Blü Security

BluLock Smart Lock

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May 2017

Signatures

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Abstract

Blu Security has developed a smart lock for home doors called the BluLock which can connect to a user's smart phone via Bluetooth. It features three separate modes which allow for easy use of the lock from a mobile device to the user's preference. In this way, the lock provides a flexible way to secure one's home and valuables without the need to worry about whether their door is locked or unlocked. Financial considerations as well as the prototyping process is included in this document.

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A. Summary/Overview

Background

To a homeowner, the home is one of the most important assets in their life. When leaving for a day at work or school, the homeowner should be confident in the security of their home. However, many stress and worry about whether they had forgotten to lock their door. Additionally, many worry about the safety of their valuables and whether they are left susceptible to thieves. Traditional locks cannot provide comfort to worrying homeowners, thus an automatic locking system with additional security measures is needed.

Work Objective Statements

While other smart locks exist, the BluLock is the only lock which can provide the user both security and peace of mind using technology that is widely available and easily accessible through use of a mobile application. In utilizing this technology, automatic locking and unlocking are key features in this product. In this way, BluLock allows for security both at home and in the mind. BluLock provides the user an easily accessible and flexible way to secure their valuables.

Methods

BluLock works in two modes: automatic and remote. Both modes utilize Bluetooth technology, connected to an Arduino Uno microcontroller, allowing the lock to securely connect to the user's phone. In the automatic mode, the BluLock will unlock, provide a time delay to allow the user the pass through the door, and then automatically lock after the user leaves. In the remote mode, the user can remotely lock and unlock the door by providing input to the phone application. Additionally, the BluLock retains the manual locking mechanism for use with a traditional key.

Significance

BluLock separates itself from the competition by allowing for both a remote mode as well as an automatic mode. Most locks currently on the market only have modes reminiscent of either of these options, but not both. Additionally, BluLock allows for the easy switch between its modes, as well as a manual lock using a traditional key.

Conclusions

BluLock is built with the goal of providing a reliable way of automatically securing a user's home while ensuring ease of mind knowing that the unit locks their door each time the user leaves their home unlocked. The BluLock provides flexibility to the user with its two modes as well as traditional locking mechanism. Overall, the BluLock is meant to be a smart lock which can make a homeowner's life more stress-free through automation and providing numerous security measures.

B. Project Description

I. Introduction/Background

In the modern era, the housing market is experiencing a shift towards the rising integration of smart home technology. This smart home technology emcompasses automated lighting, heating and cooling, and security systems. The appeal and demand for smart homes is quickly becoming mainstream; 45% of all Americans either already own some form of smart home technology, or had planned to invest in it by the end of 2016 [Coldwell Banker Real Estate LLC, website]. Blu Security plans to engage in this growing market with BluLock, an automated lock system.

The basis for the necessity of a smart lock system is safety, security, and peace of mind for the consumer. According to a 2016 survey conducted by Liberty Mutual Insurance, 60% of Americans worry about their doors being closed and locked while they are away [Liberty Mutual Insurance, website]. Our goal is to maximally mitigate or eliminate this worry by providing the technology to automatically lock the user's doors, as well as providing the capability to remotely lock or unlock at the user's discretion. The automated locking mechanism will be implemented through our use of Bluetooth technology with connection to our mobile phone application. Since an estimated 60% of Americans are interested in the use of an app to control their locks and doors [Eldorado Insurance Company, Inc., website], there is a large market of consumers that are ready and willing to assimilate the technology we will offer into their lives.

The convenience and accessibility of BluLock's automated locking features are competitive advantages on the market, but the main goal of providing enhanced security for the user's home is considered above all else. According to the FBI's Uniform Crime Reporting Program, 35.5% of burglaries involved unlawful entries, including entry into a home when the door locks are not engaged [FBI, website]. The BluLock will reduce the risk of burglary by ensuring that the door is locked in the first place and stays locked in the event of an attempted break-in.

A top competitor, Schlage, carries smart locks as well; however, all of their Sense Smart Deadbolts are used in conjunction with Apple TVs. Schlage's other locks include the keyless Touch Bump Proof Deadbolt, which does not have automatic locking features and cannot be monitored through use of a smartphone. The Lockey USA Digital Door Lock Mechanical Keyless Deadbolt has no automatic locking features, and is not considered a "smart" product. Kwikset provides deadbolts with automatic locking and remote monitoring, but they also require a touch to the lock to activate, which opens the door for unintentional user activation. The BluLock will address all of these issues and include these features mentioned in one product, proving to be competitive in the smart lock technology market.

II. Business Plan of Project

Business Focus

The BluLock is meant for the homeowner who values the security of their home. It is important that a home is locked when there is no one in it to protect it, which is why the user often worries when they leave. The BluLock is meant to give the homeowner not just physical security of their assets, but also peace of mind. Through reliable automatic locking, the user has no need to worry about the status of their lock and can go throughout their day. While other smart-locks may provide remote *or* automatic locking, many lack the ability to do both, and few retain the traditional locking mechanism. Anti-pick technology adds additional security to the BluLock, a unique aspect in home security. The use of Bluetooth to connect to a user's cellphone makes the BluLock highly accessible to any homeowner, as most people currently own a Bluetooth compatible device.

Market Analysis and Strategy

It is difficult for a startup to gain superiority in a market dominated by established companies such as Kwikset and Schlage. Blu Security aims to turn favor through consumer benefits. The Reno/Tahoe local area is the prime target for Blu Security's initial growth. Blu Security will seek integration into the local environment by supporting local business. Apartment complexes and local hardware stores will be the primary means of product movement. Because intended growth will begin in a concentrated area, Blu Security will personally handle marketing within stores and complexes. Stores will receive packages of advertisements and demonstrations to display while complexes will receive security warnings to place wherever they please. The introduction of new ideas into an established market gives the BluLock a definite lifespan. It is necessary for Blu Security to continue the innovation of BluLock features and/or new products. Being made entirely of engineers, Blu Security should meet little resistance on this front. As long as Blu Security maintains its pursuit of smart safety, an advantage over the current competition will be maintained. Current ideas for enhanced safety include facial recognition as well as upgraded structural integrity. These enhancements expand the client base into industrial environments where the BluLock would previously have been insufficient.

Financial Projections (5 years)

Initial production and marketing of the BluLock will be made possible with the investments of shareholders, loans, and business investors such as the University of Nevada, Reno. After initial production of 100 units, the next stage will rely more on business profit and net cash flow and less on loans and investments. Through approximations have been created to model the five preceding years of Blu Security's financial business model, the estimations will be followed to identify the approaches needed for a successful financial plan.

The net cash flow, describing the difference between Blu Security's inflows and outflows will be negative in the first few months due to the various initial costs that must be accounted for such as purchasing of test equipment, product design and prototyping, and marketing. This is reflected in the following figure detailing the monthly cash flow for the first year of business. A positive net cash flow will allow Blu Security to reinvest in business, pay back shareholders, and settle some of its debts.

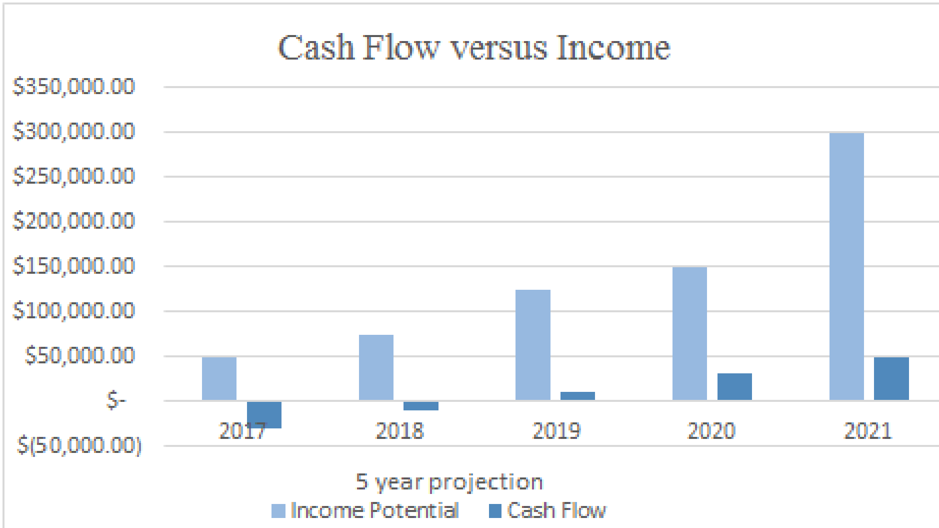

Figure 1: Cash Flow

Table 1, as shown below, details the approximate cash inflows and outflows for the first five fiscal years of business.

Table 1: Cash Flow Approximations

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
<u>Cash Received</u>					
Cash from Operations:					
Cash Sales	$150,000	$370,000	$540,000	$760,000	$950,000

<u>Cash Received</u>					
Sales Tax, VAT, HST/GST Received	$0	$0	$0	$0	$0
New Current Borrowing	$0	$0	$0	$0	$0
New Other Liabilities	$0	$0	$0	$0	$0
New Long-Term Liabilities	$0	$0	$0	$0	$0
Sales of Other Current Assets	$0	$0	$0	$0	$0
<u>New Investment Received</u>					
Subtotal Cash Received	$150,000	$370,000	$540,000	$760,000	$950,000
Expenditures					
<u>Expenditures from Operations</u>					

Cash Spending	$120,000	$260,000	$350,000	$500,000	$650,000
Bill Payments	$5,000	$10,000	$20,000	$35,000	$40,000
Subtotal Spent on Operations	$125,000	$270,000	$370,000	$535,000	$690,000
Net Cash Flow	**$30,000**	**$110,000**	**$190,000**	**$260,000**	**$300,000**

The Balance Sheet, shown in Table 2 reflects and classifies Blu Security's assets and liabilities. Assets and liabilities are detailed in the table to show how each debt and equity is divided and where Blu Security will be losing money and where shares are issued.

Table 2: Balance Sheet

Assets	
Cash	$2,500
Temporary Investments	$10,000
Accounts receivable	$38,000
Inventory	$50,000
Supplies	$5,000

Prepaid Insurance	$2,200
Total Current Assets	$78,000
Property (Land, Building)	$150,000
Other Assets	$0
Total Assets	**$335,000**
Liabilities	
Notes payable	$5,000
Accounts payable	$40,000
Wages payable	$9,000
Interest payable	$3,200
Taxes payable	$5,800
Warranty payable	$1,200
Long-term liabilities	$300,000
Total Liabilities	**$364,200**
Stockholders' Equity	

Common Stock	$160,000
Retained Earnings	$120,000
Accum. Other, comprehensive income	$280,000
Total Liabilities and Stockholders' Equity	**$560,000**

III. Technical Focus: Key Products/Services

Technical Methods

Blu Security intends on improving upon the traditional deadbolt through integration with electronics. While mechanical devices excel in protection against physical forced entry, they are susceptible to the faults of human consciousness and tampering. The BluLock is an embedded system that adds remote control, automatic locking, and tamper resistance features to a mechanical deadbolt lock. The BluLock system is built around an Arduino with a BlueTooth module for distance sensing and remote actuation via phone application. A phone application will utilize BlueTooth technology to provide a means of communication to the Arduino. Tamper resistance is attained through an array of magnetic transducer coils that convert pin movements into a logic signal that controls a secondary lock. The following describes the technical design in greater detail.

Prototypes and System Configuration

Initially, the BluLock was designed with several features in mind which were different from the final product. The preliminary designs involved including the indoor locking mechanism and an anti-pick device above the lock pins. The indoor lock had to be removed in order to allow for the 12V motor to function properly. As stated in the “Future Work” section later on, one possible development to replace this is a button on the box which allows for the motor to turn in order to lock or unlock the door. The anti-pick mechanism would have involved monitoring of the potential in a coil around a magnet and observing it for changes as the pins are moved during lock-picking. This idea was abandoned due to time constraints, but would be a good addition in the future.

Originally, Blu Security planned to create a proprietary phone application for use with the product. However, because the Bluetooth LE module purchased already came with its own phone application, Blu Security decided to use that app instead, serving as a mobile serial monitor for the Arduino code.

Once the code was finished and the motor worked properly, the components were soldered onto a circuit board and affixed to the inside of the aluminum enclosure using velcro tape. The box and bolt were then attached to a door purchased for the purpose of demonstration. The product has been tested, and it has been shown that the finished prototype works properly.

Bluetooth Module

The BluLock automated lock used Bluetooth technology to create a more efficient and secure way of locking the home. The BluLock utilized a Bluetooth LE module that works with the Arduino. The initial plan with the Bluetooth module was the ability to automatically connect and disconnect a user's phone to the Bluetooth module. Unfortunately, since a Bluetooth LE module was incorporated in the design, the user's phone cannot automatically connect. Instead, the automatic mode of the BluLock works only when the user exits their home, which is the most important security feature Blu Security was trying to accomplish. The Bluetooth module also has an incorporated phone application named 'Bluefruit' where several functionality features of the modules can be controlled. This application was used instead of Blu Security creating their own. In future product development, a more user friendly application will be created that easily switches between remote and automatic mode and allows the user to easily lock or unlock their door.

Motor Activation and Polarity

A 12V gear motor provides sufficient force to actuate the deadbolt. The actuation, however, must be controlled. Power should be supplied and removed to move the deadbolt a certain distance. Also, motor polarity needs to reverse to lock and unlock the deadbolt. To accomplish controlled deadbolt movement, a circuit of two DPDT relays is used. The circuit containing the motor and DPDT relays can be seen in Figure 1.

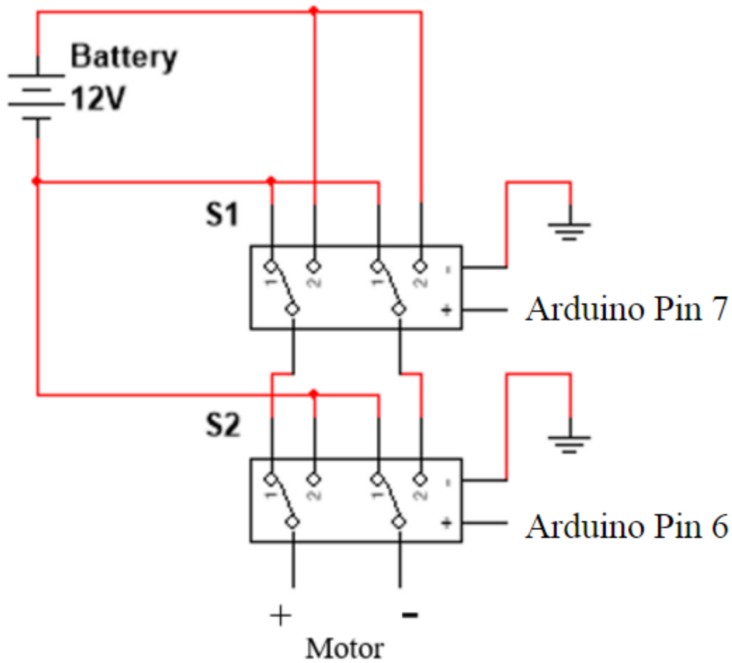

Figure 2: Circuit diagram showing method of switching motor polarity for unlocking/locking deadbolt on the BluLock

In Figure 1, the S1 relay controls the power being supplied to the S2 relay. The normally closed contacts of S1 cause every contact of S2 to grounded. When S1 is switched, 12V is now present at the first normally closed contact and second normally open contact of S2. In the normally closed position, S2 supplies 12V to the positive terminal of the motor and grounds the negative terminal. When S2 is switched, the positive terminal of the motor is grounded and 12V is supplied to the negative terminal. S2, therefore, controls the polarity and direction of the motor. 5V relays are used to allow switch control by Arduino I/O pins. The Arduino code governing the relay circuit is discussed in the following section.

Arduino Code and Phone Application

Instead of creating a proprietary phone application, the Adafruit Bluefruit LE application (available for both Android and iOS) was used. In particular, the application's UART function was used in order to act as a remote serial monitor for the Arduino Uno. Using the Bluetooth LE module on the protoboard, the Arduino was able to connect to the user's phone and the application. The flowchart of the code is shown below in Fig. 2.

First, a variable "r" is initialized to 0. This variable is used for distinguishing between remote and automatic mode (a value of 0 means remote mode is off, a value of 1 is on). The user is presented with a menu for choosing between remote and automatic mode. If the user inputs an "r", variable r is set to 1, and the menu changes for the user, now showing the remote mode menu. The user can now input either "0" or "1" to unlock or lock the door respectively. Arduino Uno first checks the current lock state, in order to prevent an unlocking action if the door is already unlocked, and vice versa for locking. Since r is still set to 1, the program still behaves in remote mode until the user inputs "a", starting automatic mode.

In automatic mode, the Arduino checks the current lock state. If the door is already unlocked, there is a delay of ten seconds to allow for the user to pass through before locking. If the door is locked when automatic mode is set, an unlocking action is performed, followed by a ten second delay and relocking.

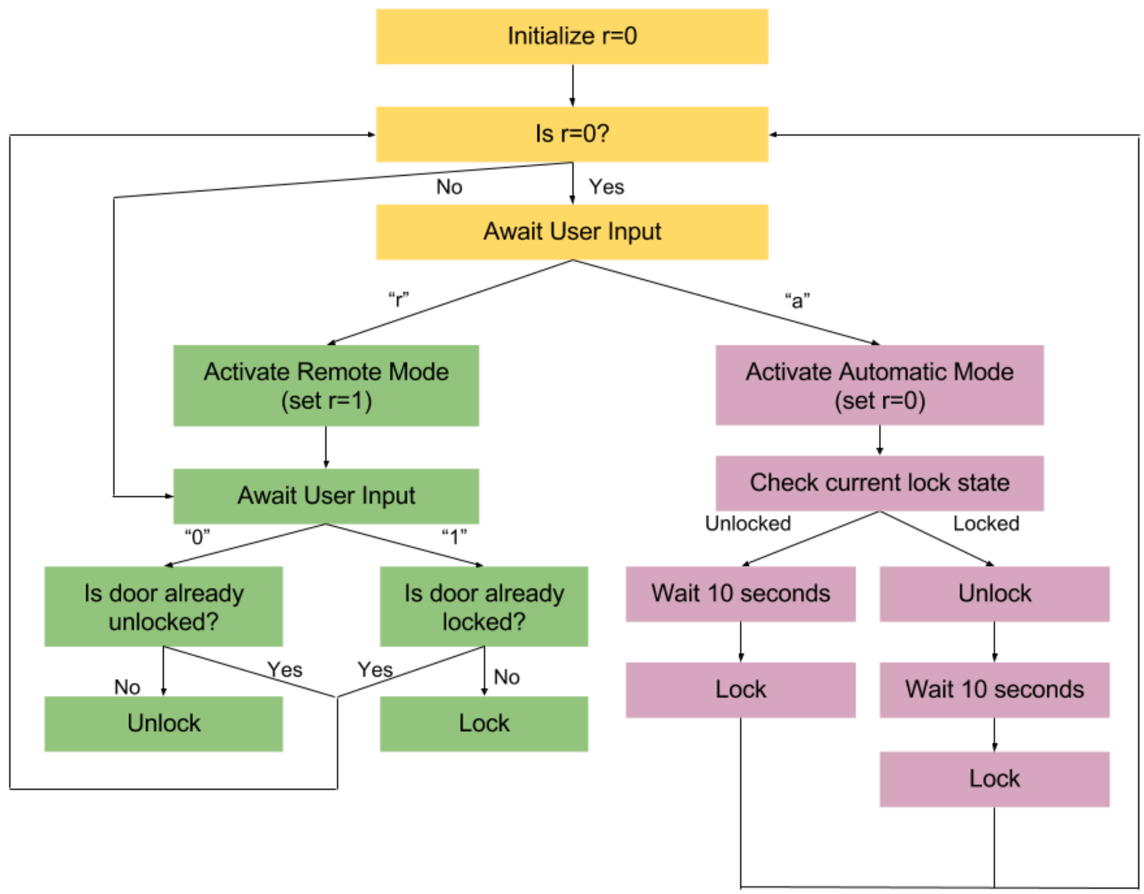

Figure 3: Arduino Code Flow Chart

The Arduino Uno controls the locking and unlocking actions for the lock by setting digital pins 6 and 7 to high or low. These pins are connected to two relays (this mechanism has been explained earlier in Fig. 1). By setting Pin 6 and Pin 7 both to high, the motor spins clockwise. Since the lock is located on the left side of the inside of the door, this constitutes an unlocking action. The motor spins for 300 milliseconds before both pins are once again set to low, stopping the motor. In order to reverse polarity to the motor and make it spin counter-clockwise, the Arduino sets pin

6 to high while leaving pin 7 set to low, constituting a locking action. Once again, the motor spins for only 300 milliseconds before stopping, with both pins set to low.

Power Source and Aluminum Enclosure

Actuating a deadbolt requires a significant amount of torque. The torque is supplied by a gear motor, a motor fitted to a gearbox. Gear motors of two different voltages are ordered: one 9V, and one 12V. An attempt has been made to fabricate the lock with the lower power motor, but the 12V motor was finally implemented due to insufficient torque with the 9V option. The 12V gear motor requires a larger rechargeable NiMH battery. The deadbolt, motor, power source, and Arduino can be seen in Figure 4 below.

It is necessary to fit the design into an enclosure to conceal inner parts and protect the circuit. The enclosure is made of aluminum to provide protection while being soft enough of a metal to drill through and/or cut. The estimated size of the design is 2 in. x 4 in. x 6 in so the enclosure purchased exceeds each of those dimensions by about a half inch. A 3 in. x 5 in. x 7 in. enclosure has been purchased as well to fit the needs of a possibly larger future design. The limitations of the project, to be discussed in a later section, necessitate preemptive thought.

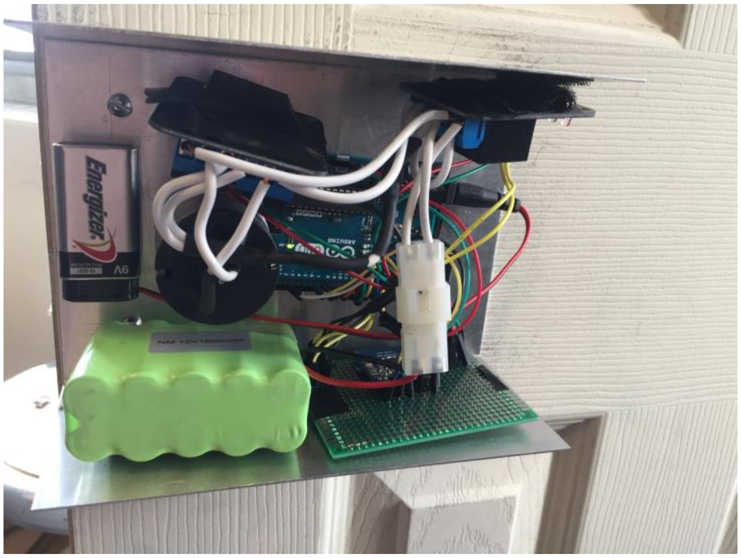

Figure 4: Inside of aluminum enclosure mounted on door

Figure 5: Outside of aluminum enclosure mounted on door with Blu Security logo

Cost and Budget

Blu Security was given a $600 budget by the University of Nevada, Reno. The team developed a budget that included the materials needed for prototyping, testing, and possible failures. The team was successful in keeping to budget and was able to create a working prototype for innovation day. The parts ordered were those shown in Table 1, creating a total cost of $219.22. In future endeavors, Blu Security hopes to buy the needed components and parts in bulk, reducing the production cost of each item to approximately $150. Since Blu Security will be selling each BluLock unit for $200, this assumes a profit of $50 per unit sold.

Table 3: List of parts required for prototyping of the BluLock

Part	***Vendor***	***Quantity***	***Price per unit***	***Total Price***
Arduino Uno	*Adafruit*	*1*	*$24.95*	*$24.95*
Bluetooth Module	*Adafruit*	*1*	*$19.95*	*$19.95*
Deadbolt I	*Home Depot*	*1*	*$17.50*	*$17.50*
9V Battery	*Home Depot*	*1*	*$9.93*	*$9.93*
12V DC Gearmotor	*Robot Shop*	*1*	*$14.61*	*$14.61*
Rechargeable 12V Battery	*Robot Shop*	*1*	*$29.95*	*$29.95*

12V Battery Charger	*Robot Shop*	*1*	*$21.95*	*$21.95*
Metal Enclosure I	*Digi-Key*	*2*	*$13.10*	*$26.20*
Jumper Wires	*Robot Shop*	*2*	*$3.95*	*$7.90*
Velcro	*Home Depot*	*1*	*$9.47*	*$9.47*
Copper Wire 18	*Home Depot*	*1*	*$4.98*	*$4.98*
Proto-board	*Jameco*	*1*	*$5.95*	*$5.95*
DBDT Relay Board	*Mouser*	*2*	*$9.99*	*$19.98*
Vinyl Sticker	*DLM*	*2*	*$2.95*	*$5.90*
			TOTAL	*$219.22*

Financial Assumptions

In order to make proper estimations, a few financial assumptions must be made. A few important assumptions are as follows:

- Blu Security assumes a positive trend in company growth once the product is available on the market.
- There will be no advancements in smart lock technology during the preliminary five years of business.
- There will be no incident or failures in which a large sum of money must be allocated.

- There will be access to sufficient funding to follow the assumed models and tables. All money assumed will be secured.
- As production costs decrease, profit increases, thus improving profit margins

Future Work

When presenting the BluLock for product evaluation, a potential problem was discovered. If the door is not properly closed, the Arduino program will continue to operate and possibly cause the motor to force the deadbolt into the door frame. The opposing force could potentially result in mechanical damage to the motor. To fix the issue, Blu Security plans on implementing an alignment sensor to ensure the deadbolt is properly aligned with the receptacle before locking the door. An ultrasonic distance sensor will be installed above the deadbolt on the door. A 30 mm hole will be cut directly above the receptacle and aligned with the ultrasonic sensor. The front view of the design can be seen in Figure 5.

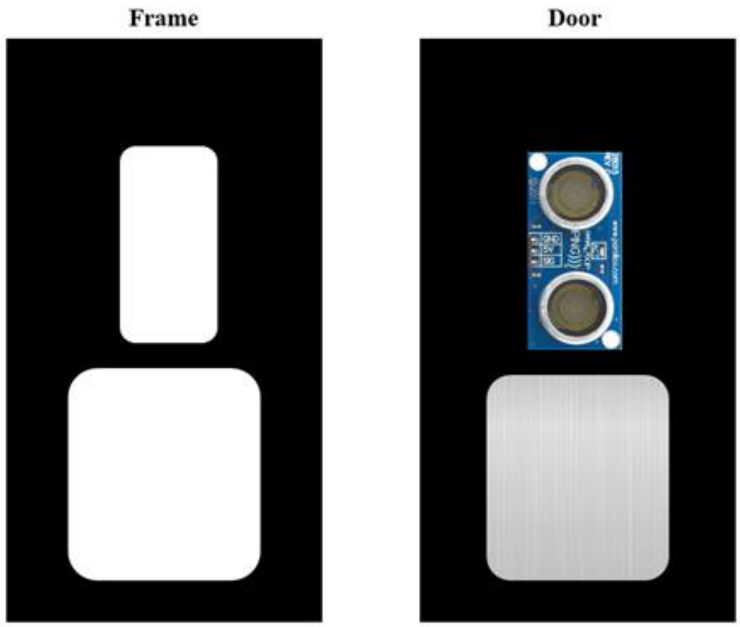

Figure 6: The front view of the door frame shows the deadbolt receptacle and location of the hole to be cut. The front view of the door shows the deadbolt and the ultrasonic sensor to show how they will be aligned.

A standard household door has 5mm of space between the door and the frame. The sensor will ignore the 5 mm distance reading and wait for a 30 mm distance reading before allowing normal BluLock function. Figure 6 clarifies the concept with an illustration of the view from above.

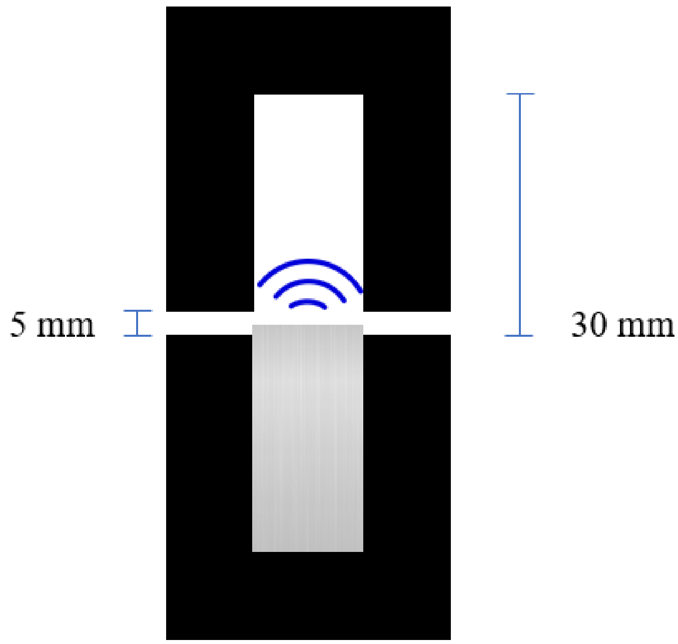

Figure 7: The top view of the door shows how alignment will be sensed by a distance sensor.

The addition of the alignment sensor also prevents automatic mode from engaging the lock while the door is being held open for longer than ten seconds. Distances considerably larger than 30 mm will be ignored.

Currently, the Bluetooth signal from the BluLock is open to any device searching for Bluetooth LE. A priority for Blu Security is adding a passkey requirement for connecting to the lock. The purpose of the BluLock is enhanced security, so the company will work to ensure the most secure connection requirements.

Another part of the future work to be performed by Blu Security is the development of a phone application. For development and demonstration purposes, a third party application was used for the BluLock. The third party app was able to execute all the tasks desired, but the aesthetics and user friendliness were drawbacks. An app with buttons instead of text input will be created to allow for a more user friendly interface. The app will also be created to allow the user to input and change the passkey for the Bluetooth signal.

The BluLock housing will also be improved upon. Future work includes adding an LCD screen to the outside of the housing to display the battery life of the lock as well as the connectivity status. An indoor button, as stated earlier, would provide for manual locking from inside the house, in order to give the user more flexibility for how they use the product. As more units are made, Blu Security will also begin to offer choices in the color and finish of the housing. Alternatives to metal or different metal looks will be available to consumers.

IV. Management and Team Profile

The structure of Blu Security is currently minimalistic to minimize costs. All work is done internally by the five management personnel with tasks being divided as equally as possible. Outside personnel are only used for occasional consultation. As the company develops, the management team will look at hiring more employees. Production will soon outpace what the current team is able to support, so more people will need to be brought on to meet those needs. Once the company is steadily producing and selling products, extra employees may also be needed to assist with some of the business aspects of the company such as a more experienced financial professional. More design and research and development personnel may also be required further down the line as Blu Security looks into creating new products. The Blu Security team will need to steadily grow to meet the needs of the growing company.

Blu Security consists of five key personnel. Kaitlyn McNerney is the Chief Executive Officer of the company. She is currently working on her Bachelor's of Science in Electrical Engineering with a Mathematics minor at the University of Nevada, Reno where she will graduate in May 2017. She has management experience from her work at NV Energy in the Major Projects department as well as from her leadership roles in the professional engineering fraternity of Theta Tau.

Garrett Hagen is the Vice President and also working on obtaining his B.S. in Electrical Engineering at the University of Nevada, Reno. He has engineering experience form an internship at Spectronix which makes him a strong technical team member. He also has hands-on experience with hardware and tools.

Baofan Pacheco is the Chief Operations Officer and will complete her B.S. in Electrical Engineering with a Mathematics minor in May 2017. She has experience in working with and leading peers to complete successful projects through organizations such Kappa Phi Lambda, the Society of Women Engineers, and the Rocketry Club.

Delian Delev is the Chief Technology Officer of Blu Security. He has experience working on engineering projects from his internship at Southwest Gas. His work in labs and in his coursework gives him a strong background in skills like programming and troubleshooting. He will graduate in May 2017 from the University of Nevada, Reno with a Bachelor’s in Electrical Engineering and a Mathematics Minor.

Gabriella Kobany is the Chief Financial Officer and has extensive experience with money management. She is the treasurer of IEEE and has held leadership positions in other organizations that require her to maintain financial records and work with a budget. She will also graduate in May with her Electrical Engineering degree and Mathematics Minor.

V. Summary and Conclusions

Home security is a major concern for every homeowner. Break-ins can occur due to things as simple as forgetting to lock the door or from burglars forcing entry. The BluLock has been created to provide homeowners a solution to some of their security concerns with a lock that is safe, versatile, and convenient. Due to the extra safety features and the ability to operate the lock in a number of ways, the BluLock has a competitive edge in the smart lock market. Where other locks focus on automatic unlocking, BluLock also features the ability to lock itself when the user leaves. Overall, the BluLock combines security and ease of use into one product.

Extensive planning and designation of key personnel have ensured that the development of the BluLock has gone smoothly and according to schedule. Deadlines have been created and goals have been reached in order to keep the project moving along. A comprehensive plan for the design, build, and testing of the BluLock has enabled the successful completion of a quality product.

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D. Facilities, Equipment, & Other Resources

The main portion of the development and testing of the BluLock was completed in the Electrical Engineering Senior Capstone Lab, SEM 341. The lab includes lab benches with enough space to create and test the product and are covered with ESD mats for protection from damage caused by static charges. The capstone lab includes testing equipment that will be helpful for the project including a bench power supply, oscilloscope, and multimeter. The bench power supply was effective in replacing the need for a 9V battery powering the motor. This prevented the need to continuously replace batteries. The multimeter was utilized for both component measurements and for ensuring that power was being distributed correctly throughout the design. The computers in the capstone lab were used for research, to take notes of the testing efforts, and most importantly to launch the Arduino IDE which was used to program the smart technology of the BluLock. Additional facilities utilized were the IEEE lounge which has testing equipment available and a big open space, and the Delamare library which were used for team meetings, progress discussions, and research.

The Department of Electrical and Biomedical Engineering includes several qualified and helpful professors that were contacted with many questions the Blu Security team has during the completion of this project. Also, Dr. Shen, the professor of the Capstone class, and Abhijaat Sidher, the teaching assistant for the Capstone class, were contacted for questions relating to our project. Tony Piazza, the associate engineer of the department was helpful in ordering the necessary parts for the project and ensuring that the team remained under the $600 budget. With these contacts, the Blu Security team was able have the resources and help needed to ensure the project's completion and success.

E. Special Info & Supplementary Documentation

APPENDIX A: ARDUINO SCHEMATIC

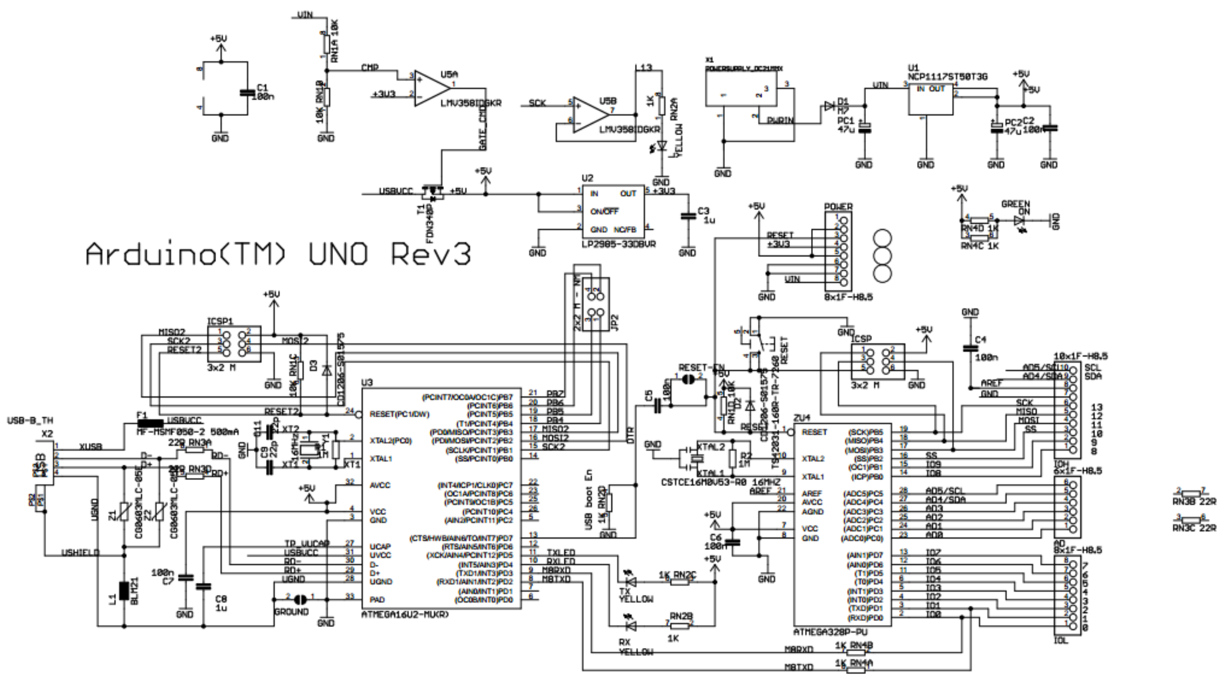

Fig. 1: Arduino Uno Schematic

Figure retrieved from

https://www.arduino.cc/en/uploads/Main/Arduino_Uno_Rev3-schematic.pdf

APPENDIX B: BLUETOOTH MODULE PINOUT

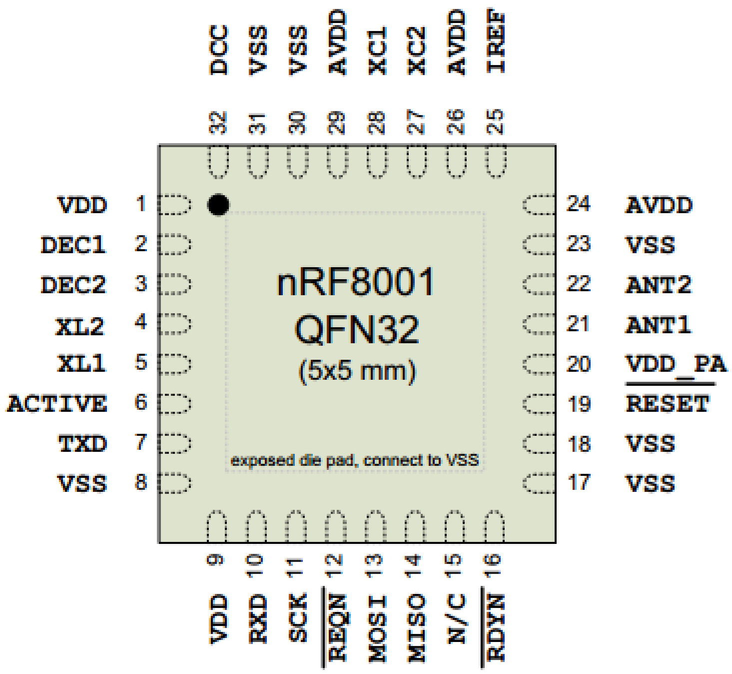

Fig. 1: BlueTooth Module Assignment

Pin	Pin name	Pin function	Description
1	VDD	Power	Power supply (1.9 – 3.6 V)
2	DEC1	Power	Regulated power supply output for decoupling purposes only. Connect 100 nF capacitor to ground
3	DEC2	Power	Regulated power supply output for decoupling purposes only. Connect 33 nF capacitor to ground
4	XL2	Analog output	Connect to 32.768 kHz crystal oscillator. If internal RC oscillator is enabled, this pin shall not be connected.
5	XL1	Analog input	Connect to 32.768 kHz crystal oscillator or external 32.768 kHz clock reference. If internal RC oscillator is enabled, this pin shall not be connected. If using a digital clock, this pin must be defined when entering sleep mode.
6	ACTIVE	Digital output	Device RF front end activity indicator
7	TXD	Digital output	UART (transmit) for *Bluetooth* low energy Direct Test Mode Interface. Leave unconnected if not in use.
8	VSS	Power	Ground (0 V)
9	VDD	Power	Power supply (1.9 – 3.6 V)
10	RXD	Digital input	UART (receive) for *Bluetooth* low energy Direct Test Mode Interface. Leave unconnected if not in use.
11	SCK	Digital input	ACI clock input. Must be high or low and not floating.
12	REQN	Digital input	ACI request pin (handshaking, active low). Must be high or low and not floating.
13	MOSI	Digital input	ACI Master Out Slave In. Must be high or low and not floating.
14	MISO	Digital output	ACI Master In Slave Out
15	N/C	Digital input	Not connected
16	RDYN	Digital output	ACI device ready indication (handshaking, active low)
17	VSS	Power	Ground (0 V)
18	VSS	Power	Ground (0 V)
19	RESET	Digital input	Reset (active low)
20	VDD_PA	Power output	Regulated power supply output for on-chip RF Power amplifier
21	ANT1	RF	Differential antenna connection (TX and RX)
22	ANT2	RF	Differential antenna connection (TX and RX)
23	VSS	Power	Ground (0 V)
24	AVDD	Power	Analog power supply (1.9 – 3.6 V DC)
25	IREF	Analog output	Current reference terminal. Connect a 22 kΩ 1% resistor to ground
26	AVDD	Power	Analog power Supply (1.9 – 3.6 V)
27	XC2	Analog output	Connection for 16 MHz crystal oscillator. Leave unconnected if not in use.
28	XC1	Analog input	Connection for 16 MHz crystal or external 16 MHz reference
29	AVDD	Power	Analog power supply (1.9 – 3.6 V DC)
30	VSS	Power	Ground (0 V)
31	VSS	Power	Ground (0 V)
32	DCC	Power	Pulse Width Modulated (PWM) driver for the external LC filter if the DC/DC converter is enabled. If the DC/DC converter is disabled this pin shall be not connected.
Exposed die pad	VSS	Power	Ground (0 V)

Fig. 2: BlueTooth Pin Functions

Figures retrieved from

http://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF8001

APPENDIX C: BLUETOOTH MODULE DATASHEET

Symbol	Parameter (condition)	Test level	Min	Nom	Max	Unit
V_{IH}	Input high voltage	I	0.7×VDD		VDD	V
V_{IL}	Input low voltage	I	VSS		0.3×VDD	V
V_{OH}	Output high voltage (I_{OH} = -0.5 mA[1])	II	VDD-0.3			V
V_{OL}	Output low voltage (I_{OL} = 0.5 mA[2])	II			0.3	V
I_{OH}	Output high level current [1] (VDD ≥ V_{OH} ≥ VDD -0.3 V)	II	-0.5		0	mA
I_{OL}	Output low level current [2] (0.3 V ≥ V_{OL} ≥ VSS)	II	0		0.5	mA

Fig. 1: BlueTooth Module Electrical Characteristics

Symbol	Parameter (condition)	Test level	Notes	Min	Nom	Max	Unit
f_{OP}	Frequency operating range	I		2402		2480	MHz
f_{XTAL}	Crystal frequency	I			16		MHz
Δf	Frequency deviation	I			250		kHz
R_{GFSK}	On air data rate	I			1		Mbps
PLL_{RES}	RF channel spacing	I			2		MHz

Fig. 2: BlueTooth Module Radio Characteristics

Figures retrieved from

http://www.nordicsemi.com/eng/Products/Bluetooth-low-energy/nRF8001

APPENDIX D: 12V MOTOR DATASHEET

Order Option							
Order Code	Input Voltage	Rated		Weight (g)	Power (w)	Diameter (mm)	L (mm)
		Speed (RPM)	Torque (mN.m)				
SPG10-30K	6	440	29.4	10	-	12	24
SPG10-150K	6	85	107.9	10	-	12	24
SPG10-298K	6	45	176.5	10	-	12	24
SPG20-50K	12	130	58.8	60	0.6	27.2	-
SPG30-20K	12	185	78.4	160	1.1	37	22
SPG30-30K	12	103	127.4	160	1.1	37	22
SPG30-60K	12	58	254.8	160	1.1	37	25
SPG30-150K	12	26	588	160	1.1	37	27
SPG30-200K	12	17	784	160	1.1	37	27
SPG30-300K	12	12	1176	160	1.1	37	27
SPG50-20K	12	170	196	300	3.4	37	23
SPG50-60K	12	56	588	300	3.4	37	26
SPG50-100K	12	34	980	300	3.4	37	26
SPG50-180K	12	17	1960	300	3.4	37	28

Fig. 1: 12V Motor Datasheet

Figure retrieved from

http://www.robotshop.com/media/files/pdf/specification-mo-spg-30-60k.pdf