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Simon Fraser University . Burnaby, BC . V5A 1S6

Feb. 8, 2010

Dr. Andrew Rawicz
School of Engineering Science
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RE: ENSC 440 Functional Specification for the Vehicle Lock-Out Prevention System

Dear Dr. Rawicz,

Attached is the functional specification document for our vehicle lock-out prevention system. It outlines specific requirements that our ENSC 440 project must meet. Our system detects the presence of the vehicle's key inside the vehicle and alerts the user when it is. In addition, if all the doors are locked, the system will unlock a door for the user. The user must push a button to shut off the system (similar to an alarm clock button).

In our document, we will give a system overview and discuss requirements for individual components of the system. The purpose of this document is to define high-level requirements to be used as a guide for our system's design and development.

Undent Solutions is composed of Marissa Hun, Daphne Mui, Dona Patikiriarachchi, and Elisa (Xuan) Lu. If you have any questions or comments regarding our functional specifications, you can contact us through email at mmh2@sfu.ca.

Sincerely,

Daphne Mui

Daphne Mui
CEO
Undent Solutions

Enclosure: Functional Specification for the Vehicle Lock-Out Prevention System

Functional Specification for the Vehicle Lock-out Prevention System

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EXECUTIVE SUMMARY

In today's fast-paced world, people have many responsibilities and precautions to be mindful of that often times we become forgetful. Getting locked out of a vehicle is one big issue that affects so many drivers daily. People have suggested many different ways to retrieve keys from a locked vehicle. Some of the existing solutions are: sliding a long rod between the car door to unlock the door which can leave an unpleasant dent in the car, calling a locksmith which costs a lot, as well as installing the Taplock finger tap keyless entry system in which the user taps a secret tap code which triggers the doors to unlock [1]. This tap entry method is innovative, but it poses a security threat as anyone who finds out the secret code will have access to the car. Also, the microphone in the device is easily susceptible to outside noise which might lead to reading in the wrong code.

The team at Undent Solutions is bringing a method that is unique and far more effective than others. We are presenting a way to prevent lockouts rather than attempting to fix the issue of being locked out. The vehicle lockout prevention system alerts the user when the keys are detected in the car. If all the car doors are locked, it automatically unlocks the main door. An override option is available in case the user is purposely trying to lock the doors with the keys inside.

The development of the Vehicle Lockout Prevention System is planned to be carried out in two phases: the working model phase and the production phase. The first phase is scheduled to be completed on April 18, 2010 and it will have the following capabilities:

- Alert the user when the keys are detected inside and a door is opened and closed.
- Alert the user and unlock the main door when the keys are detected and the doors are locked.
- Include a manual override option to temporarily shut-off the system.
- Indicate to the user when the system is running low on battery power.

The second phase of the Vehicle Lockout Prevention System will expand the sensor area to the trunk and engine in order to cover the entire car. Also, the system will alarm the user with a cell phone text message to make the system more secure. Additionally, there will be sensors at each door to increase monitoring and reduce unnecessary alerts. For further user friendly add-ons, we will upgrade the buzzer to a speaker that will play a user selected tone/song as the alarm. As an ongoing effort, we will try to minimize false alarms and increase the smartness of our system. The system will adhere to all standards and guidelines including those of FCC and CSA.

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GLOSSARY

FCC Federal Communications Commision

CSA Canadian Standards Association

AAA American Automobile Association

RFID Radio Frequency Identification

1. INTRODUCTION

The Vehicle Lock-Out Prevention System is a unique and reliable system designed to prevent accidental car lockout situations. This system is much safer and convenient than other alternatives because it prevents users from breaking into their vehicle window or calling a tow company to retrieve their keys, all of which costs money. This system can be used in older car models that only use a key entry as well as cars that have integrated power locks. With the flexibility of our design, we can target a wide consumer market. Moreover, the system has excellent usability, reliable design, and competitive pricing. This functional specification document outlines the requirements of the Vehicle Lock-Out Prevention System.

1.1 Scope

This document describes the functional requirements that must be followed by the Vehicle Lock-Out Prevention System. These requirements should be closely adhered to and monitored in the early conceptual and prototyping design stages and should be fully met by the final product design.

1.2 Intended Audience

This document is intended to be used and followed by all personnel under Undent Solutions. The project manager will use this document as a reference to oversee that all functional requirements of the design are met. System development personnel such as hardware and software engineers will refer to this document as a fundamental guideline when adding improvements or implementation into the design. Quality Assurance (QA) and manufacturing personnel will use this document to verify that all testing is done correctly and that they meet the functional requirements.

1.3 Classification

Throughout this document, the following notation shall be used to denote the functional requirements:

[Rn-p] A functional requirement.

Where n stands for the requirement number and p is the priority of the functional requirement. The priority levels are shown below:

I The requirement applies to the proof-of-concept system only.
II The requirement applies to both the proof-of-concept and final production system.
III The requirement applies to the final production system only.

2. SYSTEM OVERVIEW

The requirements for Undent Solutions' Vehicle Lock-Out Prevention System are outlined in the following sections.

2.1 System Overview

Our system alerts the user when the car key is inside the vehicle. When the door is opened and shut, the system becomes active. The RFID sensors installed in the vehicle search for the RFID tag attached to the keys. If the keys are found, the alarm sounds. If all the doors are locked, the system unlocks one of the doors. The alarm continues sounding until the user manually shuts off the alarm. The system returns to its idle state until the door activates the system again.
Figure 1 displays our system's flow chart.

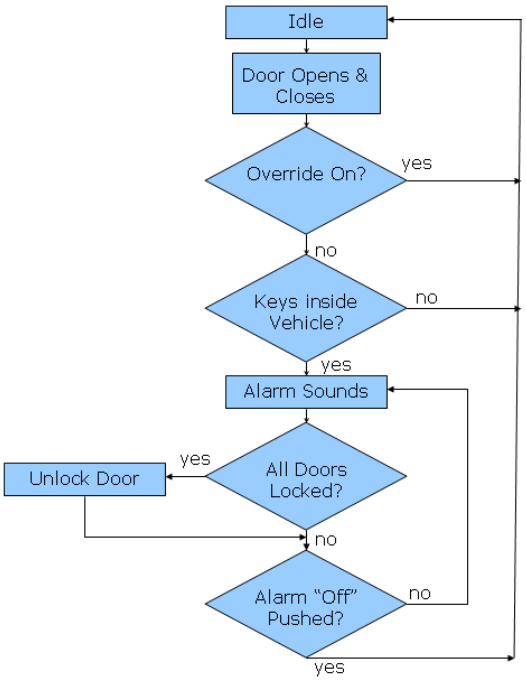

Figure 1: System Flow Chart

The following figure shows where the sensors will be placed inside the car.

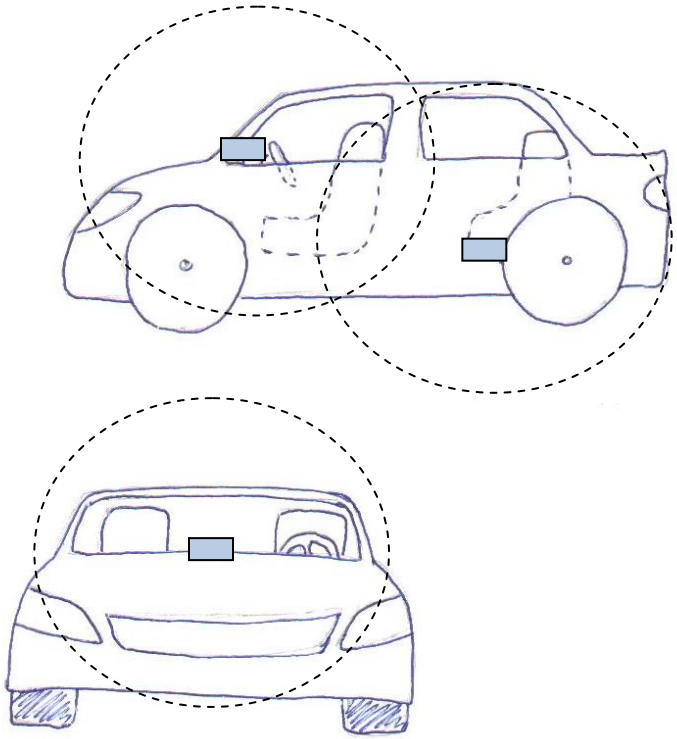

Figure 2: Transceiver range and placement within the vehicle

2.2 General Requirements

[R1-II] The system shall have an idle state where the RF reader is disconnected from the RFID tag.

[R2-III] The retail price of the system shall be under $300.

[R3-III] The RF readers and the buzzer should be minimally intrusive to the user.

2.3 Physical Requirements

[R4-III] The unlocking mechanism should be small enough to install inside the car door and sits besides car lock. The prototype car lock is around 20 cm x 15 cm x 3 cm.

[R5-III] Baseline architecture microcontroller is about 208 mm x 300 mm. The plastic case protecting the circuit board of microcontroller, buzzer and transceiver and wires would be less than hand size. (buzzer size:2cm*1cm*1cm, transceiver: 3cm x 2cm x 2cm) [2].

[R6-III] Noise from buzzer is about 76 dB.

[R7-III] Override switch shall be thumb size.

2.4 Mechanical Requirements

[R8-III] The components used by the user (off button, manual override switch) must be installed in an easy to reach, visible area.
[R9-III] The components used by the user must be installed in an area that doesn't prohibit the driver's movements and comfort.

2.5 Electrical Requirements

[R10-II] The DC motor will be powered with a 12V battery.
[R11-II] The transceiver, microcontroller and piezo buzzer power will be drawn from a portable battery source.
[R12-II] The tag will use an appropriate button cell battery for long-life use.

2.6 Environmental Requirements

[R13-III] The vehicle must be a hard-top, non-convertible car.
[R14-II] The vehicle interior must be a standard car shape.
[R15-III] There cannot be excessive materials that block radio waves inside the vehicle.

2.7 Reliability Requirements

[R16-III] The system must be able to withstand movements from driving during normal road conditions.
[R17-II] System's power indicator must be accurate.
[R18-II] Power indicator must alert the user with substantial time to change the battery.

2.8 Safety Requirements

[R19-I] The buzzer will not exceed 85 dBA [3].
[R20-II] The DC motor will be placed inside the car door.
[R21-II] The unlocking mechanism will be placed inside the car door.

2.9 Performance Requirements

[R22-I] The RF reader shall start searching for the RFID tags within 5 seconds of the door open-close sequence.
[R23-II] Upon detection of the tags, the buzzer shall go off within 1second.

[R24-II] Unless the manual override switch is pressed, the driver's side locked door should unlock within 500ms.

[R25-II] Upon selecting the manual override option, the buzzer should turn off and the RF reader should disconnect from the tags within 2 seconds.

2.10 Usability Requirements

[R26-I] The system shall turn on every time the main door is opened and closed.

[R27-III] The system's firmware shall be upgradable by a technician.

[R28-II] The RFID readers and tags, and the central microcontroller shall have an interface (such as USB) for external connection with a PC for troubleshooting/system upgrade purposes.

3. UNLOCKING MECHANISM REQUIREMENTS

The unlocking mechanism is used only when all the doors are locked. It is installed inside the car door and controlled by the microcontroller.

3.1 General Requirements

[R29-I] The mechanism must unlock the door in under 3 seconds.

[R30-II] The mechanism must not damage the vehicle's locking mechanism, door, etc.

[R31-II] The mechanism must fit inside the door of the vehicle.

[R32-II] The mechanism should be powered by the vehicle's battery or another long-lasting power source.

[R33-II] The mechanism must be installed and/or repaired by a trained professional.

4. TRANSCEIVER SENSORS AND TAGS REQUIREMENTS

The transceiver sensor is used to locate where the tags are and send relevant information to the microcontroller for unlocking the car door. The sensors are placed inside the vehicle near the front and back ends of the car.

The tags are attached to the keys, preferably on the same key ring. Each tag is button cell battery powered for compactness and long battery life.

4.1 General Requirements

[R34-III] The transceiver is connected to a battery life indicator.
[R35-II] The transceiver is encased in a plastic enclosure along with the buzzer, override button, microcontroller, low-battery indicator and battery.
[R36-I] The transceiver relays information with the microcontroller.
[R37-III] The tag is enclosed in a small plastic enclosure which also contains the button cell battery.

5. MICROCONTROLLER REQUIREMENTS

The microcontroller is the core of the system because it combines and controls each part of the system. Due to the features of our product, we need a baseline architecture microcontroller such as the PIC10 or PIC12 from Microchip Technology Inc. or the MSP430 from Texas Instruments. Important characteristics of this kind of microcontroller include low pin count, small form factor, flexible flash program memory, low power capability, and ease of use. In addition, it is ideal for battery operated or space constrained applications [4]. These qualities match the requirements of our system.

The main functions are as follows:

[R38-I] The microcontroller asks the transceiver to check if the key is inside the car once the user opens and closes the car.
[R39-I] Microcontroller controls the beeper, unlocking mechanism, override button and car door sensors.

5.1 General Requirements

[R40-I] The microcontroller features are simple.
[R41-I] The microcontroller has a fast response time and small RAM.
[R42-II] The microcontroller has low power consumption.

5.2 Physical Requirements

[R43-III] Microcontroller is installed within a plastic enclosure.

6. BUZZER REQUIREMENTS

The buzzer is used for notifying the person if the keys are locked inside the vehicle. The beeper will be controlled by the microcontroller and will use the same power as the transceiver.

6.1 General Requirements

[R44-II] The buzzer will not exceed 85 dBA [3].
[R45-I] The buzzer is controlled by the microcontroller.
[R46-III] The buzzer noise must be distinct, as to not be confused with other car alarm sounds.

6.2 Physical Requirements

[R47-III] The buzzer will fit inside a small plastic enclosure that will include the LEDs, buttons, batteries and low battery indicator.

7. USER INTERFACE

The user will be able to use the system through two switches. There will be a momentary push-button switch for use as the "Alarm Off" button. There will also be a two-way switch that is to be used for the manual override. The system will communicate to the user through a buzzer/beeper and LED indicator lights. There will be an indicator light for warning the user of a low battery and a light for indicating that the override is "on". The buzzer is for indicating the presence of the keys inside the vehicle.

[R48-II] The key and system batteries must be easy to change.
[R49-II] The system shut-off button should be intuitive to use.
[R50-II] The override switch and indicator light should be in a convenient location.
[R51-II] The battery indicator should be in a clearly visible location.

8. USER DOCUMENTATION

[R51-II] A pamphlet will be included for the end-user.
[R52-II] A detailed guide for installation will be included for technicians.
[R53-II] Documentation will be available online.
[R54-II] Documentation will be written in the official languages of our target market(s).

9. SYSTEM TEST PLAN

It is important to let the Vehicle Lockout Prevention System undergo extensive testing before rolling the final product out to production. Therefore, the general test plan will first test the individual components and their usability, then test the combined modules and finally test the entire system as a whole. Various test scenarios will be created that will put the system to test all its features in and out. Once the proof-of-concept has reached its final stages, professional QA personnel will conduct detailed user trials of the system.

Our system consists of many individual components controlled by a central microcontroller. The components are:

- Two RFID transponder tags ("the tags") attached to two of the same car keys.
- Two RFID receivers ("the reader") attached at the front and back end of the car.
- Car unlocking mechanism.
- The buzzer.
- Sensors attached to the front doors.
- The manual override switch.
- The central microcontroller.

All of these components will be tested both individually and combined. Once the tags pass the initial test of establishing communication with each reader, the signal strength of the tags inside various positions of the car as well as the degradation of the signal travelling through metal surfaces (i.e., the car body) will be tested. Using these signal strength results, an algorithm will be created to figure out whether the keys are inside the car or outside and will be used as test bench results.

The sensors attached to the front doors are the show-starters. Once it detects a door open and close sequence, it signals the reader to look for tags within proximity of the car. If a registered tag is detected, the central microcontroller triggers the buzzer to go off. To ensure that the system works accordingly, the sensors will be tested first. Once it is certain that the door open-close step triggers the reader, the reader will be tested. The reader will undergo various tests mainly consisting of:

- Detecting only the registered tags.
- Locating only the tags placed inside the car.
- Locating the tags placed in various positions of the car (excluding the trunk and the engine).
- Triggering the buzzer when any/both of the two readers detect the same tag.
- Ignoring the tags detected outside the car using the signal strength algorithm.
- Disconnecting the reader when override button is pressed; until the user opens and closes the door again.

Once the reader tests are completed, the buzzer will be tested. The test will make sure a pre-programmed alarm will set off when the keys are detected. Also, the beeper will stop when the override switch is pressed.

Upon successful completion of the above mentioned tests, the manual override switch will be tested. Pressing this override switch will only have an effect when the buzzer goes off. The override switch will turn the buzzer as well as the reader off until the next door open-close sequence commences.

Another important component is the unlocking mechanism. The ultimate goal of the Vehicle Lockout Prevention System is to unlock the door immediately after a lockout. The test will make sure the car will be unlocked only when the keys are detected and no manual override switch is pressed. It will also test that the door will unlock fast enough before the user leaves the car so that no one else will have access to the keys.

A rather simple, yet crucial test is to make sure the batteries have enough power to operate the tags and the readers. A simple circuit that turns on an LED when the device is running low on battery will avoid potential future disappointments. The tags and the readers will be tested with a set of batteries with different charge levels, if the warning LED turns on when the batteries with approximately/less than 25% charge left, the test will be considered a success.

Finally, the central microcontroller that connects almost all of the pieces together will be tested. The microcontroller's communication with the sensors, the readers, the buzzer, the manual override switch and the front door locks will be tested thoroughly. When the communication tests are passed, the microcontroller commands given to each of the individual components, such as: ask the reader to attempt to connect/disconnect to/from the tags, ask the buzzer to beep/turn off, give power to the motor placed with the lock to unlock the doors, etc. Successful completion of the microcontroller test will mark the end of the proof-of-concept stage. At this point, the QA personnel will test the Vehicle Lockout Prevention System using potential lockout scenarios as well as security and safety scenarios.

10. CONCLUSION

This functional specification defines the fundamental requirements of the Vehicle Lock-Out Prevention System which must be met and followed throughout the development phase. This system is financially sound and technically safe and reliable mean of preventing one from locking themselves out of their car. The project development will be split into two stages. The first stage will consist of a working prototype model and include all the requirements as mentioned in the document and the second stage will compose of further development. The first stage is planned to be completed by April 18, 2010. Further development will include enhancements such as text messages notifying the user that the keys are locked inside and more user friendly add-ons. Also, the enhanced design will consist of improving the sensing range and accuracy between the transceiver and tags.

11. SOURCES AND REFERENCES

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