User Specific Firearm Locking System
Design Review

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Table of Contents

1. Introduction
   1.1 Statement of Interest.. 2
   1.2 Objectives.. 2
   1.3 Benefits... 2
   1.4 Features... 2
2. Block Diagram and Descriptions
   2.1 Block Diagram... 3
   2.2 Block Descriptions... 3
   2.3 Schematics.. 5
   2.4 Flowcharts... 8
   2.5 Calculations…………………..11
3. Requirements and Verification
   3.1 Control Unit Requirements and Verifications...................... ……. 11
   3.2 Firearm Unit Requirements and Verifications.............................. 15
   3.3 Tolerance Analysis.. 17
4. Ethics
   4.1 Discussion of Ethics.. 18
5. Cost Analysis and Schedule
   5.1 Cost Analysis.. 18
   5.2 Schedule.. 19
6. Citations
   6.1 Citations…………………………………………………….. 21

1. Introduction

1.1 Statement of Interest

This project was created to increase gun safety by preventing unauthorized use of a firearm. Instead of requiring a bulky and expensive gun safe to restrict access to a weapon, our system creates a portable and user friendly way to allow gun owners to have control over the firearm's operators.

1.2 Objectives

The goal of this project is to increase firearm safety by creating a simple and portable system that allows only authorized persons to unlock the firearm. This system is not intended to stop the theft of firearms; rather it helps prevent the accidental firing of the weapon. While in lockdown, the trigger cannot be pulled and the magazine cannot be removed. The authorization is performed via a fingerprint scanner on the control unit which is separate from the firearm. The control unit wirelessly transmits a signal to the firearm unit which physically puts the firearm into the locked or unlocked state.

1.3 Benefits

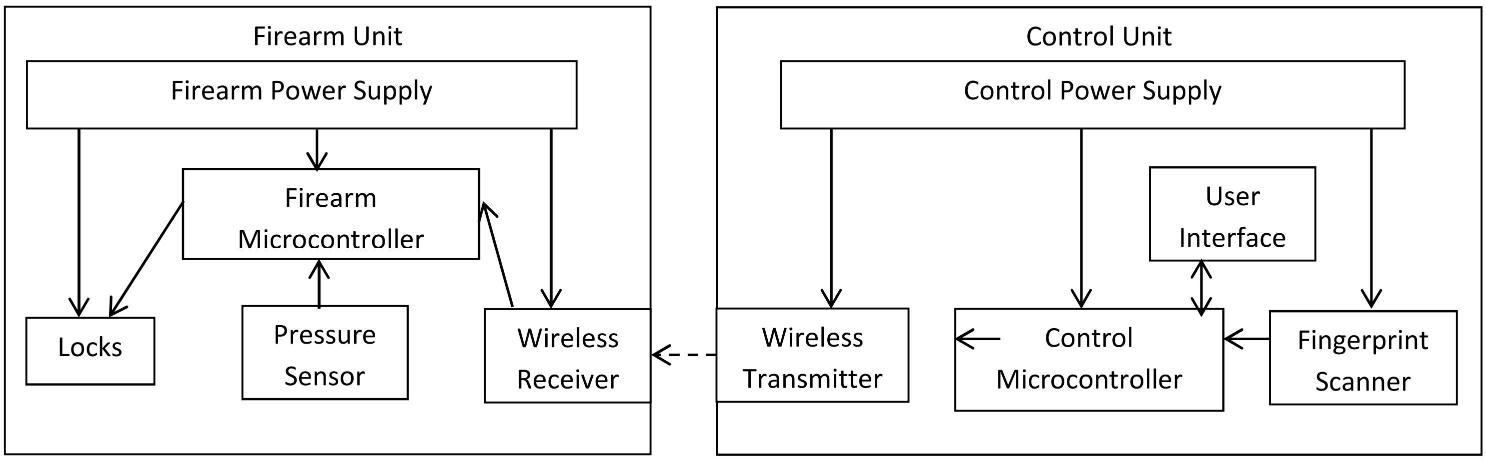
- Access to a weapon by authorized personnel only
- Additional weapon lock for increased safety
- Ease of mobility compared to traditional gun safe
- No combinations or passwords to remember
- Increased security via fingerprint identification system

1.4 Features

- Keypad and LCD screen for simple user interface
- Wireless ability throughout the home
- Multiple user fingerprints accepted
- Fingerprint/user management system
- Automated locking for trigger and magazine
- Pressure or time unlock options

2. Block Diagram and Descriptions

2.1 Block Diagram



2.2 Block Descriptions

Fingerprint Scanner:

This is the main security measure for the project and will be on the control unit which is separate from the firearm. It utilizes a fingerprint scanner to record and compare fingerprints from users. It will output unique ID codes to the control microcontroller and the management of fingerprint storage within the device will be managed by general I/O commands from the control microcontroller.

User Interface:

Composed of a keypad and LCD display, the user interface accepts prompt-based inputs from the user for the time unlock and fingerprint management options. Prompts will be displayed on the LCD screen (controlled by the microcontroller serially in the control unit). The user will respond to the prompts by entering commands on the keypad which will provide inputs to the microcontroller via general I/O pins. The main option menus will include a fingerprint management menu and an unlock timer menu.

Control Power Supply:

This uses batteries to output a constant 3.3 volts to the microcontroller, user interface, fingerprint scanner, and wireless transmitter which are located in the control unit. Simple voltage regulator chips will be used to increase or decrease voltage to the peripherals as needed.

Control Microcontroller:

This microcontroller is in charge of communicating with all of the devices on the control unit via general I/O pins and serial communication. It manages the fingerprint security data, commands the LCD display, and processes user inputs from the keypad while also running the program that generates the locking and unlocking signals to be sent serially over a wireless channel via the transmitter.

Wireless Transmitter and Receiver:

The wireless unit relays the decisions made in the control unit's microcontroller to the microcontroller on the firearm. Via serially transmitted data, the wireless unit enables the separation of the control unit and firearm unit. It consists of a transmitter in the control unit and a receiver in the firearm unit.

Pressure Sensor:

The pressure sensor is used to determine when a person is holding the firearm in order to implement the pressure unlock feature. As long as the pressure sensor is depressed, the gun will stay unlocked no matter how long the user set the timer for. The pressure sensor only interfaces with the firearm's microcontroller via an analog signal declaring if the user is holding the firearm.

Locks:

The locks receive electrical signals that have been processed through the entire system and mechanically put the firearm into the proper state. The locking system interfaces with the firearm's power supply and microcontroller. The digital signal sent by the microcontroller will control the state of the locking mechanisms.

Firearm Power Supply:

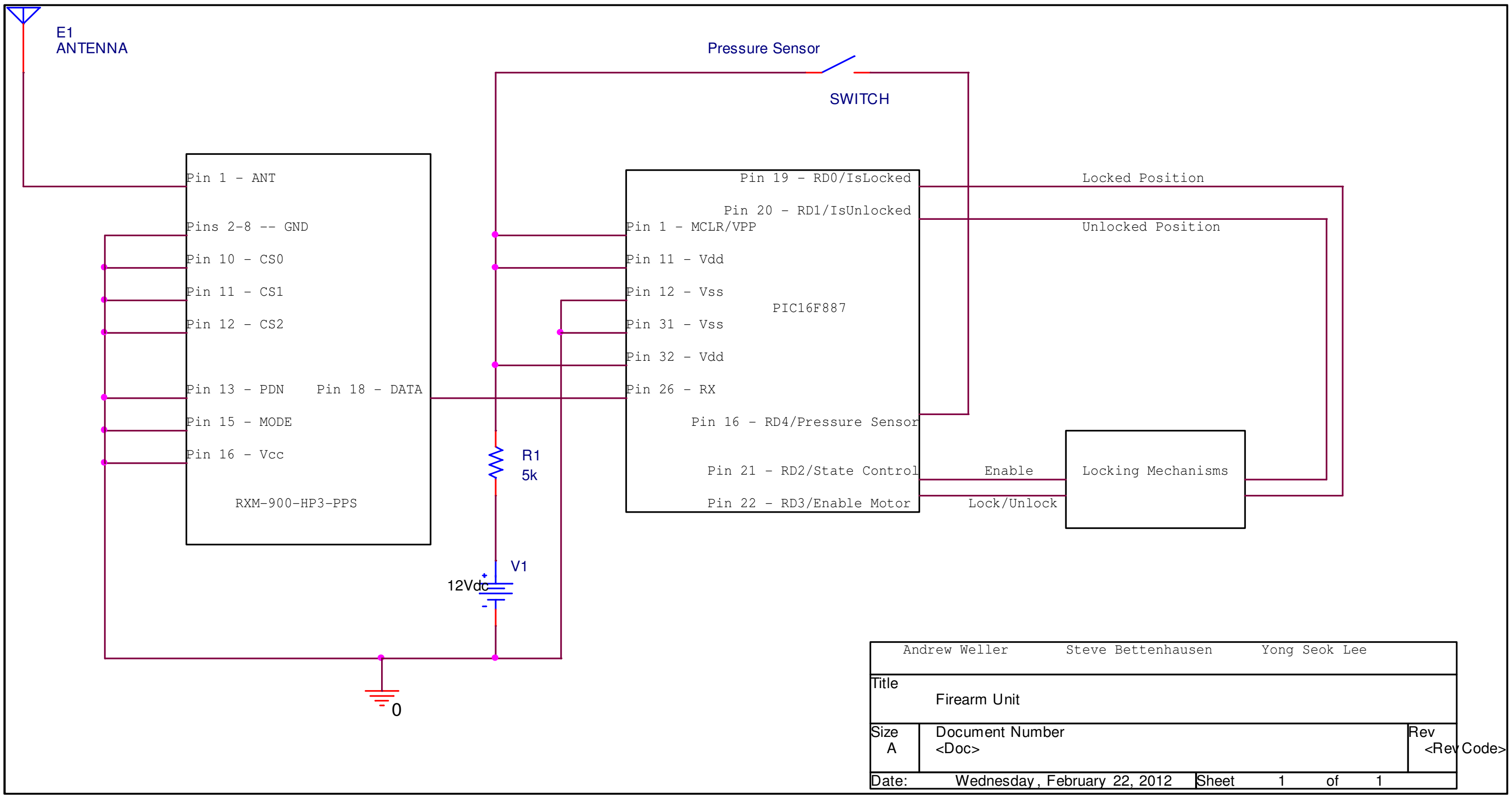
The supply uses a battery pack to provide the necessary power for the implementation and proper functionality of the mechanical locks, firearm microcontroller, and wireless receiver systems housed on the firearm.

Firearm Microcontroller:

This microcontroller accepts the locking and unlocking signals from the wireless receiver, monitors the signal from the pressure sensor, and controls the locking mechanisms.

2.3 Schematics

Firearm Unit:



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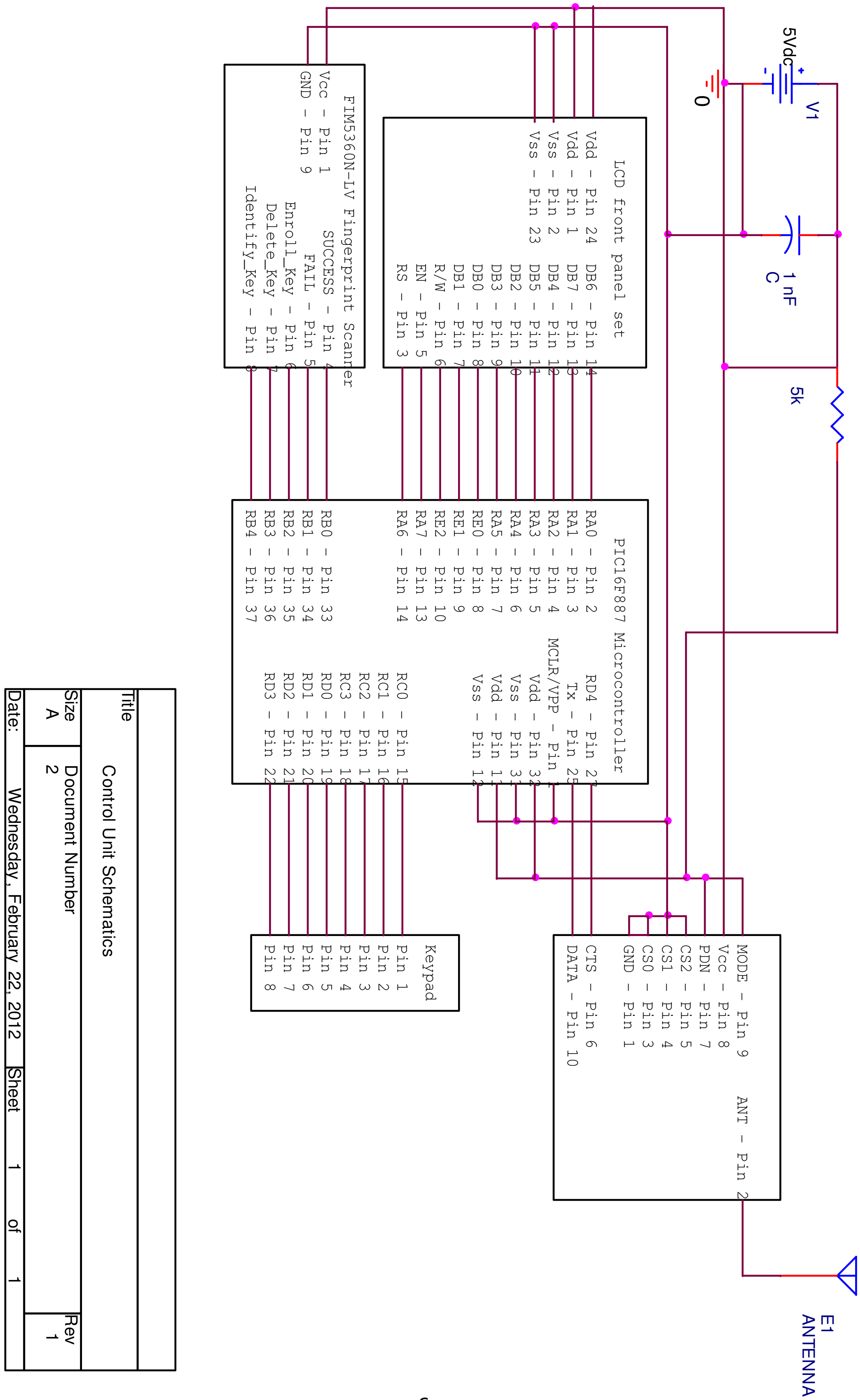
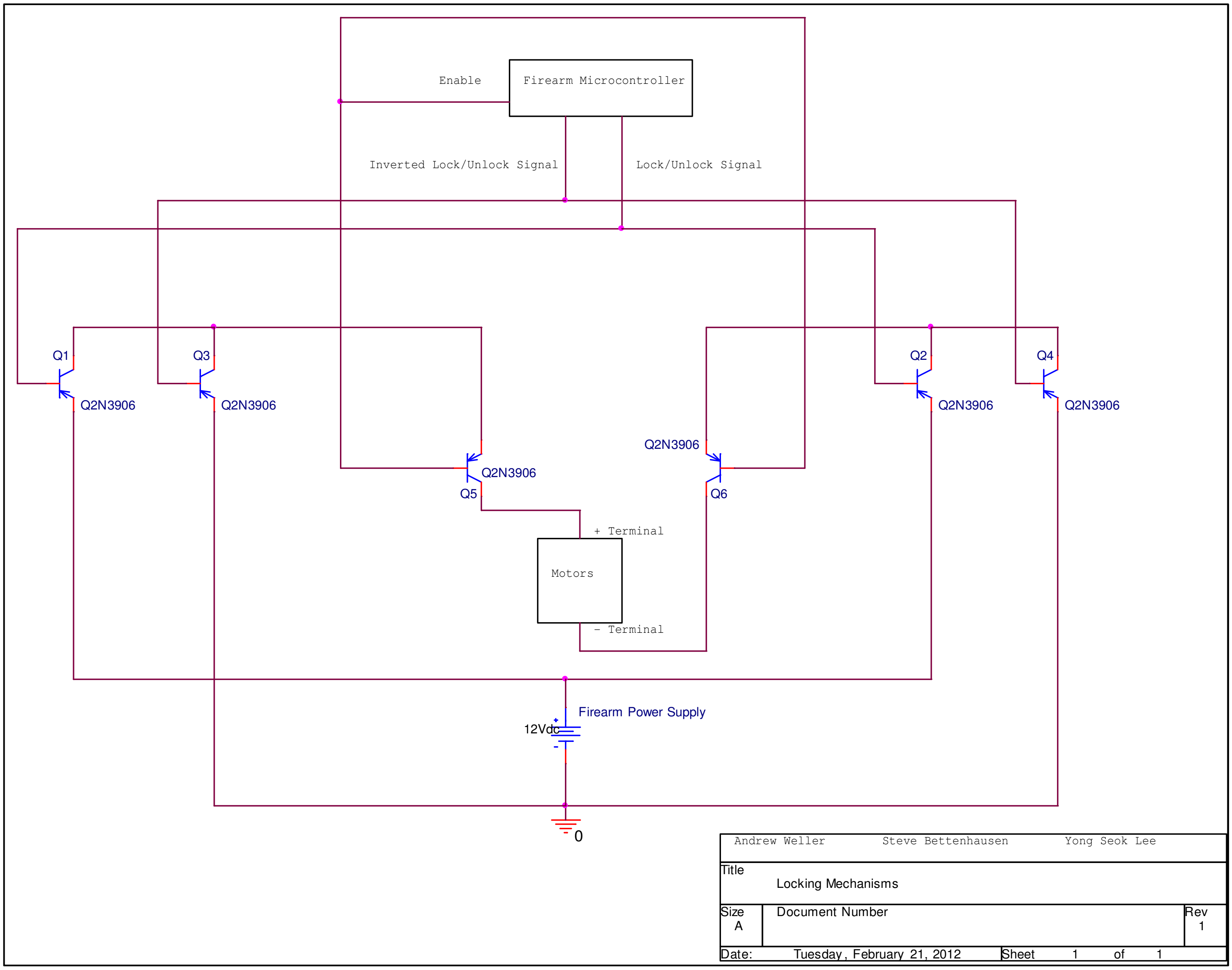
Control Unit:



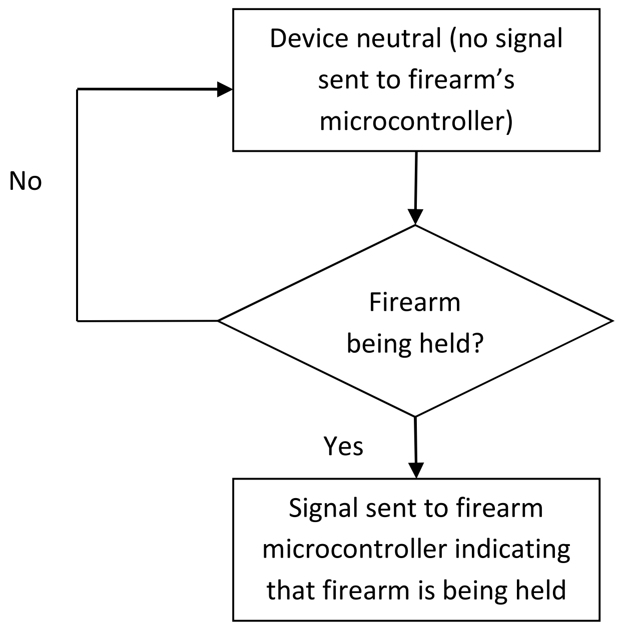
Locking Mechanisms:



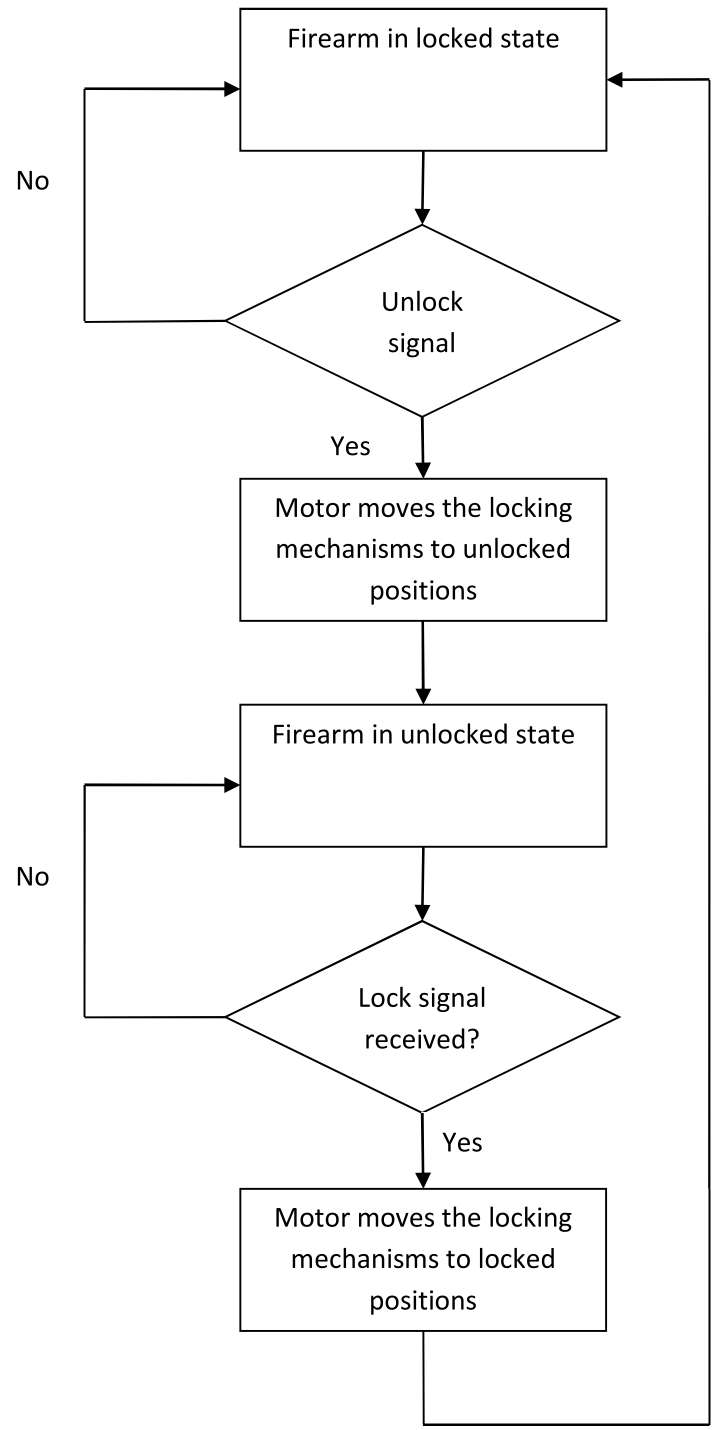
Enable	Lock/Unlock	Positive Terminal on Motors	Negative Terminal on Motors
0	X	0 V	0 V
1	Lock	12 V	0 V
1	Unlock	0 V	12 V

2.4 Flow Charts

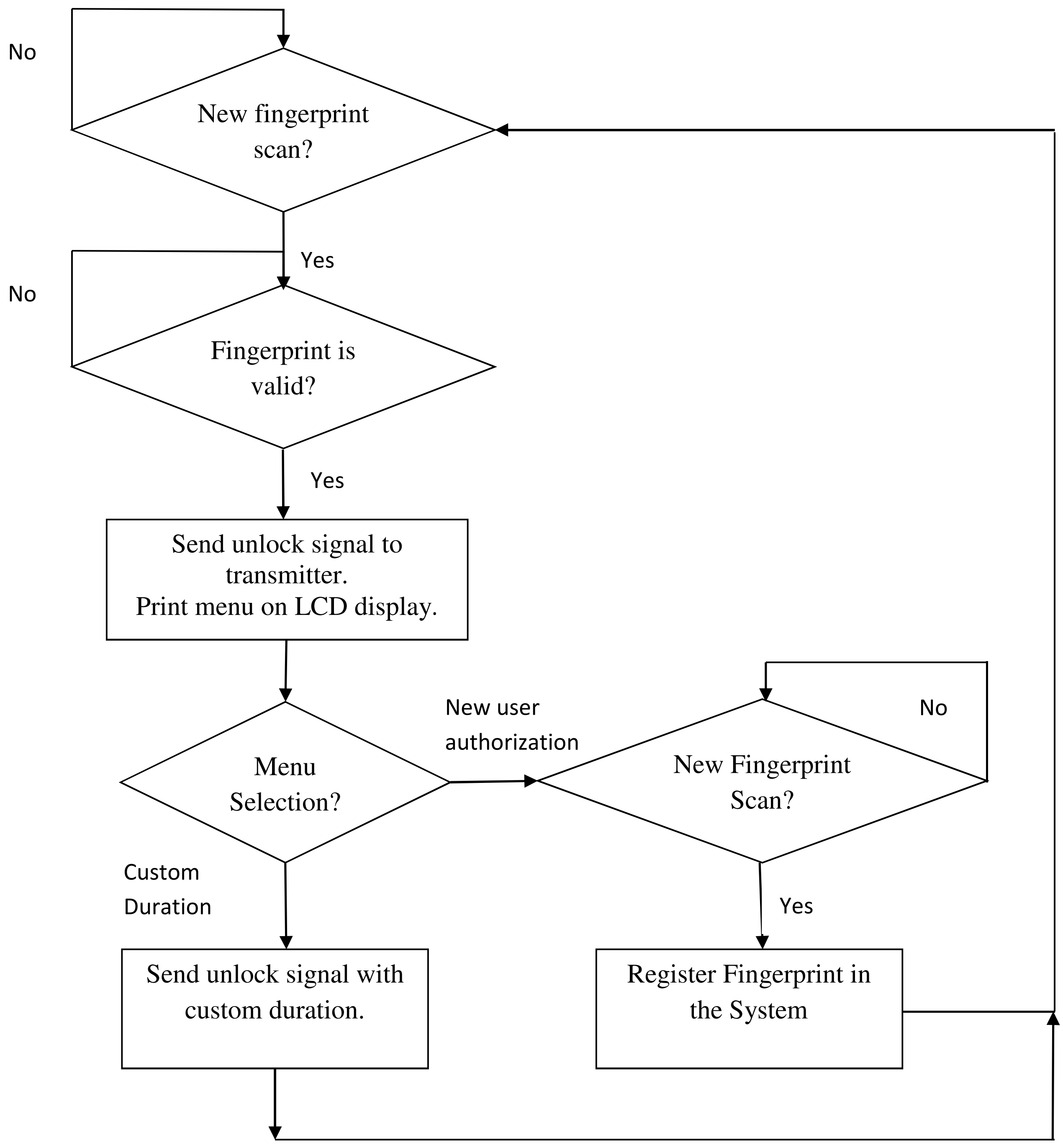
Pressure Sensor



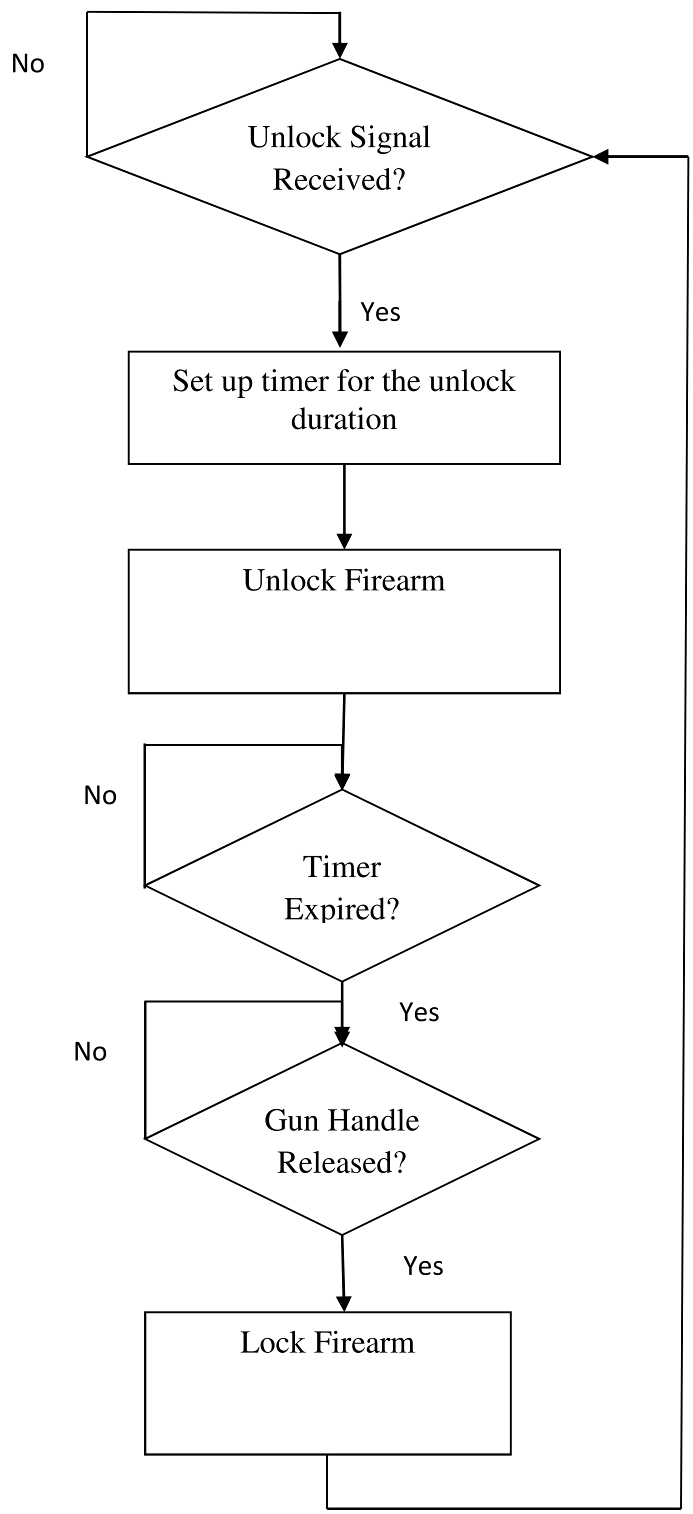
Locking Mechanisms



Control Unit Microcontroller:



Firearm Unit Microcontroller:



2.5 Calculations

The control power supply supplies power to the control microcontroller, LCD display, fingerprint scanner, and wireless transmitter.

Microcontroller: 2V to 5.5V @ 220uA nominal
LCD display: 5V @ 1.2mA nominal
Fingerprint Scanner: 5V @ 200mA nominal
Wireless Transmitter: 2.8V to 13V @ 14mA nominal
AA battery output: 1.2 V @ 250mA for 3 hours continuous use

All peripherals consuming power: 220uA + 1.2mA + 200mA + 14mA = 215.42mA ≈ 250mA
Need 5V power, so 5V / 4 = 1.25V ≈ 1.2V
Use 4 batteries: 1.2V @ 250 mA * 4 = 4.8V @ 250mA for 3 hours continuous use

Most of power usage is from fingerprint scanner, so if we scan an average of three times per use and scanning only takes 2 seconds, the batteries should last for about 1,800 uses.

$$3\ hours * \frac{60\ minutes}{1\ hour} * \frac{60\ seconds}{1\ minute} * \frac{1\ scan}{2\ seconds} * \frac{1\ use}{3\ scans} = \ 1{,}800\ uses$$

3. Requirements and Verification

3.1 Control Unit Requirements and Verifications

The control unit will consist of a fingerprint scanner, LCD display, microcontroller, power supply, and a wireless transmitter. The equipment needed to test the control unit consists of an oscilloscope and a multimeter. The top level functionality of the control unit is to read a user's fingerprint, and if authorized, allow the user to select the type and length of the unlock. The control unit accepts the user's responses to the prompts on the LCD screen and relays the choices to the wireless transmitter which will send the signals to the wireless receiver on the firearm unit.

Requirement	**Verification**
1. LCD display interface is 100% reliable. a. ASCII codes and I/O pins are working correctly on LCD display. b. LCD display correctly displays all the menu characters commanded from the control microcontroller. c. LCD display correctly displays	1. In order to verify the reliability of the LCD screen, the user will go through the prompts and each should be displayed correctly. For part a, the inputs will be hardcoded from Vcc and ground. For parts b and c, the microcontroller and LCD display are connected via I/O pins. a. Hard-code ASCII codes for some characters to be displayed to ensure the hardware is working. Also check I/O pins and logic is working. To test, display A, Z, a, z, 0,1, and 9.

appropriate length strings from the microcontroller.	b. Code alphabet and numeric characters into the microcontroller, one at a time, to be sent to the LCD display, one per second and clearing after each character. c. Code strings of random characters (lengths 1 through 16) into the microcontroller. Send these strings one at a time to make sure LCD string interface is reliable.
2. Keypad interface is 100% reliable. a. Each key pressed is correctly communicated to the I/O pins. b. Microcontroller interface will only recognize a key as being pressed once when it is held down. c. When multiple keys are pressed, only the first will be recognized.	2. In order to verify the reliability of the keypad, the user will go through the menu prompts and input information where it is asked for. For part a, only the keyboard is needed and an oscilloscope to check voltage levels. For parts b and c, the keyboard will be connected to the microcontroller and LCD display. a. Insert the keyboard pins into a breadboard and scope each pin individually to make sure the correct signal is being sent according to the datasheet. Do this for each key individually. b. Press a key to make sure that the correct key is displayed on the LCD screen. Then, press and hold that same key, the LCD display (and so the microcontroller) should only display the keypress once. Let up on the key and then press it again, the character should then display again. c. Press and hold one key (it should display on the LCD), then press another key. Only the first press should be displayed. Try pressing two or more keys at the same time, only one should be displayed.
3. User menu is 100% reliable. a. Menu logic is correct in that it follows the flow chart every time through. b. Pre-defined menu prompts are short enough to be displayed on the LCD display. c. Time delay and flags will be implemented to ensure the keypad, scanner, and LCD display are in sync.	3. In order to verify the reliability of the user menu, the user will go through the menu prompts and input information where it is asked for. If the LCD display or keyboard is not ready, use LED’s to show binary representations of the states. a. Go through every possible combination of prompts with the LCD display and keypad. If either one is not working, set up the microcontroller to display the state through LED’s via I/O pins. It should stop at each state where a user input is needed. b. Count the length of each menu prompt. Each one should be no more than 16 characters long.

	c. Try to enter commands really fast, the program should only let you enter one command every 0.5 seconds.
4. Fingerprint scanner management system should be able to save and recognize at least 10 different fingerprints. a. The system correctly decides whether the scanned fingerprint is on the saved list or not. b. Total of 10 different fingerprints can be saved.	4. The verification of the fingerprint scan and management system will be done through the LCD display menus. a. A fingerprint registered with the system, when scanned with the fingerprint scanner, will call up correct menu at the user menu. b. Try to add more fingerprints through the menu and the fingerprint scanner. After adding to reach the total of 10 fingerprints, all the fingerprints should register as valid authorization. The validity of the scan will be apparent in the LCD display.
5. Control power supply will output the correct amount of amps and voltage to sustain the LCD display, keypad, fingerprint scanner, transmitter and microcontroller. a. When power is on, an LED will be lit. b. Voltage to the LCD display: 5V +- 0.25V. c. Voltage to the transmitter and receiver is between 2.8 and 13 volts. d. Voltage to the microcontroller is between 2 and 5.5 volts. e. Operation voltage to the fingerprint scanner is 3.3 volts or 5 volts. Datasheets do not provide the acceptable deviation levels.	5. Use an oscilloscope to scope the power and ground connections to each one of the devices while it is in use. Each device should operate smoothly. a. Connect an LED to the power supply so that the LED is on when the supply is on. b. Send control signals to the LCD so that it outputs characters. Measure voltage on the oscilloscope to ensure it remains in the 4.75V to 5.25V range. c. Measure voltage on the oscilloscope of the Vcc and ground pins of the transmitter and receiver and ensure that the voltages are in 2.8V to 13V range. d. Measure voltage on the oscilloscope of the Vcc and ground wires going to the microcontroller to ensure they are in the 2V to 5.5V range. e. Ensure the fingerprint scanner is operational by scanning a fingerprint and confirming the response of the fingerprint management system.
6. Wireless interface transmits successfully in less than 100 ms, 90% of the time, at 30 feet unobstructed. a. An unlock signal from the control unit is received by the	6. In order to confirm the wireless interface operation, both microcontrollers will be configured so that some output pins will show high logic voltage when certain conditions are met. The pins may be connected to LED lights as indicators. These will only be connected during testing.

firearm unit 90% of the time at 30 feet, unobstructed. b. A timer set signal from the control unit is received with the original duration data, with the same conditions and success rate. c. The successful transmissions are received within 100 ms.	a. When an unlock signal is received by the firearm unit microcontroller, the microcontroller will output a high voltage to an indicator LED light. At least 9 out of 10 tests at 30 feet from the control unit should result in the LED light turning on. b. Two output pins of the firearm unit microcontrollers will be configured so that when a 1 minute duration request and a 2 minute duration request is detected, the two output pins will turn on for 3 seconds, respectively. Ten duration requests of 1 minute and ten duration requests of 2 minute should light up the LEDs at least 9 times each. c. A feedback wire will be connected from the firearm unit microcontroller to the control unit microcontroller, informing the latter when the former receives a signal through the wireless system. The control unit microcontroller will compare the signal transmission time and feedback reception time. If the difference is less than 100ms, an LED will light for 3 seconds. The LED should light up every time a signal is successfully received by the firearm unit microcontroller for 10 tests.
7. The firearm unit microcontroller should generate correct outputs for the firearm locking mechanisms based on the inputs. The inputs are signals from the control unit microcontroller and two feedback lines from the locking mechanisms. a. Firearm unit microcontroller generates unlock signal and enable signal from the given inputs 100% of the time. b. Lock signal from the unlock duration expiration should be correctly sent to the locking mechanism at the specified time with less than a 3 second error 100% of the time. c. After the unlock duration has expired, only lock the mechanism	7. Testing of the interface will depend on successful testing of wireless system. Voltmeter will be used to measure voltage of the three outputs from the microcontroller to the locking mechanism and two inputs to the microcontroller from the locking mechanism. a. Test all the combination of inputs to the firearm control logic, consisting of the wirelessly transmitted signal and the two feedback inputs from the locking mechanism, and verify the outputs with a multimeter. b. Send 1 minute and 2 minute unlock signals from the control unit to the firearm unit, three times each. As long as the wireless transmission is not faulty, the locking mechanism should unlock for only one minute and two minutes, respectively.

if the inputs from the pressure sensor indicates that the handle is not gripped. Otherwise, delay the locking procedure until the handle is released.	c. Test part b. with the grip held for 15 seconds after the specified unlock duration. The locking mechanism should only respond when the grip is released.

3.2 Firearm Unit Requirements and Verifications

The firearm unit will consist of a wireless receiver, pressure sensor, microcontroller, power supply, and locking mechanisms. The equipment needed to test the firearm unit consists of an oscilloscope and a multimeter. The top level function of the firearm unit is to control the locking mechanisms' motors based on the signals received from the control unit.

Requirements	**Verification**
1. Pressure sensor output goes high when the sensor is pressed.	1.The pressure sensor will be connected to a bench top power supply set to mimic the voltage and current output of the firearm's power supply. A multimeter will be used to measure the output of the pressure sensor. When the sensor is pressed, the outputted voltage and current will be within 5% of the power supply's ratings.
2. Pressure sensor output goes low when the sensor is not pressed.	2.The pressure sensor will be connected to a bench top power supply set to mimic the voltage and current output of the firearm's power supply. A multimeter will be used to measure the output of the pressure sensor. The sensor will not be pressed and the outputted voltage and current will be less than 1% of the power supply's ratings.
3.The locking mechanisms respond to the lock/unlock signal from the firearm's microcontroller in under five seconds. a.When the unlock signal is sent from the firearm's microcontroller, the locking mechanisms move from the locked position into the unlocked position in under five	3.The locking mechanisms will be attached to a bench top power supply set to simulate the output of the firearm's microcontroller. The supply will send different voltages to the locking mechanisms to simulate the different signals from the microcontroller. When a new position signal is sent, a timer will be used to verify that the mechanisms move into the new position in under five seconds. a.The power supply will send to the locking mechanisms the voltage corresponding to the

seconds. b.When the lock signal is sent from the firearm's microcontroller, the locking mechanisms move from the unlocked position into the locked position in under five seconds.	unlock signal from the microcontroller. Once this signal is sent, a timer will be used to confirm that the locking mechanisms move into the unlocked position in under five seconds. b.The power supply will send to the locking mechanisms the voltage corresponding to the lock signal from the microcontroller. Once this signal is sent, a timer will be used to confirm that the locking mechanisms move into the locked position in under five seconds.
4.The locking mechanisms will not attempt to move into the position they are currently in. a.When the locking mechanisms are in the locked state, they should ignore the signal from the microcontroller telling it to go into the locked state. b.When the locking mechanisms are in the unlocked state, they should ignore the signal from the microcontroller telling it to go into the unlock state.	4.The locking mechanisms will be connected to a bench top power supply set to simulate the output of the firearm's microcontroller. The mechanisms will be placed into the lock/unlock state, and then the supply will repeatedly send the signal for the current state to the mechanisms. The mechanisms will ignore the redundant signal and remain in the same position. a.The locking mechanisms will be placed into the locked state and the power supply will send the locked state signal to the mechanisms. The mechanisms will not respond to this signal and remain in the same position. b.The locking mechanisms will be placed into the unlocked state and the power supply will send the unlock state signal to the mechanisms. The mechanisms will not respond to this signal and remain in the same position.

3.3 Tolerance Analysis

Block Name and Basic Description	**Testing Focus**	**Acceptable Result Ranges Confirming Operation**
Block Name: Locks Description: The locks receive electrical signals that have been processed through the entire system and mechanically put the firearm into the proper state. Important Operating Characteristics: The locks are the final component of the project. They implement the commands that have been processed since the user interface system. The locks execute the most important function of this project, the proper locking and unlocking of the firearm in a timely manner.	The lock's testing focuses on how low the energy in the firearm's power supply can get before the locking mechanisms can no longer respond to the microcontroller's signal. Determining the minimum energy needed for proper functionality is key in designing the firearm's power supply so that it will store enough energy to operate all the firearm sub-system's until most of its energy, approximately 95%, has been used while also allowing for at least 24 hours of operational capacity.	The locking mechanisms need to respond to the microcontroller's signal until approximately 5% of the firearm's power supply's energy remains.

Testing Procedure:

The locking mechanisms will be connected to a bench top power supply set to the nominal voltage and current ratings of the locking mechanisms' motors. The voltage will then be stepped down incrementally under the motors can no longer operate. When this occurs, the voltage and current will be recorded. Then the current will be lowered by 0.1 amps and the voltage will once again be stepped down incrementally until the motors stop working. This procedure will be repeated until the initial voltage and current can no longer operate the motors. With the minimum voltage and current values known, the minimum energy needed to operate the motors will be calculated, allowing the power supply to be designed to power the motors until approximately 5% of its energy remains.

4. Ethics

4.1 Discussion of Ethics

The purpose of this project, improving firearm safety, reflects the first code of the IEEE Code of Ethics which refers to "making decisions consistent with the safety, health, and welfare of the public (IEEE)". Too often stories come on the news where someone was shot because they or someone else was not handling a firearm properly. Our system will help to prevent these accidents by only allowing authorized users to operate the firearm through the "appropriate application (IEEE)" of technology, the fifth IEEE code. Taking advantage of modern technologies such as fingerprint scanners and wireless transmitters/receivers this project creates a system to help fulfill the ninth IEEE code to "avoid injuring others (IEEE)". Finally, if the third IEEE code of being "honest and realistic in stating claims [...] based on available data (IEEE)" is reflected in our work, this project will fulfill its intended purpose: improving firearm safety.

5. Cost Analysis and Schedule

5.1 Cost Analysis

Labor:
$35.00 per hour * 2.5 * 120 hours = $10,500 per person
Total labor for 3 group members = $31,500.

Parts Received:

Part #	Mft.	Description	Price	For	Qty	Total
HD44780	Hitachi	2x16 STN LCD Display w/controller	$8.95	User Interface	1	$8.95
96BB2-006-R	Grayhill Inc.	16 key Conductive Rubber Keypad	$15.06	User Interface	1	$15.06
PIC16F887-I/P	Microchip	40 pin Microcontroller	$2.20	Microcontrollers	2	$4.40
TXM-900-HP3-PPS	Linx	RF Transmitter chip	$24.10	Wireless system	1	$24.10
RXM-900-HP3-PPS	Linx	RF Reciever chip	$35.94	Wireless system	1	$35.94
MPB-1	All Electronics Corp	SPST Momentary N.O. Pushbutton	$0.85	Pressure Sensor	1	$0.85

Parts Needed:

Part #	**Mft**	**Description**	**Price**	**For**	**Qty**	**Total**
FIM 5360N-LV	Nitgen	Fingerprint Scanner	$129.95	Fingerprint Scanner	1	$129.95
ANT-916-JJB-RA	Linx	Antenna, Embeddable Monopole	$1.96	Wireless System	2	$3.92
2032BP	Energizer	3 Volt Coin Lithium Watch Battery	$1.00	Firearm Power Supply	4	$4.00
DCM-318	All Electronics Corp	12 VDC 58 RPM Mini-Motor	$12.95	Locks	2	$25.90
GR-87	All Electronics Corp	12-Tooth Sprocket	$1.00	Locks	4	$4.00
SP-213	All Electronics Corp	Nylon Spacers	$1.50/10 Spacers	Locks	10	$1.50
2N3906	On Semiconductor	PNP Bipolar 40 Volt, 200mA Transistor	$0.10	Locks	6	$0.60
E91BP-4	Energizer	AA batteries - 4 pack	$4.29	Control Power Supply	1	$4.29

Total Parts cost = Parts Received + Parts Needed = $89.30 + $174.16 = $263.46

Total Cost (Labor + Parts) = $31,500 + $263.46 = $31,763.46

5.2 Schedule

Week	**Task**	**Member**
2/6	• Complete Proposal (Done) • Research LCD displays, and keypads (Done)	Steve
	• Begin designing locking systems (Done)	AJ
	• Begin studying microcontroller, transmitter, and receiver documentation (Done)	Yong
2/13	• Research serial interfaces and part options (Done) • Create pinouts for LCD display, and keypad (Done)	Steve
	• Sign-up for Design Review (Done) • Finish design of locking systems and determine parts needed (Done) • Build pressure sensor component (Done)	AJ

	• Design pinouts for microcontroller, transmitter, and receiver (Done)	Yong
2/20	• Order user interface parts • Finalize hardware pinouts for user interface	Steve
	• Have functioning pressure sensor • Order parts for locking systems	AJ
	• Complete Design Review • Research microcontroller programming methods	Yong
2/27	• Begin coding for microcontroller	Steve
	• Begin building locking system	AJ
	• Wire up the microcontrollers • Create an interface for manual sending of local unlock/lock signals on firearm unit microcontroller	Yong
3/5	• Interface with keypad	Steve
	• Finish building locking system	AJ
	• Add the fingerprint scanner to the control unit. • Test identifying different fingerprints.	Yong
3/12	• Interface with LCD display	Steve
	• Have functioning locking systems	AJ
	• Wire up the MC's and transmitter/receiver • Test wireless sending and receiving of simple bit codes	Yong
3/19	• Spring Break	N/A
3/26	• Sign Up for Mock Presentation • Testing of keypad and LCD display • Design of power supply for control unit	Steve
	• Begin build on power supply for firearm unit	AJ
	• Complete Mock-up Demo • Set up local timer-based signals for firearm unit	Yong
4/2	• Program user menus for locking • Finish design for power supply on control unit	Steve
	• Complete Mock Presentation • Continue building power supply on firearm unit	AJ
	• Implement and test controlling the firearm unit unlock/lock signals from the control unit microcontroller	Yong
4/9	• Begin testing and debug of control unit	Steve
	• Finish building power supply on firearm unit	AJ
	• Program fingerprint management logic	Yong
4/16	• Finish testing and debug of control unit with power supply	Steve
	• Sign up for Demo • Test power supply on firearm unit • Interface all systems on firearm	AJ
	• Sign up for Presentation • Full verification, testing, and troubleshooting for wireless system	Yong
4/23	• Complete Demo	Yong
4/30	• Complete Final Presentation	Steve
	• Complete Written Paper	AJ

6. Citations

6.1 Citations:

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