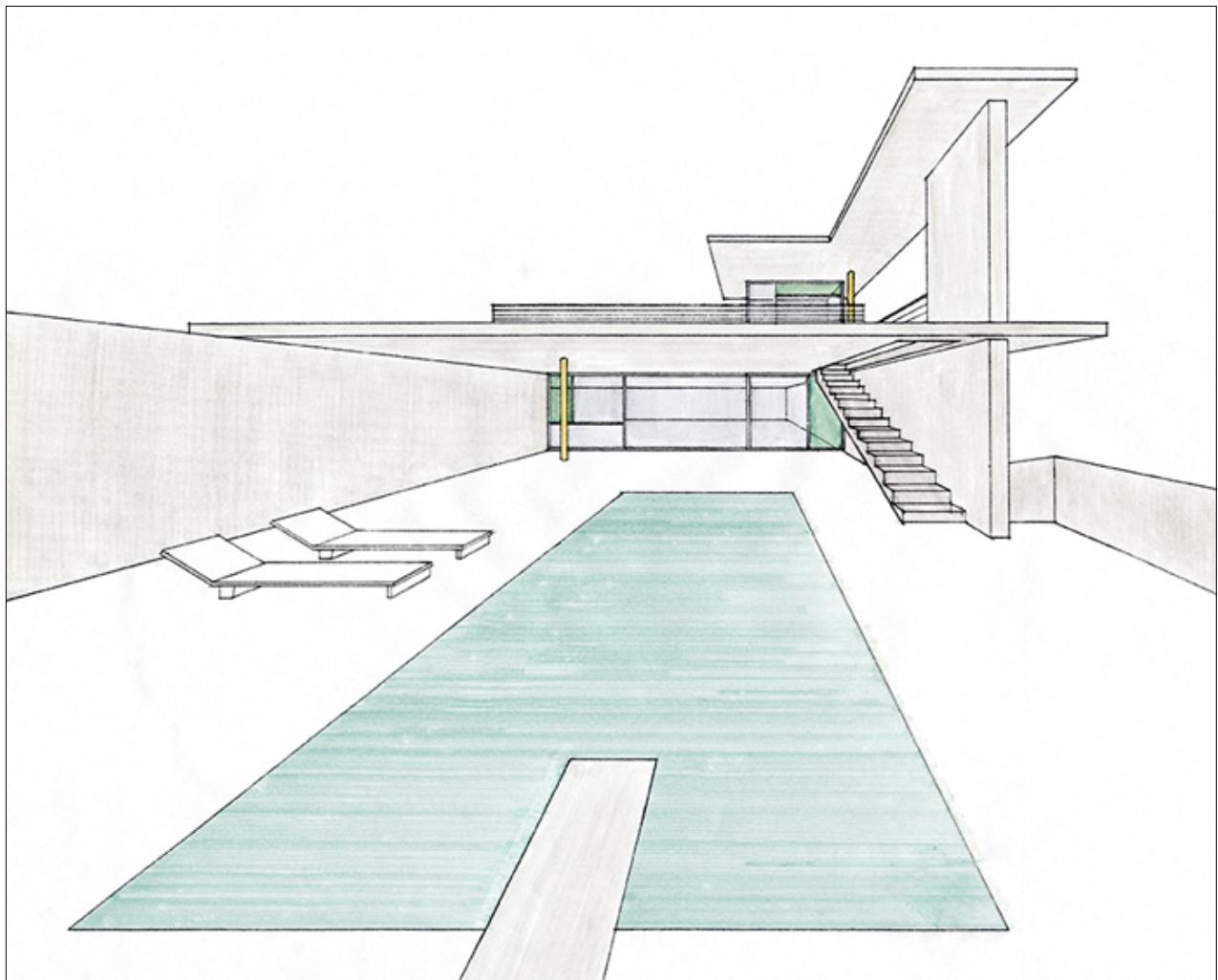

SMART GATE CONTROLLER



Project Report

Prepared for: Dr. Nicoley Gurusighe, Dr. Mahima Weerasinghe

Prepared by: AA1381 Methsara Dissanayeka, AA1359 Raviprabha Rathnayake

10 August 2022

Candidate's Declaration and Supervisor's Certification

We hereby declare that the project work entitled “Smart Gate Controller”, submitted to Sri Lanka Technological Campus in partial fulfilment of the degree of Bachelor of Engineering in Electronics of Sri Lanka Technology Campus, Padukka, is a record of our original work done by us under the guidance of Dr. Nicoloy Gurusinghe, Head of Faculty of Engineering & Technology ,Senior Lecturer (Grade II).

Name	Index
D M K Methsara Dissanayeka	AA1381
R A R K Rathnayake	AA1359

This is to certify that the above students have carried out the research “ Smart Gate Controller” for partial fulfilment of the above requirement, during the academic year 2021-2022, is an authentic work carried out under my supervision.

.....
Dr. Nicoloy Gurusinghe
Date -

Acknowledgment

We would like to express our deepest gratitude towards our project supervisor Dr. Nicoloy Gurusinghe for his valuable guidance and support throughout the project and presentation/ viva examiner Dr. Mahima Weerasinghe for his guidance and comments which helped us improve our knowledge and confidence. We also extend our thanks to our parents and our friends for their support and encouragement. Further, very thankful to all the respondents who spent their valuable time in completion of the survey. Last but not the least, we would like to thank all those who had helped directly or indirectly towards the completion of this project.

ABSTRACT

Safety is a preliminary element in our lives, in order to satisfy it living beings take various measures such as self-protection, awareness etc. As a part of it, to protect their loved ones, asserts and be safe from natural and intentional hazards, humans pay a significant attention to residential security. Besides, most of the time they prefer to have a convenient, comfortable lifestyle and avoid unnecessary manpower. Consequently, nowadays they are drastically moving towards automatic appliances. For example remote control shutters, human sensor light fittings, smart gas and fire detectors and many more equipment.

This research is dedicated to determining a new invention regarding automated smart gate controllers and interprets the importance of shifting to it. The system will be constructed utilising a RFID and NFC module and external AC/DC power adaptor. When the vehicle comes near to the gate, the scanner will read the specific tag attached to the vehicle. If the input data from the tag matches with the stored data, the gate will automatically open and allow the user to enter the premises. Accordingly, the user can easily and conveniently open the domestic gate without any manual effort. The research methodology of this project is a mixed method. The raw data is collected using a survey and samples are gathered targeting Sri Lankan families.

Keywords: RFID technology, NFC module, automated gate controllers

Table of Contents

Acknowledgment	2
ABSTRACT	3
Table of Contents	4
Table of Figures	5
CHAPTER 1- INTRODUCTION	6
1.1 Project Background	6
1.2 Problem statement	7
1.3 Objectives	7
1.4 Scope	8
1.5 Expected result	8
CHAPTER 2 - LITERATURE REVIEW	9
2.1 Introduction	9
2.2 An introduction to RFID technology	9
2.3 Working principles of RFID	10
2.4 Applications of RFID	10
CHAPTER 3 - METHODOLOGY INTRODUCTION	12
3.1 An introduction to RFID technology	12
CHAPTER 4 - DESIGN AND IMPLEMENTATION	16
4.1 Design	16
CHAPTER 5 - ECONOMICS OF SELLING THE PRODUCT	19
CHAPTER 6 - FUTURE ENHANCEMENTS & CONCLUSION	21
6.1 Future enhancements	21
6.2 Conclusion	21
6.3 Reference	22

Table of Figures

- Figure 3.1 - Results on survey : The types of gates
Figure 3.2 - Results on survey : Current of smart solutions
Figure 3.3 - Results on survey : Number of vehicles at single submission
Figure 3.4 - Results on survey : Type of vehicles at single submission
Figure 3.5 - Results on survey : Price for their product
Figure 3.6 - Printed Circuit Board diagram
Figure 3.7 - UHF RFID Reader
Figure 4.1 - Block Diagram
Figure 4.2 - Service Diagram
Figure 4.3 - Demonstration Circuit
Figure 4.4 - Schematic Diagram
Figure 4.5 - Registers Diagram of Microcontroller
Figure 4.6 - Schematic Diagram of Signal Decoder

CHAPTER 1- INTRODUCTION

1.1 Project Background

The development of humans has resulted in an increase in demands for needs and wants. Thus, to protect it they set boundaries for their attachments from the outside world. Likewise, once humans realise the importance of owning lands which can be passed on for generations to generations, they march to reserve it. With time, advancement of technology helps to design walls, that are considered as boundaries and along with it gates came up as a passage of entrance. Gates ensure security and privacy of the residence and the loved ones. In other words, it helps to keep strangers out of the house. When the house gate is designed it should be strong, unfeasible to break by unauthorised access and definitely should be easy to operate.

Even today, constructing a finished house includes designing a modern gate. There are different structures of modern gates such as swing, slide and roller gates etc. Out of them, roller gates are convenient to operate as it requires automation and zero manpower. So far in Sri Lanka any automated gate's technology is bound up to app development and remote controller accesses, hence we thought beyond that and enhanced the existing system by implementing a smart gate controller. The innovative system is designed in such a way that it operates using ultra high frequency - Radio Frequency Identification (UHF RFID) module. In this paper, we will comprehensively discuss the details on implementing the circuit, the technology that we used, risk and problems and marketing analysis by simulating the data collected from Sri Lankan families.

1.2 Problem statement

Usually roller gates or any other automated gate manufactures will hand over two remotes for the user. Just think if your family is an extended family or consists of 10 family members and faces an emergency or any situation. But, still the family has two keys to deal with. Furthermore, if one of the members suddenly forgets the remote then someone inside has to help him/her. Hence, the questions arise as “how can we distribute two keys among responsible family members?” and “how could we enter our land if a person unfortunately forgot it?”, because no one can manually operate it from outside. Thus, as a solution the new system introduces a RFID tag which is attached to each and every vehicle that the landowner owns. Therefore, the family members do not have to take another obligation on their shoulders.

Some instances using a remote controller may be irritating to the driver since he has to reach it and press the buttons. Woefully, if he had a hectic day still he has to drag the remote, press the buttons and wait until it processes. Accordingly, to avoid such situations the system is made as soon as the vehicle arrives the sensor is able to detect its unique tag which is given to the owner and allows the gate to automatically open. Thus, improvement of the technology aids to eliminate tiresome, troublesome situations and provides easiness and convenience. Similarly, the new innovation will also be able to satisfy the same comfort zone for the user.

1.3 Objectives

The objective of the project, the Smart Gate Controller is to introduce a new technology for ordinary domestic gate accesses without any physical involvement.

- It is focused on allowing multiple users in the house to access the entrance without any interruptions.
- To provide convenience and comfortability for the user.
- To provide maximum security when entering a premise as it scans the unique code programmed for each tag.

SMART GATE CONTROLLER

1.4 Scope

The project is associated with an ultra-high frequency RFID sensor detector (scanner) which has a far field read range covering a few meters and its unique tags. This kit is externally connected to the automated gate as a gate controller and powered by AC/DC power adapter. Moreover, a passive tag is placed on the top of the windscreen at a position where the scanner can read its uniquely coded tag. The gate is only accessible or open for the specific tags, not for unauthorised tags thus it has a high security and no room for hacking.

The targeted audience of the project is the users who benefit from automated gates and are willing to purchase new gates. It is easy to design the product and motivate the customer via the regular users. In order to gather qualitative as well as quantitative data, a survey was conducted using 21 families in Sri Lanka. Additionally, the survey was the base for the marketing strategies and in the future hoped to generalise it to the whole Sri Lankan community.

1.5 Expected result

The system is operated based on radio frequency (RF) waves, the scanner is fed with data from the RFID tag. If the input data is matched with the corresponding stored data, then the feedback is sent to the gate by indicating to open it.

CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

This chapter will describe great pre-work done by different researchers and scholars and will also bridge the gap that was nonexistent. This will include an introduction to RFID technology, RFID based automated gates and access control systems and RFID applications at entrance gate.

2.2 An introduction to RFID technology

Radio Frequency Identification (RFID) system consists of two components namely, the tags and the reader. The tag is integrated with an object in order to identify or match the object/ individual by mode of radio waves.

Initially, RFID technology was limited for military purposes owing to cost factors; after 1970's with the new advancement of the technology, it has spread a wide range of applications in the commercial fields. According to the authors [1] "however RFID is replacing barcode technology and enjoys the major advantage of being independent of line of sight problems and scanning the objects from a distance." and they state that Walmart is the second largest commercial user of RFID. The following are the advantages that the article has pointed out,

- It is a passive wireless technology.
- The scanner can read the data without having line of sight.i.e. The data is fed to the scanner from a far distance recognition according to its frequency ranges.
- Radio waves are used to receive data from the tag to the scanner as the communication medium.
- Has an effective lifetime of 10 years and can read/write data within a few milliseconds and modern tags are composed with good memory space varying from 16-64 KB.

2.3 Working principles of RFID

Once the transceiver and the scanner are conjugated, they are known as the reader/ interrogator. It is a network connected device which is portable or permanently attached and it activates and communicates with tags. The radio waves sent by the reader carry out three purposes: it induces enough energy into the tag, provides a synchronisation clock to the passive tag and acts as a carrier to the return data from the tag.

The tag itself is considered as the transponder, any RFID tags come in forms as passive and active. An active tag is in need of a power source/battery and its lifetime depends on it. Sometimes it is quite seldom and impractical to use due to the high cost, size, lifespan[1]. Apart from it, passive tags are independent from a power adapter and have a much longer lifetime.

A passive RFID tag comprises mainly three parts: an antenna, a semiconductor chip attached along with the antenna, and encapsulation to protect the tag. The antenna of the tag, couples with the external energy which is provided by the reader to get activated. Subsequently, activating the tag, the waves are sent back to the reader to translate into data. Apart from the architecture, the tags are designed under three frequency ranges namely, low, high and ultra high frequency which varies from 30Hz to 300KHz, 3MHz to 30MHz and 300MHz to 3GHz frequency respectively and UHF has a much longer read range.

The low and high frequencies RFID work based on inductive coupling (near field coupling) and Ultra high frequency is based on Electromagnetic coupling (far field coupling).

2.4 Applications of RFID

From a commercial perspective RFID has numerous applications. There are tracking items along a supply chain, identifying check in/out books in a library system, security purposes when needed to differentiate fake video or audio clips, at the toll gates in the transport sector, tracking animals, currency and many more.

In the determination of finding a solution for the problem, we noticed interesting research on automated gates systems and security and control systems. “Hyung Rim Choi” and his team have done research “based on RFID technology, for automation of truck and container identification at

the container terminal gate system” [2]. They also state the frequencies they used for tags in Korea for trucks 900 MHz and for containers 433MHz, in the frame of international standards. Further their ultimate goal was to identify the truck and container numbers by applying the theories of RFID technology. After carrying on several tests they developed the gate system in a suitable environment to place the tags and antennas, i.e. the optimal position is at the middle of the top most area on the windscreen, driver’s visibility, etc. The mechanism of the gate system works in such a way that when the 2 frequency tags pass the terminal gate, the antenna and reader read the tag information. So the extracted tag information is transmitted to the identification system, then and there it compares the information with the container pre-notification which is sent via EDI, e-mail, or fax machine. If the comparison is successful then it will send a confirmation message to the terminal operation system.

Another project was conducted in hostels inside the Punjab University premises. It is also a system that “combines RFID technology and biometrics to accomplish the required task. When the RFID reader installed at the entrance of hostel detects a number, the system captures the user image and scans the database for a match”[3]. According to the document if the identity does not match with the registered details then an emergency alarm will turn on to indicate suspicious access. This system is made up of 3 modules such as entrance, existing and mess monitoring for authentication check. All these 3 modules are connected with the main server, after receiving the data the module is processed by the computer and then the signals are sent to the module for granting and denial. After reading and researching some reports we noticed a deficit in the applications of RFID in the domestic level and in Sri Lanka also there is less number of research related to it. To bridge this gap we thought of continuing our project and implementing it physically. Hence, we started over by running a background search on automated gates, which are controlled by remote controllers that are accessed under 2 frequencies namely, 433 MHz and 315 MHz and mobile apps. Nevertheless, gates are not the only case that have been accessed under these frequencies. There are plenty of other appliances which will respond to above frequencies such as smart home equipment. As the building blocks, an ATMega328p microcontroller, RFID module, transmitter and a receiver are used to build the new system.

CHAPTER 3 - METHODOLOGY INTRODUCTION

This chapter will give an overview of the procedure used to address the research problem and the objective of the project. A survey was created and circulated among 21 families in Sri Lanka to gather their opinions on this subject.

The Google survey forms fulfilled the purpose of creating an easy handling and instant response survey. The methodology of this applied research can be considered as a mixed method of quantitative and qualitative approaches. Despite having the project scope limited up to users who benefit by automated gates, conducted a mixed survey to collect data for marketing strategies and other information such as number of tags needed for one family.

3.1 An introduction to RFID technology

The research was designed by collecting primary data due to the reliability and it was hard to gather secondary data as less number of researches have been conducted in this scope in Sri Lanka. At the 1st place the project initiated by being aware of the fact that heretofore none of the large scale automated gates have invented gate access via RFID technology. It was confirmed by contacting a few leading companies. Afterward, created the survey by including the following questions.

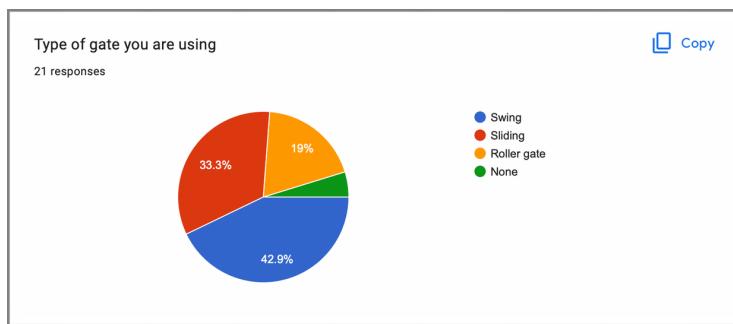


Figure 3.1

According to the figure 3.1, it is observed that the majority of the families are using swing gates and the 2nd highest in use is sliding gates and 19 percent are using roller gates. Also it noticed that

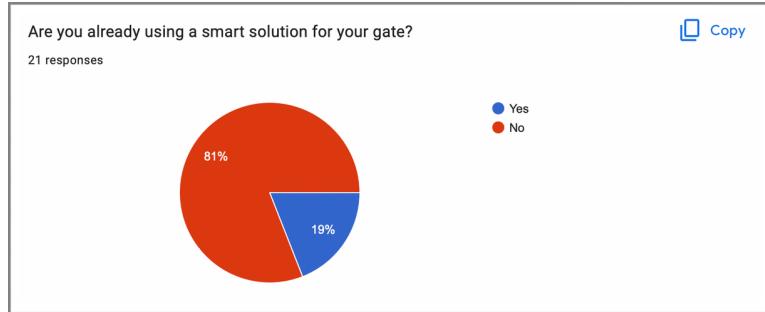


Figure 3.2

the majority is still not adopted to use automated gates. Only 19% who are using roller gates are adopted for smart gates.

But it is glad to show that more than 60% of the respondents are willing to shift to smart gate systems. This is a positive remark for the new innovation. The figure 3.3 and figure 3.4 pictures show the quantitative data of the vehicles that one owns at home and from this data we can decide where the tag should be placed.

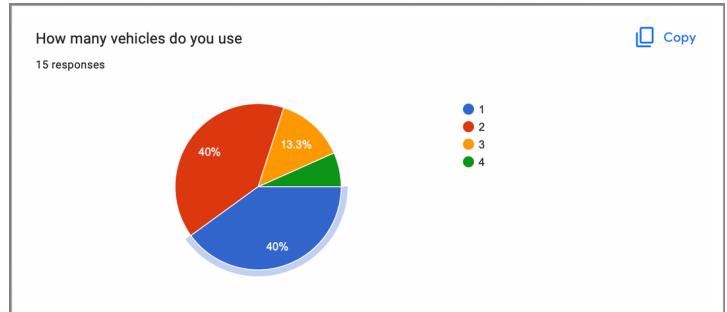


Figure 3.3

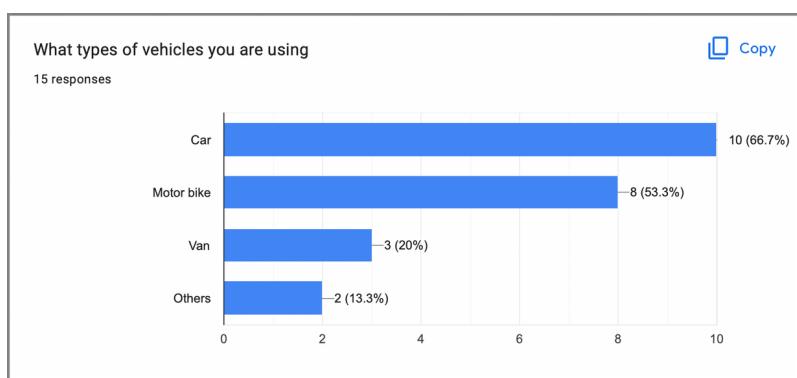


Figure 3.4

It is mainly because some tags can be placed on the windscreens of the vehicle while others have to be placed at a position where the sensor can detect them.

Nextly it is decided how many tags are needed for one home. Basically these all are decided after having a field visit and negotiating with our customers.

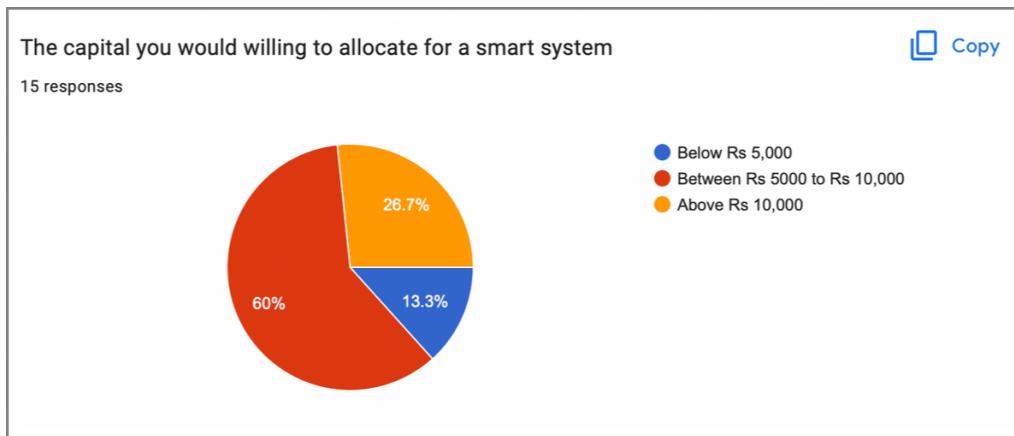


Figure 3.5

The last picture gives the rate that the user is willing to allocate but now unfortunately it has changed drastically due the crisis. hence, compared to gates and other components, this system will be provided at an affordable price.

Following are the components required to assemble the system;

- ATMega328P microcontroller
- Printed circuit board
- UHF RFID module
- NFC module
- AC/DC power adapter

The ATMega328P microcontroller is a 8 bit megaAVR (family) single-chip microcontroller created by ATMEL, it has a high performance along with a low power consumption. The main reason for building the circuit around it, is that it can be easily and quickly found in the local market at an affordable price, and not that complex to program also has a memory space which suits the requirements of the system. When the cost of the raw materials are at a lower price, it eventually leads to a good price for the end product.

A double layer Copper printed circuit board is purchased through a private company, but in the future we are hoping to print it for ourselves. It is very important to be mindful of the distance between the components, when placing it. It should avoid overlapping traces which can cause noise interference and unnecessary space consumption. If the design is too poor, it will overheat and damage the circuit. Thus, designing a correct PCB by considering every possible aspect is very crucial. It is recommended to build a mini version of the blueprint before the final output. The figure 3.6 represents the design view of the PCB. There are 2 jumper connectors designed in-order to solve the troubleshooting that are arising from the circuit after the installation.

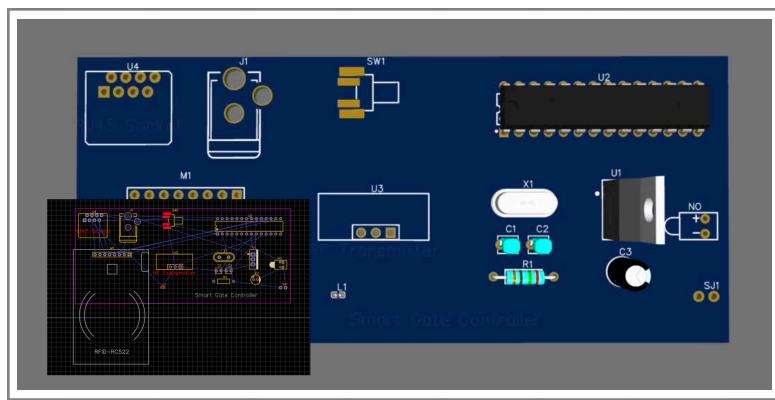


Figure 3.6

As stated above, the UHF RFID module is the main device and the most expensive component of our system. It is even under good operation in haze and foggy environments. The RF signals make the channel for the data transmission and covers a wider range of vicinity. In the future we are hoping to modify the system to control without using power adapters, as a result, anyone is able to enjoy its service during power failures.



Figure 3.7

SMART GATE CONTROLLER

CHAPTER 4 - DESIGN AND IMPLEMENTATION

4.1 Design

It is clear that, the Smart Gate Controller can simply give access to operate an automated gate via the RFID module. The diagram below gives the basic interpretation of the whole system. It helps the user to understand the key features of the product and shows how it is linked.

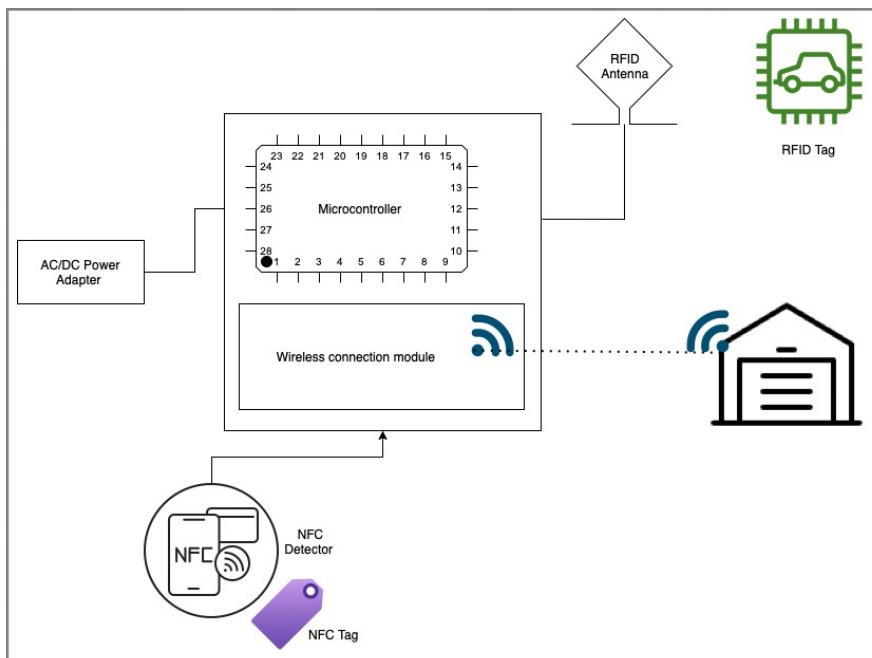


Figure 4.1

The figure 4.2 shows the sensitive distance coverage of our whole system. The RFID module is placed at the top edge of the wall with an inclination, covering its maximum distance up to 85m.

The figure 4.4 shows the back end of the circuit. Here, a transmitter, a RFID module and 2 capacitors, one crystal oscillator that helps to maintain the clock speed of the microcontroller and a led bulb are used to construct the circuit.

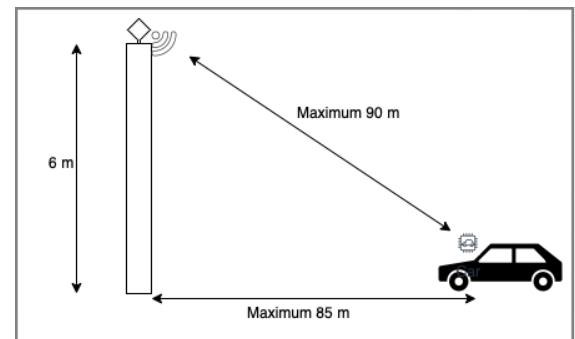


Figure 4.2

Moreover, figure 4.6 is very much similar to the previous one, the difference is that a receiver is connected instead of a transmitter. As this provides detailed information about components and implementation of the system, it is very important for the technician who is connecting and programming the device. The purpose of the receiver and the

RFID module are to scan and decode the RF signal from the existing remote controller and unique ID from the RFID tag.

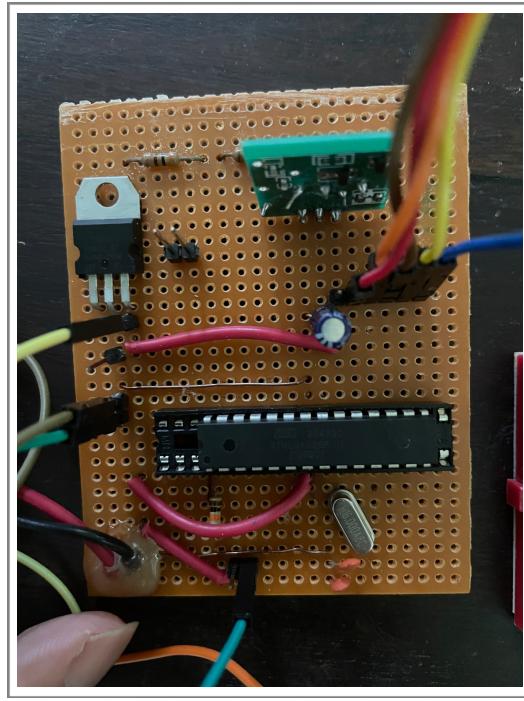


Figure 4.3

To program the microcontroller and maintain the industrial standards on the device we used AVR programming with ATMEL studio. The microcontroller consists of several ports and registers, out of them we mainly used Port B and Port D.

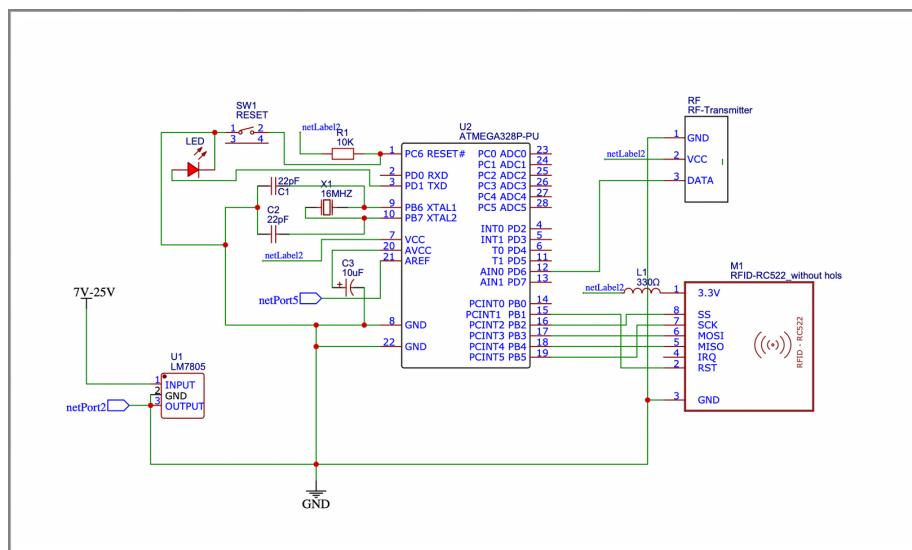


Figure 4.4

SPI communication was utilised for the purpose of communicating with the RFID module. Hence, according to the microcontroller's data sheet, it can be done by PORT B. In addition, to

communicate with the RF transmitter, serial communication was used with the aid of a few libraries from ATMEL Studio. As a result, we were able to reduce the complexity of the code and being able to execute with the help of Port D.

Serial Peripheral Interconnect (SPI) was programmed with the aid of Arduino libraries because it reduces the complexity of the code and in the industrial level it has a greater preference in using it. For the reset of the data lines we used serial communication powered by simple C programming.

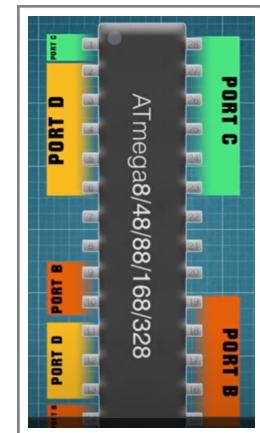


Figure 4.5

To implement this system, it was required to find the outstanding code in the RF remote controller. Thereupon, another diagram was developed to achieve it and the diagram is only for the usage of the manufacturer's. It can decode RF signals in serial monitors. Hereby, the following diagram is the structure to decode the signal.

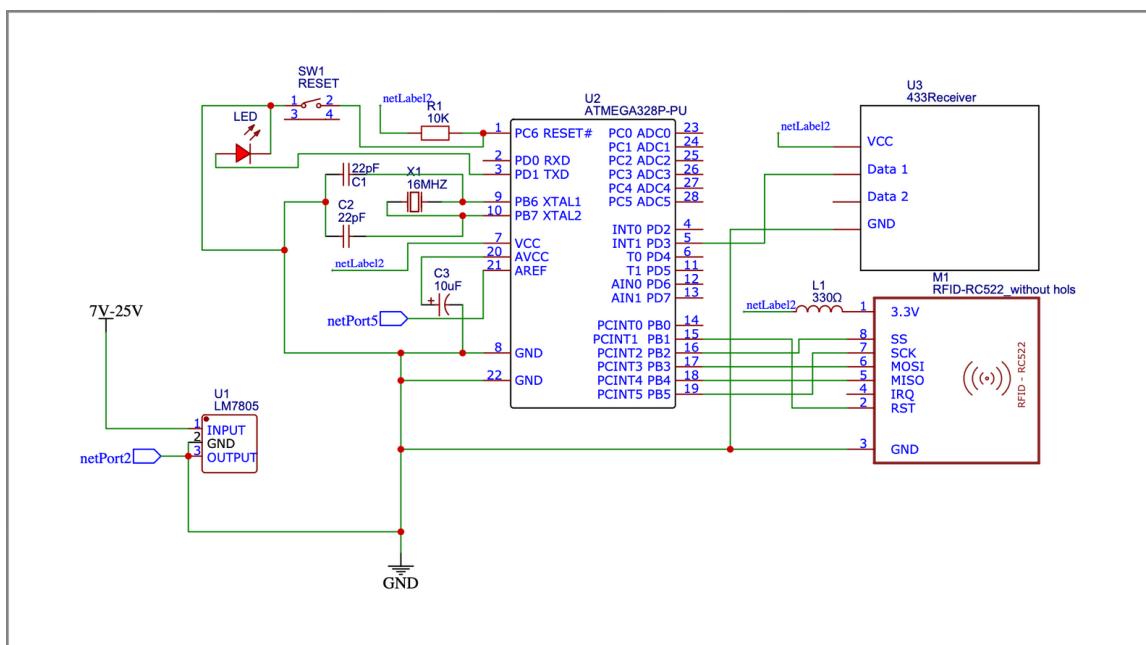


Figure 4.6

CHAPTER 5 - ECONOMICS OF SELLING THE PRODUCT

The estimated budget plan of the system for per sensor kit is shown below, it includes the direct material and labor cost as well as rough overhead cost. Hence the product will be sold at amount of LKR 35,000 together with the profit.

Direct material	Estimated Cost (LKR)
Microcontroller- ATMEGA328P	1,300
RFID antenna	17,000
Power Adapter	500
NFC kit & minimum 3 tags	1,200
Cables	300
433 MHz Module	750
PCB Printing	500
Other Electronic Components	600
Total	21,950

Description	Costs
Direct material	21,950
Direct labour	1,000
Overhead Cost	500
Total cost	23,450

The product will approach the customer in two ways:

1. By Indirect selling, it means, the manufacturers will sell the product to an organisation who design automated gates in large scales.
 - Thus, the product will reach customers as a full package(automated gate and the sensor kit). Here, the customer will be easily aware about the product and they will purchase this for an affordable amount.
2. By direct selling, as it will be available in the general market so that the customer can order and purchase it. Furthermore, one of our technicians will be provided to avoid confusions when fixing the product.

Out of these 2 methods our main target forces for the 1st way due to the promotion circumstances. Additionally, regardless of the methods of approaching the customer, the sensor kit will be available as packages. Such as the RFID sensor plus 3 tags (1 vehicle tag and 2 NFC tags) and the RFID sensor plus 5 tags(2 vehicle tags and 3 NFC tags). Besides, if a customer requests more number of tags for commercial purposes, it will be provided accordingly by considering the modifications/updates in the software and number of tags at a negotiable price. All the selling products will be individually customised with its specific set of tags, hence it will avoid unauthorised tags accessing the system.

CHAPTER 6 - FUTURE ENHANCEMENTS & CONCLUSION

6.1 Future enhancements

The future enhancement or the upgrade of the product will be an improvement in the sensors. To this point the gate is only accessible to open, after the new improvement it will open and close. It is understandable that closing a gate or a door just using sensors is quite dangerous, therefore, the smart gate controller needs to be boosted with motions and other necessities.

Thus, the new key features will be a motion sensor and back sensor tags attaching to the vehicle. As a result the gate can be closed as well as opened, automatically and electronically.

This study focuses on developing a new technology to access automated gates. Basically, this operates under RFID sensor detection. RFID is a widely used technology in the world's commercial platform thus, as Sri Lankans we need to take the best out of it and let our people live like kings and queens.

6.2 Conclusion

It consists of two major parts called the tag and the reader/interrogator which works under RF signals. The scanning antenna reads the respective land owner's sensor tag and automatically allows the gate to be operated with zero manpower. This benefits the user as it reduces the responsibility of having an extra key/ remote controller with them. Also, multiple users can access the premises without any interruption. For example if the driver forgets the remote or faces an emergency situation where he needs to access but cannot operate the gate, all these circumstances can be recovered with the aid of the Smart gate controller. The goal of the system is achieved by providing convenience and comfortability for the user and maximum privacy when entering a premise as it scans the specific code programmed for each gate module. Due to the safety precautions we will program the system for the user and we will position it for them.

Furthermore, ATMega328P microcontroller, a PCB, external AC/DC power adapter and a RFID Antenna and its tag are the main compositions used to assemble the system. Due to personalised tags, it helps to avoid hacking and other unfavourable threats.

This product will be available in the market as indirect selling (through a large scale organisation) and direct selling in the local market. According to the user's preference they can purchase it and we believe that the users will embrace the system with a good impression. Eventually, this technology will give a break for remote control automations and will turn a new leaf for advanced control systems.

6.3 Reference

- [1] 2022. [online] Available at: <https://www.researchgate.net/publication/271292563_An_introduction_to_RFID_technology> [Accessed 1 August 2022].
- [2] 2022. [online] Available at: <https://www.researchgate.net/profile/Nam-Kyu-Park-2/publication/262254755_An_automated_gate_system_based_on_RFID_technology/links/54d306f50cf250179181303d/An-automated-gate-system-based-on-RFID-technology.pdf> [Accessed 12 July 2022].
- [3] 2022. [online] Available at: <https://www.researchgate.net/profile/Umar-Farooq-15/publication/275685766_RFID_Based_Security_and_Access_Control_System/links/57f79c5308ae280dd0bcaed7/RFID-Based-Security-and-Access-Control-System.pdf?_sg%5B0%5D=started_experiment_milestone&origin=journalDetail> [Accessed 23 July 2022].
- [4] Youtube.com. 2022. [online] Available at: <<https://www.youtube.com/watch?v=d05s7SXvd2M>> [Accessed 1 July 2022].
- [5] Youtube.com. 2022. [online] Available at: <<https://www.youtube.com/watch?v=8aMsJWpXyE8&t=1s>> [Accessed 23 July 2022].