RFID Anti-Theft Door Lock

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1. Introduction

1.1 Objective

For most people, home is both the start and the end of their days. Home is also the place where people spend the most time staying in. However, home is also a private place; nobody is happy if everyone can enter his or her home without any limits. Therefore, most people install locks on their doors to prevent others to easily get inside. Nevertheless, the traditional door lock has become undependable. Sometimes, the key or the lock might be corrosive, and the lock becomes very hard to open. Many people have the experience that they plug in the key and spin it clockwise, but the door does not open. Then, they spin it counterclockwise, but it still does not open. Then, they try to spin it clockwise again, and the door finally opens. This process is absolutely annoying. Besides that, some people even meet the situation in which the keys are broken and parts of the keys are stuck inside the door. More importantly, those traditional locks do not have any anti-theft function. Burglars who master the skills of opening the locks can easily enter people's houses.

Our goal is to design an RFID anti-theft door lock. This lock utilizes an RFID tag to open, so it is much more convenient than the traditional lock. It only takes less than one second to open the door, and people does not need to worry about the direction to spin. Also, this lock contains a crime alarm and camera. If a burglar attempted to open the lock without the tag or destroy the lock, the alarm would ring to notice the surrounding people and the burglar might leave immediately. The camera would also take a photo of the burglar so as to help the police to apprehend the criminal.

1.2 Background

Currently, most people still use the traditional door locks. They install door locks only because they think that they need locks. They subliminally consider that all kinds of locks have the same security level, so they are unwitting that their locks cannot effectively impede burglars. Therefore, many people's houses are actually in danger, but they are not aware of this fact.

In the past, the traditional lock was economical and reliable in some degree, but the technology is now able to provide higher security and protection for people.

1.3 High-Level Requirements

- The RFID lock must be convenient and reliable to be opened.

- The buzzer must be loud enough to make the burglar forsake his plan.

- The camera must be able to capture a clear photo of the criminal.

2. Design
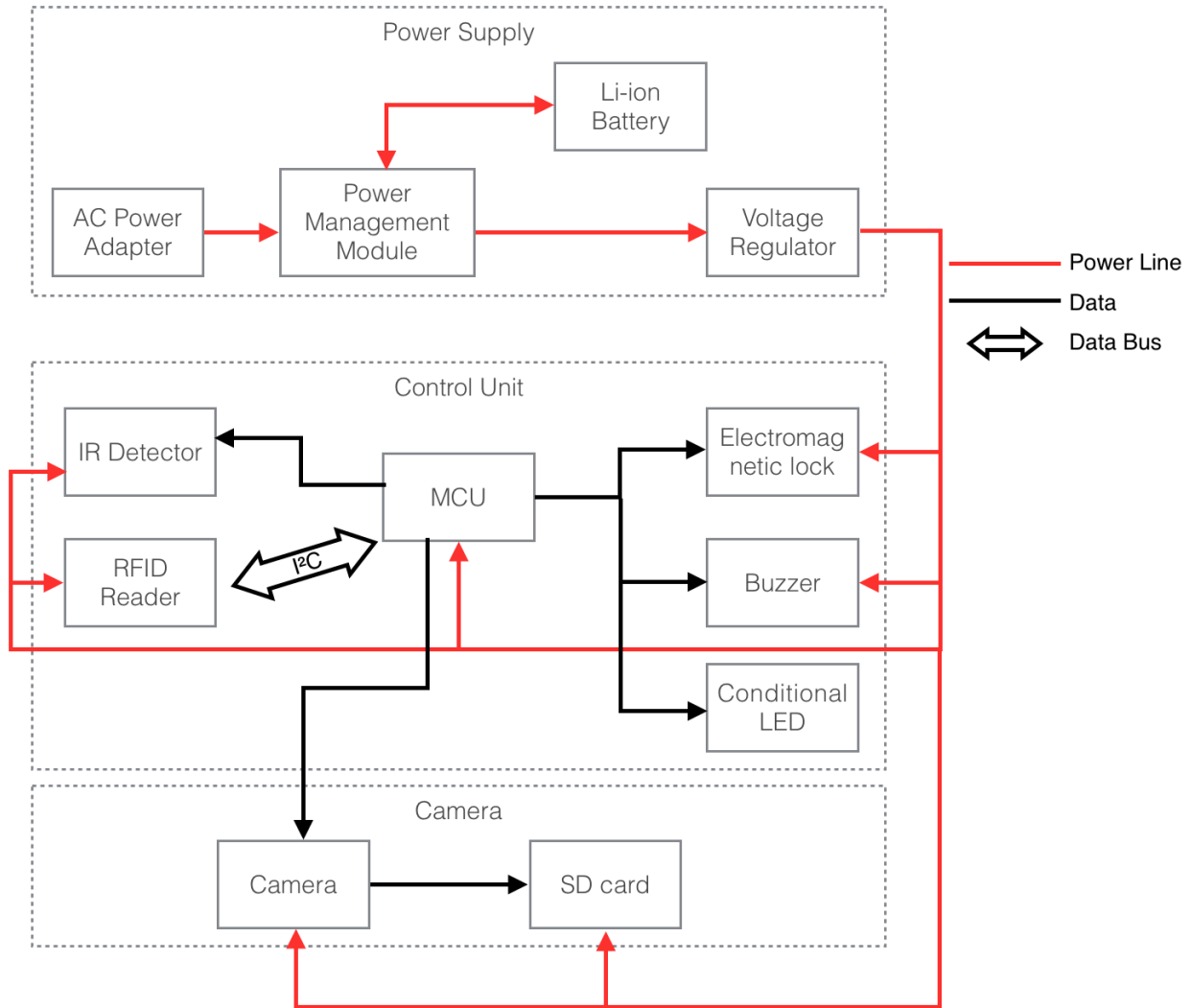
2.1 Power Supply

The power supply has to assure that the lock works 24/7. We do not want people to be locked out of their houses due to a lock without power.

2.1.1 AC Power Adapter

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

Requirement: The input must be 100-240V AC.

2.1.2 Power Management Module

The module is used to both directly provide power to the system and charge the Li-ion battery.

Requirement: Must be able to fully charge the battery in 12 hours.

2.1.3 Li-ion Battery

The battery is used when a power cut occurs in the house. The battery must be safe and ready to work 24/7. If the battery exploded, the lock would lose the meaning of its existence.

Requirement: Must work for at least 12 hours without power outlet.

2.1.4 Voltage Regulator

The regulator is used to provide a stable 3.3 V voltage for the system.

Requirement: Must provide 3.3V with ±5% voltage to the system.

2.2 Control Unit

The control unit is to accomplish the main functions of this lock. It contains a micro control unit to send data to the lock, buzzer, and LED.

2.2.1 MCU

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.

Requirement 1: Must have I²C interface.
Requirement 2: Must have 8 gpio pins.

2.2.2 IR Detector

The infrared detector is used to detected if the door is opened. In order to have a nice appearance, we need a small detector. The one we select is T1 size (3mm diameter)

Requirement : The detector must be compatible with the photo emitter.

2.2.3 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.

Requirement 1: The operating voltage must be around 3.3 V.
Requirement 2: The reading distance must be less than 10 cm.

2.2.4 Electromagnetic Lock

We use an electromagnetic lock since it is easy to control. Also, it is appropriate for diverse doors and has an anti residual magnetism design.

Requirement 1: The holding force must be at least 50 kg.
Requirement 2: Must be able to work from 0 - 90% humidity.

2.2.5 Buzzer

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 can wake up the house owner.

Requirement: The noise must be at least 110 dB.

2.2.6 Conditional LED

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

Requirement: Must peep when an incorrect tag is detected.

2.3 Camera

When the lock detects a person who attempt to intrude, the camera will take a photo for that person.

2.3.1 Camera

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.

Requirement: The camera must be at least 5 mega-pixel.

2.3.2 SD 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.

Requirement 1: The read and write speed must be at least 4.5 Mbps.
Requirement 2: The storage must be at least 512 Mb.

2.4 Risk Analysis

The first challenge we met was the power supply. At first, we planned to simply use batteries, but this approach might not be as durable as we expect. We did not want people to worry about the batteries all the time, so we gave up this approach. Then, we thought about the solar energy. If we combined the solar energy and battery, we could achieve 24/7 power supply. However, we realized that the solar panel was usually placed outside. As a result, burglars might cover the panel or destroy it to cut the power supply, and the lock would become useless. Finally, we decide to use the power from the power outlet. We will also use a Li-ion battery in case of a power cut.

Moreover, we opine that drawing the PCB is also a challenging part since we do not have relative experience. However, we already have a clear thinking of our project, so drawing the PCB would not be a big hamper for us.

3. Safety and Ethics

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 [1]. 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. The ACM code of ethics mentions that engineers are required to respect the privacy of others [2]. In fact, this is also the main goal of our project. For most people, their houses are the most important place, and they absolute want to protect the privacy in a considerably high level. Our RFID anti-theft lock is able to accomplish this desire for people.

Finally, based on the IEEE code of ethics, engineers should "improve the understanding of technology; its appropriate application, and potential consequences [3]". Many people knows the necessity of protecting their houses; they just do not know the appropriate approach. We design this lock not only to provide convenience and high-level protection, but also to make people realize the reliable approach to protect their privacy and property.

References

[1] D. Doughty and E. P. Roth, "A General Discussion of Li Ion Battery Safety," The
    Electrochemical Society Interface, Summer 2012
[2] ACM Council, "ACM Code of Ethics and Professional Conduct", 1992. [Online]. Available:
    https://www.acm.org/about-acm/acm-code-of-ethics-and-professional-conduct.
    [Accessed: 19- Sept- 2017]
[3] ieee.org, "IEEE IEEE Code of Ethics", 2016. [Online]. Available:
    http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 19- Sept- 2016].