Microcontrollers Final Project - Portable Security System

Harrison Bounds & Brandon Donaldson - UCA Department of Physics and Astronomy

Date: May 4, 2022

Executive Summary:

The purpose of this security system project is to bridge the gap between expensive subscription based security systems offered by companies such as SimplySafe and ADT and the idea of a simple home based monitoring system that doesn't require a subscription. The issue that arises with subscription based security systems is that if a customer lives in a dorm room or an apartment, landlords may be hesitant to let tenants install these systems due to them needing to be either professionally wired or campuses may not allow residents to install a permanent system within their dorm rooms.

A local police officer on campus, Durwin Lasker, holds the patent for this security system. We met with Officer Lasker several times over the course of the security system to receive ideas and guidance for the correct path to take for completion. Using the information provided by Officer Lasker, we have been tasked with developing a security system that is accessible to people without the need of a subscription system or professional installation. Throughout this project summary, we will be discussing the components being used to accomplish the goal of accessible security for all residents who would like an alternative to subscription based monitoring systems.

We will be using the Raspberry Pi 3 as our Microcontroller, as well as several components that we have ordered separately. These components include reed switches, a Raspberry Pi camera module, and a keypad. With these elements of our project, we will summarize the steps it takes to build a fully functional portable security system.

Component Summary:

A Basic security system should consist of several components: door/window monitoring (whether or not a door/window is open or closed), camera recording to monitor who enters/leaves the room or building, a fume detection system to monitor potential hazardous inhalants or fires, an alarm to alert either the user or assailant that the system has been triggered, and an arming system to activate or deactivate the system.

By implementing a door and window monitoring system, the user can be alerted when either have been opened, allowing the user to know where entry has been made to the protected area. For our project, we will be monitoring doors and windows using a reed switch. A reed switch contains two ferromagnetic blades that will touch when a magnet approaches them causing the circuit to close. A program can monitor if the circuit is opened or closed based on the signal being sent from the reed switch (if power is flowing, the circuit is closed and the door is closed. If power is not flowing, then the circuit is open meaning the door is open).

Alerting others of an incident in the area can be a big help in stopping an intrusion. Even when you are in your own residence, there needs to be a way you know if someone has broken in. A buzzer is a perfect device to alert the resident of an issue. It is quite loud, which means it can be heard around the house. Although a simple tool in our security system, it can be highly effective for bringing the residents attention to an incident.

A camera can be installed to function a few different ways. It can be installed to monitor all the time by recording constantly to a storage source, or it can be set up to record when triggered to save storage space. Our camera is the Raspberry Pi camera module, so it is fairly easy to install and use with our Microcontroller. The camera's function is to record when the reed switch goes off, therefore capturing a video of what is happening in your place of residence. This clip is then sent to the owner's email so they can view the circumstance quickly and assess what needs to be done.

Finally, implementing an arming system will allow the user to turn on or turn off monitoring for the area. For our early prototype, we plan on using a simple on off switch to make sure everything functions together then upgrading to a keypad entry for a PIN number to increase security to avoid the possibility of an unauthorized person disarming the system upon entry. This keypad consists of 12 buttons which act like separate codes. Entering the correct code will arm the system, while entering the incorrect code three times will result in the alarm going off. This is to ensure that no unwanted guests can disarm the security system. Along with the arming system, we will be installing a screen so the user is aware of the system being armed or unarmed to avoid confusion. The final goal of the project is to set up a messaging system that can alert the user while they are away by either email or text that an event has been detected by using their existing wifi network within their living area to communicate updates.

Equipment List:

Item	Quantity
Raspberry Pi	1
Breadboard	1
Wiring	1
Raspberry Pi Camera Module	1
Reed Switch	1
4x4 Matrix Keypad	2
4.7kΩ resistor	1

Table 1. This is the list of items you need to run this experiment

Components:

Reed Switches:

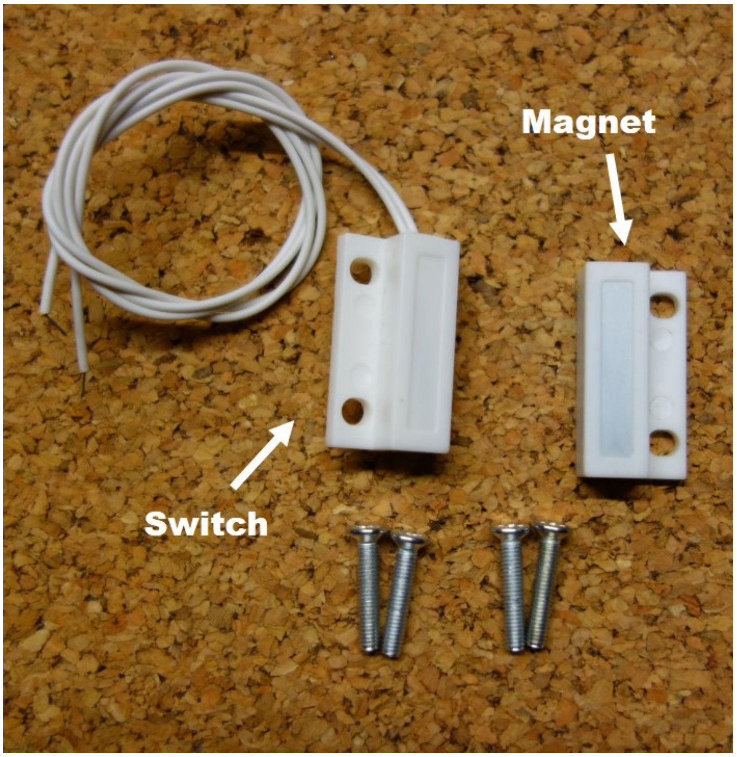


Figure 1: Reed switches used to monitor doors and windows

We chose to use a reed switch for this project instead of other components such as IR sensors because they have a simple method of operation and the chances of component failure are minimal compared to other options. The reed switch used for our security system is a normally open/off switch. When a magnet is not near the switch, the circuit that the reed switch is wired into is “broken” therefore no electricity flows through the system due to a gap in the circuit and when a magnet is near the switch, the circuit closes allowing current to flow through the entire circuit. With simple, nondestructive attachment methods such as simply attaching double-sided tape to the reed switch to attach it, the decision of choosing the reed switch was not only beneficial for the simplicity of our design but also allows for ease of installation for residents using our security systems.

Buzzer:

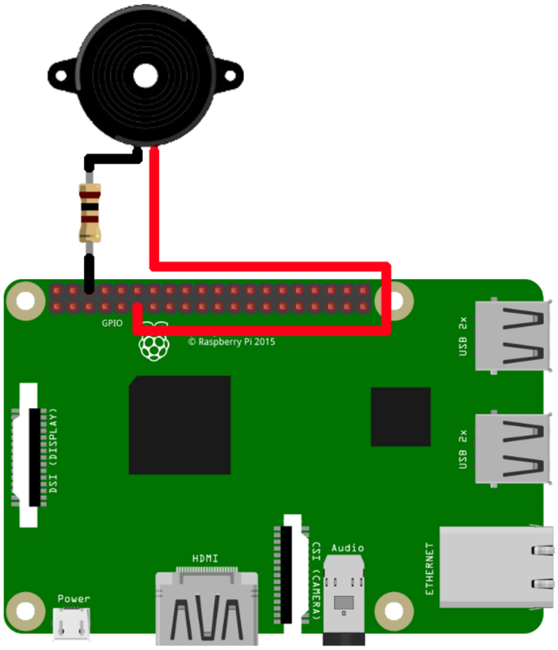


Figure 2: This diagram shows how to wire the buzzer. Although the buzzer is wired separately, it will be used in parallel with our security system program.

Camera:

The Raspberry Pi camera module is fairly easy to use. The first step to getting a working camera is to hook it up. Luckily, the Raspberry Pi has a dedicated port for the camera module. Once you plug in the camera, boot up your Pi. To set up the software and library for the camera module, you need to head to the terminal. In the terminal, enter the raspi-config command. This command will pull up a menu where you can select the camera and enable it. After enabling the camera, your Pi will most likely need to be rebooted. Now that the library setup is complete, we can import the picamera library into our program and use all of the functions of the Raspberry Pi camera module.

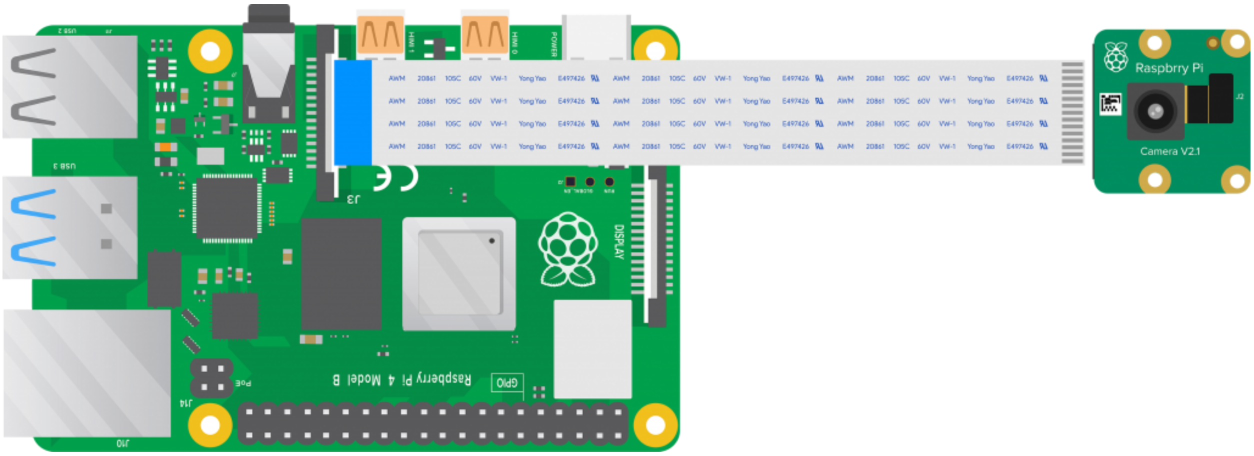


Figure 3: This image depicts the exact location of where to plug in the raspberry pi camera module

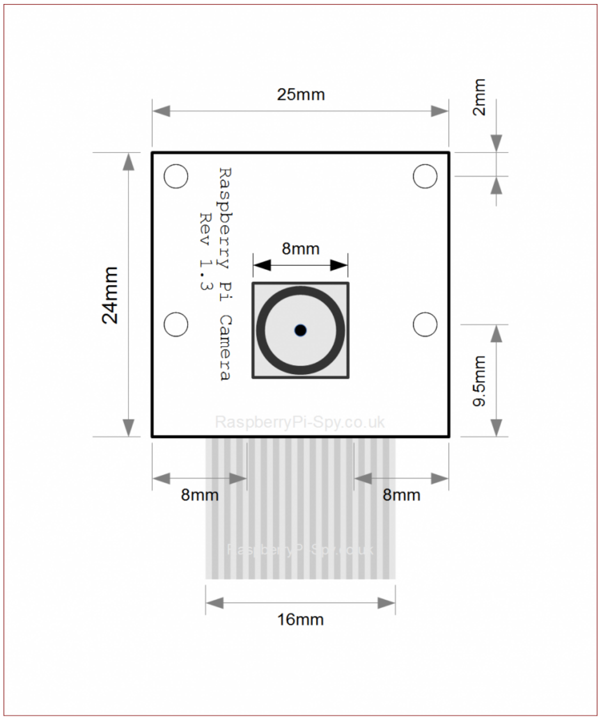


Figure 4: This image is a schematic representation of the raspberry pi camera module. At 1080p it records 30fps, making it a great choice to capture intruders.

Keypad:

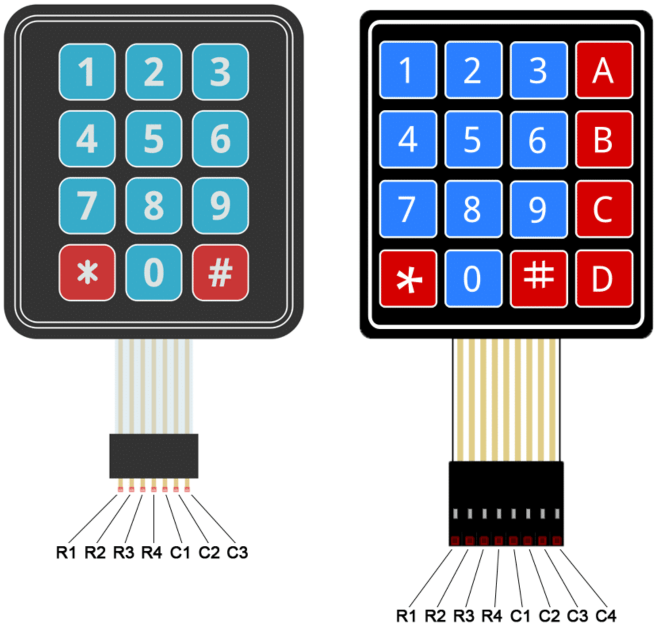


Figure 5: This graphic is the frontend of the keypad functionality. Our keypad does not have numbers on it, but it is the same dimensions as the graphic.

Results/Analysis:

Part 1: Circuit Design:

Our circuit design consists of three pieces of hardware: a keypad, reed switch, and an alarm. The keypad has 8 individual pins attached, so each pin requires its own GPIO pin to monitor when the user presses a button, the program can record what button was pressed. The keypad circuit is able to signal which button has been pressed through a circuit matrix. To simply explain the process, if a user presses the '5' button on a 4x4 matrix keypad, the corresponding location on the keypad would be in the second column and second row (represented by [2][2]).

The reed switch circuit is normally open if a magnet is not near the switch blades. As long as a magnet is near the switch blades, the circuit remains closed. By connecting one of the reed switch wires to a GPIO pin of the RPi along with a 4.7k ohm resistor wired to the positive power rail and the other reed switch wire to the negative power rail to complete the circuit (a hardware and schematic visual will be provided in the **Appendices** section). The purpose of the resistor is “to ensure a defined state is present at the microcontroller’s input, otherwise the input could be left free floating” [1]. When the reed switch is away from a magnet, the GPIO pin will receive a signal that the circuit has been broken and a program can be written to monitor the event and alert the user that the circuit’s connection has been broken by displaying a message on screen. To audibly alert the user that the reed switches’ circuit has been broken, an alarm can be implemented and triggered when the reed switches’ circuit is broken.

Part 2: Logic:

Our security system program starts by waiting for keypad input. If the input is correct, the system is armed. Consequently, if the incorrect password is entered three times, then the “alarm” or buzzer is sounded. Once the security system is armed, the reed switches start detecting the state. If the magnet is near, then the contacts remain closed. However, if the magnet moves away (the door opens) and the contact is broken, our camera activates and the buzzer sounds. The camera will record for a set amount of time before sending an email with a video attachment to the current resident. Once the resident arrives at the keypad, they can deactivate the alarm and proceed.

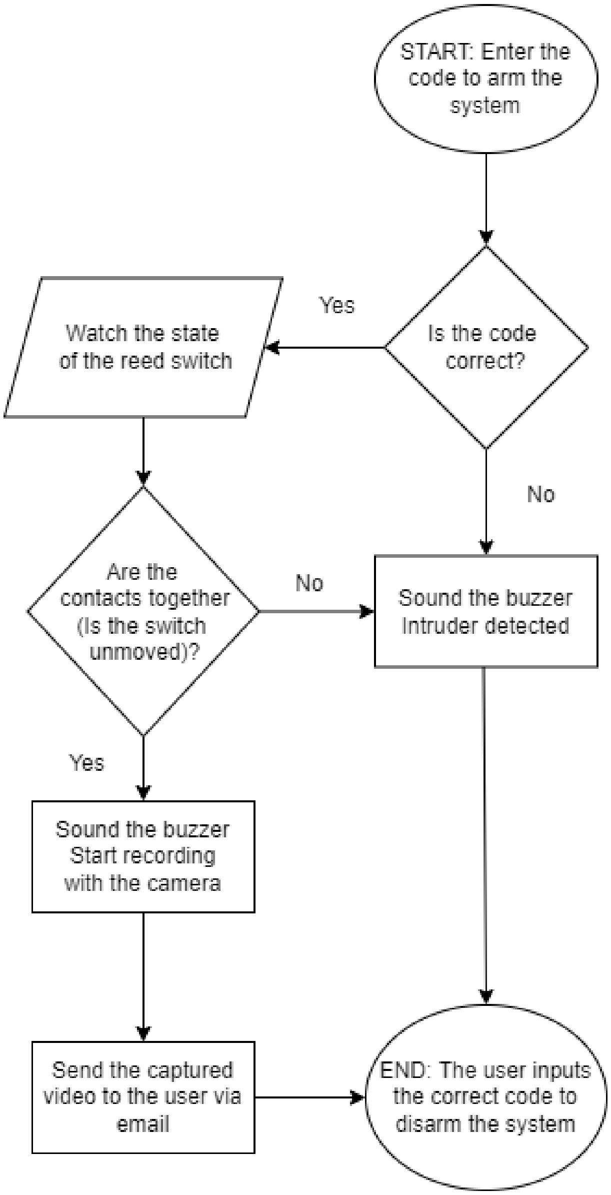

START: Enter the code to arm the system
Is the code correct?
Yes
Watch the state of the reed switch
No
Are the contacts together (Is the switch unmoved)?
No
Sound the buzzer Intruder detected
Yes
Sound the buzzer Start recording with the camera
Send the captured video to the user via email
END: The user inputs the correct code to disarm the system

Figure 6: This diagram walks through the logical steps to execute when the security system is activated

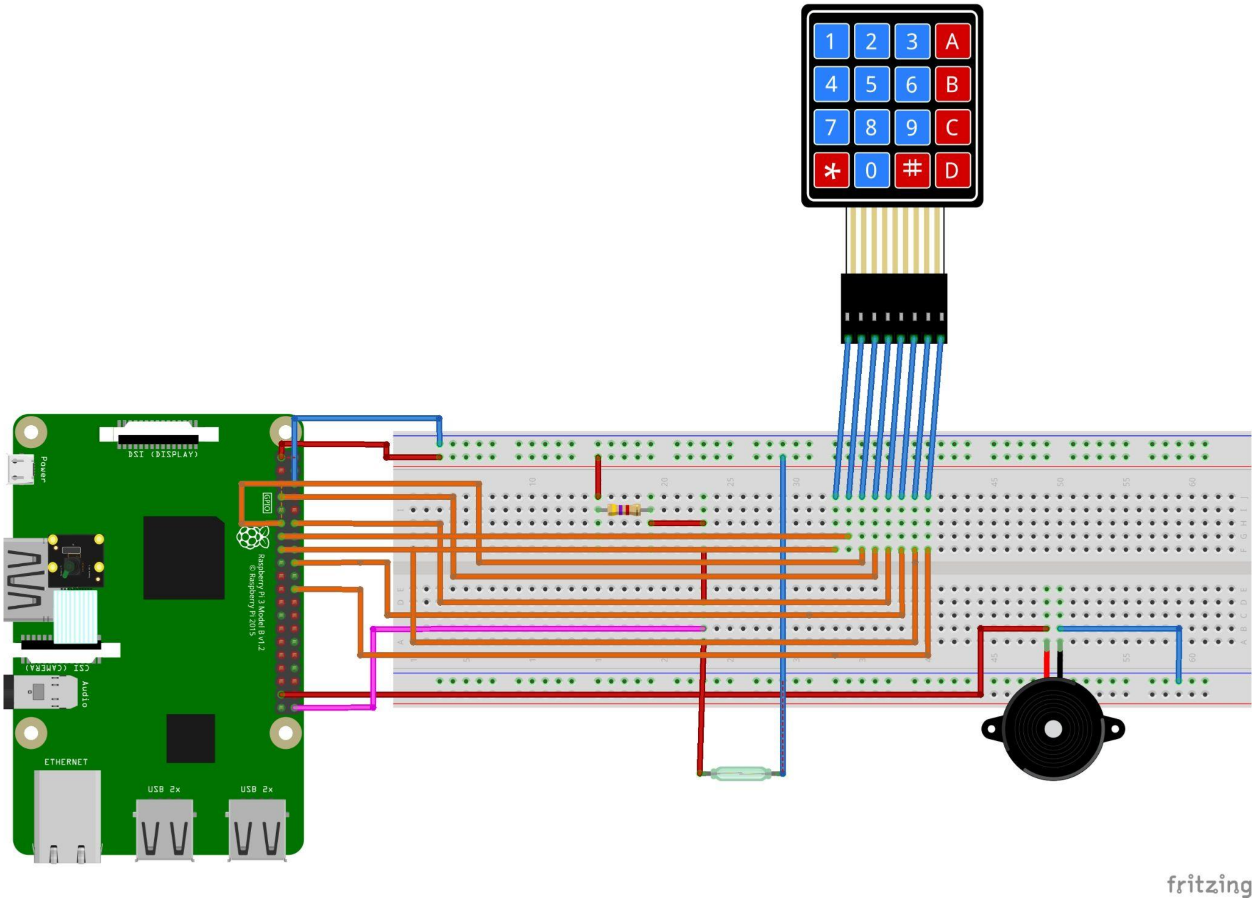
Next Steps:

Having a broad project such as this gave us many different paths of exploration when creating this security system. In the end, we stuck to the basics and created a functional security system. One of the next things to implement would be sending a video via email to the owner. This capability would enhance the application of our project and make it more versatile as a security system. Another step to take would be adding a disarming sequence so the owner doesn’t have to manually go into the Raspberry Pi and stop the program. This function would make the security system more user-friendly and quicker to stop an accidental trigger. The final implementation could be an LCD screen to interact with the security system. Although being extremely user-friendly was not at the top of our list when making this project, it would be useful for the owner to easily access the system by a screen. This would especially be true if the owner is not tech savvy. Unfortunately, due to the time constraints of this project, we were not able to add these things in this version of the prototype. However, in the future, these improvements would be a nice addition to the security system's functionality.

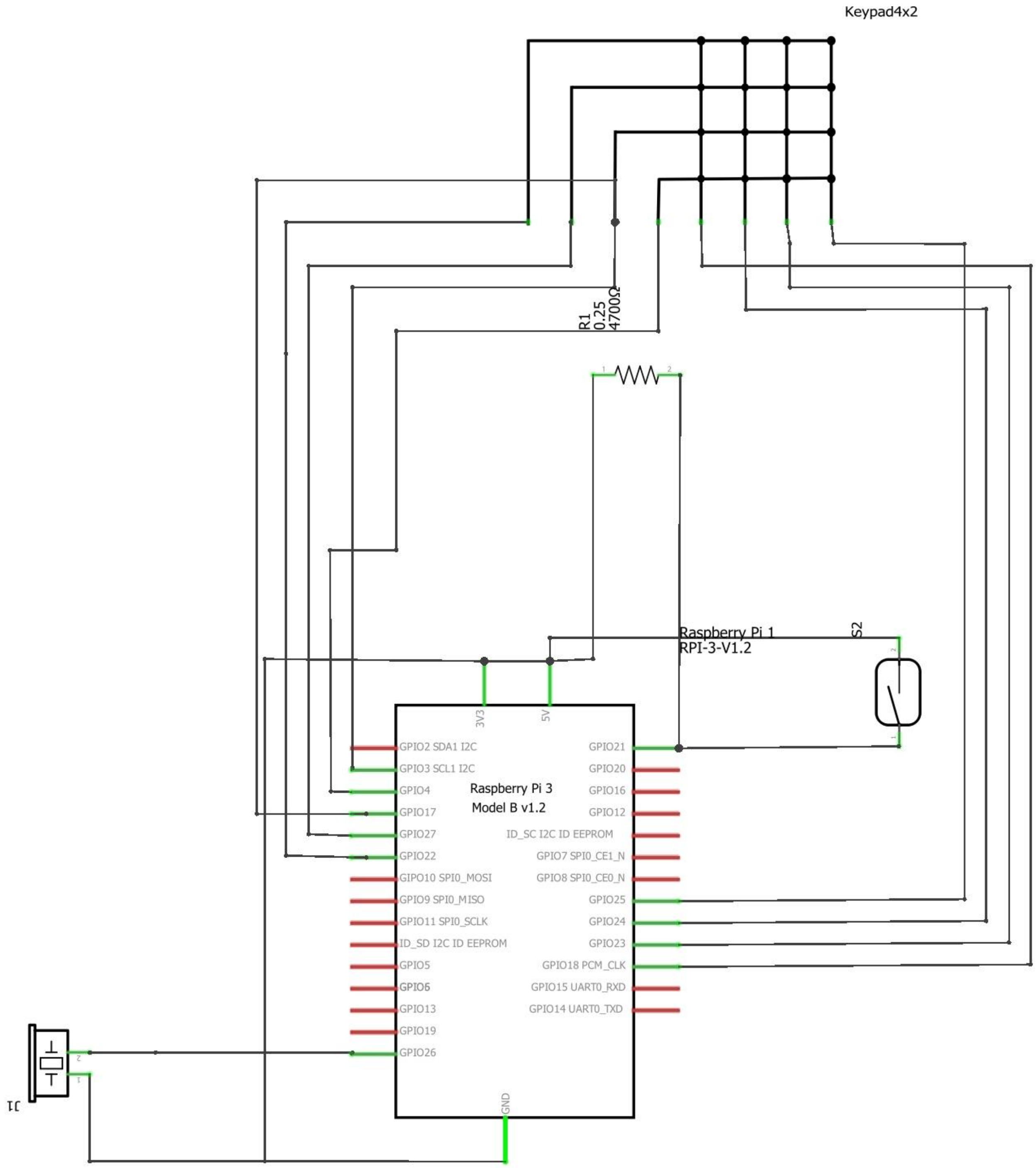
Conclusions:

Our goal for this project was to successfully design, wire, and program a portable security system so people can feel safe in their place of residence. Keeping the functionality large while the cost small was a crucial part in this project to prove that you do not need to pay a large sum of money to feel protected. Although basic, our security system works with the use of reed switches, a buzzer, a camera, and a keypad. With the easy to use interface and small overall design, we believe we were successful in making this idea not only functional, but portable as well. With one final meeting with Officer Lasker, we will demonstrate our working prototype and its different moving parts. The final product is a working security system that can be armed, detect intruders, and send a video to the user's email. This report walked through the process of how to recreate this system so that anyone with the correct materials can bring this project to life as we did.

Appendices:



Appendix 1. Hardware visual of security system



Appendix 2. Schematic of security system