RFID Lock Design Document

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1 Introduction

1.1 Problem

The problem we aim to solve is the difficulty of use of classic door key locks especially when under adverse conditions such as frozen debris, low light levels, inebriation, or disabilities such as parkinsons or blindness making location and use of these locks a challenge. For example, resources for people who are blind on unlocking doors and managing keys can be found here. While there is not a formal study done on it, a quick google search shows resources for people who are blind or those afflicted with parkinsons on how to renovate their homes or homes of loved ones to make lives simpler. Examples of that can be found here and here.

However, not everyone is able to undertake such drastic measures for home renovations and some likely cannot afford the home itself. For college students or any age range, renting an apartment may be the best and only option available to them. Modern solutions for example found here require replacing the previous door lock entirely. For those of us renting a place, that might not be an option since we could lose our security deposit either screwing in new mounts to the door or since the locks are swapped it could lock landlords out from inspections or apartment showings which is a new problem entirely.

1.2 Solution

Our solution is to create a renter friendly system that works in tandem with current infrastructure on your door and will mount with the deadbolt lock. Since our solution will be mounting using the same screw and friction system the deadbolt lock uses, our product will slip into the deadbolt position without marking up or requiring new screw holes to be installed on the door and losing security deposit after you move out.

Our solution will be an RFID scanner mounted on the deadbolt that will be connected to an inner pcb system to ensure the RFID tag is allowed to open this door and will then power a linear actuator to rotate the deadbolt into the unlocked position. The whole system will also be powered

by induction where the RFID tag will be housed with a powerbank with remote power transmitter. The doors RFID scanner will also have a remote power receiver coil that when the RFID tag is scanned on the door the bank and transmitter will also be in contact to wirelessly power the system. This will ensure the RFID door system will never require a battery change out and also only be useful when a proper RFID tag is touching it which is an indirect security measure.
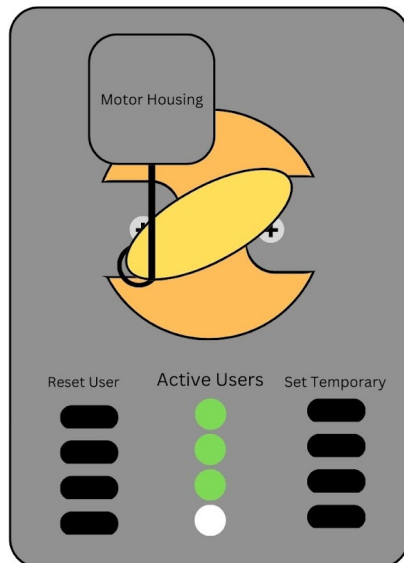
1.3   Visual Aid

Mounted on a door deadbolt similar to this one

Figure 1.1 Shows a deadbolt with keys in it from the outside view

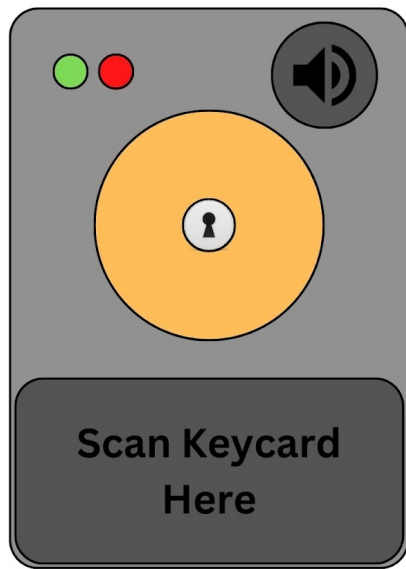**Figure 1.2** Shows a deadbolt lock for both the inside and outside of the door

Motor Housing

Reset User   Active Users   Set Temporary

Indoor Lock Housing

Figure 1.3 Shows initial idea in a visual aid of the indoor housing of our system

Outdoor Lock Housing

Figure 1.4 Shows the outdoor view of the deadbolt door lock

Underneath the RFID pad will be where the power receiver lies so that when the tag is scanned the powerbank and transmitter are also in contact with the receiver inside the door unit.

1.4 High Level Requirements

1. Does not require the battery to be replaced, main power method is through the wireless transmitter/transceiver bank
2. The CPU is fast enough to process RFID and turn door lock since the bank has to be held to the scanner for the system to have power (aim for under 30 seconds)
3. System would have short term power ~1 minute so that the system could run even when the power brick is pulled away

2 Design

2.1 Block Diagram

System this report is based off of uses only wireless power transmitting and scrapped solar and battery (We might need to change this depending on efficiency of power transmission)
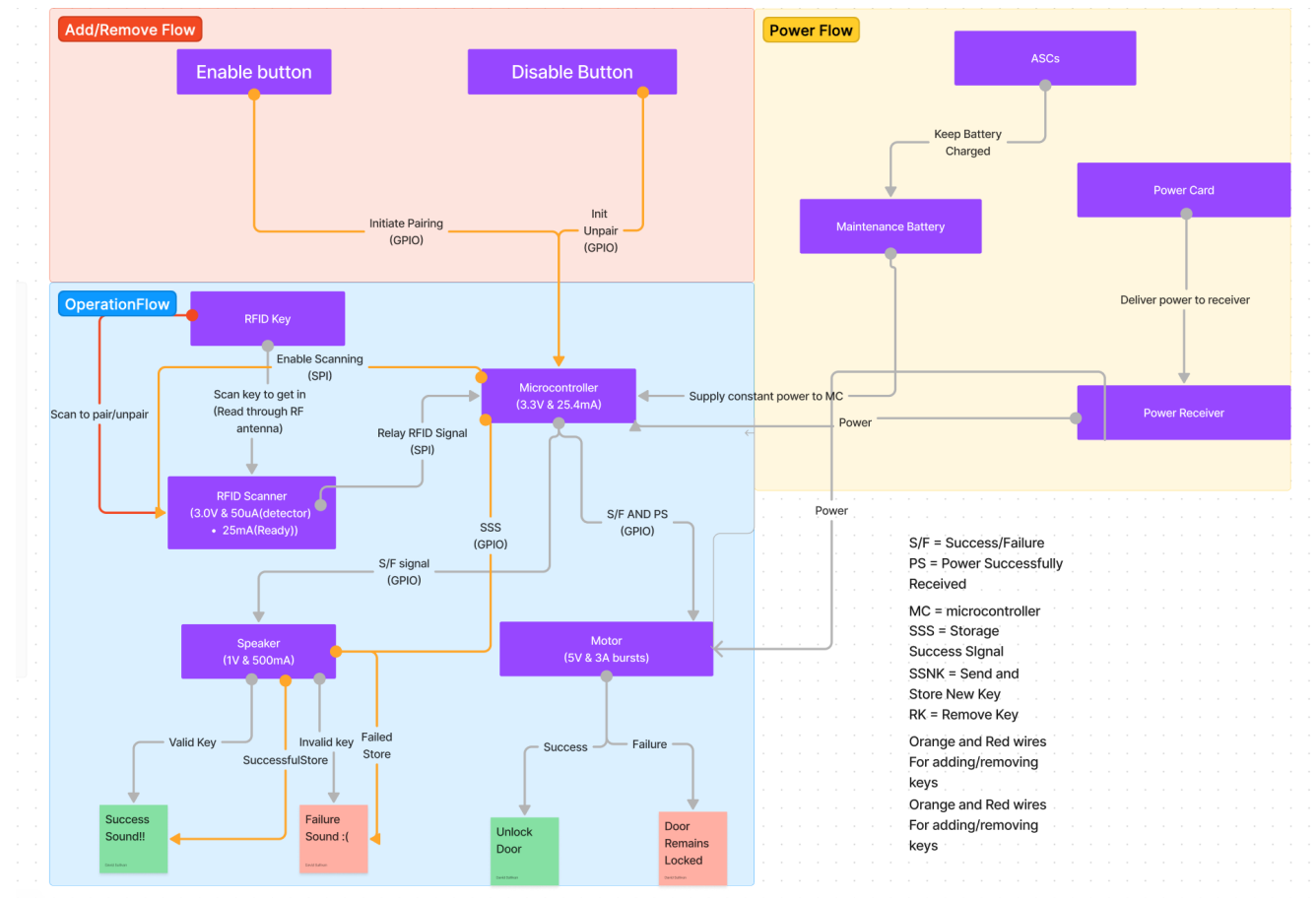

Figure 1.5 Shows a block diagram for the initially proposed unit

2.2   Subsystems

2.2.1   Power

Located next to the RFID scanner under the pad on the outside, this power receiver will be the main power component to the door locking system. When the RFID tag and power bank combo are pressed onto the door, this receiver will draw power from the bank and power the door system. The power receiver will be in charge of regulating voltage to the operating circuit containing things such as a motor, speakers, microcontroller etc. and the component requiring the highest input voltage is the RFID scanner needing a 5 V difference to work. Using the LP5912-EP allows for a linear regulated output of 5 Volts DC. This linear regulator requires an input voltage of 6.5 V to maintain a 5 V DC output. Meaning the power transmitter will need to transmit 6.5 V peak waves across to the receiver. Since the goal is to keep the transmitter small and sleek using smaller batteries stacked in series such as this 3.7V 500mAh Lithium Polymer mini rechargeable battery the power supply could reach a 6.5 V input on the transmitter coil. However, induction coil properties shown in equation 1.1 allows the transmitter to not require as much input voltage to output higher at the receiver.

$$Vp/Vs = Np/Ns \hspace{4cm} \text{Equation 1.1}$$

Meaning for a higher secondary voltage (aka voltage in receiver) there must be an increase in the number of turns in the secondary (receiver) coil. Using this info, a smaller input voltage and keep the transmitter pack smaller and more sleek for a user to carry with them.

Tolerance analysis also shows the maximum power needed for components such as microcontroller, rfid scanner, and motor to operate is 6.5484 W. This is fleshed out more in tolerance analysis on power and current draw for each component but peak power and current values for each component is added up below.

Ppeak = 5.76 W + 450 mW+ 18.4 mW +320 mW = 6548.4 mW = 6.5484 W
Ipeak = 1200 mA + 4.6 mA + 160 mA + 150 mA = 1514.6 mA = 1.5146 A

Induction charging usually shows a loss of around 30-50% loss in power during transmission across induction coils. Meaning the power transmitter will need to be able to put around 9.3548 to 13.0968 W through the transmitter coil for enough power to be on the receiver end for the circuit to operate at peak power draw. One thing to be aware of is the peak current draw is at 1.5146 amps when everything is turned on, meaning voltage regulator, induction coils and capacitors must be able to operate at that level for a possibly extended period of time (10-20 seconds) if necessary.

2.2.2   RFID Scanner

Will be mounted on the outside of the door, will receive RFID tag signal and send that data to the pcb/microcontroller located on the inside of the door. It is powered by the power receiver. The circuit shown below in the circuit schematics section will be the power to the load circuit where all our computation and microcontroller lie including the RFID scanner. The MLX90109 datasheet shows a 3.1-5.5 V steady input requirement for this scanner as discussed previously.

2.2.3   LED's and Speaker

Are located on the outside of the door unit on the external portion of the casing. These LED's and speakers will provide feedback if the door was unlocked or not. LED's will flash green or red and the speaker will play a distinct success or failure noise.

2.2.4   Servo Motor

 This is the main mechanical component of the lock as it will turn the deadbolt lock into the unlocked position. It is located inside the door and will be powered on on a successful RFID tag scan. It will then push the rotating portion of the deadbolt until the door is unlocked. The Pololu Corporation 3426 works at 5 volts which is the same as the RFID scanner. Meaning there should be no problem turning this motor on and off as long as voltage is maintained at levels necessary to run the rfid scanner when this motor is powered on and off which should be possible with

implementation of voltage regulator. This servo also contains an encoder that gives positional feedback so that the lock can freely rotate and the microcontroller can also determine whether it needs to turn the servo left or right to lock or unlock the door on activation based on current position.

2.2.5 Microcontroller

The main component on the indoor unit, this microcontroller will be powered on when the power receiver is powered and will receive the RFID tag at the same time it is powered on. It will determine if the tag is a valid tag to unlock the door and will instruct the linear actuator to turn the deadbolt as well as instruct the outdoor LED and speaker to display proper colors and noises. The STM32F103C8T6 microcontroller will draw 2.2-3.6V (minimum voltage is -0.3V and maximum voltage is 5.5V) at an operating current of 27 mA in run-mode. If operating in standby, current consumption will can drop as low as 2 microA

2.2.6 Indoor Programming Buttons

Since this unit is meant for people renting, roommates are a likely scenario or even caregivers who may want ease of access when this unit is installed. Therefore the indoor portion of the unit will have buttons to add new RFID tags as users to the door as well as removing and setting users as temporary access.
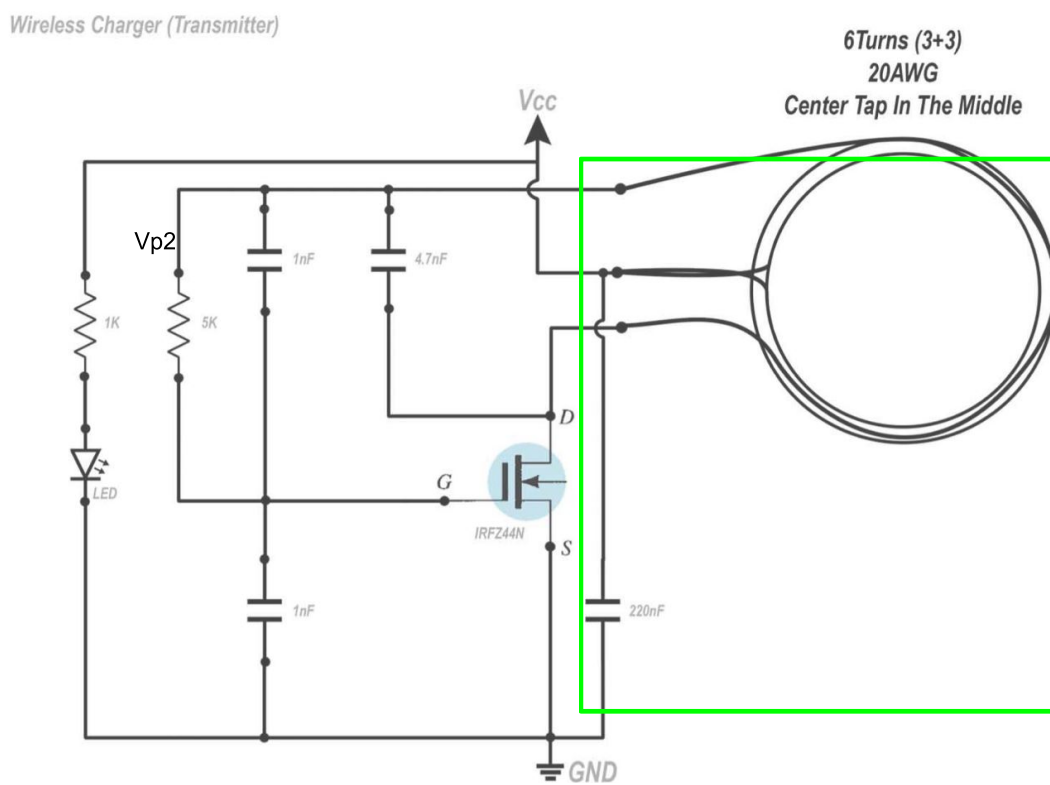
Circuit Schematics

Figure 1.6 Is an LC oscillator circuit using a N-type mosfet and coil as an inductor

2.2.7 Transmitter

Transmitter:

The circuit pictured above in Figure 1.6 features an LC oscillator using a N-type mosfet and freewheeling diode with values not yet confirmed but will be referenced to indicate specific parts to note. Shown outlined in green is the LC tank where voltage and current is traded off between the inductor coil and the capacitor. This will either have a voltage across the capacitor or the power will be stored as a field within the loop. To start, the 220 nF capacitor will begin to change until the voltage at Vcc and Vp2 are similar (Vp2 should be slightly lower at this point since there will be a drop across the inductor coil). Mosfet drain D will also act as an open circuit since there is not enough difference across gate and source for it to drain making D high voltage and Vp2 low voltage. Once Vp2 has reached a threshold there will now be a voltage difference across the mosfet G and S, gate to ground so D will now drain through mosfet to S. This turns D to low voltage since it is shorted to ground and flips current across the inductor coil as the 4.7nF capacitor discharges. In turn Vp2 will drop as capacitors discharge causing voltage difference from G and S to drop and shut off mosfet and repeat this cycle. Again, one big thing to look out for here is making sure the coils are rated for the amount of power required (9.3548 to 13.0968 W) since peak power draw will pull a lot more current through to the system.

The diode path just shows when the circuit is on, which is not necessary for our final circuit but will be a useful connection point for visual troubleshooting when testing the circuit.
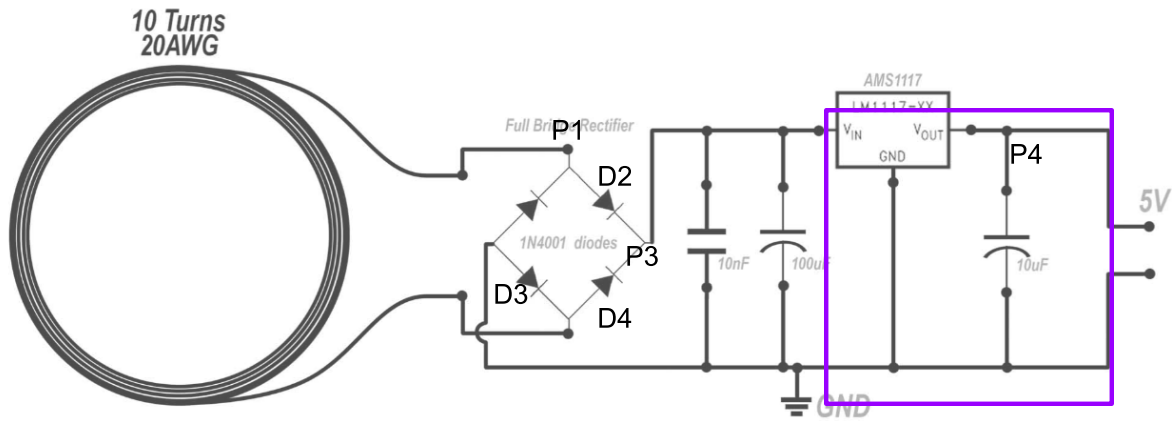
Figure 1.7 Shows the wireless power inductance coil for receiving power and how it will be turned into a DC wave for components to be used

2.2.8 Transceiver

Looking now at the receiver it can be broken down into a few sections. The first being the full bridge rectifier. Knowing our transmitter coil oscillates as a sine wave, the receiver coil voltage will oscillate with a similar wave shown below in Figure 1.8. Designating when the P1 of the circuit is a positive voltage as a forward signal when the voltage shown in Figure 1.8 is positive the circuit has a forward signal. This means that both diodes D2 and D3 are forward conducting and will make P1 a positive voltage and P2 0 volts. This results in P3 also being a positive voltage since D4 is not forward biased. Inversely, when the voltage in the loops flips due to the AC nature of the transceiver receiver relationship, D4 and D1 will now be forward biased making P1 0 volts, and P2 a positive voltage again leaving P3 at a positive voltage due to D4's forward bias and D2's shut off.
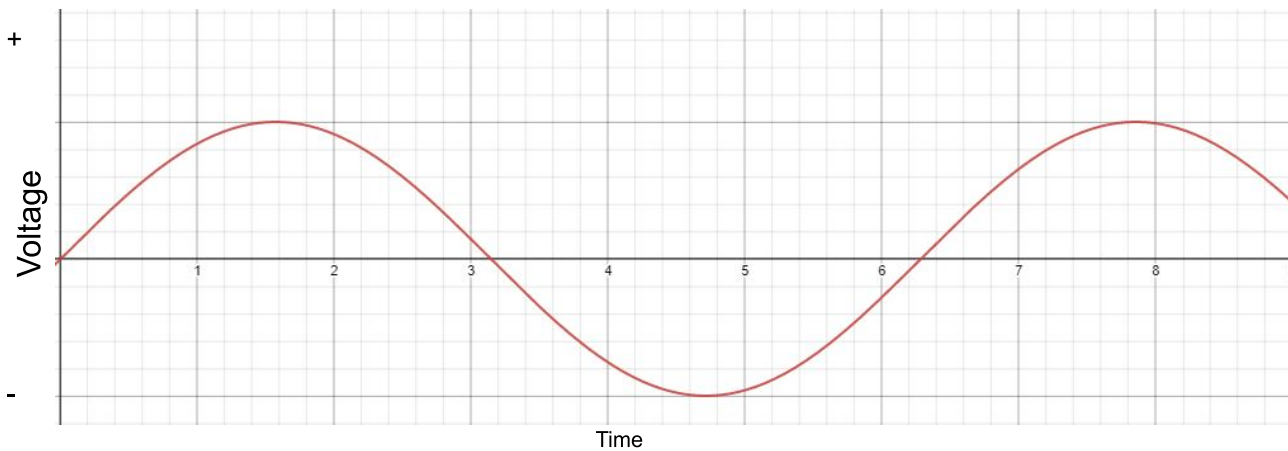
Figure 1.8 Is the AC voltage measure across P1 and P2

After this full bridge rectification is implemented the voltage behavior at P3 is shown below in **Figure 1.9**

Figure 1.9 Is the rectified voltage at P3

Looking at the portion boxed in green in Figure 1.7 focuses now on the filtering system. Figure 1.4 shows an |Sin(x)| wave but this wave still drops to 0 and fluctuates. The two capacitors in parallel act like filtering systems where they will charge to the voltage peaks of each sin wave and when the voltage begins to drop, those capacitors will begin to discharge. The capacitor on

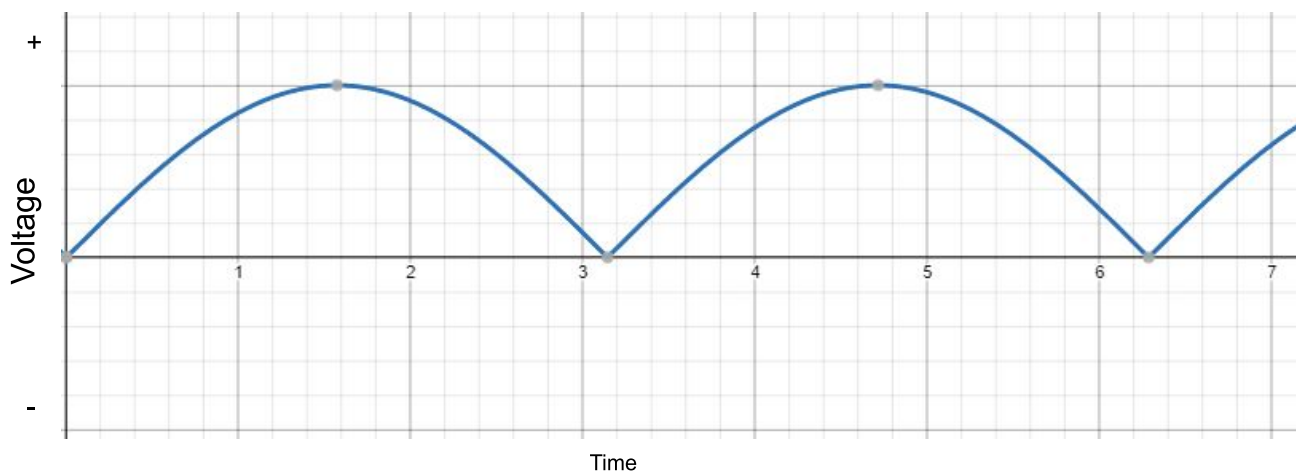the left will discharge normally from P3 down to ground, but the one on the right is polarized meaning it will discharge through the capacitor on the left keeping the voltage at P3 similar to its peak voltage as shown below in Figure 1.9
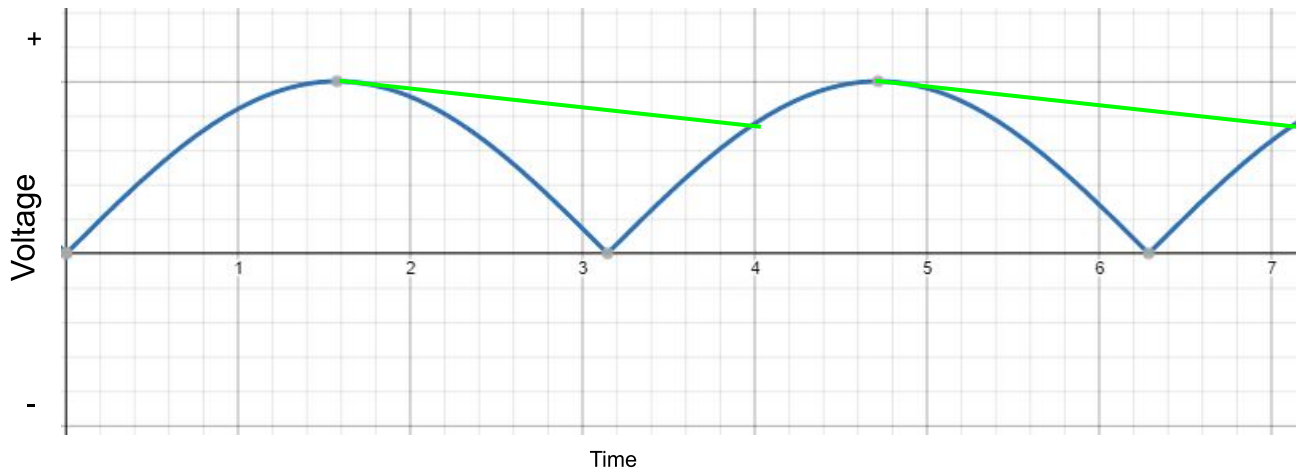
Figure 1.10 Shows P3 voltage with capacitor filtering implemented

Finally, boxed in purple is the output voltage regulation. Depending on how much voltage can be pulled from the induction system, this regulator will likely be an LDO or possibly an LDO in combination with a step up or step down regulator. Looking at operating ranges for the linear regulator picked out for this project so far shown in Figure 1.11, once the input voltage hits a certain value known as the group out voltage or threshold voltage, the linear voltage regulator will hold a steady voltage. However, if the input voltage falls below the drop out voltage, the output voltage will drop to zero semi-slowly. That is why there is another polarized capacitor here as it will charge up and once the voltage regulator output drops to zero, this capacitor will discharge through the circuit creating a softer turn off for the components.

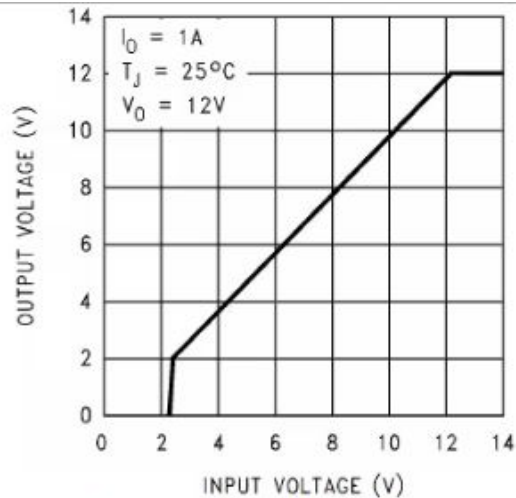**Figure 13. Low Voltage Behavior**

Figure 1.11 Is the output as a function of input voltage of the LP5912-EP voltage regulator

2.3   Tolerance analysis

Battery:

Since our system is not connected to a wall socket it will have to be battery powered in some fashion. The current design shows a battery pack sending power from the portable power supply to the door mounted unit. We can measure both how much power the induction wireless power transmitter sends, and how much power the induction wireless power receiver gets/power needed to run the circuit. To do this we can measure the current out of the battery and voltage difference across battery output using equation 1.2.

$P=IV$ Equation 1.2

Knowing the power consumption per-use of our system, we can divide the power capacity of the battery by per use power for total uses before battery recharge/device failure occurs shown by equation 1.3.

$TotalUses = Ppc / Ppu$ Equation 1.3

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Motor:

Another main component and moving part on the unit is the servo motor. Servo motors are used in a variety of applications which range from low to high intensity with optimal and suboptimal working conditions. Motors can last anywhere from a year on the short end to up to 20-30 years on the high end depending on a few factors. The main points of failure for servo motors are current draw, ball bearings giving out, motor speed, and environment conditions such as humidity and temperature.

Since the unit is designed to be used in rental properties and the servo is located on the inside of the door, the ideal conditions 25 celsius or 77 Fahrenheit will be the most likely operating conditions. Due to the nature of the product the power to the components themselves will be inconsistent meaning lots of impulse current however, the design of the power transmitter and receiver circuit are built to ramp up powering on and off the circuit including the motor so it should be protected from any damage in terms of current spikes. However, all mechanical components are susceptible to wear and tear over time, especially ball bearings.

Most major OEM's for servos rate their servos for around an average of 20,000 working hours. Assuming a user will use their key for both lock and unlocking with the servo, it should take ~3 seconds on average to rotate the door lock. Converting 20,000 working hours to seconds by multiplying by 60 min/hour *60 seconds/min gives us a total of 72,000,000 working seconds. Assuming ~5 seconds to unlock and another ~5 to lock each time the door is used. Since no studies have been done on how many times the average person leaves and returns to their house a day a reasonable assumption is 4 times a day, leaving for work or school is a lock and unlock on both leaving and return and then again running errands or going out for personal reasons is another lock and unlock on both leaving and returning. Giving 4 Exits per day * 5 seconds per turn * 2 turns per exit = 40 seconds of working time per day. Dividing 72,000,000 total working seconds by 40 seconds/day = 1,800,000 days divided by 365 days/year gives ~4,932 years which is an incredibly unlikely number of years for any commercial product to last. Even running continuously for 24 hours a day 20,000 working hours translates to ~833 days or ~2.3 years.

More likely, the casing and infrastructure around the servo motor such as the unit buttons will wear down, rechargeable batteries will need to be replaced or electrical components will burn out before the servo stops working. However, this means the unit when made out of other quality materials in terms of casing, circuit components and care should last a customer throughout college or through a few years living through apartments before fixes or a new unit needs to be considered.

Power Draw:

Starting by looking at Servo

Servo motor we are using is the Pololu FS5115M. Looking at the datasheet, operating at 4.8 V which is what we will be operating at there is a passive current draw of 5mA. When running it pulls a current of 160 mA. However, the stall current is 1200 mA (1.2A). 1.2 A is peak amperage and motors should have this amperage and a little over just in case. This peak amperage is usually hit upon start-up or when it starts to stall when turning a door lock and when the motor receives physical resistance from the lock. Since we need to account for this we need to be able to supply 1.2A at 5 V. This has both an idle, peak and operating current. Using equation 1.2 again.

Pidle = 5mA*4.8V = 24 mW

Ppeak = 1.2A * 4.8 V = 5.76 W

Poperating = 160 mA * 4.8 V = 768 mW

Next we look at MicroController. We are using the STM32F103C8T6 microcontroller. Absolute maximum ratings for voltage is 4.0 Volts across the microcontroller and an operating range of 2 to 3.6 V. We will likely keep an operating voltage of around 3.0 V. Maximum current into the microcontroller is 150 mA. Assuming we operate at maximum current to give us extra breathing room in case we do operate there P=IV = 3.0V * 150mA = 450 mW.

Finally looking at the RFID tag reader datasheet the operating voltage between 3.1 and 5.5 V. Likely the operating voltage will be kept at 4.0 volts. The reading unit and antennae unit use 1.8

and 2.8 mA respectively for a total of 4.6 mA for the RFID tag reader and antenna. P=IV for unit and antennae = 4.6mA*4.0V = 18.4 mW.

Additional components: Our circuit will have LED's as well for visual feedback to the user. No specific research has been done on LED types but a guess of around 8 LED's will be used for our unit. LED's draw an average of around 20 mA on the high end at a voltage of around 2.0 volts on average. Using 8LEDs * 20 mA per LED = 160 mA total. P=IV at 2 volts is 320 mW total for LEDs.

Putting this all together for an idle, peak and operating power draw depending on motor function.
P_{idle} = 24 mW + 450 mW+ 18.4 mW +320 mW = 812.4 mW = .8124 W
I_{idle} = 5 mA + 4.6 mA + 160 mA + 150 mA = 319.6 mA = .3196 A

$P_{operating}$ = 768 mW + 450 mW+ 18.4 mW +320 mW = 1574.4 mW = 1.5744 W
$I_{operating}$ = 160 mA + 4.6 mA + 160 mA + 150 mA = 474.6 mA = .4745 A

P_{peak} = 5.76 W + 450 mW+ 18.4 mW +320 mW = 6548.4 mW = 6.5484 W
I_{peak} = 1200 mA + 4.6 mA + 160 mA + 150 mA = 1514.6 mA = 1.5146 A

Peak power and current needs to be our main focus on determining what our circuit can handle since the circuit needs to be able to reach and operate at its max power requirements.

2.4   Requirements and Verification Table

Requirement	Verification
As shown in previous power requirement calculations, a power of 6.5484 W will be drawn by the system.	Figure 1.7 shows a point labeled P1, measuring voltage from P1 to ground and current out of P3 the power supplied by the power transmitter across induction coils can be measured and using equation 1.2 the overall power delivered can be measured.
The output in figure 1.7 labeled 5V is where our load (microcontroller,motor,leds…) will go. This must maintain a steady 5V when powered on. The same points here will also have a max current draw of 1.5146 A.	Placing voltage probes here across the 5V output will allow verification of a steady or as close as possible to steady DC 5V. Any steady voltage above 5V is also acceptable and can be dropped over a resistor to get load to 5V. Placing an ammeter at this same location using a resistor to simulate a similar system load will allow verification of hitting the 1.5146 peak current.
Motor has to be able to turn the deadbolt lock and overcome stall when starting from stop or peak resistance of deadbolt.	Verification of peak current and power delivery should satisfy the motor getting enough power. However, to be certain the motor should be hooked up in parallel with the rest of the system load such as microcontroller and rfid tag scanner and be able to rotate deadbolt lock when all other components are turned on.

Motor needs to turn at a safe slow speed in order to better protect human operators from any pinching that may occur during operation.	Operating speed needs to be tested both when other components are turned on and turned off. They may not always be turned on when the motor is operating so verification of safe speeds needs to be confirmed in both scenarios. This should be done by controlling the motor using the motor's encoder which is then hooked up to a microcontroller.

3 Cost and Schedule

3.1 Cost Analysis

Part	Description	Quantity	Unit Price	Link
Polulu, 3426 - Motor with Encoder	Small servo motor to be mounted onto door to rotate deadbolt	1	$20.49	https://www.digikey.com/en/products/detail/pololu-corporation/3426/10450115
RFID Reader	Melexis RFID Receiver capable of transmitting encoded and decoded RFID	1	$5.71	https://www.digikey.com/en/products/detail/melexis-technologies-nv/MLX90109E

	signals			DC-AAA-000-RE/1647934
RFID Tag	Parallax Inc 28141 ROM card	1	$0.99	https://www.digikey.com/en/products/detail/parallax-inc/28141/1774533
Vishay Dale, IWAS4832AEEB120KF1 - Induction Coils	Manufactured induction coils from copper wire with metallic backing to increase induction.	2	$2.89 Each	https://www.digikey.com/en/products/detail/vishay-dale/IWAS4832AEEB120KF1/10223651?utm_adgroup=Inductors&utm_source=google&utm_medium=cpc&utm_campaign=Shopping_Supplier_Vishay&utm_term=&utm_content=Inductors&gclid=EAIaIQobChMIgLLB2v7v_AIVKcmUCR1wXQ7uEAQYASABEgIWafD_BwE
International	Small N-type	1	$1.45	https://www.digi

Rectifier,IRFZ44 NPbF - Mosfet Transistor	mosfet transistor used in power transmitter circuit			key.com/en/prod ucts/detail/infine on-technologies/ IRFZ44NPBF/8 11772
TI, LP5912-EP - Voltage Regulator	12 volt regulator used in power receiver circuit to provide steady DC current to microcontroller, servo, and RFID reader	1	$3.49	https://www.ti.c om/product/LP5 912-EP#order-q uality
STM32F103C8 T6 Microcontroller	ARM Cortex M3 microcontroller for storing RFID keys and managing door opening	1	$6.66	https://www.digi key.com/en/prod ucts/detail/stmic roelectronics/ST M32F103C8T6/ 1646338
Parts Total			$44.57	

Machine Shop Labor:

Machine shop already had a miniature door with a deadbolt installed which is nice for a demonstration but for purposes of this project, a piece of wood with a deadbolt installed would be sufficient enough to demonstrate the deadbolt opening and closing via servo motor. On top of this they would need to manufacture a custom base plate for the servo motor to mount with the deadbolt which would likely be the more difficult part taking around a total of 3 hours of

machine shop work when building a wood mounted deadbolt and custom deadbolt plate. If making the same miniature door with deadbolt attachment from scratch that is currently available it would be closer to 5 to 6 total man hours for the machine shop. Analyzing from higher man hours at a cost of $35 an hour, 6 Hours * $35 an hour for a total of $210 for machine shop labor.

Student Labor:

After graduating University of Illinois Urbana Champaign average yearly computer engineering salary is $105,352. A 40 hour work week is 2,080 total working hours a year which comes to $50.65 hourly wages. Assuming 8 hours of work per week per student on the project the weekly salary for all three students is $50.65 per hour*8 hours per week * 3 students= $1215.6 per week in student wages. Starting the week of 2/6/2023 and going through the week of 4/17 is 10 weeks of work when accounting for spring break off as vacation. 10 Weeks * $1215.6 per week = $12,156 total in student salaries.

Grand total of costs in this project will be a combination of machine shop labor, parts and student labor with a likely heavy cost into student labor as that is where most man hours will be spent for building, debugging, planning and presenting which comes out to $12,410.57 total spent on the project.

Grand Total of costs = Machine Shop Labor + Parts + Student Labor
= $210 + $44.57 + $12,156 = $12,410.57
An overhead factor on student labor hours for extra work as necessary of 3x brings the total hours to 3 Students* 8 Hours a week* 10 weeks * 3 Overhead Factor * $50.65 per hour = $36,468 for a total of $210+$44.57+$36,468 = $36,722 total for this project when accounting for an overhead factor on student labor.

Looking at competitors on the market there is a wide range of electronic door locks that have a similar function but do not fit the exact niche the proposed design fills.

Name	Cost	Description	Link
TEEHO TE001 Keyless Entry Door Lock	$49.99	Keyhole and number pad unlock system to replace deadbolt. Lacks any rfid technology and does not work with existing deadbolts.	Hyperlink
SMONET Fingerprint Keyless Entry Smart Deadbolt with Auto Lock Touchscreen	$69.99	Number pad, key hole, key fob, wireless electronic door lock. However, it does not co exist with existing deadbolts.	Hyperlink
ETEKJOY Electronic Door Lock 3-in-1	$72.00	Number pad screen, hidden keyhole, and rfid reader. Again will not fit over the current deadbolt lock and has a higher cost than parts of the proposed unit.	Hyperlink
ULTRALOQ U-Bolt Pro, 6-in-1 Keyless Entry Door Lock	$219.00	High tech smart deadbolt lock with number pad, finger print, bluetooth and app companion.	Hyperlink

There are lots of competitors out on the market but again none fitting the exact niche that the proposed RFID lock would fill. The parts cost analysis is when pieces are ordered in a batch of 1 and sites like digikey show reduces prices when parts are ordered in bulk meaning the proposed RFID lock which is already a drastically cheaper cost than most competitors could be mass produced at an even cheaper price and offer a nice margin while still being cheaper than most competitors.

Likely this product could be produced entirely on PCB's with parts shipped in and likely around 1 man hour to assemble per unit depending on our efficiency in getting PCB's soldered. After it is soldered, there would be about another half hour for assembly of PCB's into door unit casings, and the custom deadbolt plates can be drilled out quite easily and would likely take only a few minutes of machine work. This would require manufacturing and assembly for around 2 hours give or take. To make this process efficient we would use reflow soldering which would allow us to buy reusable templates for the PCB soldering as well as require an oven to bake the solder on. This requires purchasing of PCB oven, we will do this per unit so around $600 for the Quincy lab, Inc. 10GC Gravity Convection Oven found here but the oven can be reused. We will also require some sort of drill, a mounted consistent drill for building base plates. The Speed Bench Drill Press found here would be a good unit for this costing around $80. Running electricity for these machines costs money, the oven takes around 600 W and for a minute per PCB bake is 600 * (1/60) / 1000 = 10/1000 = .01 kWhr * $.151 per kWhr = $.00151 utilities cost per unit. The initial investment into the oven and drill is a hefty price but will be continuously working on multiple units so they are not a per unit purchase.

3.2   Schedule

Week	Task	Person
1/30	Project Approval	Everyone
2/6	Proposal	Everyone
	Soldering	Individual-Everyone
2/20	Design Document	Everyone
	Team Contract	
2/27	Design Review	Everyone
3/6	First round of PCB Orders due (Tuesday)	Everyone

	Team Evaluation(Wednesday)	
	Last day for revisions to machine shop (Friday)	
	Build and troubleshoot power transmitter and receiver circuit	Everyone-Individual
3/13	Work on design of RFID, microcontroller and servo motor connections	Everyone
	Work microcontroller coding for controlling RFID and motor connections	
3/20	Assembly of components without PCB	Everyone
	Work on motor and microcontroller	
	Finalize design of circuit	Everyone
3/27	Second Round of PCBway Orders(Tuesday)	Everyone
	Individual Progress Reports (Wednesday)	Everyone-Individual
4/3	Soldering PCB components	Everyone
	Component and RFID Testing	Everyone
4/10	Team Contract Fulfillment	Everyone-Individual

	(Friday)	
4/17	Mock Demo	Everyone
4/24	Final Demo	Everyone
5/1	Final Presentation	Everyone

4 Ethics and Safety

The team is committed to following the IEEE code of Ethics as well as the ACM code of ethics during the entirety of the development of the project. This project aims at providing a safe way for users to secure their apartments and homes. The IEEE Code of Ethics states that the "safety, health, and welfare of the public" must be a priority. Because our project centers around security, we will make sure to perform accurate and extensive testing to ensure that the project does not fail the user. Ways this could happen include unexpected dead battery, not recognizing the RFID tag, and failing to register other RFID tags. During development we will test and ensure that the system can detect low battery levels. This way the user knows and can take action once they know the scanner is low on battery and not be randomly surprised. We also added a speaker that will work to alert the user when an RFID tag has been added and when an RFID tag has not been successfully added. If an RFID tag has not been successfully added, the user will be alerted and can try adding the RFID tag again.

Aside from this, this locking mechanism is built to add on to the door lock security, not replace it, so the actual keyhole will remain exposed to be used normally with the original key, this way landlords will not get locked out of their tenants unit or any user wishing to use a key can still do so if he RFID scanner fails.

There is one mechanical component to this project. We use a motor to help turn the door lock once the RFID has been scanned. In order to prevent the user from being hurt by the turning of

the lock, we will be using a motor with an encoder to ensure the speed of the motor is set at a slow rate that will prevent all users from being accidentally pinched by motor or lock movement.

Because the rest of the project is heavy in electrical parts, there is an electrical hazard to the user. Knowing this, the project is designed to protect the user and electrical parts by ensuring that any electrical pieces are completely encased inside the unit. Since the user's body will come close to the motor which pulls voltage and current there is always the possibility of shock. To add in extra safety precautions there will be a rubber encasing around the motor and the wires connected to the motor in order to add an extra level of protection to the user.

Other ways we will sustain proper ethical protocol is by recording everything in the engineering notebook, cleaning our lab station after use in the 445 lab, and accepting all errors and criticism during and after development of the project.

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