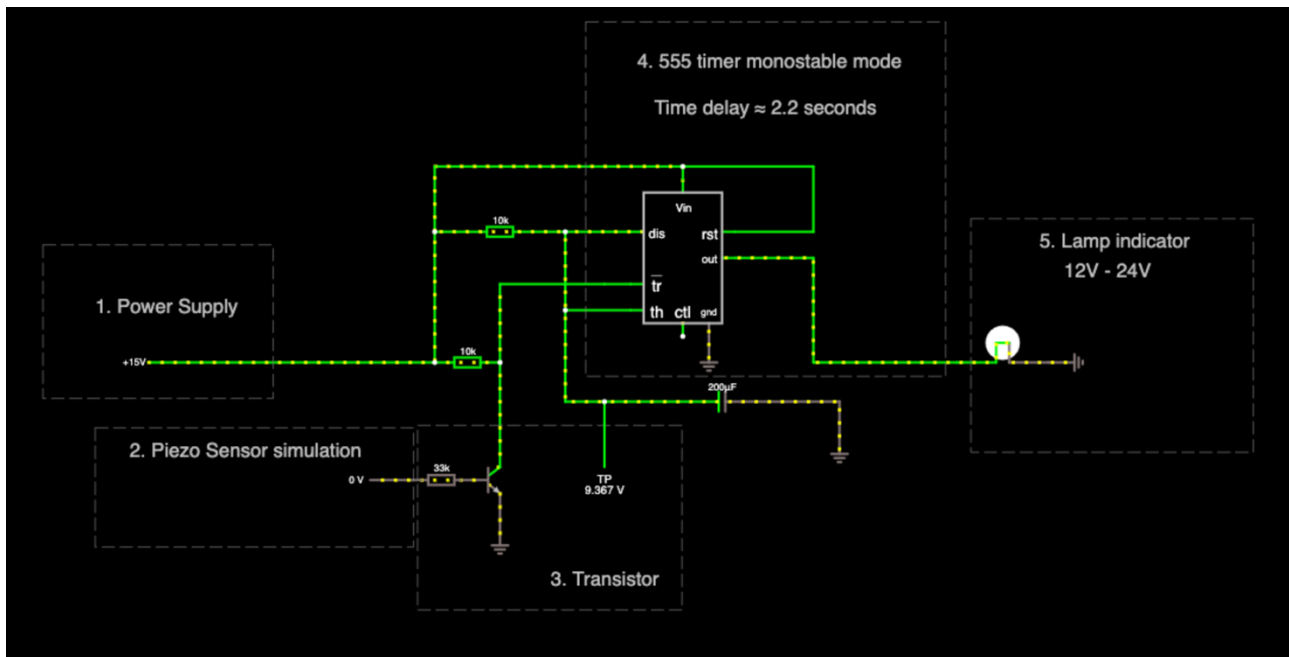
First model:



Second model:



7. Simulation:



[Click here to the full simulation for this project.](#) (8)

8. Reference:

- (1) [Online]: <https://www.sparkfun.com/products/10293>
- (2) [Online]: <https://www.onsemi.com/pub/Collateral/BC546-D.PDF>
- (3) [Online]: <http://www.ti.com/lit/ds/symlink/lm555.pdf?&ts=1589819176603>
- (4) [Online]: <https://www.12vmonster.com/collections/12v-24v-led-lamps-and-light-bulbs>
- (5) [Online]: https://fi.rsdelivers.com/product/panasonic/cr-2032-bn/panasonic-cr2032-button-battery-3v-20mm-diameter/4574757?gclid=CjwKCAjw5lj2BRBdEiwA0Frc9QVC3m8RiHMWITjqCDxku0BM_TPI0N8AyuSisYGRdH2TvhN1dUfkPhoCoikQAvD_BwE&gclsrc=aw.ds
- (6) [Online]: <https://www.amazon.com/100-240V-Switching-Converter-Adapter-American/dp/B07B45C3Y8>
- (7) [Online]: <https://www.sparkfun.com/products/119>
- (8) [Online]: <http://tinyurl.com/yahw3jhu>