Self-Charging Automatic Bike Lock

Team 18

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Contents

1. Objectives and Background

1.1 Problem

According to bikelab.shop, 856 to 1070 bikes were stolen in 2014 [1], resulting in an approximate loss of 150,000 dollars worth of bikes [2]. These alarming statistics necessitate security precautions like bike locks and alarms. However, conventional bike locks are prone to mechanical tampering, making it straightforward for them to be bypassed. Furthermore, the majority of bike alarms require some type of remote to enable and disable it.

1.2 Solution

Our solution to this issue is an automatic bike lock with an alarm system. This device will be attached to a bike with a clamp and will contain a physical locking mechanism and an alarm component. The physical lock will consist of a linear actuator that inserts itself through the wheel spokes, preventing the wheel from spinning, and a keypad whose input will change the linear actuator's state. The alarm device will have a small speaker.

The device also contains a self charging subsystem, which will charge the device when the bike is in motion. This will be achieved by attaching a friction generator to the back wheel of the bike, with the energy generated by the generator going into the device's battery. To satisfy the requirements of our project, we will be designing a PCB using a microcontroller. The microcontroller we will use will have bluetooth functionality in order to implement our locking mechanism,

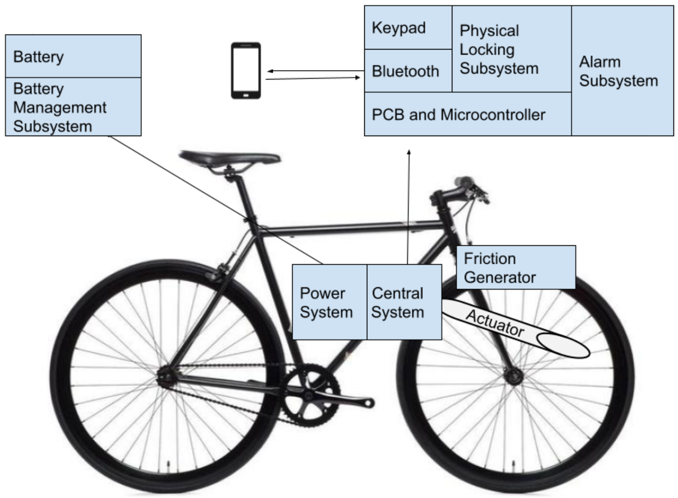
To lock and unlock the device, it has to be paired to the user's phone with bluetooth, after which the user can press on the keypad to lock or unlock the device. If the user does not have the Bluetooth device (in the case where they forgot their phone or it ran out of charge) the user must input a correct sequence into the keypad.

1.3 Benefits and Goals

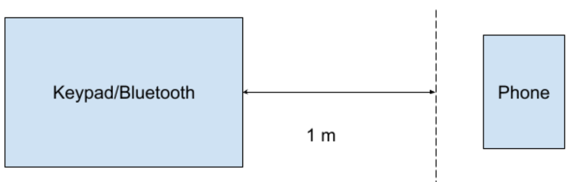
- Provides a secure bike locking mechanism by providing two levels of security with the bluetooth functionality and keypad
- Device comes with alarm system that does not require use of a remote
- Modular design to ensure encompassing compatibility with various if not all bike designs.
- Rechargeable system allowing for usage without worrying about constantly replacing/removing batteries.

1.4 Visual Aids

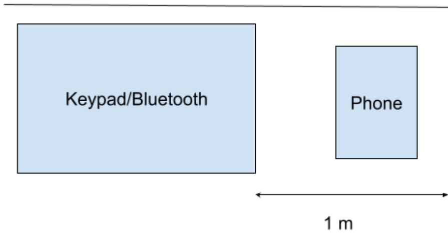
Overall Visual Aid



Locking Mechanism Visual Aid

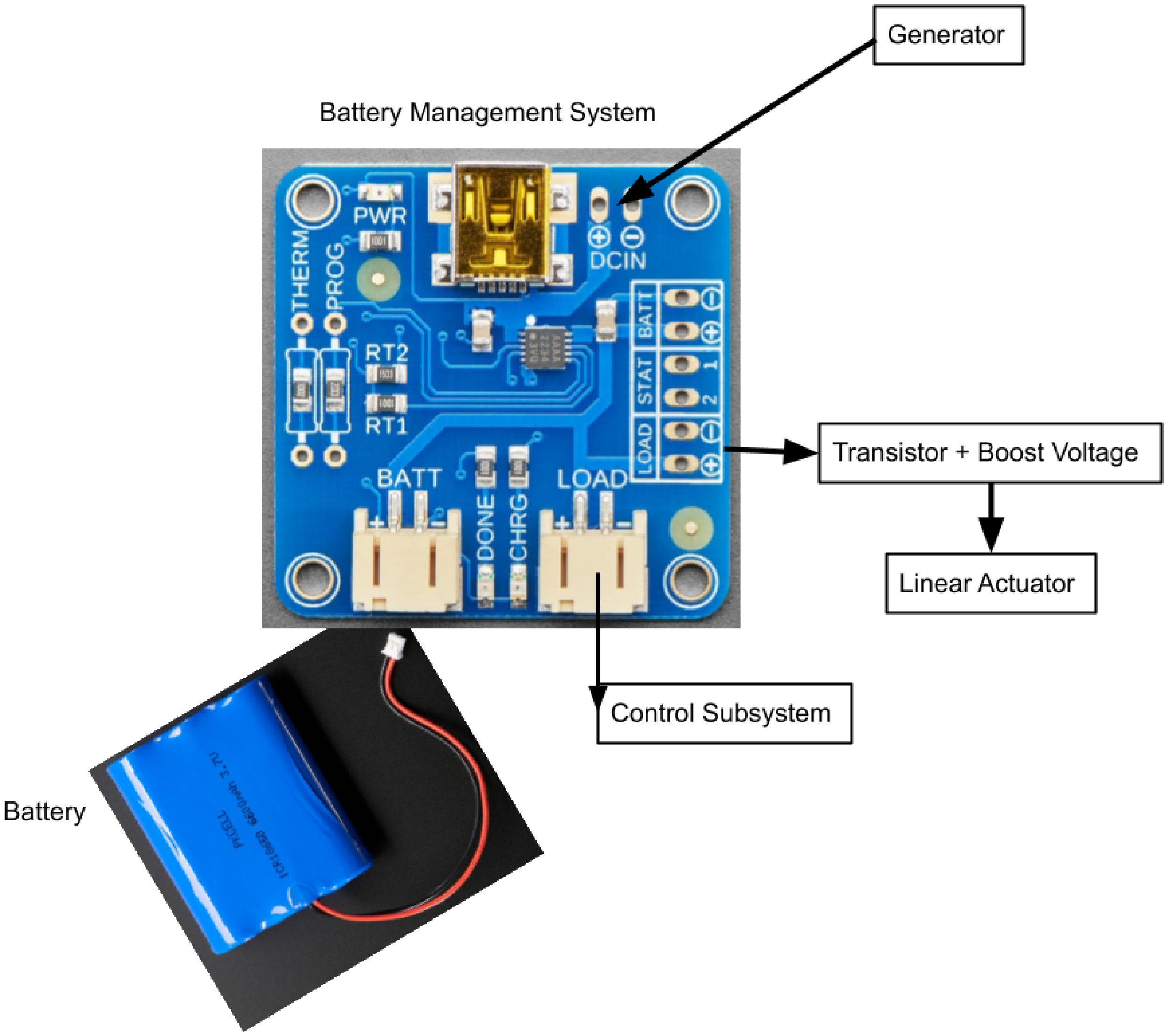


If phone is not within 1 ft of the bluetooth module, the user will need to input a specific combo into the keypad in order to change the status of the lock. This is so that the user will be able to change the status of the lock, even if they forgot or lost their phone.



If phone is within 1 ft of the bluetooth module, the user just needs to touch one of the keypads on the keypad in order to change the status of the lock. The status of the lock does not automatically change with an established bluetooth connection in order to avoid a scenario where the bike locks up mid-use if the user loses their phone while on the bike.

Power and Charging Visual Aid

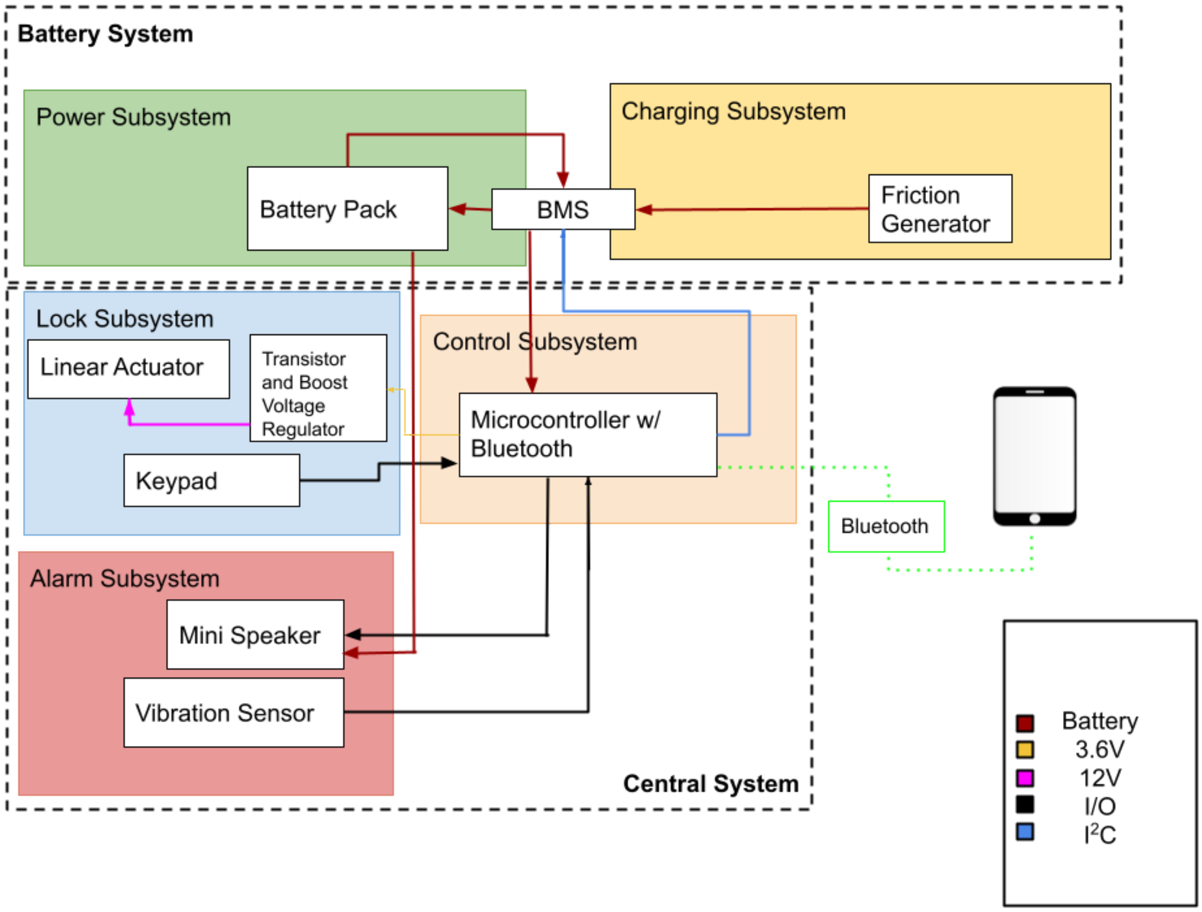


1.5 High-Level Requirements List

- The bluetooth range must be limited to about a 1 meter radius from the device, resulting in the ability to change the state of the device by touching any one of the keys on the keypad.
- The self charging system must be able to generate 6 watt-hours and be able to power the device through multiple trips.
- If there is not an established bluetooth connection to the device, the device's state can be changed by inputting the correct pattern into the keypad.
- When in the locked state, the linear actuator should extend to its full length of 4 inches and prevent the front wheel from spinning, thus preventing someone from stealing the bike.

2. Design

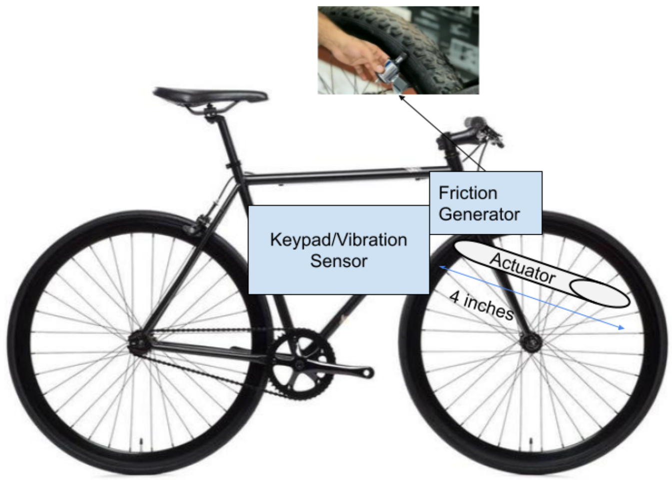
2.1 Block Diagram



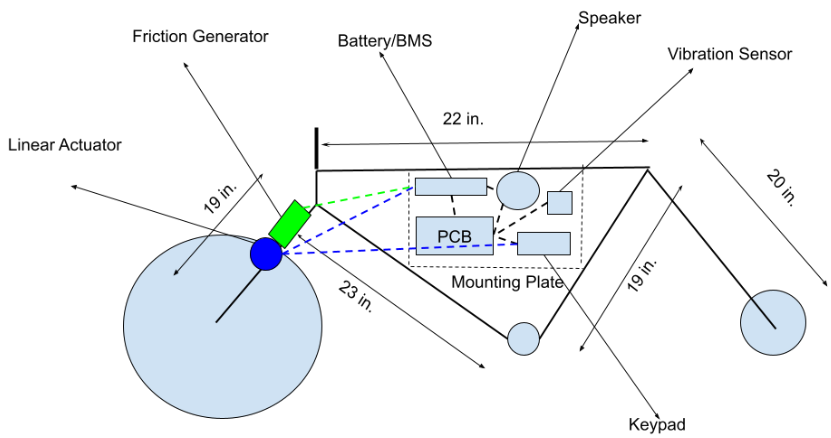
Our device consists of two systems: the battery system and central system. The battery system consists of the power subsystem and the charging subsystem. The power subsystem contains the battery pack, while the charging subsystem contains the friction generator. The two are connected by the battery management system. The central system consists of the alarm subsystem, the lock subsystem, and the control subsystem. The alarm subsystem contains the components used for the alarm, including a mini speaker and a vibration sensor. The lock subsystem houses everything used for the physical locking mechanism, including the linear actuator, keypad, and transistor/boost voltage regulator. The control subsystem includes the microcontroller, which has bluetooth connectivity.

2.2 Physical Design

Overall Physical Design



In-Depth Physical Design



The physical locking mechanism consists of a linear actuator, which is 4 inches in length and located on the front wheel of the bike, and keypad, which will be located in the center of the bike. The vibration sensor, which is used as part of the alarm subsystem and connected to the control subsystem, will be located within the PCB enclosure. The friction generator, which is part of the charging subsystem and connected to the BMS, will be located on the back wheel of the bike.

2.3 Subsystem Overview:

2.3.1 Control Subsystem

The control subsystem contains the microcontroller for our device. We plan on using the STM32WB55RG microcontroller. The STM32WB55RG [11] includes a bluetooth system. If a bluetooth connection from the user's phone to the device is established, a tap on any one of the keys on the keypad is required to unlock the physical subsystem as well as disable the alarm subsystem. If there is no bluetooth connection, then the locking subsystem can still be disabled by a correct sequence into the keypad. The microcontroller. This subsystem controls the overall interactions among all subsystems.

2.3.2 Power Subsystem

Our power subsystem features a rechargeable Lithium ion Battery (3.7V 6600mAh) [3] in parallel that allows us to power the PCB and microcontroller. To ensure that we meet the demands of all of our subsystems and consistent power distribution, we plan on including a USB Lilon/LiPoly charger [4] to ensure no power spikes or drops affect the overall apparatus. Depending on the feedback from the charger, the power system will either be in a state of charging or in a state of discharging

2.3.3 Charging Subsystem

In our charging subsystem, we will use a friction generator. We will attach this friction generator (G.I. Bicycle Steel Dynamo) [10] to the side of the front wheel on our bicycle. As the wheel spins, the friction generator will make contact with the spinning wheel, generating energy that will be used to charge our rechargeable battery pack. We must first pass the generated power to the battery management system (USB Lilon/Lipoly charger). This is done to regulate the voltage before charging the battery pack directly.

2.3.4 Locking Subsystem

The locking subsystem is the first layer of security for our device. It contains a linear actuator, a keypad, and a boost voltage regulator. In case the bluetooth signal is recognized by the microcontroller, the user must press one of the keys on the keypad to unlock or lock the device. This is to ensure no unwanted automatic locking and unlocking.

In the situations where the bluetooth device is unavailable, then the device will require a correct sequence on the keypad. With the correct input sequence, the physical locking subsystem will disengage or engage depending on its previous state. This second level is needed as a user safety device, rather than an anti-theft mechanism. This will address certain edge cases, such as when the bluetooth device is within range but the owner wants to maintain the current lock status and when the user is riding their bike without their bluetooth device.

This subsystem also contains the primary physical component of our system. Consisting of a linear actuator (Mini Linear Actuator B07ZJ46947) [5] that extends through the wheel spokes when the lock is activated, the linear actuator prevents the movement of the wheel the locking apparatus is clamped to. We plan for this subsystem to be attachable to the front wheel through the use of a clamping mechanism that connects to the different cylinders that make up a bicycle.

The linear actuator we are using requires 12 V to power, while our microcontroller operates on a maximum 3.6 V power supply. To ensure that the linear actuator gets the power it needs to operate, we include a boost voltage regulator[12] that will mediate power requirements from the microcontroller to the linear actuator.

2.3.5 Alarm Subsystem

The alarm subsystem acts as the second layer of security for our device. This subsystem consists of a speaker (PUI Audio) [8] that should act to draw attention to the fact that someone is attempting to steal a bike. This subsystem should be activated if the overall system is being tampered with. This includes repeated mistakes in the keypad combination in the case a bluetooth device is not nearby and the vibration sensor detecting large movements like attempting to forcefully close the linear actuator.

2.4 Subsystem Requirements

2.4.1 Control Subsystem:

- STM32WB55RG Microcontroller [11]:
    - In order for the microcontroller to be fully functioning we need to deliver it with a range of 1.7 - 3.6 Volts(V), and output 3.3V in order to fully power all of our components.
    - Max input: 5.2mA, max output/sink to GPIO: 8mA
    - There is a maximum of 1MB Flash Memory for burning.

2.4.2 Power Subsystem:

- Adafruit Lithium Ion Battery (3.7V, 6600mah)[3];
    - This battery pack must supply the microcontroller, which runs at 3.6V and a maximum of 12mA
    - This battery pack charges at a constant 1.5A or less
    - This battery pack can discharge at 3.7V, 6600mAh.
- USB Lilo/LiPoly charger [4]:
    - The fast-charge current is 100 mA, but can be adjusted between 100mA and up to 1000mA

2.4.3 Charging Subsystem:

- GI Bicycle Steel Dynamo Friction Generator [10]:
    - The maximum voltage the generator can deliver to the battery is 12V.
- TI Battery Charger IC [4];
    - This IC accepts a wide input voltage operating range: 4.2 to 70V.
    - With a wide battery voltage operating range: max 70V

- With input regulation of 400mA to 20 Amps(A) Charge current.
- In order to properly power the microcontroller chip, we need to deliver it with 3.6V given it has a range of 1.7 to 3.6V.

2.4.4 Locking Subsystem:

- Mini Electric Linear Actuator [5]:
    - For full functionality we must deliver 12V and a range of 0.1 to 0.2A to the linear actuator.
    - We must be able to measure a stroke of 2 inches from the linear actuator if fully functional.
- Onsemi Boost Voltage Regulator [12]:
    - We use this in order to boost our voltage delivered from our microcontroller (1.7 to 3.6V) to the necessary voltage needed for our linear actuator (12V), we know this is fully working if we are able to deliver 12V and a range of 01 to 0.2A to the linear actuator.
    - Input Voltage Range: 3V to 40V
    - Output Voltage: Adjustable (up to 40V)
    - Output Current: Up to 3A

2.4.5 Alarm Subsystem:

- Grove - Piezo Vibration Sensor [7]:
    - In order to ensure successful operation of the vibration sensor, the operating temperature must be maintained at a range of 0 to 85C.
    - We must code in the ability to distinguish between minimal and therefore inconsequential vibration and the vibration that would occur from attempted thefts or tampering.
- PUI Audio Mini-speaker [8]:
    - In order for the mini speaker to be operational we need to deliver 0.15W of power.
    - It also has an impedance of 8 ohms, making the voltage:~1V and current: 13mA
    -

2.5 Requirements and Verification

Control Subsystem:

Requirements	Verification
• The bluetooth connection must have a reasonable range that must ignore a mobile device until it is within arms reach. Program for 1ft.	• Slowly approach the Control Subsystem from 1 meter away with an already paired bluetooth device and record when the device automatically connects • Slowly back away from the Control Subsystem and record when the connection disconnects

Requirements	Verification
	● Confirm that the record is ~1ft. If not, double check the limit range and consider what may be interfering with the signal
● Ensure microcontroller is receiving 3.3-3.6 V from the battery	● Use a multimeter to measure the voltage at the power input pin of the microcontroller

Power Subsystem:

Requirements	Verification
● Ensure the Power subsystem properly charges when the bike is not in motion	● Use a multimeter to measure the voltage at the power input pin of the microcontroller when the bike is not in motion. It should read some amount of voltage
● Ensure that Power Subsystem does not discharge when the bike is in motion	● Use a multimeter to measure the voltage at the power input of the microcontroller when the bike is in motion. It should not read any significant voltage

Locking Subsystem:

Requirements	Verification
● Ensure that the Boost Voltage Regulator boosts voltage to 12 V for linear actuator	● Use a multimeter to measure the voltage at the power input pin of the linear actuator
● Ensure the keypad works in both the scenario that the bluetooth connection is active and inactive	● Press any of the keys on the keypad when the bluetooth connection is active. The status of the lock should change ● Enter a pattern into the keypad when the bluetooth connection is not active. If the combo matches the set pattern, the lock status should change. Otherwise, the lock status should not change
● Ensure the linear actuator works properly as a physical locking mechanism	● Attempt to roll the bike when the linear actuator is extended. It should not be able to move

Alarm Subsystem:

Requirements	**Verification**
● Ensure that the Alarm Subsystem is able to ignore small and periodic motions that are likely due to wind, bumping, etc.	● Simulate by nudging the bike with little force.
● Ensure that the Alarm Subsystem is able to recognize substantial and continuous vibrations	● Simulate by picking up and carrying the bike away ● Simulate by fidgeting with the components and frame of the bike

2.6 Tolerance Analysis

In our comprehensive subsystem analysis, the foremost risk-prone group of subsystems within our overall system pertains to the power and charging subsystem. This subsystem plays a pivotal role in managing the electrical power supply for our bike lock. Within this subsystem, two key components demand our attention: the rechargeable Lithium Polymer 3.7V 6600mAh battery and the GI Bicycle Steel Dynamo Friction Generator [11]. Our research has yielded specific electrical parameters: the friction generator's capability to deliver 12 Volts (V) and 0.5 Amps (A), and the lithium polymer battery's requirement of a controlled 1.5A charging current. We know that on average a human can generate 100 to 150 watts during a biking session. Through calculation we see that our friction generator can generate:

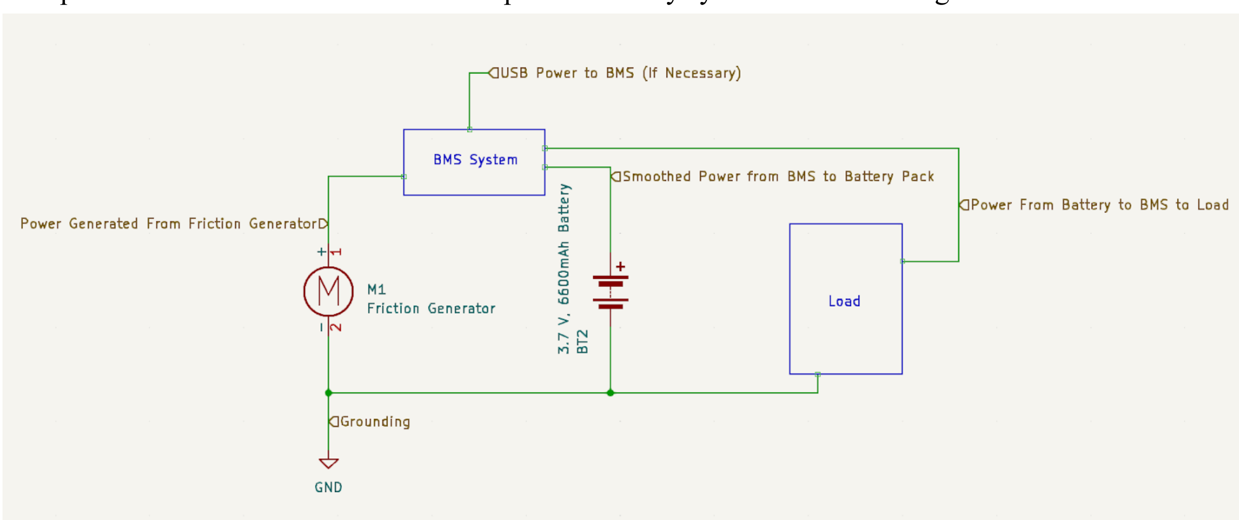
$$P_{friction\ generator} = V_{friction\ generator} * I_{friction\ generator} = 12V * 0.5A = 6\ Watts$$

And our battery can take a maximum power during recharging of:

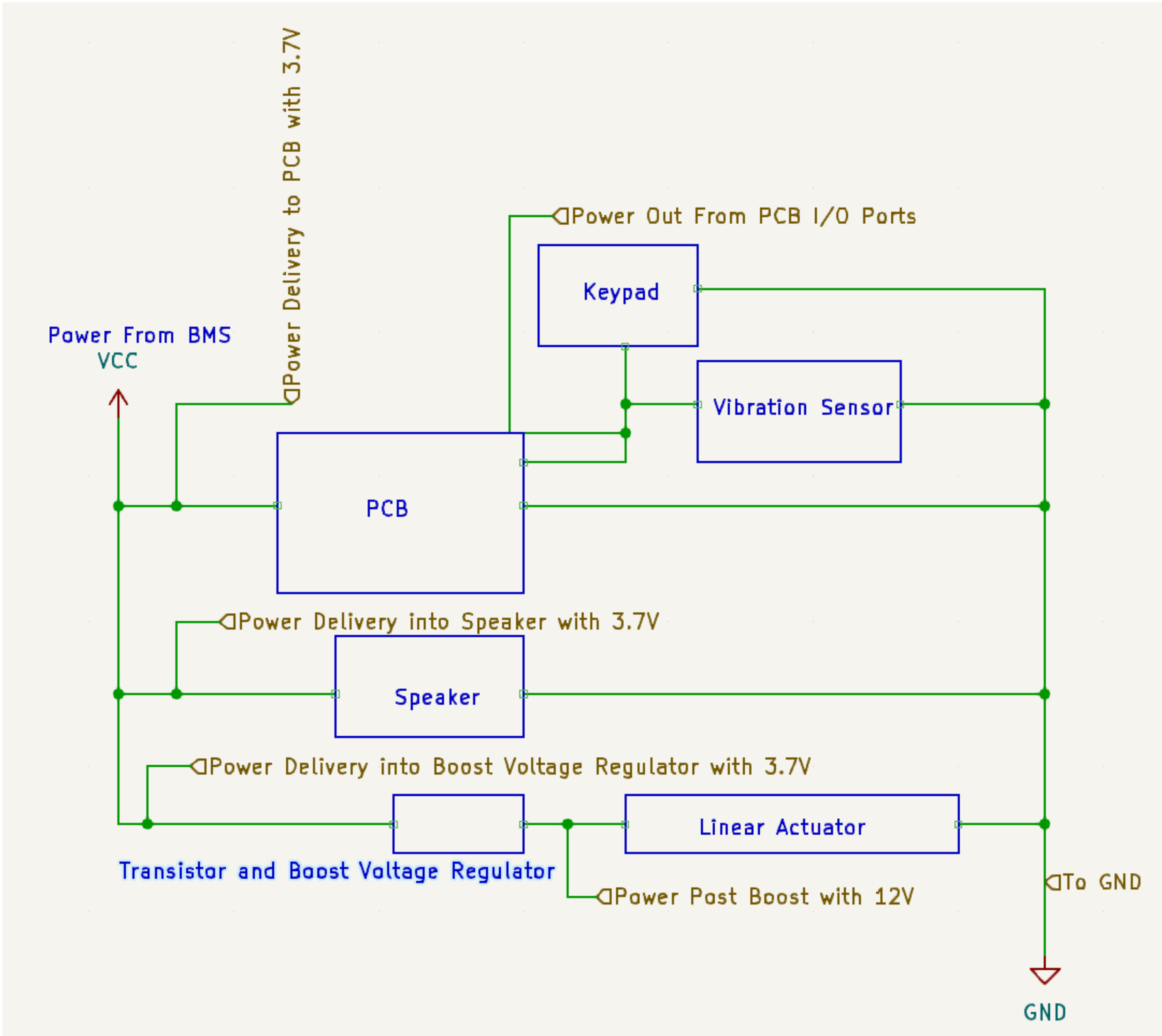
$$P_{battery} = V_{battery} * I_{battery} = 3.7V * 1.5A = 5.55\ Watts$$

With this difference in wattage, we see that we are at risk to overload the battery with power from the generator. To address the risk of overloading the battery with power from the generator, we plan to implement Adafruit's BMS system [4], either through the module itself or integration of the system into our PCB design to ensure consistent and smooth power delivery.

The most critical section of failure in our power subsystem is the power duration of our entire system. Given that we have multiple components connected directly to the battery, including the PCB, linear actuator, and speaker. We need to ensure that we are able to maintain system power for a practical amount of time. Our overall power delivery system is as following:



We must also look within the load black box to see how power is delivered to our separate sensors and further modules:



Through examination of our power delivery method as well as the following formula we can calculate how long our system can be powered:

$$Battery\ Life = \frac{Battery\ Capacity(maH)}{Load\ Current(mA)}$$

First, we know that our chosen battery's capacity is 6600 mAh. We then have to consider how each sensor and module that requires power from the battery interacts with the overall power subsystem. In our current design, we want the linear actuator to only draw current when we need to lock the bike. We also only want the speaker to draw current in the case that an alarm is needed (i.e. someone is attempting to steal or tamper with the bike). As such, we cannot consider the two current draws from the linear actuator (through the Boost Voltage Regulator) and the speaker to be constantly drawn current. We must consider them both instances of Event-Based Current Draw. In order to calculate the effect of Event-Based Current Draw on battery life, we must base the load current draw of these events based on its approximate duty cycle. We find duty cycle through the following equation:

$$Duty\ Cycle = \frac{Time\ On}{(Time\ On + Time\ Off)} * (100) = \%\ Duty\ Cycle$$

Where (Time On + Time Off) is the total amount of time per day in seconds. We have to find the duty cycle for both the speaker and linear actuator. Our linear actuator extends at a rate of 1.97 inches per second for a total of 2.03 seconds of current draw per full extension or full retraction of the 4 inch stroke. On an average day, we say that the system's user will use the bike from their home/apartment to their first location, and then from their first location to their second location, and finally from their second location back to their home/apartment. That accounts for six activation triggers for the linear actuator. Therefore we can calculate the daily duty cycle of the linear actuator as follows:

$$Duty\ Cycle_{Linear Actuator} = \frac{(6 * 2.03\ seconds)}{(86400\ seconds)} * (100) = 0.01042\%$$

We must also complete the calculation for our speaker. We approximate in the case that the alarm sounds one per day, the system will detect abnormal movement from anywhere from 60 to 120 seconds. Let us say that we expect 90 seconds of the speaker drawing current. Therefore we can calculate the duty cycle of the speaker as:

$$Duty\ Cycle_{Speaker} = \frac{(90\ seconds)}{(86400\ seconds)} * (100) = 0.10417\%$$

Now we must calculate the average current draw of both the linear actuator and the speaker, this can be done by multiplying the duty cycle of both components by their respective current draws when they are in use. In use, the linear actuator draws 200 mA, while the speaker draws 13mA of current. Therefore we get the average current draw for both components as:

$$Average\ Current = Duty\ Cycle * Current\ Draw_{active}$$

$$Average\ Current_{LinearActuator} = \frac{0.01042}{100} * 200mA = 0.02819mA$$

$$Average\ Current_{Speaker} = \frac{0.10417}{100} * 13mA = 0.01354mA$$

We then add these two average currents to the only consistent current draw of our system: the PCB which draws 5.2mA. Therefore we can fully calculate the battery life of our system as:

$$Total\ Current\ Draw = Average\ Current_{LinearActuator} + Average\ Current_{Speaker} + Current_{PCB}$$

$$Total\ Current\ Draw = 0.02819mA + 0.01354mA + 5.2mA = 5.24174mA$$

$$Battery\ Life = \frac{6600mAh}{5.24174mA} = 1259.125\ Hours$$

Which gives us approximately 52.5 days of system power per full charge of the battery. This ensures that even if the bike is not charged (not in motion) for nearly two months, we can ensure the locking system is still functioning, therefore addressing the greatest risk of our project.

3. Cost Analysis

Labor Cost

The average salary of a Computer Engineering graduate from the University of Illinois Urbana-Champaign is $109,176 per year as of 2021/2022 [13]. Assuming graduates are working eight hours per day, totaling 40 hours a week, for 52 weeks in a year, we calculate the total amount of hours worked in a year is 2080 hours. Dividing the annual salary by 2080 gives us our per hour cost of $52.49. We find the number of weeks we work on our project by subtracting the total amount of weeks in a semester (16) by the number of weeks it took for our project to be approved (3) and remove fall break. Our result is a total of 12 weeks. We can also assume that each individual will work a total of 12 hours per week on the 445 project. Having acquired all of this data, we can find our per individual labor cost for the project:

$$LaborCost_{individual} = \frac{\$}{hours} * \frac{hours}{Weeks_{number}} * Weeks_{number} = \frac{\$52.47}{1hour} * \frac{12hours}{Weeks_{number}} * 12Weeks_{number} = \$7555.68$$

We then multiply our calculated per individual cost of $7555.68 by 3, and find the total labor cost of this project to be $22667.04 for our three-member team.

Parts Cost

Part	Part Number	Part Description	Quantity	Price per Unit	Total Price
STM32WB55RGV6 Microcontroller	STM32WB55RGV6	Ultra-low-power dual core Arm Cortex-M4 MCU 64 MHz	1	$7.30	$9.17
Adafruit Lithium Ion Battery	ICR18650	Lithium Ion Battery Pack - 3.7V 6600mAh	1	$24.50	$24.50
TI Battery Charger IC	BQ25756	Stand-alone or I²C controlled 70-V bidirectional buck-boost charge controller	1	$2.50	$2.50
GI Bicycle Steel Dynamo Friction Generator	B01CTBILWG	12 Volts Friction Generator with Fitting Clamp	1	$17.99	$17.99
Mini Electric Linear Actuator	B01CTBILWG	Mini Electric Linear Actuator Stroke 4"–Force 4.5 lbs–12V	1	$30.99	$30.99
Onsemi Boost Voltage Regulator	LM317MBDTG	1.2 to 37 V Adjustable Output Voltage Regulator	1	$1.79	$1.79
Grove - Piezo Vibration Sensor	101020031	Suitable for measurements of flexibility, vibration,	1	$6.50	$6.50

		impact and touch.			
Mini-Speaker	AST-03008MR-R	Minispeaker used for alarm system	1	3.01	$1.30
TOTAL					**$103.24**

<u>Total Cost</u>

To find out total cost we add our labor cost and part cost and find that our total cost for our project to be $22,767.80.

4. Schedule

	Week of 9/18	Week of 9/25	Week of 10/02	Week of 10/9	Week of 10/16	Week of 10/23	Week of 10/30	Week of 11/06	Week of 11/13	Week of 11/20	Week of 11/27	Week of 12/04
Complete Design Document	Paul/Jake/Rithik	Paul/Jake/Rithik										
Complete Initial PCB Design in KiCAD		Paul/Jake/Rithik	Paul/Jake/Rithik									
PCB Review			Paul/Jake/Rithik									
Design Review			Paul/Jake/Rithik									
Have Bicycle in hand			Rithik	Rithik								
Begin physical design with Machine Shop			Paul/Jake/Rithik	Paul/Jake/Rithik								
First Round PCB Order				Paul/Jake/Rithik								
Soldering components onto our PCB(s)					Rithik/Paul	Rithik/Paul	Paul/Jake/Rithik	Paul/Jake/Rithik				
Begin coding and testing the PCB					Jake	Jake	Paul/Jake/Rithik	Paul/Jake/Rithik				
Teamwork Evaluation 1				Paul/Jake/Rithik								
Second Round PCB Order					Paul/Jake/Rithik							
Third Round						Paul/J						

PCB Order						ake/Rithik						
Individual Progress Report						Paul/Jake/Rithik						
Assemble our overall prototype								Paul/Jake/Rithik	Paul/Jake/Rithik			
Mock Demo									Paul/Jake/Rithik			
Team Contract Fulfillment									Paul/Jake/Rithik			
Make last changes to our project, assemble prototype for final dem										Paul/Jake/Rithik		
Final Demo											Paul/Jake/Rithik	
Final Presentation												Paul/Jake/Rithik
Lab Checkout												Paul/Jake/Rithik
Lab Notebook Submission												Rithik

5. Safety

The safety considerations within our project can be categorized into three distinct subcategories: mechanical safety, electrical safety, and laboratory safety. Each of these areas poses specific risks that require careful mitigation measures.

1. <u>Mechanical Safety:</u>
   One significant aspect of mechanical safety pertains to the testing phase of our project. The primary concern here is the potential for a malfunctioning locking mechanism to activate while the bicycle is in motion. Such an event could lead to a catastrophic scenario, including a potential collision that could result in injuries to both the rider and nearby pedestrians. To address this risk, we have implemented a two-pronged locking and unlocking procedure. This procedure ensures that changes in the state of the locking mechanism from locked to unlocked, or vice versa, cannot occur while a user is actively riding the bicycle. Another mechanical risk arises from improper installation and fitting of the clamping mechanism onto the bike frame. An insecure attachment could result in the system detaching during use, posing safety hazards to users and pedestrians alike. To mitigate these concerns, we plan to conduct initial testing in an isolated environment with only team members present. After successfully passing multiple trials, we will proceed to test the product in more populated areas.

2. <u>Electrical Safety:</u>
   The primary electrical safety concern revolves around our battery implementation. If the battery is insecurely integrated into our testing prototype (e.g., incomplete soldering, loose wires, poor fit), it could lead to electrical damage to both the prototype and potential harm to users, including the risk of electrical shock. To mitigate these risks, we are committed to ensuring the utmost safety in the wiring of components and overall assembly of our prototype. Our safety protocols include thorough inspections by all three group members and external experts to provide fresh perspectives and comprehensive assessments of safety.

3. <u>Laboratory Safety:</u>
   In a hypothetical market launch, our product is designed to operate without requiring access to laboratory materials, placing the responsibility for laboratory safety squarely on our team. Potential laboratory risks encompass a range of scenarios, from soldering-related hazards such as fume inhalation and burns to mishandling of wiring and power supplies during breadboard testing, leading to sparks and the risk of electrocution. To prevent these risks, our group is committed to strictly adhering to laboratory procedures and safety protocols as instructed during the University of Illinois Urbana-Champaign Lab Safety Course. Additionally, we will not engage in laboratory work without qualified supervision, and we will diligently follow any safety instructions provided by our supervisors.

By systematically addressing safety concerns in these three core areas - mechanical, electrical, and laboratory safety - we aim to ensure the overall safety and reliability of our project throughout its development and potential market deployment.

6. Ethics

As members of Team 18, we pledge our unwavering commitment to upholding the highest standards of ethical and professional conduct throughout the duration of this project, guided by the principles set forth in section 7.8 of the IEEE Code of Ethics [10]. Our foremost priority is to prioritize the safety, well-being, and welfare of the public, particularly during the testing phases of our project. We are dedicated to ensuring transparency in all our testing activities, particularly those that may carry hypothetical risks to the public or the environment.

We are steadfast in our commitment to identifying and addressing conflicts of interest, whether actual or perceived, and will communicate them openly to parties who may be affected. Constructive criticism, grounded in factual observations and supported by available data, will be actively sought, accepted, and acted upon to rectify any errors in our technical work. We recognize the importance of crediting the contributions of others appropriately in recognition of their valuable input.

Our commitment to professional growth is unwavering, and we will continuously enhance our technical competence through ongoing training and learning endeavors. We pledge to undertake technological tasks only when we possess the necessary qualifications to do so competently. Treating all individuals equitably and with respect is a fundamental principle that we hold. We vow to abstain from engaging in any form of harassment or discrimination based on attributes such as race, religion, gender, disability, national origin, sexual orientation, gender identity, or gender expression. We are resolute in our determination to avoid causing harm to others, their property, reputation, or employment through false or malicious actions, including the spread of rumors or any form of verbal or physical abuse.

In embracing these principles, we are dedicated to conducting ourselves with integrity, professionalism, and a deep sense of responsibility to society, our project, and all those we interact with during its execution.

7. Citations

[1] Bikelab. “Bike Theft In Champaign-Urbana”. bikelab.shop. https://bikelab.shop/blog/bike-theft-champaign-urbana#:~:text=Capt.,the%20CU%20area%20ever%20year (Accessed 9/11/23)

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