

October 19, 2015

Dr. Andrew Rawicz  
School of Engineering Science  
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**Re: ENSC 440W Functional Specifications for Audolok**

Dear Dr. Rawicz,

The enclosed document contains the functional specifications for our product Audolok. Audolok is an automatic, secured access, lock/unlocking and open/closing door controlled by Smartphones. The goal of our project is to eliminate challenges faced by physically disabled individuals of locking/unlocking and opening/closing secured doors.

The succeeding document contains a detailed description of the system overview, component and material selection with consideration of cradle-to-cradle design, and requirements on electrical, mechanical and performance functionalities. It also includes details about safety and engineering standards requirements associated with the product.

The eLOK Systems team consists of four goal driven engineering students with diverse backgrounds and skill sets: Lexi Chor, Ellson Dai, Christy Tao and Chi Zhang. Should you have any questions or concerns, please do not hesitate to contact us at [lchor@sfu.ca](mailto:lchor@sfu.ca)

Sincerely,

A handwritten signature in black ink, appearing to read 'Lexi Chor'.

Lexi Chor  
Chief Executive Officer  
eLOK Systems

*Enclosure: Functional Specifications for Audolok*



## Functional Specifications for Audolok

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## Executive Summary

The freedom to move around comfortably in homes and offices is often taken for granted. But it is this freedom that is embraced by individuals with limited mobility and strength, such as elderly and physically disabled individuals. Not all individuals with limited mobility and strength have the luxury of being accompanied by a helper, or feel the need to have one, so they often face difficulties. Such difficulties include locking and unlocking doors, and opening and closing them, especially if they have limited strength or hand dexterity, or use wheelchairs. The most common difficulties are associated with the hardware used, the weight of the door and the height of the lock or door knob [1].

To eliminate these challenges, eLOK Systems has designed a smart secured door called Audolok. Audolok provides convenience and comfort when opening, closing, locking and unlocking doors, because it requires minimal movement by making use of smartphone technologies. With a touch of a finger, Audolok will unlock and open, then close and lock itself behind you. In addition, because Audolok uses Wi-Fi technology to communicate, individuals are able to check the status of their door remotely. Audolok's companion mobile application will include a log of when the door is locked and unlocked. Three different levels of electronic keys are also available: Admin User, Trusted User and Temporary User. This functionality allows users to give access to other users so they can access their door for cases when they aren't home, or for emergencies.

This documentation contains all the functional requirements needed for Audolok, as well as the engineering standards for the overall system design. Sustainability and safety will also be considered and the cradle-to-cradle design cycle will be put into great consideration when selecting the materials and components.

eLOK Systems plans to complete a proof-of-concept design by the end of October and have a working prototype of Audolok by December 2015. Our goal is to eliminate as many challenges faced by individuals with limited mobility and strength when it comes to opening secured doors.

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## Glossary

<b>3G</b>	Third Generation of Mobile Telecommunications Technology
<b>4G</b>	Fourth Generation of Mobile Telecommunications Technology
<b>AC-DC</b>	Alternating Current - Direct Current
<b>CAN/CSA</b>	Canadian Standards Association
<b>IEEE</b>	Electrical Electronic Engineers
<b>IFTTT</b>	If This Then That Protocol
<b>iOS</b>	iPhone Operating System
<b>MCU</b>	Microcontroller Unit
<b>PWM</b>	Pulse Width Modulation
<b>SPI</b>	Serial Peripheral Interface
<b>UI</b>	User Interface
<b>V</b>	Volts

# 1. Introduction

Audolok is a smart door system aimed to alleviate the challenges faced by individuals with limited mobility and strength. Audolok has four main features:

- 1) Lock/Unlock using mobile application
- 2) Automatically open and close door
- 3) Notification when doorbell pressed and when door is unlocked
- 4) Electronic shareable keys

Since Smartphone's are becoming very popular in today's generation, all the features are conveniently accessed via the companion mobile application: eLOK App (figure 1). Not only does Audolok alleviate challenges of unlocking and opening doors, it also prevents injuries involved in performing such tasks. Audolok is an assembly of systems containing Arduino microcontrollers, Wi-Fi shields and motor drivers. Mechanical parts controlled by the MCU's are step motors, rotating arms, buttons and motion sensors. A database will provide locations for authority and server based actions.

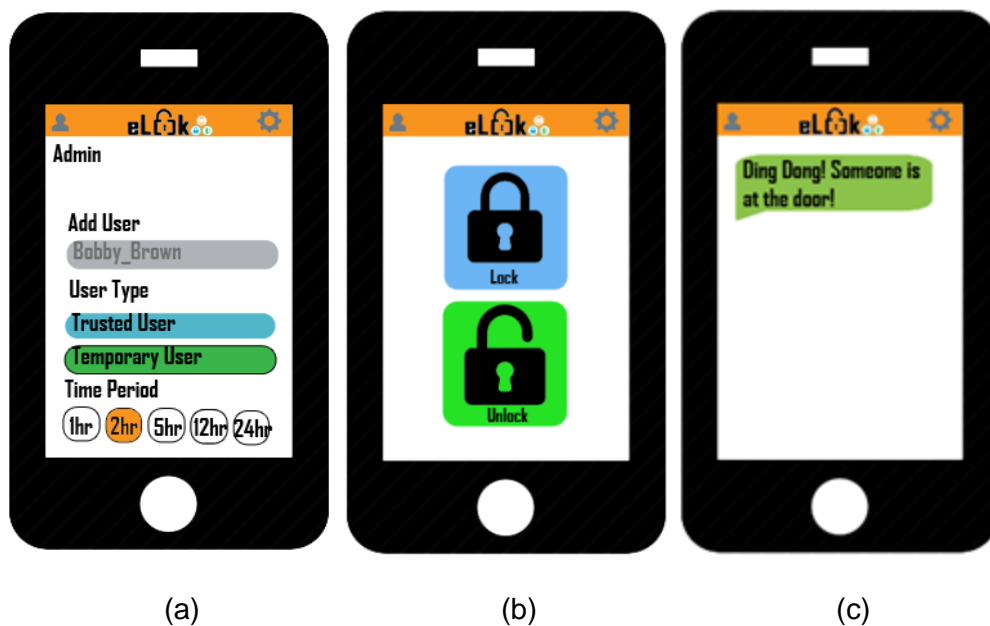


Figure 1: eLOK app page of (a) Admin Page, (b) Lock/Unlock Page, (c) Doorbell Notification

A conceptual diagram of each system is shown in figure 2.

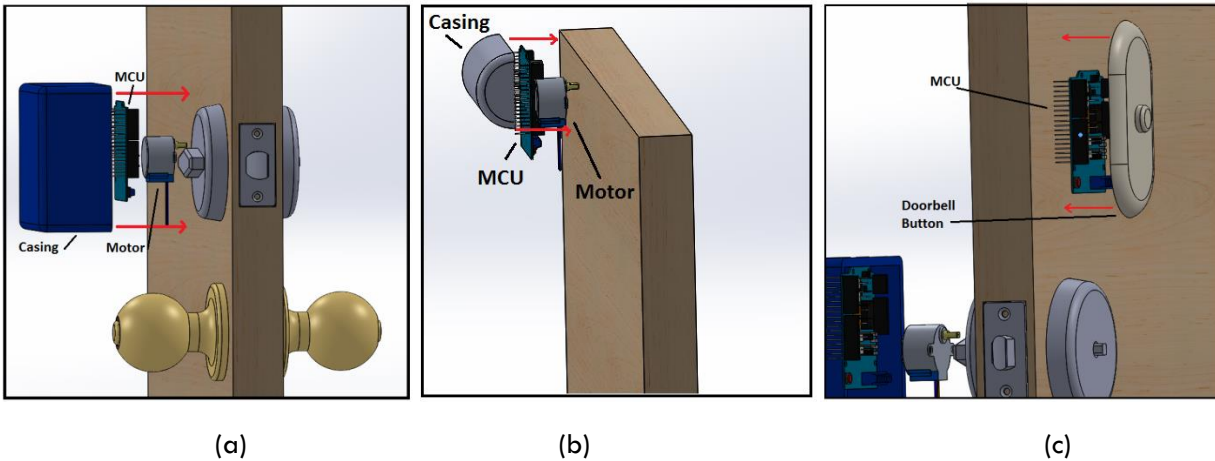


Figure 2: Conceptual diagram of (a) lock mechanism, (b) automatic door opener, (c) doorbell mechanism

## 2. Scope

This document outlines the functional requirements of Audolok. The functional requirements outlined cover the microcontroller, locking mechanism and circuits, automatic opening mechanism and circuits, wireless communication and mobile application. The requirement categories are broken down as follows (note that not all categories are required for each system):

- **General:** refers to general requirements for the overall system
- **Physical:** refers to dimensions, materials, shape and weight
- **Electrical:** refers to power supplies, components and microcontrollers
- **Mechanical:** refers to all moving parts such as motors and rotating arms
- **Standards:** refers to Engineering standard codes which must be met
- **Safety:** refers to the safety of users when using the product
- **Performance:** refers to the final state of how the product should perform
- **Environmental:** refers to cradle-to-cradle cycle sustainability
- **Reliability and Durability:** refers to strength and lifetime of the systems

In addition, this document will also prioritize each requirement as proof-of-concept, prototype or final product.



### 3. Audience

Our functional specifications are intended for use by all members of the eLOK Systems team. Each member will use this document as a reference guide for each phase of development to ensure the final product meets the functional specifications. In addition, the functional specification document will be used to measure progress during the development period and to aid the marketing department of eLOK Systems to find potential investors.

### 4. Classification

The functional requirement specification is shown as follows:

[Rn-p]

Where 'R' is an abbreviation for requirement, 'n' is the functional requirement number, and 'p' represents the priority of the requirement as one of the following three development stages:

- i High Priority** - Essential for the main function of the product. The proof-of-concept must meet these requirements.
- ii Medium Priority** - Desirable features which do not affect the main functionalities. Prototype will include these features if time allows.
- iii Low Priority** - Features and refinements which will only be presented in the final production of the product.

For example [R7-i] is the seventh requirement, which is of high priority and must be implemented for the proof-of-concept.

## 5. System Overview

The block diagram of the system overview of Audolok is shown below in figure 3.

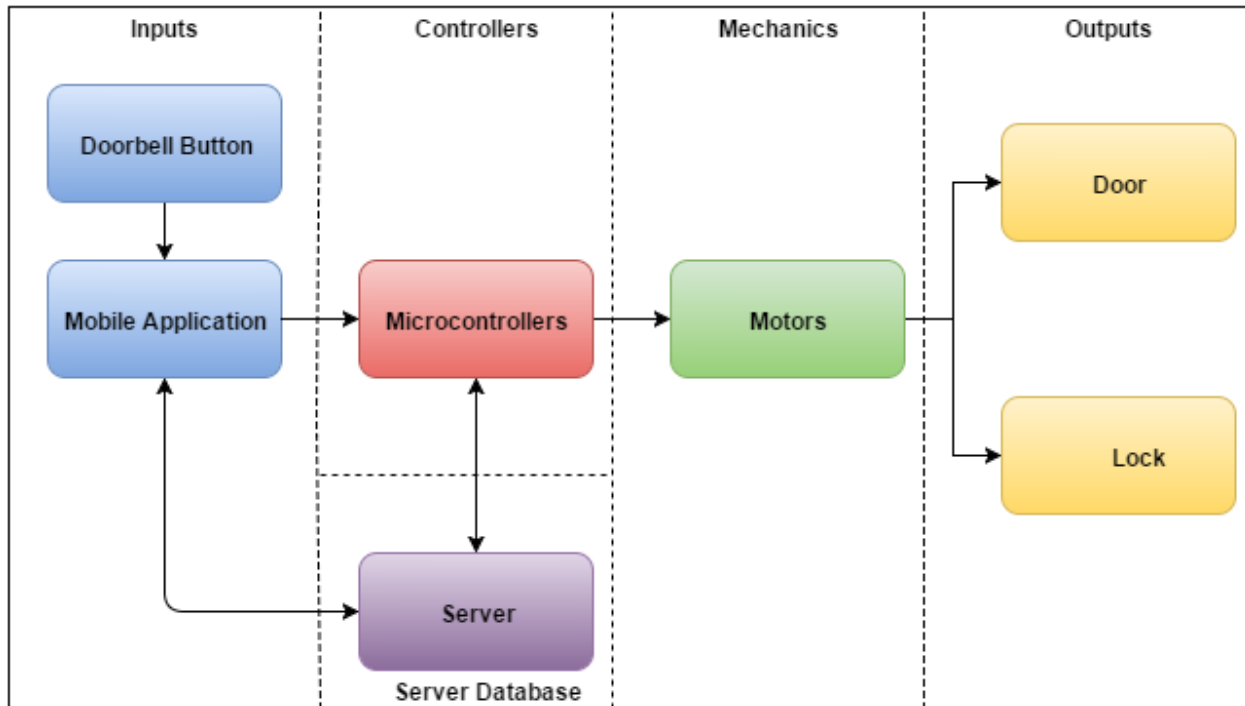


Figure 3: Block Diagram of Audolok's Systems

Audolok consists of two inputs, a server, controllers, mechanics and two outputs.

### Inputs

- **Doorbell Button:** The doorbell communicates with the mobile application when it is pressed. The button sends a signal to the application, which then notifies the user that someone is at their door. A cloud based server or IFTTT protocol will be used for this function.
- **Mobile Application:** The mobile application is the key to open the lock and the door. The mobile app communicates with the microcontrollers and the server. Users are able to lock/unlock, open/close the door with the app, as well as check the door status and view a log of when the door has been unlocked. In addition, the users are able to share keys to other users.

### Controllers

- **Microcontrollers:** The microcontrollers receive signals from both the server, for authentication, and the application for commands. When a command is received, the microcontroller tells which motors to run.

## Server

- **Server:** The server communicates with the microcontroller and the mobile application. The server is where all the authentication data is stored. Once the server confirms the identity of the user, it allows access to the system. It also stores data of when the door is locked and unlocked which can be shown in a log on the mobile application.

## Mechanics

- **Motors:** There are two motors. One for the door and one for the lock. Once the microcontrollers receive command to unlock the door, the motors receive the signal and start turning. Once the door is unlock, the second motor will turn to open the door.

## Outputs

- **Lock:** The motor, along with mechanical parts such as rotating arms, will turn the lock, which unlocks the door. When the door closes, these mechanisms will turn back to lock the lock.
- **Door:** On the door, there will be a motor and rotating arms which will open and close the door.

# 6. Overall System

This section describes all requirements needed for the prototype and final product of Audolok.

## 6.1 General Requirements

- [R1-ii] Audolok shall be easy to operate
- [R2-ii] The mobile application shall be available for free in the Apple Store
- [R3-iii] Installation shall be easy and require minimal tools
- [R4-iii] Maintenance shall be affordable, easy and accessible
- [R5-iii] Audolok shall operate under all weather conditions
- [R6-iii] The final production price of Audolok shall not exceed \$200
- [R7-iii] Doorbell shall be placed on the exterior of the door

## 6.2 Physical

- [R8-ii] Audolok shall be compatible with traditional deadbolt locks
- [R9-iii] All components shall be well insulated
- [R10-iii] The closure shall have round edges
- [R11-iii] The closure shall not exceed 10cm x 10cm x 5cm (WxLxH) in dimension
- [R12-iii] The weight of each system shall not exceed 2kg for a total of 6kg as to not weigh the door down and increase the torque required

## 6.3 Electrical

- [R13-i] Power shall be sourced from AC-DC 110V wall plug power
- [R14-ii] No electric shock shall occur between door and electrical components
- [R15-ii] All electrical components shall be protected from rusting
- [R16-iii] The battery of doorbell shall be rechargeable and replaceable
- [R17-iii] There shall be power backup plan in case of power supply failure

## 6.4 Mechanical

- [R18-ii] The door shall open automatically after unlocked
- [R19-ii] The door shall close automatically or with owners command
- [R20-ii] Mechanical components shall move easily
- [R21-iii] The lock shall lock and unlock smoothly
- [R22-iii] Door shall open and close smoothly and with ease
- [R23-iii] mechanical components shall not protrude casing

## 6.5 Safety

- [R24-ii] Audolok shall be highly secure for customers
- [R25-ii] Casing for lock and door motors shall be on inside to prevent tampering
- [R26-ii] Notifications shall be sent when door has been unlocked
- [R27-ii] Logs shall be saved when door unlocks

## 6.6 Standards

- [R28-iii] The system shall comply with the standard CAN/CSA C22.2 NO. 68-09 (R2014) - Motor-operated appliances (household and commercial) [2]
- [R29-iii] The system shall comply with the standard CAN/CSA C22.2 NO. 247-14 - Operators and systems of doors, gates, draperies and louvres [3]
- [R30-iii] The system shall comply with the standard CAN/CSA-C22.2 NO. 60335-1:11 - Safety of household and similar appliances - Part 1: General requirements [4]
- [R31-iii] The system shall comply with the standard CAN/CSA-E730-2-12-94 (R2013) - Automatic Electrical Controls for Household and Similar Use - Part 2: Particular Requirements for Electrically Operated Door Locks [5]

## 6.7 Performance

- [R32-iii] The system shall not expect mechanical or electrical failure during the first 5 years of its lifetime
- [R33-iii] Broken components shall be easily replaced by customer

## 6.8 Environmental

- [R34-ii] Lock and door motor shall be installed inside
- [R35-iii] Casing of lock and door motor shall be recyclable
- [R36-iii] System shall operate under temperatures of -20 to 40 degrees Celsius

## 6.9 Reliability and Durability

[R37-iii] Casing for Audolok systems shall be resistant against human force

# 7. Mechanical System

The Mechanical System of Audolok consists of 2 motor based subsystems. Each subsystem is built with a motor and drive circuit. The 5V electric motors are powered by 110V to 5V AC-DC plug in power supplies, and the motor drive circuit board is connected to the MCU system. The motor drive will receive commands from MCU to achieve movement, steering and braking for the door. Based on functional differentiation, one subsystem takes responsibility of opening and closing the door, and the other for locking and unlocking. Even with different real time functions, the functional specifications for those 2 subsystems are identical in communication with the MCU. The motors will supply the amount of torque required to open and close the door.

## 7.1 General Requirements

- [R38-i] The motor system shall provide both forward and reverse directional torque
- [R39-ii] Rotation of the door lock and opening/closing of doors shall be achieved using motor
- [R40-ii] The module of motor system shall be easily attached to a door and its lock handler

## 7.2 Physical

- [R41-iii] All motors shall be protected and well enclosed
- [R42-iii] All motors shall not be blocking the doorway or be sticking out

## 7.3 Electrical

- [R43-i] The electric motors shall operate at 5V
- [R44-i] All components shall operate under AC-DC power supply
- [R45-iii] There shall be insulation between electrical components and door

## 7.4 Safety

- [R46-i] Door shall not close when people are standing in the door way
- [R47-ii] Traditional lock shall still be able to used in case of power failure
- [R48-iii] All components shall be secured strongly on the door

## 7.7 Performance

- [R49-ii] Motors shall rotate smoothly in order to open/close and lock/unlock door
- [R50-ii] Delay to transfer data from MCU to motor shall not exceed 5s

## 8. Microcontroller Unit Requirements

The Arduino based microcontroller units in each subsystem are responsible for the integration of all parts in the subsystem. In addition, it also act as transceivers for the push button, cellphone, database and other subsystems via wired or wireless connection channels such as Wi-Fi and Bluetooth.

### 8.1 General

- [R51-i] The microcontroller unit shall have low power capacity
- [R52-i] The microcontroller unit shall have slots for jump wire connection with external components
- [R53-i] The microcontroller unit shall be able to receive or transmit both digital and analog signals

### 8.2 Electrical

- [R54-i] The power supply of microcontroller units shall be shared with other subsystems from a 110V-5V AC-DC plug in voltage converter
- [R55-i] The operating voltage of microcontroller units shall be 5V

### 8.3 Safety

- [R56-ii] All components must withstand operation temperature and currents
- [R57-ii] All circuitry must be properly isolated with no conducting surfaces exposed

### 8.4 Standards

- [R58-i] The microcontroller unit shall be integrated with standard serial ports for communications, and PWM ports for motor driven
- [R59-ii] The microcontroller shall be integrated with standard peripherals such as SPI and PWM

### 8.5 Performance

- [R60-i] The microcontroller unit shall have capable clock frequency to synchronize wireless communication standards such as Wi-Fi or Bluetooth

## 9. Software Requirements

The software component takes care of the mobile application as well as the servers and database. The mobile application enables the user to control Audolok and the database server takes care of the authority and background services.

### 9.1 General

- [R61-i] The app shall operate properly on iOS systems

- [R62-i] The app shall have a login page allowing the user to input username and password
- [R63-i] The app shall be connected to the server if and only if the authentication of the user is confirmed
- [R64-i] The app shall be connected to the server under Wi-Fi/3G/4G network or Bluetooth environment
  
- [R65-ii] The app shall be free and easy to install from the Apple store
- [R66-ii] The app shall be easy to open/close with short response time limited to 3 seconds
- [R67-ii] The server based database shall have backup storage
- [R68-iii] The app shall have a user-friendly UI

## 9.2 Safety

- [R69-ii] User information within database shall be secure in server
- [R70-ii] The app shall not unlock the lock without the user's permission
- [R71-ii] The app shall not unlock the lock automatically when the lock is out of battery/power
- [R72-ii] Temporary access assigned to other users shall be terminated when set time expires
- [R73-ii] The temporary users shall not be able to assign accesses to others

## 9.3 Performance

- [R74-i] The app shall only allow one user to be the administrator
- [R75-i] The app shall allow the user with administration to assign temporary accesses to other users
- [R76-i] The app shall allow the user with administration to terminate temporary accesses to other users
- [R77-i] The app shall send notifications to the user's cell phone when doorbell is rung
- [R78-ii] The app shall always show the current state of the lock

## 10. User manual

- [R79-iii] User manual shall be included with product
- [R80-iii] User manual shall be available on the company website
- [R81-iii] User manual shall be written for an audience with minimal knowledge in electronic devices
- [R82-iii] User manual shall include graphics, texts and step-by-step instructions on how to install and operate the system
- [R83-iii] Contact information shall be available for customer service and inquiries

## 11. Sustainability and Safety Considerations

### 11.1 Sustainability

At eLOK Systems, the “cradle-to-cradle” cycle is important when designing Audolok. Each component and material selected for Audolok has been put under careful consideration in order to make the components recyclable and reusable. The material selected for the casing of each component, as well as the mechanical moving parts will be steel. Steel is durable, light and is recyclable. Other materials such as carbon fiber, wood and ceramic have also been considered as usable material, however steel came out to be the most fitting for our design. In addition, Audolok’s systems will be placed in homes where wheelchairs may be present, therefore strong and durable casing must be considered in the case that wheelchairs accidentally run into it. Although plastics are lighter in weight, they require more thickness to obtain the same strength as metals. In addition, when some plastics become too cold, they become brittle and can easily break. A comparison of different materials considered is presented in table 1.

Table 1: Material Comparison

Material	Hardness	Weight	Cost	Recyclable	Elasticity
Steel	High	High	Medium	Y	Low
Plastic	Variant	Variant	Medium	Y	Medium
Carbon Fiber	Medium	Low	High	N	High
Aluminum	Low	Low	Low	Y	High
Ceramic	High	Variant	High	N	N/A
Wood	Low	Medium	Low	Y	Low

The microcontrollers used in our product are reprogrammable, so they can be reused if not damaged. Otherwise, they can be recycled at electronic recycling depots. All software components will not affect the cradle-to-cradle design as they are not physical. Most other electrical components can be recycled.

### 11.2 Safety Considerations

Audolok is designed to eliminate challenges to limited mobility and strength individuals. Since these individuals are weaker, eLOK Systems strives to make their products as safe and user friendly as possible. All electrical and mechanical components are safely contained in enclosed compartments to prevent any tampering or accidental contact. All software systems will include high encryptions so that user information is not compromised. Engineering safety standards, such as CSA standards are followed in order to provide a safe product.



## 12. Conclusion

This document covers the detailed functional requirements of the overall Audolok system and also specifies future implementation phases for all subsystems. The major sections mapped out in this document are:

- Hardware (Microcontrollers): designed to control the lock, receive commands from the software and give suggestions when systems are idle;
- Software (App, Server): designed to allow users to give commands via a server based database through a user friendly mobile app;
- Mechanics (Motors): designed to control movement and rotation of the lock and the door;

The individual requirements about physical appearance, mechanical components, performance requirements, safety and standards of each subsystem are all stated in above contents. Test plans will be included in the design specification document to ensure the overall system in the future. Specific designs may be modified to be more user-friendly, however the high standard which have been raised will remain. The engineers at eLOK Systems are working diligently together to improve people's living conditions from each corner of our daily lives, and that is also the reason why Audolok is superior to other similar existed products in the market.

## References

[1] Fall Prevention Center of Excellence, “Home Modifications” [Online]. Available: <http://www.homemods.org/resources/doable-home/adaptability.shtml> [Accessed 10 October 2015]

[2] CSA Group, “Motor-operated appliances” [Online]. Available: <http://shop.csa.ca/en/canada/appliances/c222-no-68-09-r2014/invnt/27002302009> [Accessed 15 October 2015]

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[4] CSA Group, “Safety of household and similar appliances - Part 1: General requirements” [Online]. Available: <http://shop.csa.ca/en/canada/appliances/cancca-c222-no-60335-111/invnt/27023152011> [Accessed 17 October 2015]

[5] CSA Group, “Automatic Electrical Controls for Household and Similar Use - Part 2: Particular Requirements for Electrically Operated Door Locks” [Online]. Available: <http://shop.csa.ca/en/canada/component-standards/cancca-e730-2-12-94-r2013/invnt/27001291994> [Accessed 17 October 2015]