Appendix A Schematics

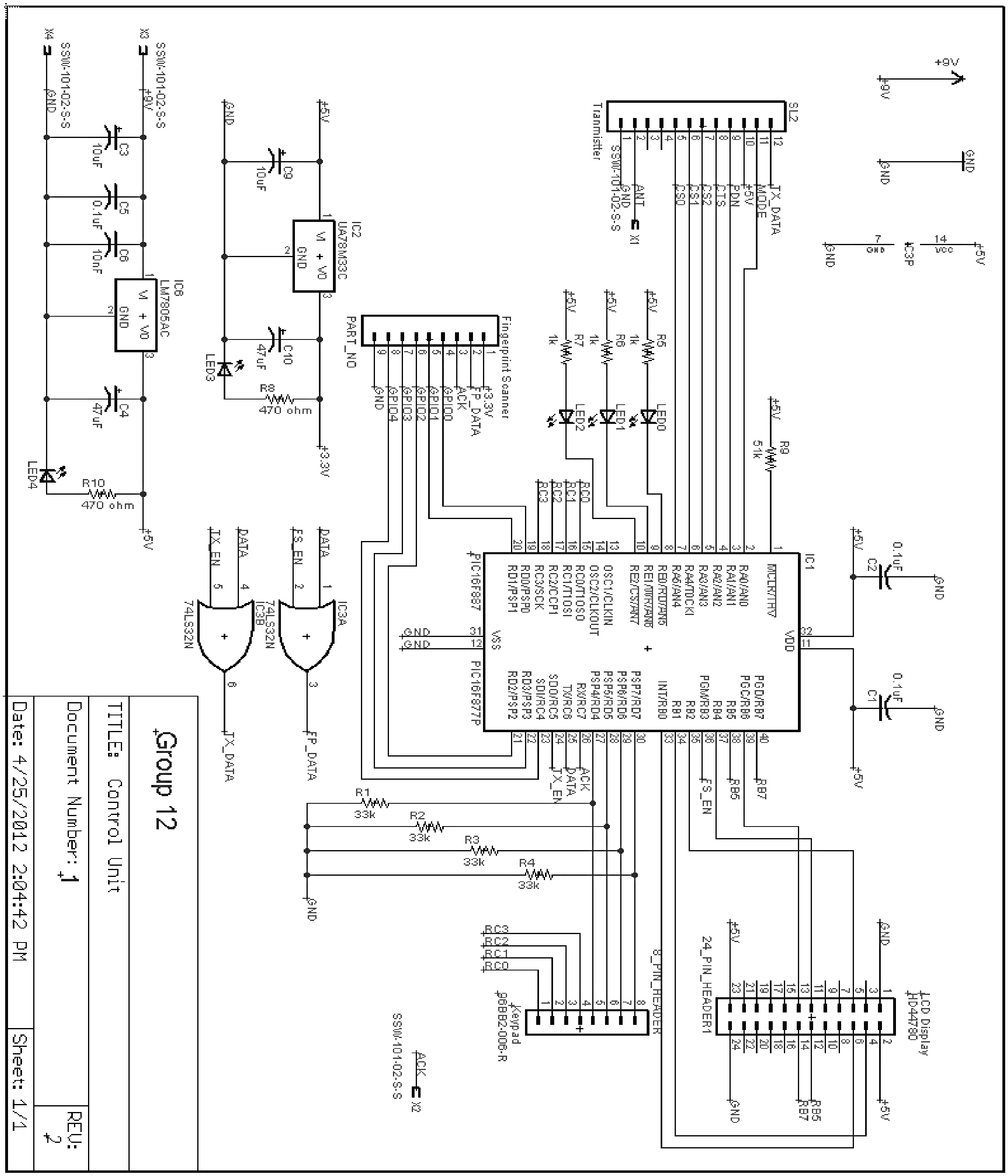

Figure A.1 Control Unit Schematic

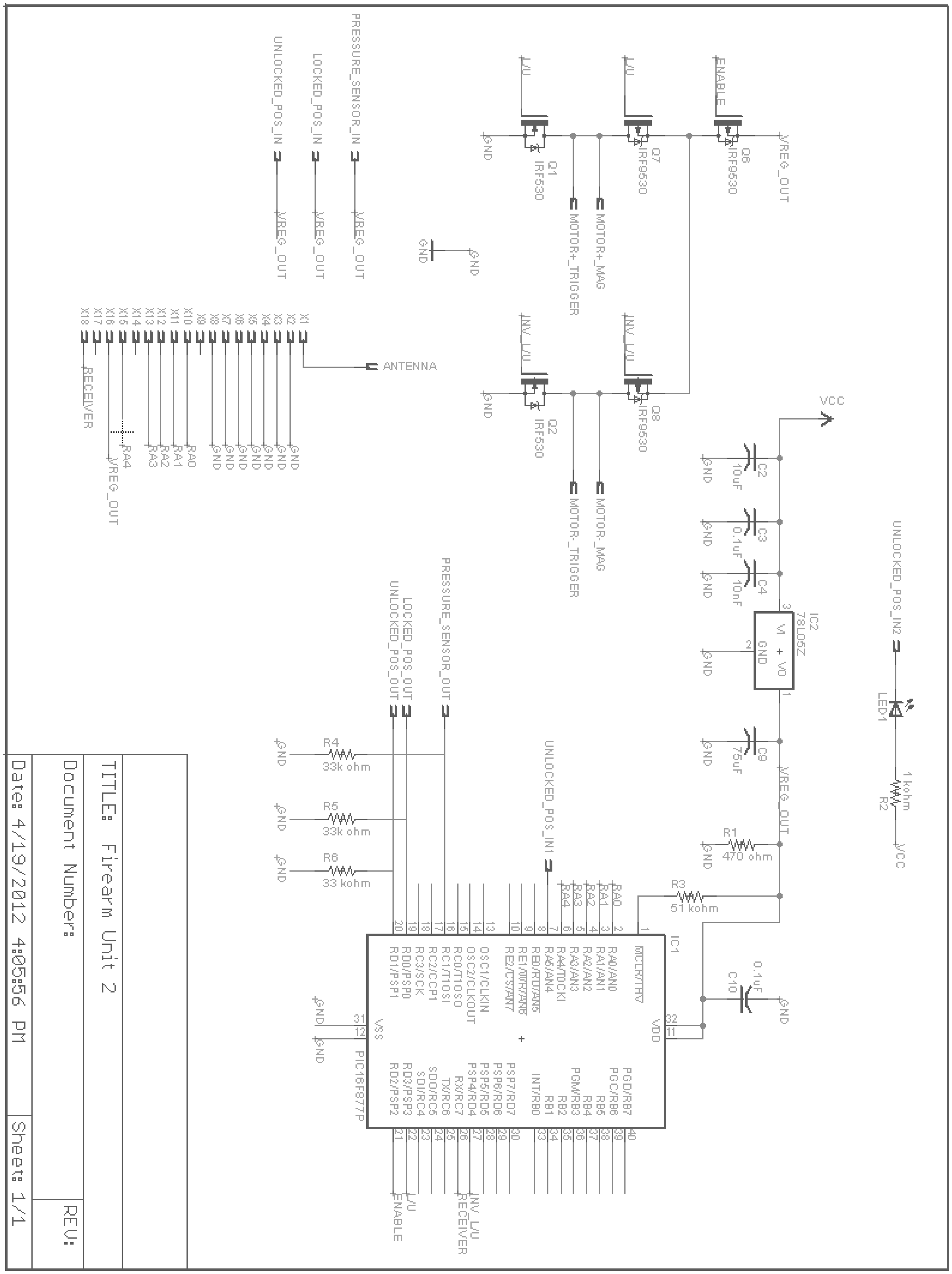

Figure A.2 Firearm Unit Schematic

Appendix B Keypad Matrix

Table B.1 shows the pins on the keypad that go high and the function return value for each key on the keypad.

Table B.1 Keypad Matrix

Pins High	Function return value	Key on Keypad		Pins High	Function return value	Key on Keypad
1 and 5	1	1		3 and 5	7	7
1 and 6	2	2		3 and 6	8	8
1 and 7	3	3		3 and 7	9	9
1 and 8	12	A		3 and 8	14	C
2 and 5	4	4		4 and 5	10	*
2 and 6	5	5		4 and 6	0	0
2 and 7	6	6		4 and 7	11	#
2 and 8	13	B		4 and 8	15	D
None	16	None				

Appendix C Flowcharts

Figure C.1 shows the flowchart for the user menu. Figure C.2 shows the flowchart for firearm's microcontroller.

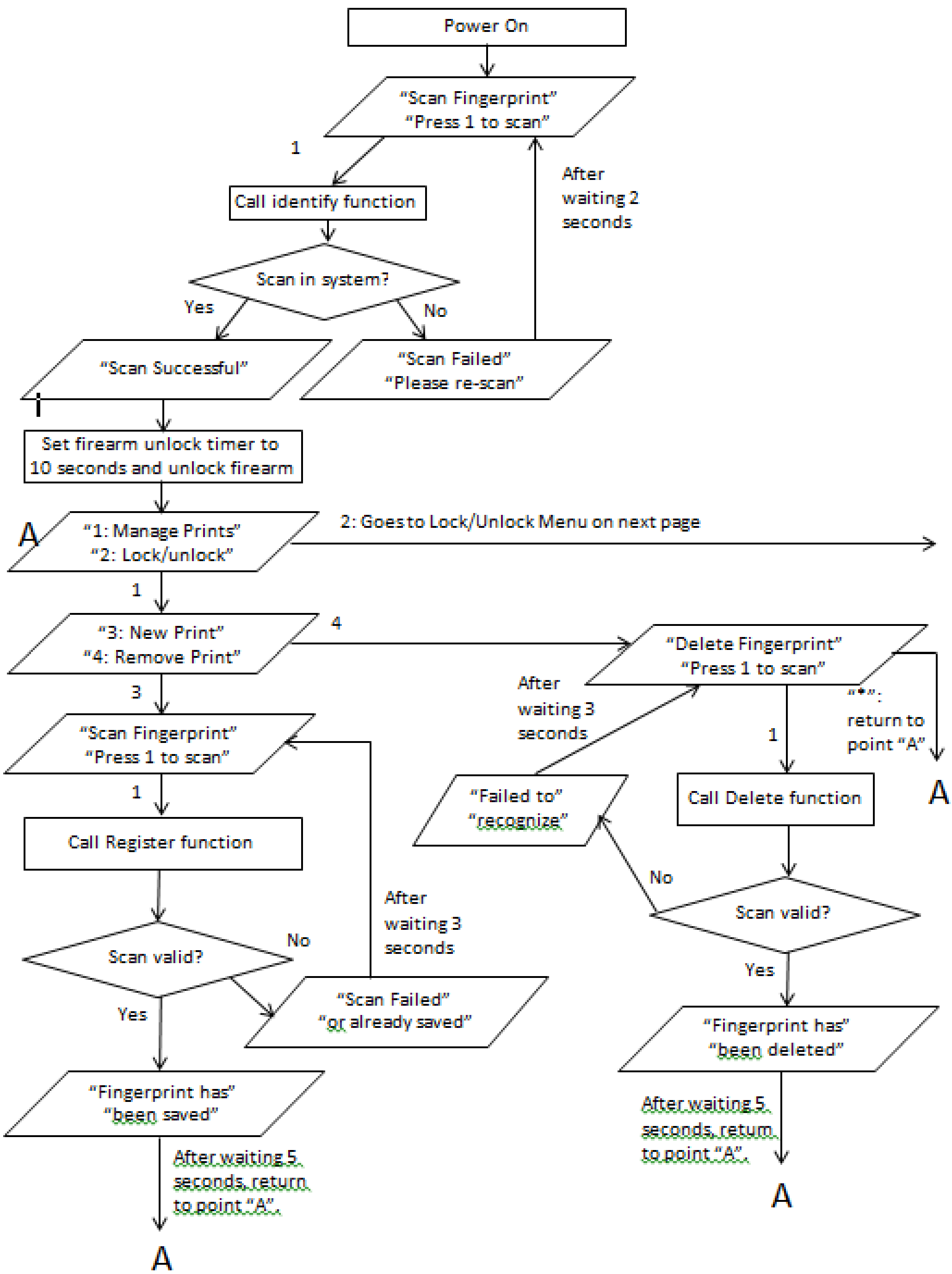

Figure C.1 User Menu Flowchart

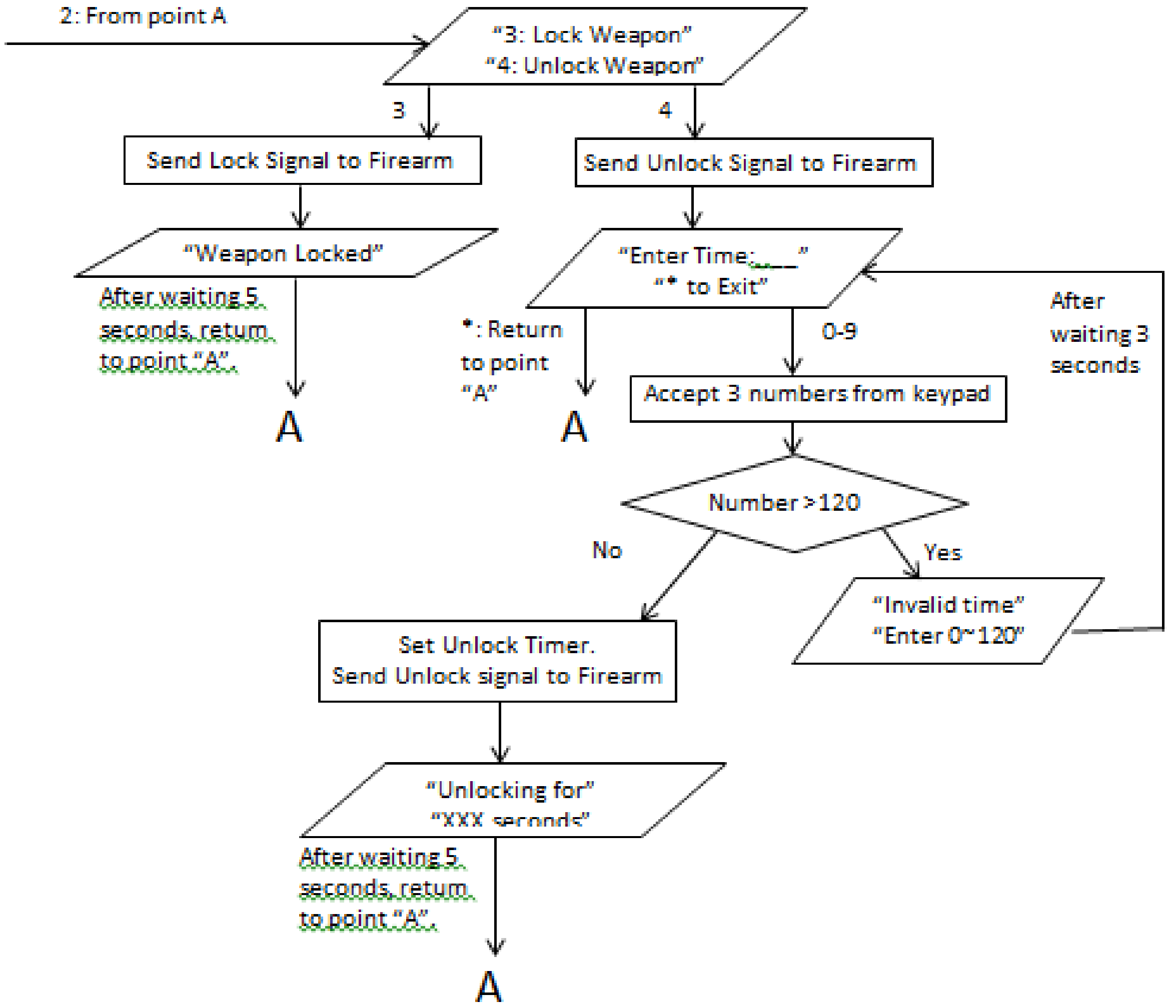

Figure C.1 Continued

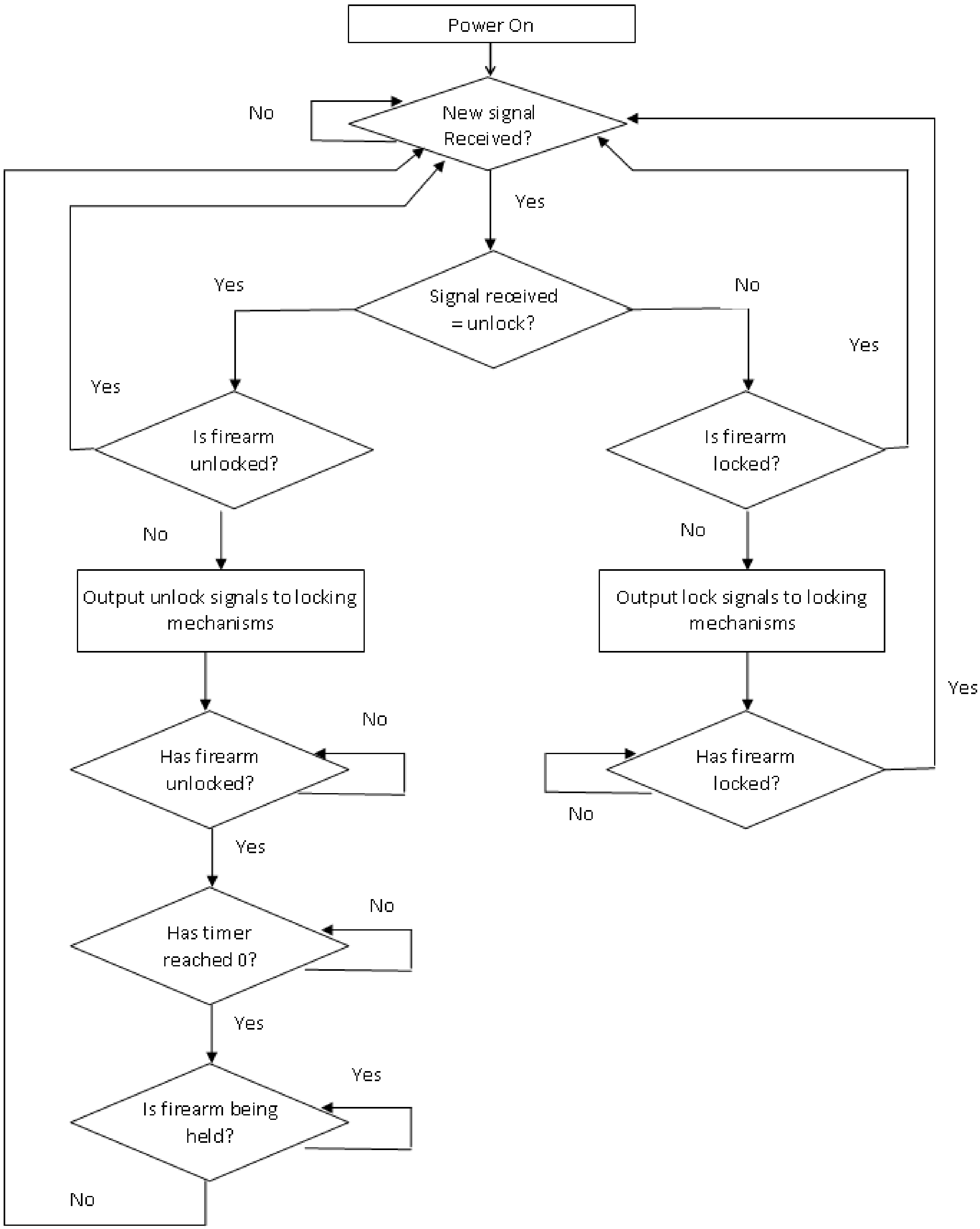

Figure C.2 Firearm Microcontroller Flowchart

Appendix D Testing and Verification

Table D.1 lists the specifications and tests for each specification for the control unit. Table D.2 lists the specifications and tests for each specification for the firearm unit.

Table D.1 – Control Unit Specifications and Tests

Requirement	**Verification**	**Verified?**
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 appropriate length strings from the microcontroller.	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. 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.	Yes
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	Yes

	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.	Yes
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.	Yes
5. Control power supply will output the correct amount of amps and voltage to sustain the LCD display, keypad,	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.	Yes

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.	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 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.	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. 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	No

	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.	

Table D.2 – Firearm Unit Specifications and Tests

Requirements	**Verification**	**Verified?**
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.	Yes
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 2% of the power supply's ratings.	Yes
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	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 unlock signal from the microcontroller. Once this signal is sent, a timer will be	Yes

under five 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.	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.	Yes
5. 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	5. 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	Yes

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 if the inputs from the pressure sensor indicates that the handle is not gripped. Otherwise, delay the locking procedure until the handle is released.	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. 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.	
6.The firearm power supply provides enough power for 24 hours of continuous use.	6. An oscilloscope will be used to measure the voltage from the source at various points in time. A plot of voltage vs. time will be made and fitted with a line. The line will be used to calculate the time it takes for the battery to reach the voltage at which the subsystems can no longer function concurrently.	No

Appendix E Voltage vs. Time Plots

Figure E.1 shows the voltage vs. time plot for the 9V batteries in the control unit and firearm unit.

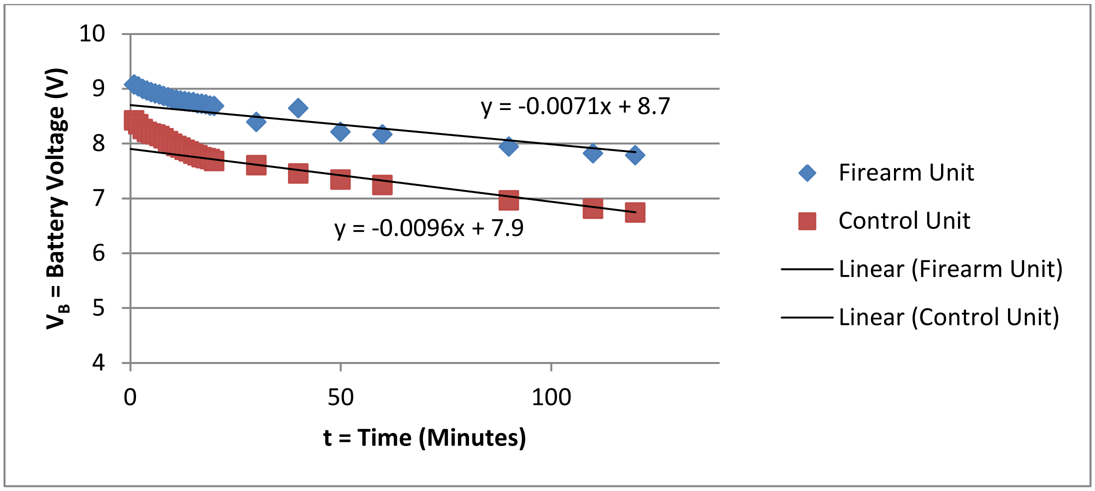

Figure E.1 Voltage vs. Time for Control and Firearm Batteries

Appendix F 9V Battery Constant Current Performance Plot

Figure F.1 shows the constant current performance for the 9V battery used as the power supply for the control and firearm units.

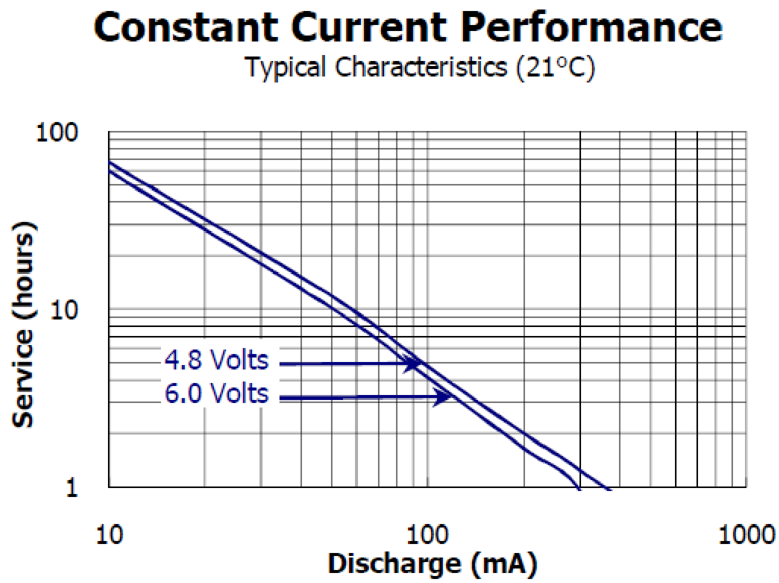

Figure F.1 9V Battery Constant Current Performance

Appendix G Voltage Measurements

Figure G.1 shows the input of the wireless transmitter. Figure G.2 shows the input of the transmitter and output of the wireless receiver. Figure G.3 shows the voltage for the input and output of the pressure sensor when the pushbutton is not pressed. Figure G.4 shows the voltage for the input and output of the pressure sensor when the pushbutton is pressed.

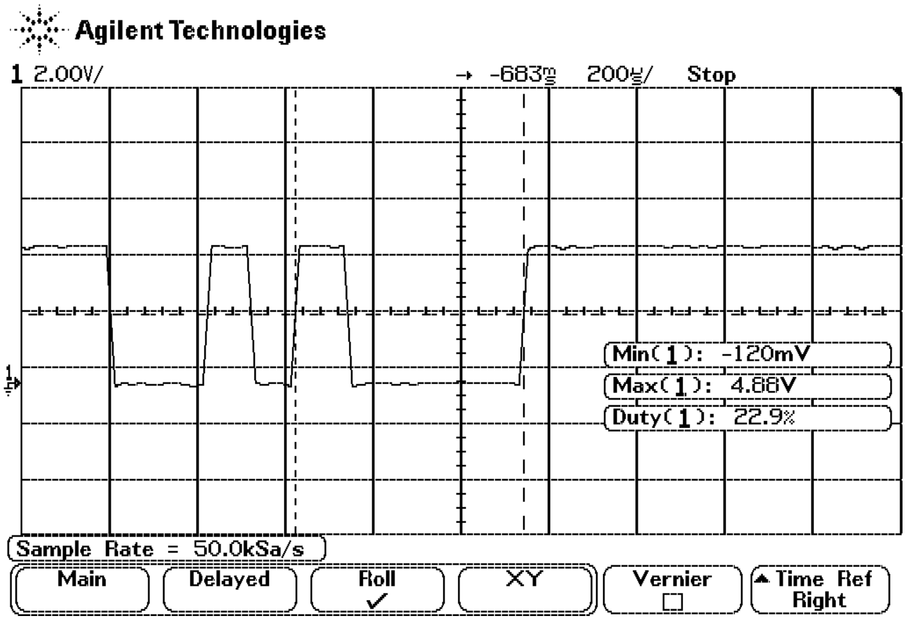

Figure G.1 Wireless Transmitter Input

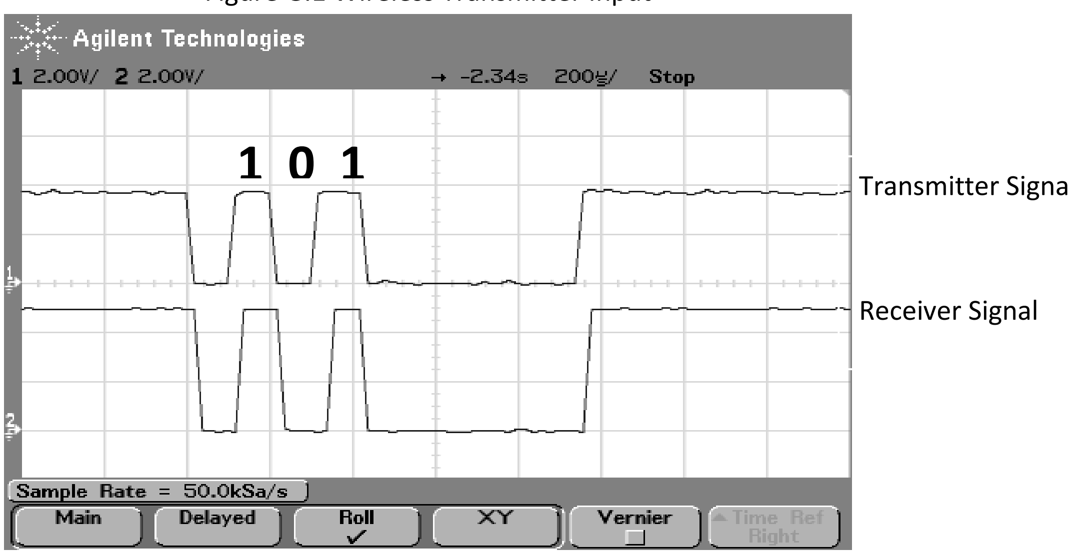

Figure G.2 Wireless Transmitter and Receiver Signals

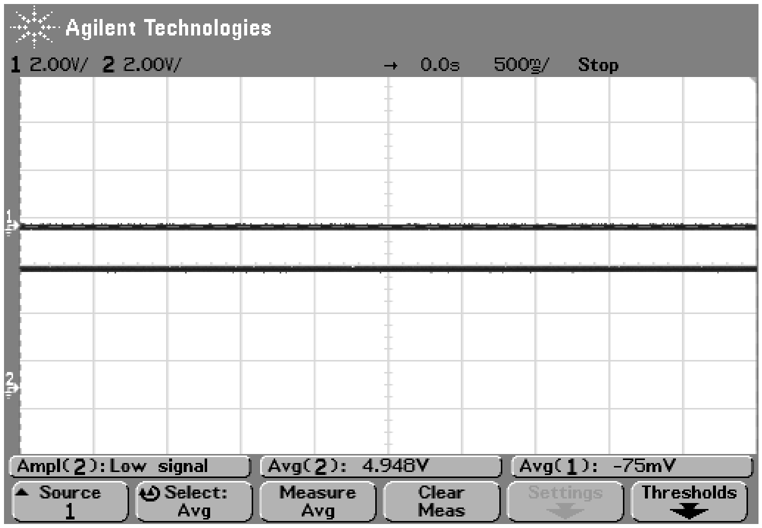

Figure G.3 Pressure Sensor Input & Output – Not Pressed

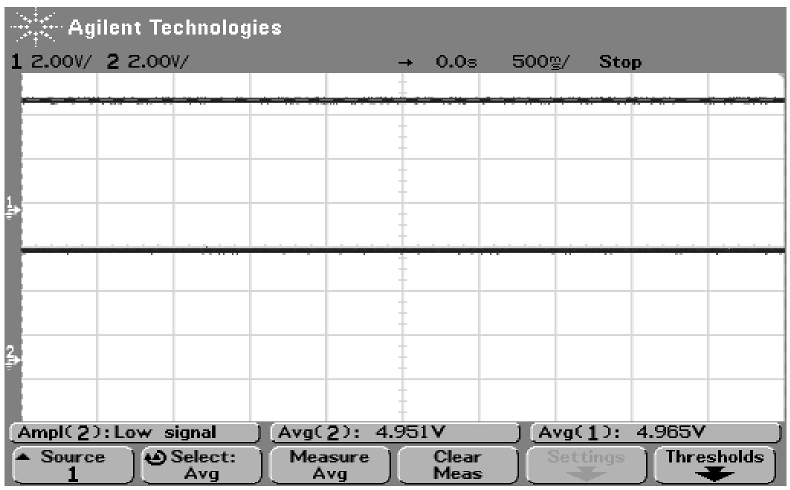

Figure G.4 Pressure Sensor Input & Output –Pressed

Appendix H Project Pictures

Figure H.1 shows the size of the connector pins on the fingerprint scanner's microcontroller. Figure H.2 shows the completed control unit. Figure H.3 shows the completed firearm unit. Figure H.4 shows the magazine lock. Figure H.5 shows the trigger lock.

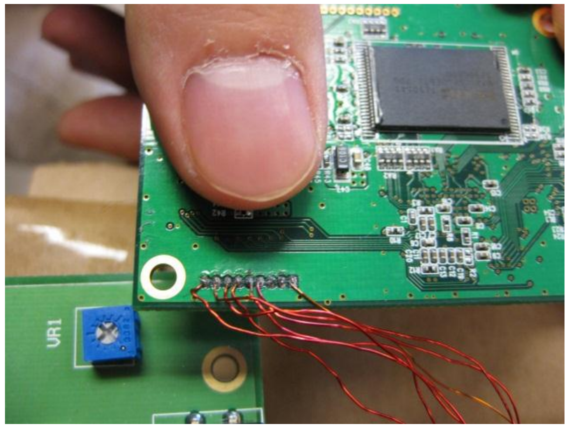

Figure H.1 Fingerprint Scanner Connector Pins

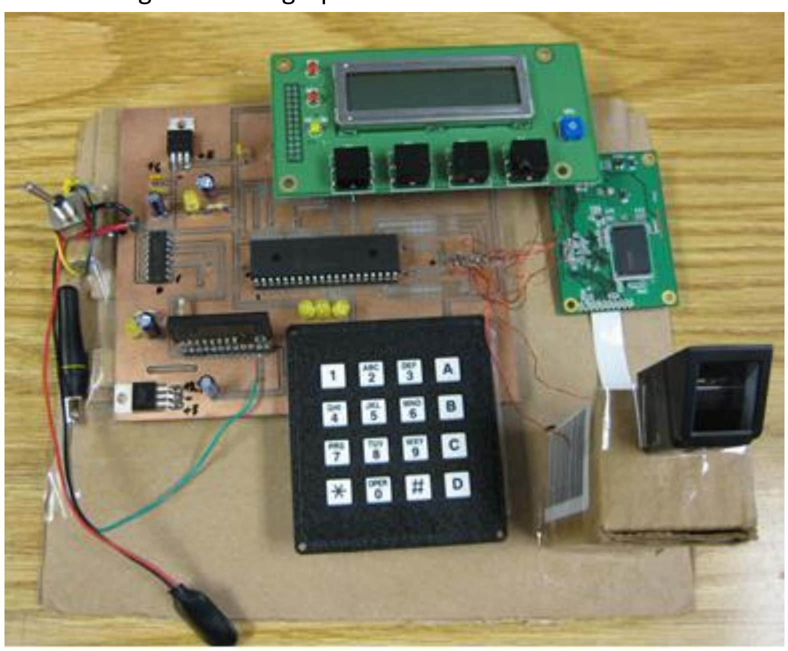

Figure H.2 Control Unit


Figure H.3 Firearm Unit

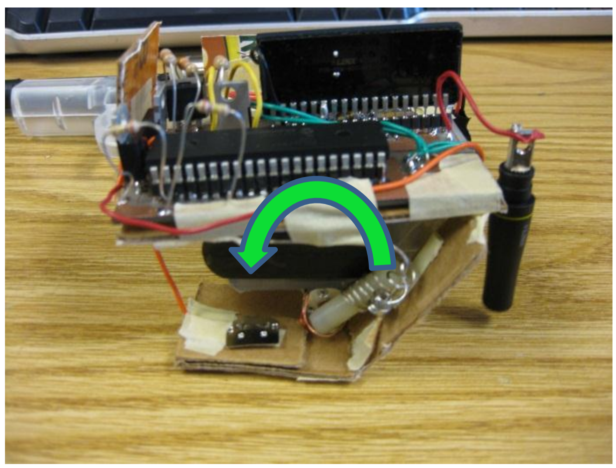
Figure H.4 Magazine Lock

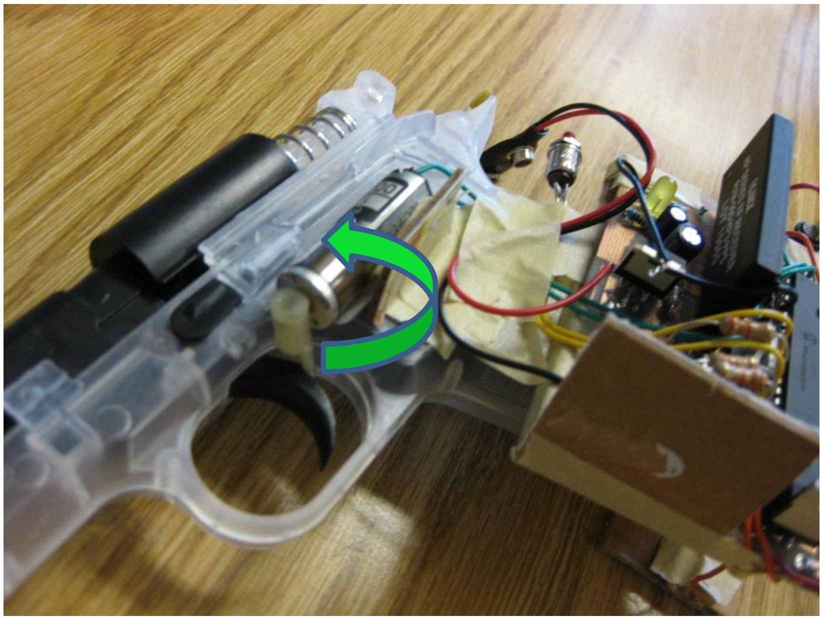

Figure H.5 Trigger Lock

Appendix I Project Costs

Table I.1 shows the costs for the components in the control unit. Table I.2 shows the costs for the components in the firearm unit.

Table I.1 Control Unit Parts Costs

Part	Manufacturer	Description	Retail Cost ($)	Quantity	Actual Cost ($)
EN22	Energizer	9V Battery	1.75	1	1.75
HD44780	Hitachi	2x16 STN LCD Display w/controller	8.95	1	8.95
96BB2-006-R	Grayhill Inc.	16 key Conductive Rubber Keypad	15.06	1	15.06
PIC16F887-I/P	Microchip	40 pin Microcontroller	2.20	1	2.20
TXM-900-HP3-PPS	Linx	RF Transmitter chip	24.10	1	24.10
FIM 5360N-LV	Nitgen	Fingerprint Scanner	129.95	1	129.95
ANT-916-JJB-RA	Linx	Antenna, Embeddable Monopole	1.96	1	1.96
7201SYZQE	C&K Components	DPDT Toggle Switch	7.22	1	7.22
CFR-25JR-52-470R	Yageo	470 Ohm Resistor	0.07	2	0.14
MFP-25BRD52-1K	Yageo	1 Kilo-Ohm Resistor	0.55	3	1.65
CFR-25JB-52-33K	Yageo	33 Kilo-Ohm Resistor	0.07	4	0.28
CFR-12JR-52-51K	Yageo	51 Kilo-Ohm Resistor	0.09	1	0.09
SN74LS32N	Texas Instruments	Quad 2-Input OR Gate	0.68	1	0.68
SSL-LX3044YD-5V	Lumex Opto/Components Inc.	5-Volt LED	0.67	5	3.35
CC0402ZRY5V7BB104	Yageo	0.1 Microfarad Capacitor	0.01	3	0.03
ECA-1VM470B	Panasonic – ECG	47 Microfarad Capacitor	0.04	2	0.08
ECA-1HM100I	Panasonic - ECG	10 Microfarad Capacitor	0.04	2	0.08
CC0805JRNPO9BN102	Yageo	10 Nanofarad Capacitor	0.03	1	0.03
UA78M33C	Texas Instruments	3.3 Volt Linear	0.60	1	0.60

		Voltage Regulator			
LM7805AC	Fairchild Semiconductor	5 Volt Linear Voltage Regulator	0.69	1	0.69
Total					**198.89**

Table I.2 Firearm Unit Parts Costs

Part	Manufacturer	Description	Retail Cost ($)	Quantity	Actual Cost ($)
DCM-318	All Electronics Corp	12 VDC 58 RPM Mini-Motor	12.95	2	25.90
SP-213	All Electronics Corp	Nylon Spacer	0.15	2	0.30
78L05Z	Fairchild Semiconductor	5V Voltage Regulator	0.45	1	0.45
ECA-1HM100I	Panasonic - ECG	10 Microfarad Capacitor	0.04	1	0.04
CC0402ZRY5V7BB104	Yageo	0.1 Microfarad Capacitor	0.01	2	0.02
CC0805JRNPO9BN102	Yageo	10 Nanofarad Capacitor	0.03	1	0.03
ECA-1VM470B	Panasonic - ECG	47 Microfarad Capacitor	0.04	1	0.04
CFR-25JR-52-470R	Yageo	470 Ohm Resistor	0.07	1	0.07
CFR-25JB-52-33K	Yageo	33 Kilo-ohm Resistor	0.07	3	0.21
MFP-25BRD52-1K	Yageo	1 Kilo-ohm Resistor	0.55	1	0.55
CFR-12JR-52-51K	Yageo	51 Kilo-ohm Resistor	0.09	1	0.09
NTP2955	ON Semiconductor	-60 V, -12 A, Single P-Channel MOSFET	1.00	3	3.00
IRF530	International Rectifier	100 V, 14 A, N-Channel MOSFET	0.86	2	1.72
EN22	Energizer	9-Volt Battery	1.75	1	1.75
PIC16F887-I/P	Microchip	40 Pin Microcontroller	2.20	1	2.20
RXM-900-HP3-PPS	Linx	RF Reciever Chip	35.94	1	35.94
ANT-916-JJB-RA	Linx	Antenna, Embeddable Monopole	1.96	1	1.96
SSL-LX3044YD-5V	Lumex Opto/Components Inc.	5-Volt LED	0.67	1	0.67
Total					**74.94**