EGR 220: ELECTRONICS
TITLE: MOTION SENSOR PASSCODE LOCK

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Abstract

When researching daily applications of electronics, we searched for a circuit that would be feasible to build and incorporate many aspects that we learned in class. After researching many electronics projects, we decided to build "motion sensor passcode lock" that can ensure security from hacking PIN code due to thermal signature. Using an open source website tool- Autodesk Circuits, we will be able to design and simulate the motion sensor passcode lock that will use 555 IC timers, resistors, logic gates, capacitors, LEDs, and Passive Infrared Motion Sensor (PIR motion sensor). Due to lack of space in breadboard, we decided to use only four different buttons for code that would be composed of four inputs. To make things more interesting, we used four motion sensors instead of push buttons to have more secure input. After analyzing how to build the circuit, we decided that inputting code would not be the same input in a row.

Introduction and Background

Today, we are familiar with digital code locks which are very popular to input a specific code for unlocking any kind of device. This kind of digital lock has 555 IC timers, but requires the user to press the buttons at the same time. We thought that this method was too trivial. Therefore, we wanted to obtain more satisfying results with a more complex circuit. After analyzing the functionality of 555 IC timers, we came up with a way to use them to simulate a passcode that would be inputted one input at a time. We figured that to do that we would need to use logic gates that we have learned in computer engineering courses. For the simulation, we used push buttons because the software didn't enable the use of motion sensors. However, for the real-life implementation, we would be using motion sensors which would provide a unique way to input a password. Also, it comes with some advantages compare to the traditional push buttons inputs. The most important advantage is security. When inputting a PIN on an ATM machine or a code for a door lock, one leaves heat from human skin interaction with the button, which can be recovered using thermal imaging. Nowadays, it becomes extremely easy to use thermal imaging since inexpensive equipment can be bought and used with smartphone application to analyze thermal signatures left on any object. By using motion sensor buttons, one does not leave a thermal signature after inputting a PIN or entering a lock code.

Problem Formulation

To build the circuit, we decided that we would not use any kind of micro-controller

to stay within the area of electronics, and thus only work with hardware. Therefore, we used 555 IC timers in monostable mode. The configuration of the 555 IC timers is set in such a way that to trigger an output voltage. The pin number 2 of the 555 IC must be fed to ground. The trigger will then cause the output to be emitted for a length which can be determined by a formula that will be discussed in mathematical framework section. When the output is ON should be configured so that the user has enough time between each input. However, after a set span, the code will reinitialize and the user will need to type it all over again. When the code is typed successfully, an LED will be turned ON for a determined span of time, simulating a successful input. If there is a mistake in the input, the 555 IC timers will be reset and the code needs to be typed all over again. To build the project, we developed a list of materials. The components that will be used are: four 10 nF capacitors, four 470 µF capacitors, one quad AND gate, one quad OR gate, two Hex inverters, five 5k resistors, four 555 IC timers, four LEDs, a 5V power supply and jumper wires.

Methodology

First, we adapted our idea to the conditions in which the IC timer works. By connecting each motion sensor to a voltage source, and then to an inverter logic gate, when the button is pressed a low output comes from the gate. The correct first input motion sensor of the code is then connected to the TRIGGER pin of the first IC timer, which outputs a high state on the OUTPUT pin when the input is low. The output of the first IC timer is connected to the AND gate with the next correct motion sensor input. The output is again inverted and connected to the TRIGGER pin of the second IC timer. Moreover, we needed to design a way to reset the pin if the input is wrong. For the circuit to function properly, the motion sensor that activates the next IC timer cannot reset the current IC timer or it would create a race condition on whether the circuit works or not. Thus, the other two motion sensors are connected to an OR gate which output will be connected to the RESET pin of the IC timer. This configuration is repeated for each IC timer so that the passcode would be successfully inputted when the right combination of passcode has been detected at a time by the motion sensor. Since the IC timers are set in the monostable mode, the output length will follow the formula:

$$T = 1.1 * R1 * C1 \qquad (1)$$

The desired length of output of the 555 IC timer was chosen to be around 5 seconds. Therefore, we used a 10kΩ resistor and a 470µF capacitor. Using the formula (1), we calculated the output time to be approximately 5.2 seconds. The user will then have 5.2 seconds between each input of the passcode, and the LED will light up for 5.2 seconds once the passcode has been detected successfully.

Challenges

Due to complexity of the circuit, it takes consequent amount of space. Therefore, we could not simulate all of it but we demonstrated the principle with two IC timers. The two IC timers with the hex inverter and logic gates barely fitted on one breadboard, so an actual simulation of the entire circuit would require two

breadboards, which would make the circuit too confusing. Again, we could not fit four motion sensors for the simulation part due to complexity of the circuit and having one single breadboard in the website tool. So, we have used only one motion sensor to show its functionality and for other three motion sensors we have used push buttons instead. However, the circuit we have simulated, demonstrates the function we want it to accomplish. To make the circuit more understandable, we have added an LED that lights up when correct passcode has been detected by the motion sensors. Also, to avoid having two breadboard and function generator for getting voltage input and ground, we have used PAD-234 circuit trainer board to build the circuit. The overall circuit can be seen in Appendix A.

Simulation and Results

The configuration described in the methodology section was simulated using Autodesk Circuits. This is an open source website tool that enables one to simulate circuits with a large gallery of circuit components in 3D. When the first IC timer is ON and correct button is pressed, the first LED lights up for about 5 seconds and turns off if a wrong button is pressed after pressing the first one. But, if the next input of the passcode is successfully pressed within the span the first IC timer is activated, the second IC timer outputs high and the second LED is turned ON for the same time span. This continues until the last button is pressed correctly and thus it shows that the code has been unlocked. The simulation can be shown in Appendix B.

Conclusions

Motion Sensor Passcode Lock is an application of electronics based project. The 555 IC timer we have used in this project, is an integrated circuit that has comparator, RS flip flop and BJT transistor (Appendix A). Not only this project reinforced what we learned in this class about electronic devices but also it introduced us to few concepts that covers in some computer engineering courses. So, overall it was a success that we were able to combine two different discipline for making this project successful.

References

[1]. "555 Timer Based Electronic Code Lock Circuit." *Dilip Raja,* December 2016.

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[2]. "I-Phone ATM PIN code hack- how to prevent" *Mark Rober*. Published on August, 28, 2014.

< https://www.youtube.com/watch?v=8Vc-69M-UWk>

[3]. "Bring Ideas To Life With Free Online Arduino Simulator And PCB Apps | Autodesk Circuits". *Circuits.io*. N.p., 2017. Web. 2 May 2017.

<https://circuits.io/>

Appendix A

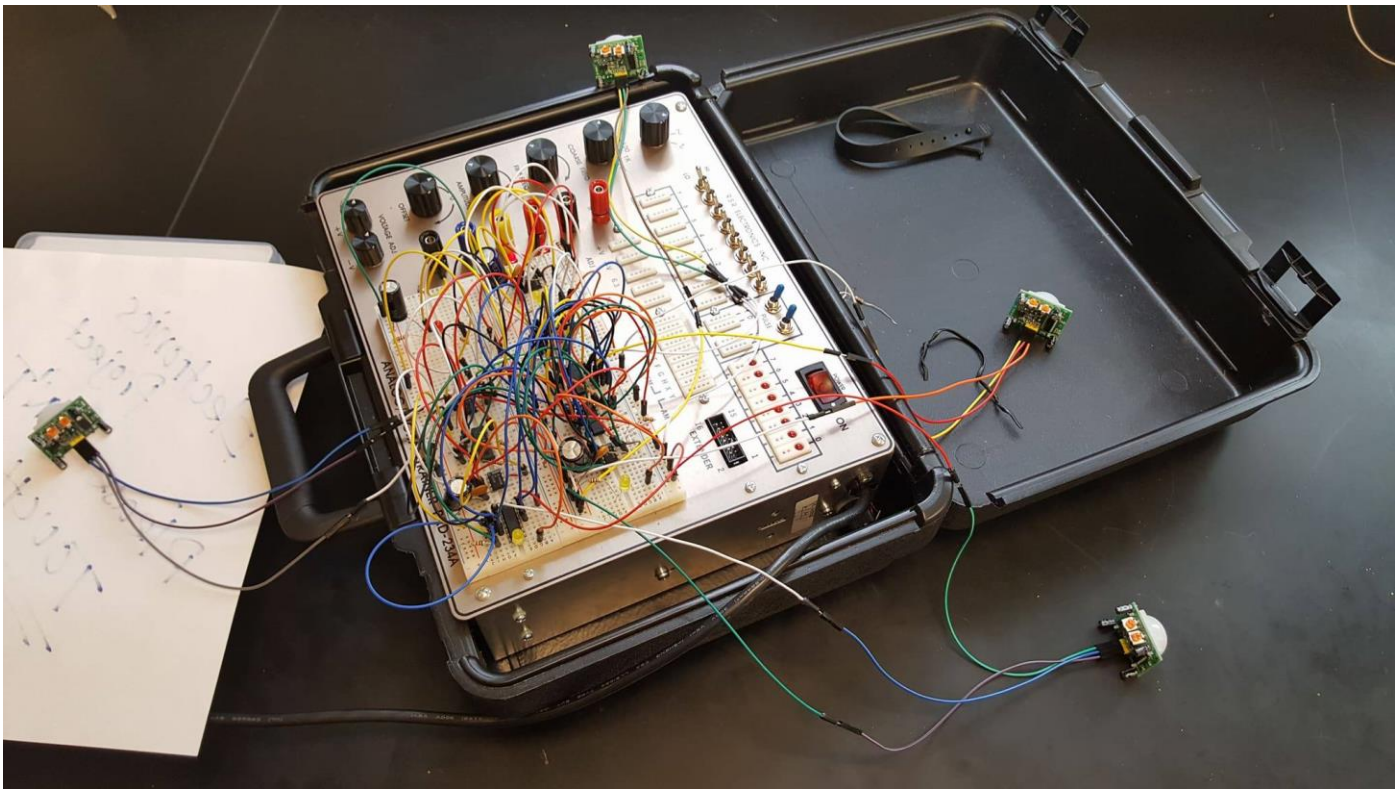

Figure 1: Overall Circuit with four PIR (Passive Infrared) motion sensor

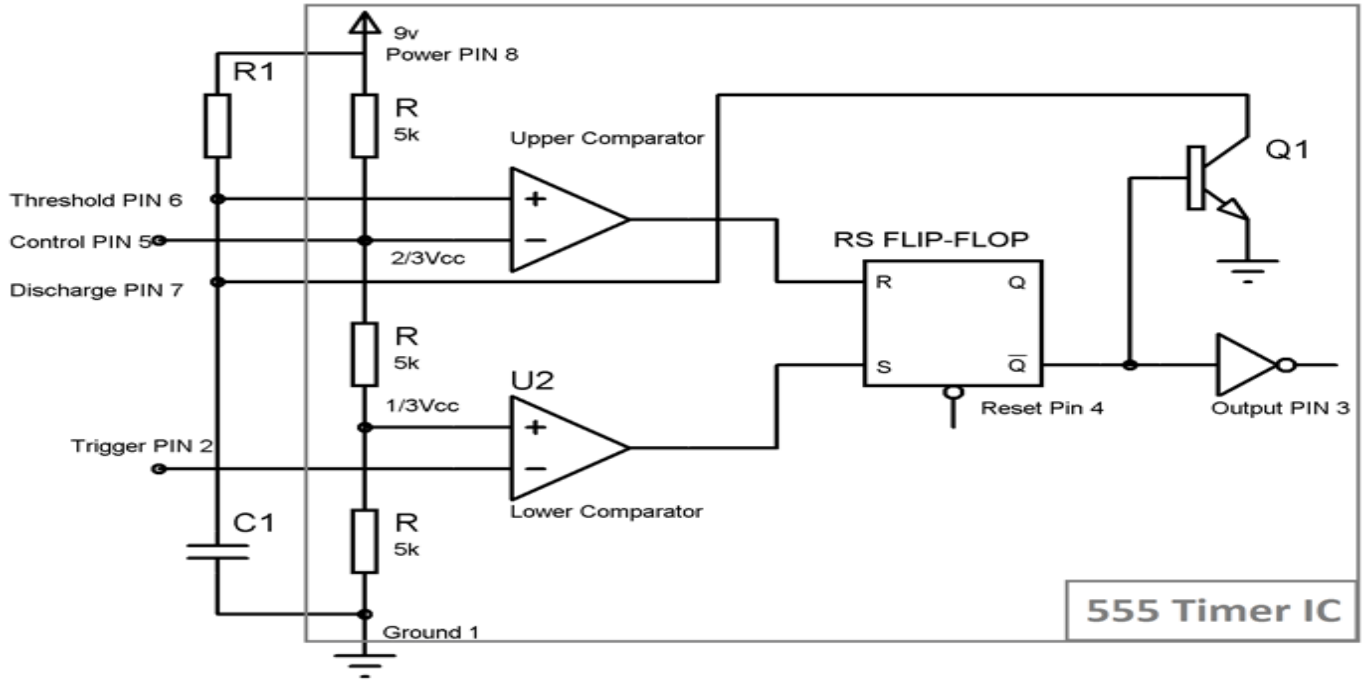

Figure 2: 555 IC timer circuit schematic

Appendix B

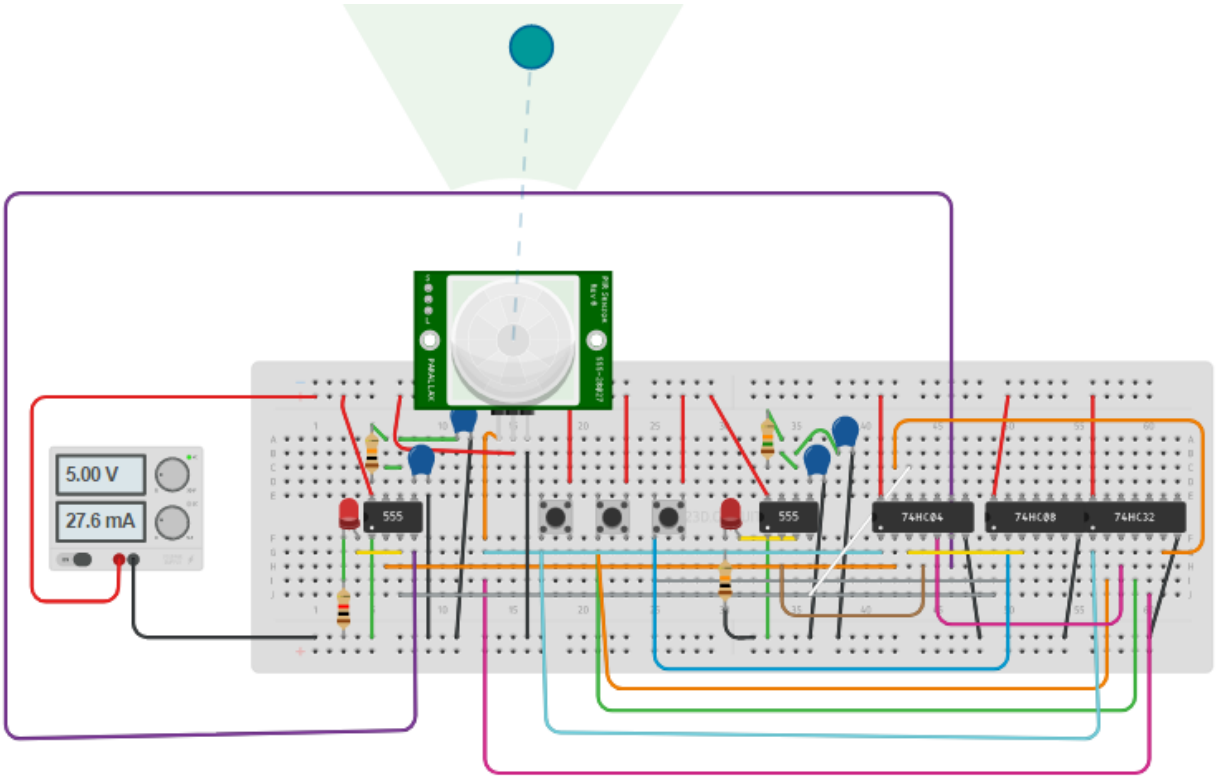

Figure 2: Simulation AUTODESK CIRCUITS