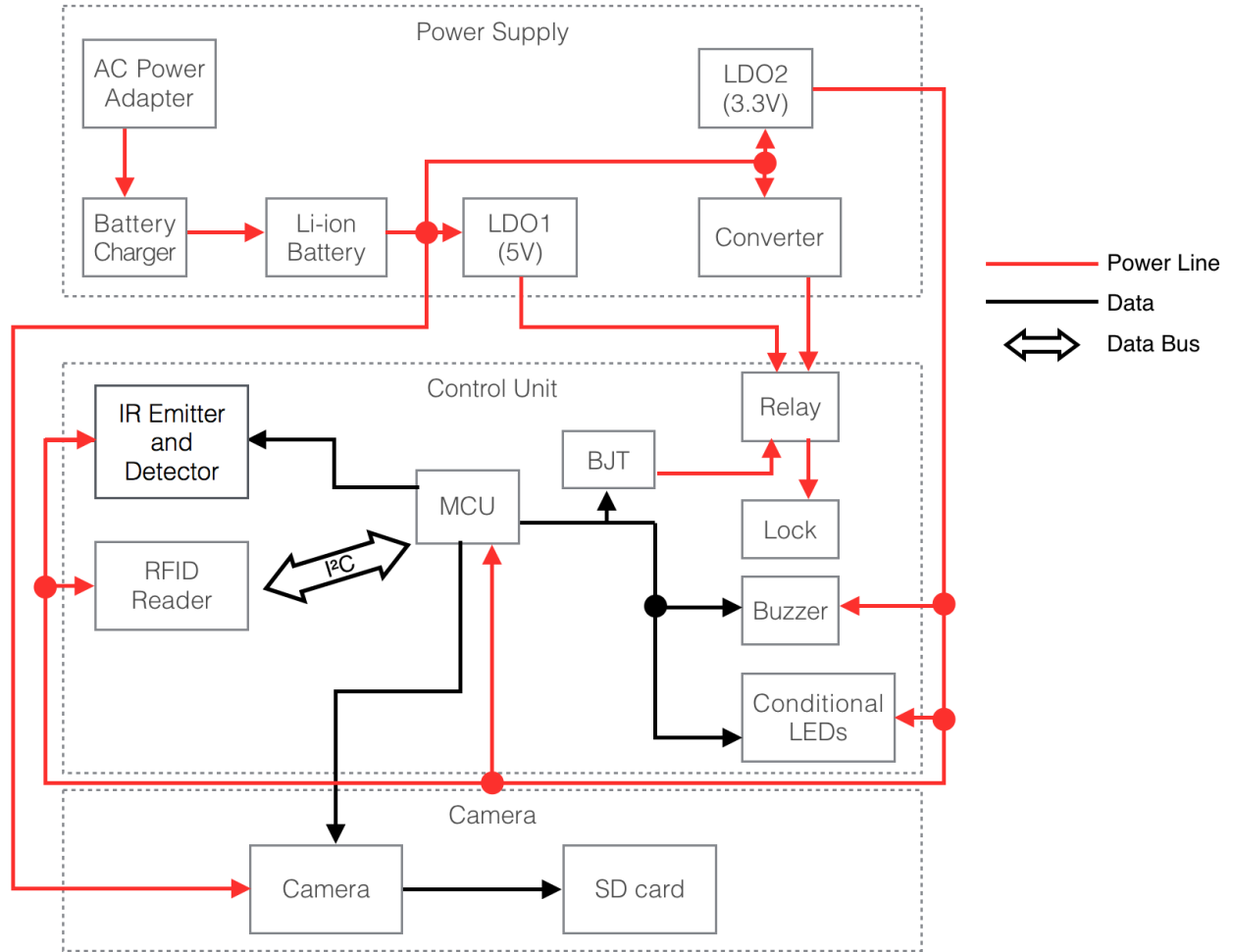
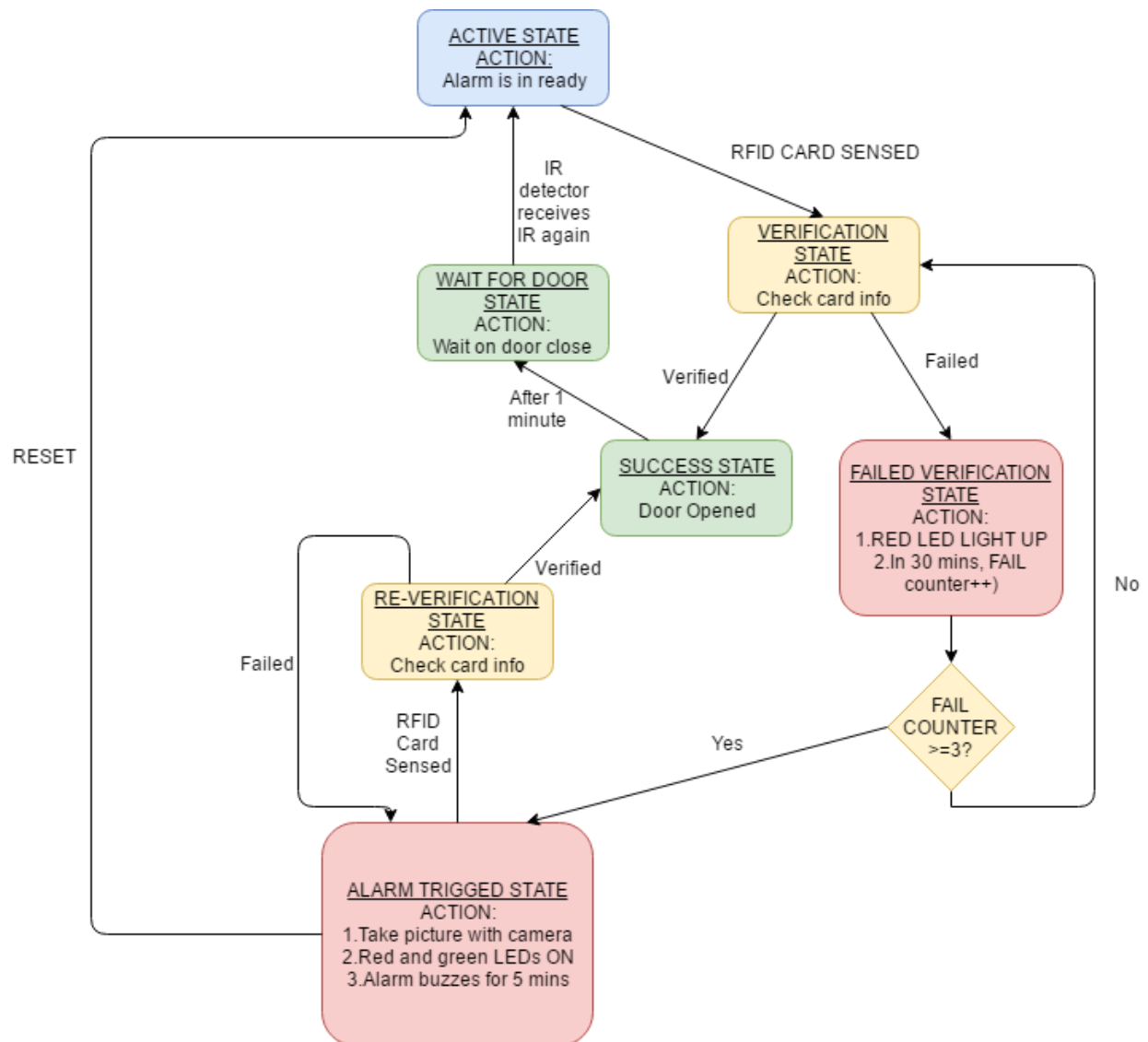


# Diagrams

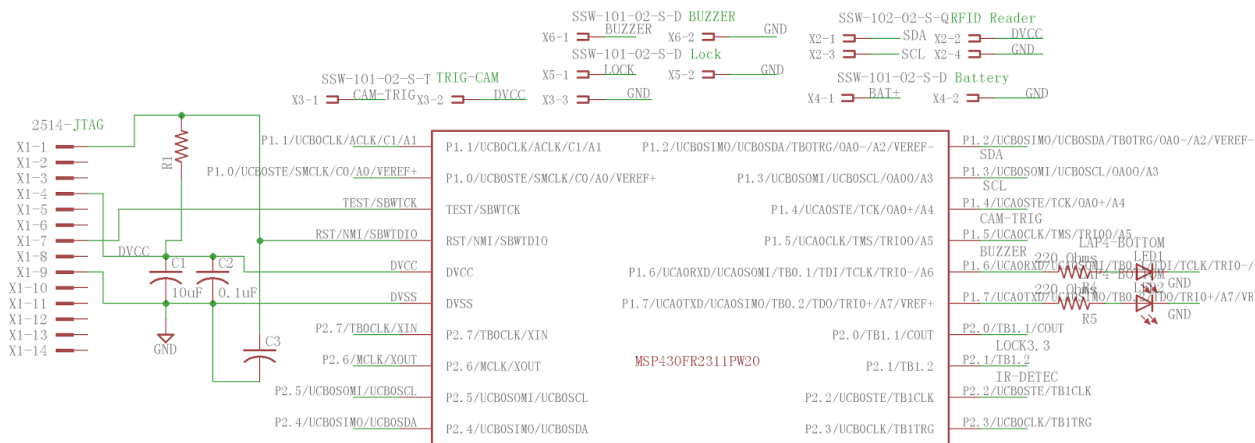


# Flow Chart

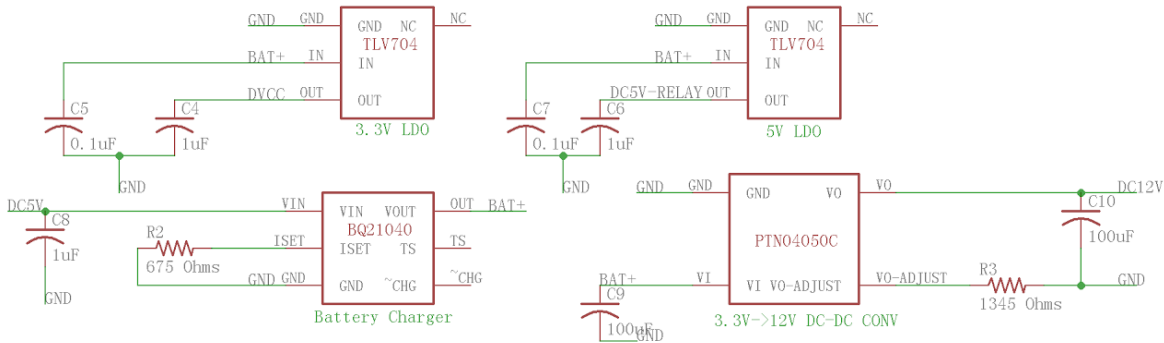


# Circuit Schematics

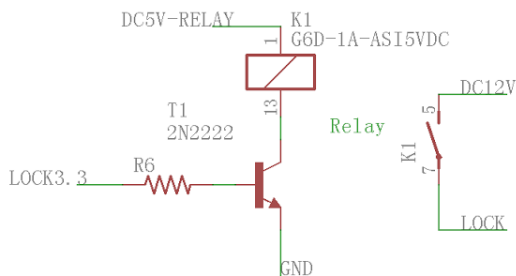
## Control Unit with Camera



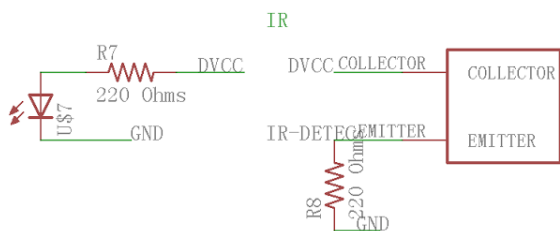
## Power Supply



## Lock Unit



## IR Unit



# Calculations

Devices connected to LDO2 (3.3V)	Current
MCU	2.432mA
Buzzer	50mA
LEDs	40mA (20mA each)
IR Emitter	20mA
Phototransistor	6mA
RFID Reader	20mA
TOTAL	138.432mA

The maximum current output of the LDO is 150mA, so this design is feasible.

Current input of LDO1 =  $138.432\text{mA} \times 3.3\text{V} \div 3.7\text{V} = 123.5\text{mA}$

Current input of LDO2 =  $40\text{mA}(\text{current of Relay}) \times 5\text{V} \div 3.7\text{V} = 54.1\text{mA}$

Current input of Converter = current of lock = 450mA

Current input of Camera = 80mA

Total current consumption=707.6mA

Duration of batteries =  $4 \times 9800\text{mAh} \div 707.6\text{mA} \approx 55 \text{ hours}$

## Plots

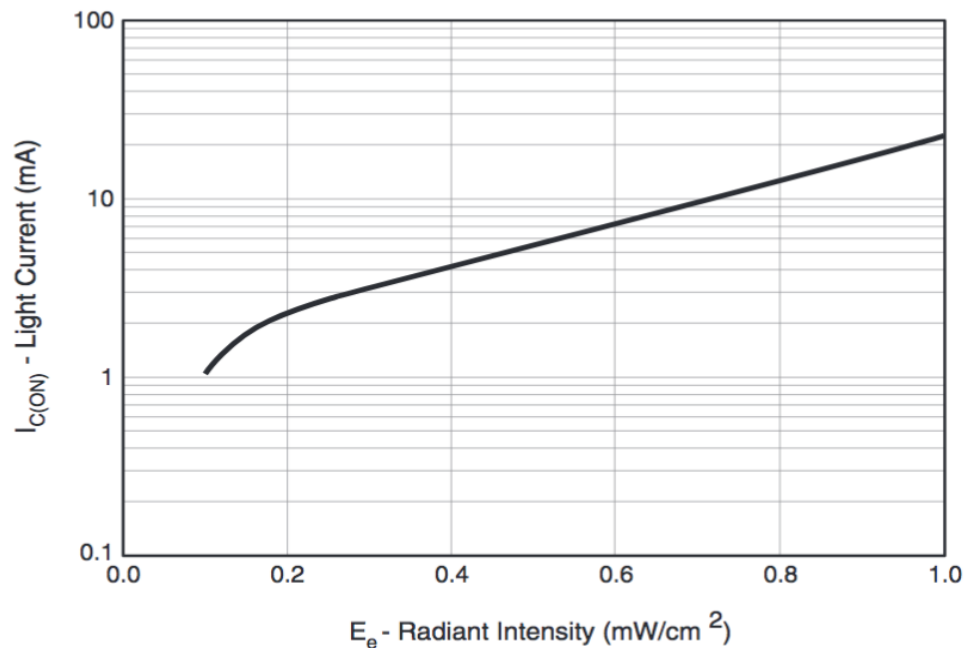


Figure 1. Light Current cs. Radiant Intensity [1]

## Requirements and Validation Plans

### 1. Power Supply

AC Adapter: SoulBay 12W Universal Multi-Voltage AC/DC Adapter

Our lock requires a reliable power supply, so we choose the power outlet.

Requirements	Verification
<ol style="list-style-type: none"><li>1. Must be able to convert AC input voltages from 100V to 240V.</li><li>2. The output voltage must be 5V VDC.</li><li>3. The output current has to be at least 1.25A.</li></ol>	<ol style="list-style-type: none"><li>1. The input voltage is 100-240V.</li><li>2. The output voltage contains 5V.</li><li>3. The output current is 5.5A when the output voltage is 5V.</li></ol>

Battery Charger: BQ24040

This is used to charge those Li-ion batteries.

Requirements	Verification
<ol style="list-style-type: none"><li>1. The input voltage must be 5V.</li></ol>	<ol style="list-style-type: none"><li>1. The input voltage is 3.5-28V.</li></ol>

#### Battery: YKS Universal Li-ion Rechargeable Batteries

The battery is used when a power cut occurs in the house. The battery must be safe and ready to work 24/7.

Requirements	Verification
1. Must be able to provide power for the system for at least 48 hours without power outlet.	1. We use 4 pieces of 9800mAh Li-ion batteries. They are able to provide power for approximately 55 hours.

#### LDO1 (low dropout voltage regulator): TLV704

This LDO is used to provide power for the relay.

Requirements	Verification
1. The output voltage has to be 5V.	1. The output voltage is 3V, 3.3V, 3.6V, and 5V.
2. The input voltage has to be 3.7V.	2. The input voltage is 2.5-24V.

#### LDO2 (low dropout voltage regulator): TLV704

This LDO is used to provide power for the buzzer, conditional LEDs, MCU, RFID reader, IR emitter, and IR detector.

Requirements	Verification
3. The output voltage has to be 3.3V.	3. The output voltage is 3V, 3.3V, 3.6V, and 5V.
4. The input voltage has to be 3.7V.	4. The input voltage is 2.5-24V.

#### DCDC Converter: PTN04050C

Since the voltage input of the lock is 12V, we need a converter to convert 3.7V voltage to 12V voltage.

Requirements	Verification
1. The input voltage has to be 3.7V.	1. The input voltage is 2.95-5.5V.
2. The output voltage must be 12V.	2. The output voltages are 5V, 9V, 12V, and 15V.
3. The output current must be larger than 450mA, which is the input current of the lock.	3. The range of output current with 12V output is 100-1000mA.

## 2. Control Unit

MCU: MSP430FR2310

The micro control unit is used to process all the data. It receives data from the IR detector and RFID reader and tells the lock, buzzer, and the LED what to do. We decide to use MSP430FR2310 made by Texas Instruments.

Requirements	Verification
<ol style="list-style-type: none"><li>1. The operating voltage has to be 3.3V.</li><li>2. Must have I2C interface.</li></ol>	<ol style="list-style-type: none"><li>1. The operating voltage is 1.8-3.6V.</li><li>2. This MCU contains one I2C interface.</li></ol>

IR Emitter: WP3A10SF4BT

The IR emitter is placed on the door and makes the phototransistor know that the door is closed.

Requirements	Verification
<ol style="list-style-type: none"><li>1. The current consumption must be less than 34mA to be comparable with the LDO2.</li></ol>	<ol style="list-style-type: none"><li>1. The current consumption is 20mA.</li></ol>

Phototransistor: QSD122

The phototransistor is used to detect if the door is open. If the phototransistor cannot detect the IR, that means the door is open.

Requirements	Verification
<ol style="list-style-type: none"><li>1. The wavelength detected must be 880nm since the wavelength of the IR Emitter is 880nm.</li></ol>	<ol style="list-style-type: none"><li>1. The wavelength detected is 880nm.</li></ol>

RFID Reader: RC522 RFID Reader

The RFID reader is used to detect the tag in order to open the door. The reading distance of our RFID reader has to be short. Otherwise, people may unintentionally open the door when they just walk by.

Requirements	Verification
<ol style="list-style-type: none"><li>1. Must have I2C interface.</li><li>2. The reading distance must be less than 10 cm.</li><li>3. The operating voltage must be 3.3V.</li></ol>	<ol style="list-style-type: none"><li>1. This RFID reader contains I2C and SPI interfaces.</li><li>2. The reading distance is 0-5 cm, which is perfect for a door lock.</li><li>3. The operating voltage of this RFID reader is 2.5-3.6V.</li></ol>

#### Lock: Electric Drop Door Lock Z9W0

We use an electronic lock since it is easy to control. Also, it is appropriate for diverse doors and has an anti residual magnetism design. The lock we choose is made from durable and high aluminium alloy material and durable for use.

Requirements	Verification
<ol style="list-style-type: none"><li>1. Due to the advantage in size, the lock has to be a deadbolt lock, instead of a lock using electromagnetic suction.</li><li>2. The working current has to be less than 2.4A since the maximum output current of the converter is 2.4A.</li></ol>	<ol style="list-style-type: none"><li>1. This lock is a deadbolt lock.</li><li>2. The working current is 450mA.</li></ol>

#### Buzzer: Uxcell Electronics Buzzer LZQ-3022

If someone tries to intrude, the buzzer will ring to notice the surrounding people. In most cases, the burglar will choose to leave immediately. Also, if the burglar comes at night, the buzzer has to be loud enough to wake up the house owner.

Requirements	Verification
<ol style="list-style-type: none"><li>1. The noise must be at least 100 db.</li><li>2. Operating voltage has to be 3.3V.</li></ol>	<ol style="list-style-type: none"><li>1. The decibel of this buzzer is 110 db.</li><li>2. The operating voltage of this buzzer is 3-12V.</li></ol>

#### Conditional LED: LED Light Emitting Diodes

When a proper tag is detected, the LED is green. When an incorrect tag is detected, the LED is red.

Requirements	Verification
<ol style="list-style-type: none"><li>1. Must have green light and red light.</li><li>2. The operating voltage has to be 3.3V.</li></ol>	<ol style="list-style-type: none"><li>1. These LEDs contains green and red light.</li><li>2. The operating voltage is 3.0-3.6V.</li></ol>

#### Relay: Omron G6D-1A

The relay is used to control the lock. Lock with power and unlock without power.

Requirements	Verification
<ol style="list-style-type: none"><li>1. Must be able to control 12V voltage and 450mA current, which are the requirements of the lock.</li></ol>	<ol style="list-style-type: none"><li>1. Switches loads up to 30V voltage and 5A current.</li></ol>



### 3. Camera

Camera: Mini Spy Trigger Camera for Photo or Video

If a person tries to intrude, his or her face is usually closed to the lock, so we can simply install the camera in the lock, instead of the place closing to the peephole. However, capturing the face of the person is not our only concern. Sometimes, the camera might fail to capture the face due to some factors, such as light. If the camera could capture some details of the person's clothes or accessories, that would be considerably helpful. Therefore, the resolution has to be relatively high.

Requirements	Verification
<ol style="list-style-type: none"><li>1. The photo resolution has to be at least 1280x720 to capture enough details.</li><li>2. The operation voltage has to be 3.7V.</li></ol>	<ol style="list-style-type: none"><li>1. The photo resolution is 1280x720.</li><li>2. The operation voltage is 3.7-5V.</li></ol>

SD card: SanDisk 8GB Class 4 MicroSDHC Card

The SD card is used to store the photos taken by the camera. Since the camera is not often used, the storage can be relatively small.

Requirements	Verification
<ol style="list-style-type: none"><li>1. Must be microSD card since there is only a microSD slot on the camera board.</li><li>2. The storage must be at least 512 MB.</li></ol>	<ol style="list-style-type: none"><li>1. This SanDisk card is a microSD card.</li><li>2. The storage is 8GB. Currently, there is no big difference between 8GB and those small storages in prices, so 8GB is an economical choice.</li></ol>

## Costs

Parts	Price
AC Adapter	\$10.97
Battery Charger	\$1.12
Battery	\$6.00
DCDC Converter	\$0.77
LDO	\$1.54 (\$0.77 each)
MCU	\$1.60

IR Emitter	\$0.52
Phototransistor	\$0.40
RFID Reader	\$5.28
Lock	\$17.82
Buzzer	\$9.08
Conditional LED	\$0.02 (100 pieces for \$1.68)
Camera	\$12.5
SD Card	\$6.99
TOTAL	\$74.61

## Safety statements

Our lock contains a Li-ion battery, so we have to pay attention to the safety of the battery. If the battery is placed in an extreme temperature, there is a possibility of explosion [2]. Most houses are not located in places with extremely high temperature, so the air temperature is not a big deal. However, if the lock is under direct sunlight, the temperature of the battery may become much higher than the air temperature, which will be hazardous. The lock is a half outdoor and half indoor device, so we plan to place the battery in the indoor part to avoid the direct sunlight. Moreover, the basic function of our lock is to protect people and their properties. Therefore, we have to make sure that our lock is considerably reliable. It is our duty to build a high-quality product.

## Citations

- [1] Fairchild, "QSD123, QSD124 Plastic Silicon Infrared Phototransistor," 2016 [Online].  
Available: <http://www.mouser.com/ds/2/308/QSD122-1125283.pdf>. [Accessed: 2- Oct- 2017]
- [2] D. Doughty and E. P. Roth, "A General Discussion of Li Ion Battery Safety," The Electrochemical Society Interface, Summer 2012