REPORT OF INDIVIDUAL DESIGN PROJECT

INTAKE 39

RFID BASED SMART MASTER CARD FOR BUS METRO TICKETING

BY

G.R.ILAMPERUMA

D/ENG/22/0052/ET

<BACHELOR OF SCIENCE IN ENGINEERING IN ELECTRICAL & ELECTRONIC >

< BACHELOR OF SCIENCE IN ENGINEERING IN ELECTRONIC & TELECOMMUNICATION >

GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

2024

ABSTRACT

Public transportation systems in urban areas face challenges in terms of efficiency, reliability, and convenience. The conventional ticketing methods often lead to long queues, delays, and fare evasion, thus hampering the overall commuter experience. To address these issues, this project proposes the development of an RFID-based smart master card for bus and metro ticketing systems. The aim of this project is to design and implement a seamless, efficient, and user-friendly ticketing system that utilizes Radio Frequency Identification (RFID) technology. The RFID-based smart master card will serve as a convenient alternative to traditional paper tickets, allowing commuters to simply tap their cards against RFID readers installed at the entry and exit points of buses and metro stations. The system will consist of three main components: the RFID smart master card, RFID readers installed in buses and metro stations, and a centralized database server. Each RFID smart master card will be embedded with a unique identifier that is linked to the commuter's account in the database. When a commuter taps their card against the RFID reader, the reader will communicate with the database server to verify the validity of the card and deduct the appropriate fare from the commuter's account. Key features of the proposed system include real-time transaction processing, automatic fare calculation, and the ability to reload the RFID smart master card through various channels such as kiosks, online portals, and mobile applications. Additionally, the system will incorporate security measures to prevent unauthorized access and fraudulent activities. The implementation of this RFID-based smart master card for bus and metro ticketing is expected to significantly enhance the efficiency of public transportation systems, reduce operational costs, and improve the overall commuter experience. By simplifying the ticketing process and reducing congestion at entry and exit points, this project aims to promote the widespread adoption of public transportation and contribute to sustainable urban mobility.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Public transportation systems play a crucial role in urban areas by facilitating the movement of millions of people every day. However, the effectiveness and efficiency of these systems are often hindered by outdated ticketing methods, which can lead to long queues, fare evasion, and operational inefficiencies. To address these challenges, there is a growing need for innovative solutions that streamline the ticketing process and enhance the overall commuter experience. One promising technology that has emerged in recent years is Radio Frequency Identification (RFID).RFID technology utilizes radio waves to identify and track objects equipped with RFID tags or cards. These tags contain electronically stored information that can be read remotely by RFID readers, making it ideal for various applications such as inventory management, access control, and transportation ticketing. In the context of public transportation, RFID-based systems offer several advantages over traditional ticketing methods, including speed, convenience, and accuracy.

The concept of RFID-based ticketing systems has gained traction globally, with many cities and transit agencies adopting this technology to modernize their fare collection processes. One notable example is the Oyster card system in London, which utilizes RFID smart cards for travel on buses, trams, the London Underground, and other public transportation modes. Similarly, cities like Singapore, Hong Kong, and New York have implemented RFID-based fare payment systems to improve the efficiency and reliability of their transit networks. In line with these developments, the project "RFID based smart master card for bus metro ticketing" aims to leverage RFID technology to revolutionize the ticketing process in urban transportation systems. By introducing a smart master card equipped with RFID technology, commuters will no longer need to rely on traditional paper tickets or magnetic stripe cards, which are prone to wear and tear and can be easily lost or damaged. Instead, they can simply tap their RFID smart master card against readers installed at entry and exit points to quickly and seamlessly access buses and metro stations.

One of the primary motivations behind this project is to address the shortcomings of existing ticketing systems and improve the overall commuter experience. Conventional ticketing methods often lead to long queues, especially during peak hours, resulting in delays and inconvenience for passengers. Moreover, the use of paper tickets and magnetic stripe cards can be cumbersome and inefficient, as they require manual validation and are susceptible to errors and fraud. By transitioning to an RFID-based ticketing system, transit agencies can streamline the fare collection process, reduce operational costs, and enhance the security and reliability of their networks. RFID technology enables real-time transaction processing, automatic fare calculation, and seamless integration with backend systems, allowing for more efficient management and monitoring of passenger flows. Additionally, RFID smart cards can be easily reloaded with funds through various channels, such as kiosks, online portals, and mobile applications, providing commuters with greater flexibility and convenience.

Furthermore, the implementation of RFID based ticketing systems can contribute to the promotion of sustainable urban mobility by encouraging more people to use public transportation. By making the ticketing process more Fast , convenient and reliable transit agencies can attract new riders and reduce reliance on private vehicles, thereby alleviating congestion, reducing carbon emissions and improving air quality in urban areas. The development of this project involves the utilization of an ARDUINO mega microcontroller, MFRC522 RFID tag and reader along with a LCD display to achieve improved outcomes. In addition, this system consists of a potentiometer which is used to display that the bus is travelling from one point to another. In summary, the project “RFID based smart master card for bus metro ticketing represents a significant step towards modernizing public transportation systems and enhancing the overall commuter experience.

CHAPTER 2: PRODUCT SURVEY

2.1 EXISRING PRODUCTS

2.1.1: PORTABLE TICKETING MACHINE

Fig 2.1.1: Portable ticketing machine

Portable ticketing machines revolutionize the efficiency and convenience of fare collection on buses. These handheld devices enable bus conductors or drivers to issue tickets swiftly and accurately, enhancing the overall commuter experience. Equipped with features like RFID readers, barcode scanners, and wireless connectivity, portable ticketing machines facilitate seamless integration with backend systems for real-time transaction processing and data management. They reduce the reliance on manual ticketing methods, minimizing errors and fraud while improving revenue collection. Additionally, portable ticketing machines support multiple payment options, including cash, contactless cards, and mobile payments, catering to diverse passenger preferences. Overall, these devices optimize operational workflows, enhance passenger satisfaction, and contribute to the modernization of public transportation systems.

However this portable ticketing machine has several disadvantages to consider. Some of them are miscalculations, battery life limitations, easy to break and cost of implementation. Additionally bus conductors or drivers may require training to effectively use portable ticketing machines. Learning to operate the devices troubleshoot any issues can consume time and resources. Portable ticketing machines may be susceptible to security threats such as unauthorized access or tampering. This portable ticketing machines require regular maintenance to ensure proper functionality.

2.1.2: Mobile ticketing apps

Mobile ticketing apps revolutionize the way passenger access and pay for bus fares, offering convenience and flexibility in urban transportation. These apps allow users to purchase, store, and present tickets directly on their smartphones, eliminating the need for physical tickets or cash payments. With user-friendly interfaces and secure payment options, mobile ticketing apps streamline the fare collection process, reducing boarding times and enhancing the overall commuter experience. Additionally, these apps often provide real-time information on bus schedules, routes, and service updates, empowering passengers with valuable travel information at their fingertips. By leveraging the power of mobile technology, mobile ticketing apps contribute to the modernization of public transportation systems, promoting efficiency, accessibility, and sustainability in urban mobility. Users relying on mobile ticketing apps may face challenges in areas with poor or no network coverage. Without a stable internet connection, passengers may be unable to purchase tickets. Technical issues, battery drain and security concerns are some of the other problems associated with mobile ticketing apps.

Fig 2.1.2: Mobile ticketing apps

2.1.3: Fixed ticketing machine

Fig 2.1.3: Fixed ticketing machine

2.2 Main drawbacks of existing products

Product Name	Drawbacks
Portable ticketing machine	• Miscalculations • Battery life limitations • Security concerns • Cost of implementation
Mobile ticketing apps	• Technical issues • Must need a proper internet connection • Security concerns • Battery drain
Fixed ticketing machine	• Security concerns • High cost • Lack of efficiency

Table 1: Major drawbacks of the existing products

CHAPTER 3: OBJECTIVES AND AIMS

3.1: OBJECTIVES

- Improve ticketing efficiency
- Enhance user convenience
- Support multiple payment options.
- Enhance security
- Enable real-time data collection
- Reduced queue times
- Integration with public transportation networks
- Data collection and analysis
- Promotion of sustainable transportation
- To improve accessibility for passengers with disabilities by introducing features such as contactless payment and easy to use interfaces.

3.2: AIM

The main aim of the project is to revolutionize the ticketing system for public transportation by introducing a technologically advanced and user-friendly solution. That means to provide a more convenient and seamless experience for passengers.

CHAPTER FOUR: METHODOLOGY

4.1: SMART MASTER CARD

This RFID based smart master card is installed at entrance and exit of every buses and passengers should tap their cards when they enter to the bus as well as they left from the bus. When they tap their card at the entrance, the current amount in the card is been displayed by the LCD display. As the bus moved from one place to another, the system will calculates the distance and again the amount to be paid is been displayed by the LCD display when the passengers tap their cards at the exit. Not only the amount to be paid but also the remaining balance is been displayed by the LCD display. Potentiometer is used to calculate the distance travelled by the bus (potentiometer is used to display the root of the bus as it doing the same thing which will be done by the GPS module). This advanced technology sets a new standard in transportation industry, providing easy and comfortable ride for the passengers. The features can be described further as bellow.

1. Displaying messages: LCD display will help to display the no of seats available in the bus as well as the amount to be paid for the passenger. Additionally, LCD will display the current amount in the RFID card at the entrance as well as the remaining amount at the exit. This allows passengers to check their balance before boarding a bus or entering a metro station, ensuring they have enough credit for their journey. After tapping the RFID card on the reader, the LCD display can show a confirmation message to the user indicating that the transaction was successful. This provides immediate feedback to the user, assuring them that their card has been read correctly and the fare deducted. If there are any issues with reading the RFID card or processing the transaction, the LCD display can show error messages to alert the user. This could include messages such as "Insufficient balance" or “You cannot enter”. Overall the LCD display plays a crucial role in providing feedback and guidance to users, ensuring smooth and efficient operation of the RFID- based ticketing system.

2. Ability to tap the card: In this system, there is a place where the passenger can place the RFID card when he enters and exits from the bus. When the passenger placed the RFID card, the system will identify that the passenger has entered to the bus by using the radio frequency signals. RFID card serves as the primary means of ticketing and fare payment. The RFID card allows passengers to access bus and metro services without the need for physical contact with a ticketing machine or fare gate. This enhances convenience and efficiency for travelers, as they can simply tap their card on a reader to validate their fare. The RFID card typically stores value electronically, allowing passengers to preload funds onto the card. This stored value can then be used to pay for fares, with the appropriate amount deducted each time the card is tapped on a reader. This system eliminates the need for passengers to carry cash or purchase tickets for each journey. The RFID card contains information that enables the fare calculation system to deduct the appropriate amount from the card's balance based on the distance traveled. Each RFID card is uniquely identified by its embedded RFID chip. This allows the ticketing system to associate the card with a specific passenger account, track usage, and manage fare transactions accurately. RFID cards are often reloadable, allowing passengers to add additional funds to their card as needed.

4.2: HARDWARE IMPLEMENTATION AND COMPONENTS USED

4.2.1: ARDUINO MEGA

The ARDUINO Mega microcontroller serves as the backbone of the innovative project. As a versatile and powerful development platform, the ARDUINO Mega provides the necessary computational capabilities and interfaces to implement the complex functionalities required for modern ticketing systems. Equipped with an ATmega2560 microcontroller, the ARDUINO Mega offers an ample amount of digital and analog input/output pins, enabling seamless integration with various peripheral devices such as RFID readers, LCD displays, and communication modules. This extensive connectivity facilitates the creation of a robust and flexible ticketing solution capable of meeting the demands of urban transportation networks. The ARDUINO MEGA's open-source nature and extensive community support further enhance its suitability for the project. Developers can leverage a wealth of resources, including libraries, tutorials, and example codes, to expedite the development process and overcome technical challenges. Moreover, the ARDUINO MEGA's affordability and accessibility make it an ideal choice for deployment in mass transit systems, offering a cost-effective solution without compromising performance or reliability. In summary, the ARDUINO Mega microcontroller serves as the backbone of the RFID-based smart master card project, empowering designers to realize a seamless, efficient, and user-friendly ticketing experience for commuters in bus and metro systems. The ARDUINO mega is a highly versatile and widely adopted due to its impressive features.

1. High Processing Power: Powered by an ATmega2560 microcontroller running at 16 MHz, the ARDUINO Mega offers significantly higher processing power compared to other ARDUINO boards. This allows it to handle complex computations and tasks efficiently.

2. Abundant Input/ Output Pins: One of the key features of the ARDUINO Mega is its extensive array of digital and analog input/output pins. With a total of 54 digital I/O pins (of which 15 provide PWM output) and 16 analog input pins, the Mega provides ample connectivity for interfacing with various sensors, actuators, and peripheral devices.

3. Multiple Communication Interfaces: The ARDUINO Mega supports a range of communication interfaces, including UART, SPI, and I2C, enabling seamless integration with external devices such as RFID readers, LCD displays, GPS modules, and wireless communication modules. This versatility allows for the creation of interconnected systems with enhanced functionality.

4. Large Flash Memory: With 256 KB of flash memory (8 KB used by the boot loader), the ARDUINO Mega offers ample storage space for storing program code, libraries, and data. This is particularly advantageous for projects that require extensive code or data storage.

5. Compatibility with Existing ARDUINO Ecosystem: The ARDUINO Mega is fully compatible with the ARDUINO software development environment, including the ARDUINO IDE and a vast collection of libraries and resources. This simplifies the development process and allows users to leverage existing code and community support.

6. Expandability: The ARDUINO Mega features additional features such as multiple UARTs, which allow for simultaneous communication with multiple devices. This expandability enhances the versatility of the platform and enables the implementation of more complex systems.

Overall, the ARDUINO Mega microcontroller offers a compelling combination of processing power, connectivity, and expandability, making it well-suited for a wide range of projects, including the sophisticated RFID-based smart master card system for bus metro ticketing.

Fig 4.2.1: ARDUINO MEGA ATmega2560

Specifications about ARDUINO MEGA ATmega2560:

The ARDUINO Mega ATmega2560 is a versatile microcontroller board renowned for its robust capabilities and extensive connectivity options. Powered by the ATmega2560 microcontroller, it operates at 5V and a clock speed of 16MHz. With 54 digital I/O pins, including 15 PWM outputs, and 16 analog input pins, the Mega provides ample opportunities for interfacing with various sensors, actuators, and peripheral devices. Its generous flash memory capacity of 256 KB (8 KB allocated for the boot loader), 8 KB of SRAM, and 4 KB of EEPROM enable storage of complex programs, data, and configurations. Physical dimensions of approximately 101.52 mm in length and 53.3 mm in width, with a lightweight design of 37 g, ensure ease of integration into diverse projects. Alongside its core specifications, the Mega offers multiple communication interfaces, including UART, SPI, I2C/TWI, and USB, facilitating seamless interaction with external devices and systems. This blend of processing power, extensive I/O capabilities, and connectivity options makes the ARDUINO Mega ATmega2560 a favored choice for a wide array of applications, from hobbyist projects to industrial automation and beyond.

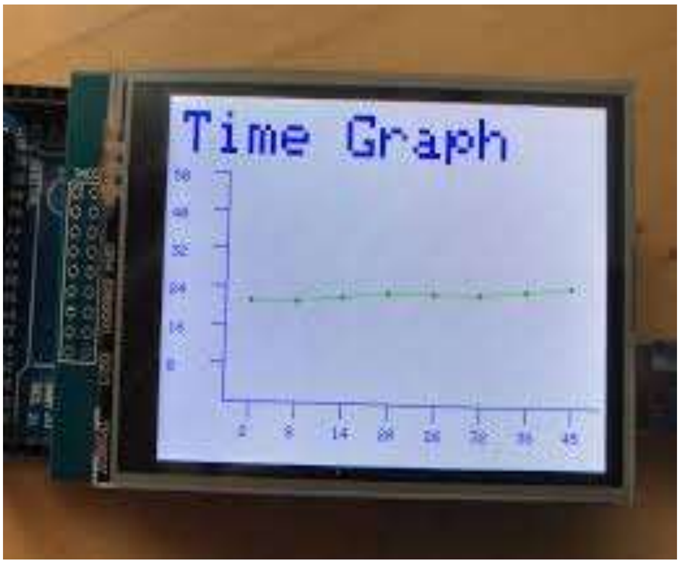


Fig 4.3: TFT Graphing of ARDUINO MEGA

4.2.2: RFID READER MODULE

The EM4100 HZ-1050 125KHz RFID reader module is specifically designed for seamless integration into public transportation networks, this reader module offers unparalleled precision and reliability in identifying RFID tags embedded within smart cards, thus facilitating efficient access control and ticket validation processes. Operating at a frequency of 125 KHz, the EM4100 HZ-1050 module ensures swift and accurate detection of RFID tags, enabling quick authentication of passengers' credentials as they embark on their journeys. Its advanced features and sophisticated decoding algorithms guarantee consistent performance, even amidst high-traffic conditions, ensuring smooth and hassle-free transit experiences for commuters. The compact and versatile design of the EM4100 HZ-1050 module allows for easy installation and integration into existing ticketing infrastructure, minimizing disruptions and simplifying upgrades. Its robust construction ensures durability and longevity, making it a cost-effective solution for modernizing public transportation systems. By leveraging the EM4100 HZ-1050 125KHz RFID Precise Reader Module, transit operators can enhance security, improve operational efficiency, and elevate the overall passenger experience. With its ability to streamline ticketing processes and optimize fare collection, this reader module plays a pivotal role in shaping the future of smart mobility solutions in urban environments. Some key features are;

1. High Sensitivity: The module boasts high sensitivity, enabling it to detect RFID tags embedded within smart cards with precision and accuracy. This ensures reliable identification and authentication of passengers' credentials, even in crowded or busy environments.

2. Advanced Decoding Algorithms: Equipped with sophisticated decoding algorithms, the EM4100 HZ-1050 module can accurately interpret RFID tag data, minimizing errors and ensuring smooth operation during ticket validation processes.

3. Fast Read Speed: With its efficient read speed, the module enables swift processing of RFID tag information, facilitating rapid authentication of passengers as they pass through access control points in bus and metro stations.

4. Compact Design: Featuring a compact and space-saving design, the EM4100 HZ-1050 module can be easily installed in ticketing terminals, turnstiles, or gates without occupying excessive space, making it suitable for both retrofitting and new installations.

5. Low Power Consumption: The module is engineered for efficient power management, consuming minimal energy during operation. This helps optimize the overall energy efficiency of ticketing systems, reducing operational costs and environmental impact.

Specifications of RFID reader module

The EM4100 HZ-1050 125KHz RFID Precise Reader Module is a versatile and reliable component designed to meet the demands of RFID-based applications, particularly in access control and ticketing systems. With its comprehensive set of specifications, this module offers exceptional performance and functionality in various environments. Operating at a frequency of 125 KHz, the EM4100 HZ-1050 module ensures compatibility with a wide range of RFID tags commonly used in smart card applications. Common frequencies include 125 KHz, 13.56 MHz, 860-960 MHz (UHF) and others. RFID reader modules may support different RFID standards such as EM4100, ISO 14443, ISO 15693, EPC Gen2 (ISO 18000-6C) and others. The EM4100 HZ-1050 module features versatile interface options, supporting multiple communication protocols such as RS232, RS485, USB, Bluetooth or Ethernet, allowing for easy integration into existing ticketing infrastructure. Its compact design ensures easy installation in constrained spaces, while its robust construction guarantees durability and long-term reliability. Additionally, the module boasts low power consumption, optimizing energy efficiency and reducing operational costs. They require a power supply within a specific voltage range to operate which could be 5V DC or 12V DC. RFID reader module may support different operating modes such as continuous reading, trigger-based reading or anti-collision algorithms for reading multiple tags simultaneously. Overall, the EM4100 HZ-1050 125KHz RFID Precise Reader Module stands as a high-performance solution for enhancing security, efficiency, and convenience in RFID-based ticketing systems for bus and metro transportation.

Fig 4.2.2: EM4100 Hz-1050 125 KHz RFID Reader Module

4.2.3: LCD DISPLAY

Fig 4.2.3: 16*2 LCD display

Designed to provide clear and concise information, the LCD display enhances the user experience by presenting important details such as fare amount, remaining balance, and transaction confirmations. This display typically features a backlit screen for readability in various lighting conditions, making it suitable for both indoor and outdoor environments commonly found in bus and metro stations. Its compact size allows for seamless integration into ticketing terminals or fare collection devices, ensuring minimal footprint while maximizing usability.

With intuitive menu navigation and user-friendly interfaces, the LCD display simplifies the ticketing process for passengers, enabling quick and hassle-free transactions. Additionally, for operators and administrators, the display may offer diagnostic information, system status updates, and configuration options, facilitating efficient management and maintenance of the ticketing system. LCD display will also display the no of seats available in the bus. Overall, the LCD display plays a vital role in enhancing communication and interaction within the RFID-based ticketing project, contributing to its effectiveness, reliability, and user satisfaction.

Principle of LCD display

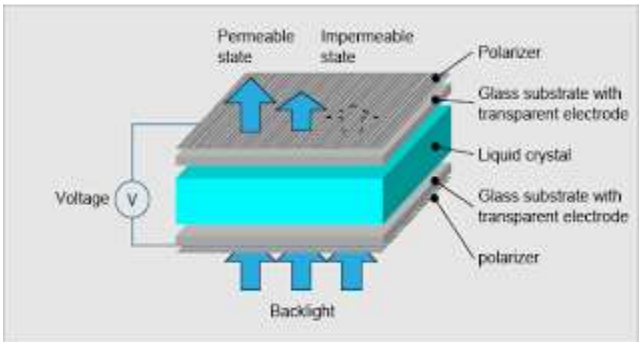


Fig4.2.3.1: Working principle of LCD display

The LCD (Liquid Crystal Display) used in the "RFID-based smart master card for bus metro ticketing" project operates based on the principle of controlling the orientation of liquid crystals to manipulate light and create images or text visible to the user. LCD technology relies on the properties of liquid crystals, which can change their orientation in response to an applied electric field. In an LCD display, two transparent electrodes sandwich a layer of liquid crystal material. The liquid crystals align themselves in a specific direction when no electric field is applied, causing them to block or transmit light depending on their orientation. When a voltage is applied across the electrodes, the orientation of the liquid crystals changes, altering the light's polarization and allowing it to pass through or be blocked selectively.

The display is divided into individual pixels, each containing a sub-pixel for red, green, and blue (RGB) colors. By applying appropriate voltages to the electrodes, the liquid crystals in each pixel can be controlled to modulate the intensity of light passing through the RGB sub-pixels, thereby generating a wide range of colors and shades. To display text or graphics, the controller circuitry sends signals to specific pixels, instructing them to change their orientation and control the passage of light accordingly. This process enables the creation of characters, symbols, and images on the display surface. The LCD display used in the project is typically equipped with a backlight to improve visibility in low-light conditions. The backlight illuminates the liquid crystal layer from behind, ensuring that the displayed information is clearly visible to users regardless of ambient lighting conditions. In summary, the LCD display operates by manipulating the orientation of liquid crystals using electric fields to control the transmission of light and create visible text and graphics for users.

Specifications of LCD display

The LCD display used in the project is tailored to meet specific requirements for visibility, durability, and functionality in the context of public transportation ticketing systems. While exact specifications may vary depending on the project's needs and the manufacturer's offerings, here are some common specifications:

1. Size and Resolution: The display size is typically chosen to balance visibility with the space available on ticketing terminals or fare collection devices. It may range from a few inches to around 5-7 inches diagonally, providing sufficient real estate for displaying ticketing information. Resolution could be standard (e.g., 800x480 pixels) or higher for improved clarity.

2. Interface Compatibility: The display is designed to interface seamlessly with the ticketing system's controller or processing unit. Common interface options include Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C), or Universal Asynchronous Receiver-Transmitter (UART) protocols, ensuring compatibility and ease of integration.

3. Durability: Given the high-traffic nature of public transportation settings, the display is constructed with durable materials capable of withstanding frequent use, vibrations, and potential impacts. It may feature scratch-resistant glass or polycarbonate coatings to protect the screen from damage.

4. Power Consumption: The display's power consumption is optimized to minimize energy usage, prolonging battery life in portable ticketing devices or reducing operational costs in stationary terminals

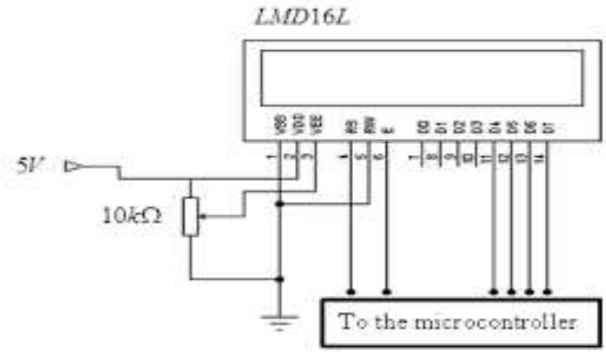


Fig 4.2.3.2: Circuit diagram of LCD display

4.2.4: GPS MODULE (NEO-6M GPS MODULE)

GPS module emerges as a critical component revolutionizing the efficiency and functionality of public transportation systems. Embedded within ticketing terminals or fare collection devices, the GPS module harnesses satellite technology to provide real-time location tracking and positioning information, facilitating seamless integration of ticketing services with route management and passenger tracking. The module, made by U –BLOX, is small and combines a GPS receiver, antenna, and other necessary parts into one unit. It uses the U-BLOX 6 positioning engine, which provides accurate and reliable location information. The Neo 6M module gets signals from GPS satellites in space to figure out the device's exact position, speed, and time. It works with both GPS and GLONASS satellite systems to improve its location accuracy. The module communicates with the main device, like a microcontroller or computer, using a serial connection. It often uses the NMEA protocol to send the GPS data in a standard format, which makes it easy to work with different systems and programming languages. Neo 6M module has useful features like real-time location, speed, and altitude data. It can also give precise timing, which is helpful for applications that need accurate timing. Additionally, it supports geo fencing, allowing virtual boundaries to be created and alerts triggered when the device enters or leaves certain areas.

To use this module, it needs a steady power supply, and the antenna must be positioned properly to get the best signal. Some versions of the module need an external antenna that can be either active or passive. With its ability to pinpoint the exact location of buses or metro trains, the GPS module enables operators to optimize transit routes, improve scheduling accuracy, and enhance overall service reliability. Passengers benefit from accurate real-time arrival predictions, reducing wait times and enhancing their travel experience. Moreover, the GPS module empowers transit authorities with valuable insights into ridership patterns, enabling data-driven decision-making to address congestion, optimize fleet deployment, and allocate resources effectively. This data-driven approach enhances operational efficiency and ensures responsive service delivery tailored to the needs of passengers. By incorporating the GPS module into the RFID-based smart master card system, the project revolutionizes public transportation ticketing, offering not only streamlined fare collection but also advanced route management and passenger tracking capabilities, ultimately leading to improved service quality and customer satisfaction.

Fig 4.2.4: NEO-6M GPS Module

Principle of GPS Module

The principle of operation for the Neo 6M GPS module is based on the Global Positioning System (GPS), which is a network of satellites orbiting the Earth. The module receives signals from these satellites to determine the device's precise location, velocity, and time information. This module consists of a GPS receiver, an antenna, and supporting circuitry. It works by actively scanning the signals transmitted by GPS satellites in view. Each satellite sends out signals that contain information about its location and the exact time the signal was transmitted. Then the module receives these signals and measures the time it takes for them to reach its antenna. By comparing the time, it took for the signals to arrive from multiple satellites, the module can calculate the distance between itself and each satellite. Using the distance information from multiple satellites, the Neo 6M module performs a process called trilateration. Trilateration involves intersecting spheres or circles around each satellite to determine the precise location where the spheres intersect. This intersection point represents the device's position on the Earth's surface. In addition to location, the Neo 6M module can calculate the device's velocity by analyzing the change in location over time. It also provides accurate time information by synchronizing with the highly precise atomic clocks onboard the GPS satellites. To communicate the GPS data to the host device, the Neo 6M module typically uses the NMEA (National Marine Electronics Association) protocol. This protocol standardizes the format of the GPS data, making it compatible with various platforms and programming languages.

In the final demonstration, it was not required to connect the device into a bus. Thus, there was no need to connect a gps module. Therefore a potentiometer was used in the project to find the location and this potentiometer will do the same function of the GPS module.

4.2.5: BUZZER

A 5V buzzer is a device that creates sound when powered from a 5-volt source. It is often used in things like alarms, electronic projects, robots, and toys to make sounds that we can hear. The buzzer has a special part called a piezoelectric element. This part is like a little disc or plate that can vibrate and create sound when electricity is sent through it. When connected the buzzer to a 5V power source, the piezoelectric element starts vibrating at a certain speed, and that creates sound waves that we can hear. It can control the sound of the buzzer by changing the voltage, frequency, and how long the applied electrical signal. This makes different kinds of sounds and patterns. The 5V buzzer is designed to be small, light, and easy to use in electronic circuits. It usually has two connection points: one for the positive 5V power supply and the other for the ground connection. Sometimes the buzzer also has a built-in driver circuit. This circuit helps make the buzzer work better and easier to connect to things like microcontrollers or other electronic devices. It might have a transistor or other parts that boost and control the electrical signal.

Fig 4.2.5: Buzzer

Specifications of buzzer

A 5V buzzer, like other electronic components, comes in various models and brands, and their specifications can vary accordingly. There are some common specifications you may find when looking at 5V buzzers. They typically require a 5-volt power supply to operate. The operating current, measured in milliamperes (mA), indicates the amount of current the buzzer consumes during operation. Sound output level is often specified in decibels (dB) and determines the loudness of the buzzer. The frequency range, given in hertz (Hz), indicates the span of frequencies at which the buzzer can produce sound. Mounting options, such as through-hole or surface mount, might be specified for different models. Dimensions, including height, width, and depth, are typically provided to help determine the physical size of the buzzer. The termination specifies the type of connection used, such as pins, wires, or solder pads, to attach the buzzer to a circuit. It is important to remember that these specifications can vary depending on the specific buzzer model.

4.3: WORKING PROCEDURE

4.3.1: WORKING PRINCIPLE

- First the passenger should place the RFID card when he entered to the bus.
- LCD display will show the no of seats available in the bus and the current amount in the RFID card.(If the amount is not sufficient a message will display as “You cannot enter to the bus”)
- Moving of the bus from one place to another is demonstrates by rotating a potentiometer.(This method is used to calculate the distance travelled by the bus)
- Passenger should place the RFID card again when he/she wants to get down from the bus.
- Then the LCD display will show the amount to be paid and the remaining amount in the RFID card.(No of seats reamining also displayed again)

Working principle of potentiometer

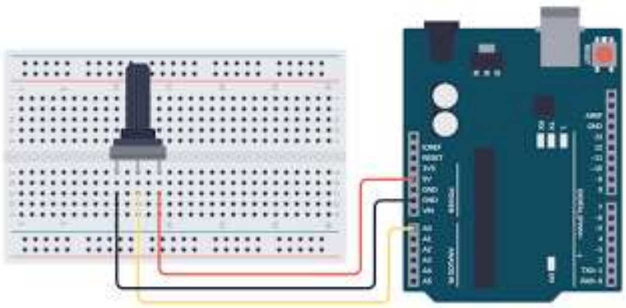


Fig 4.3.1: Connecting a potentiometer to ARDUINO

A potentiometer is a simple device used to vary the voltage across its terminals by manually adjusting a knob or slider. When connected to an Arduino Mega, the potentiometer can be used as an analog input device, allowing the Arduino to measure the voltage being outputted by the potentiometer. A potentiometer typically consists of a resistive track and a sliding contact (wiper) that moves along this track as the knob or slider is adjusted. The resistive track has a constant resistance value, usually between its two outer terminals, while the wiper can move along the track, creating a variable resistance between one outer terminal and the wiper. The potentiometer is wired to the Arduino Mega such that one of its outer terminals is connected to ground (GND) and the other to the 5V supply voltage. The wiper terminal, which outputs a variable voltage depending on its position along the resistive track, is connected to one of the analog input pins (e.g., A0 to A15) on the Arduino Mega.The

Arduino Mega's analog-to-digital converter (ADC) continuously samples the voltage at the analog input pin connected to the potentiometer's wiper terminal. It converts this analog voltage into a digital value, which the Arduino can read and process.As the knob or slider of the potentiometer is adjusted by the user, the voltage at the wiper terminal changes. This change in voltage is directly proportional to the change in position of the knob or slider along the resistive track. The Arduino reads this voltage through its analog input pin and translates it into a numeric value. In summary, the potentiometer connected to an Arduino Mega allows for analog input from a variable voltage source, enabling a wide range of applications in which user-adjustable control or feedback is required.

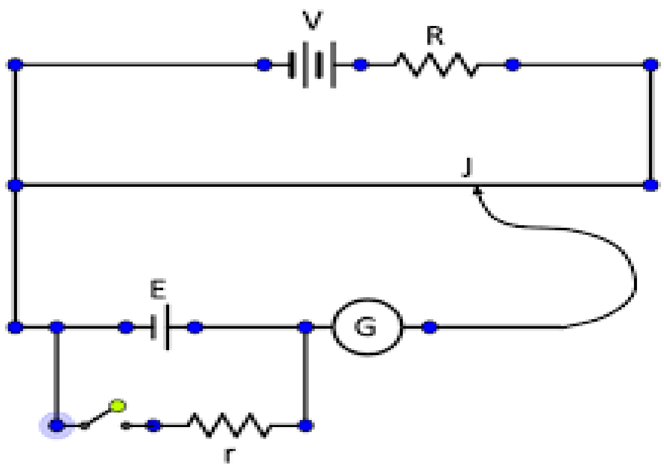
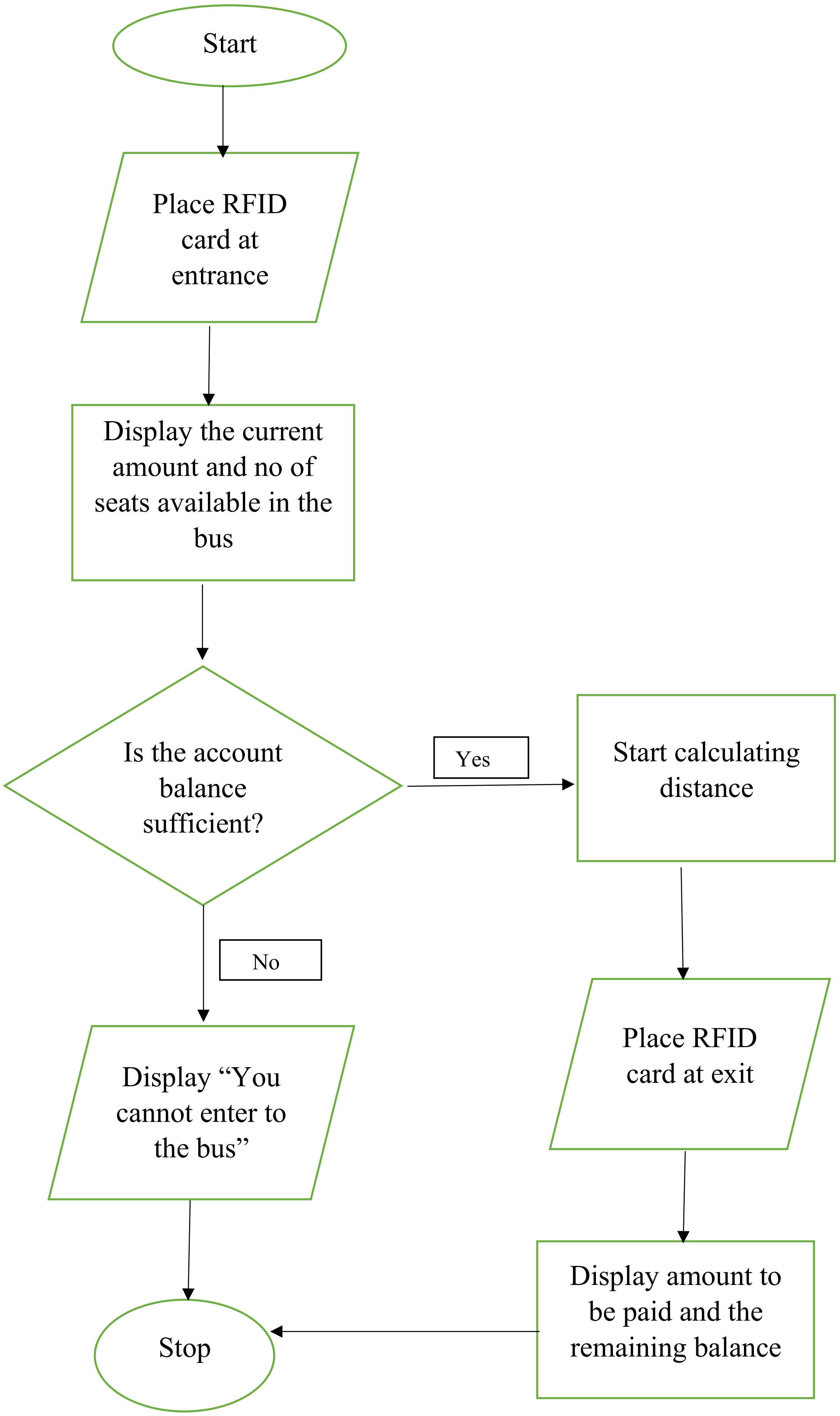


Fig 4.4: Circuit diagram of potentiometer

4.3.2: FLOW CHART



4.3.3: CIRCUIT DEVELOPMENTS

The circuit schematic was developed by using PROTEUS software.

(The RFID module was not included)

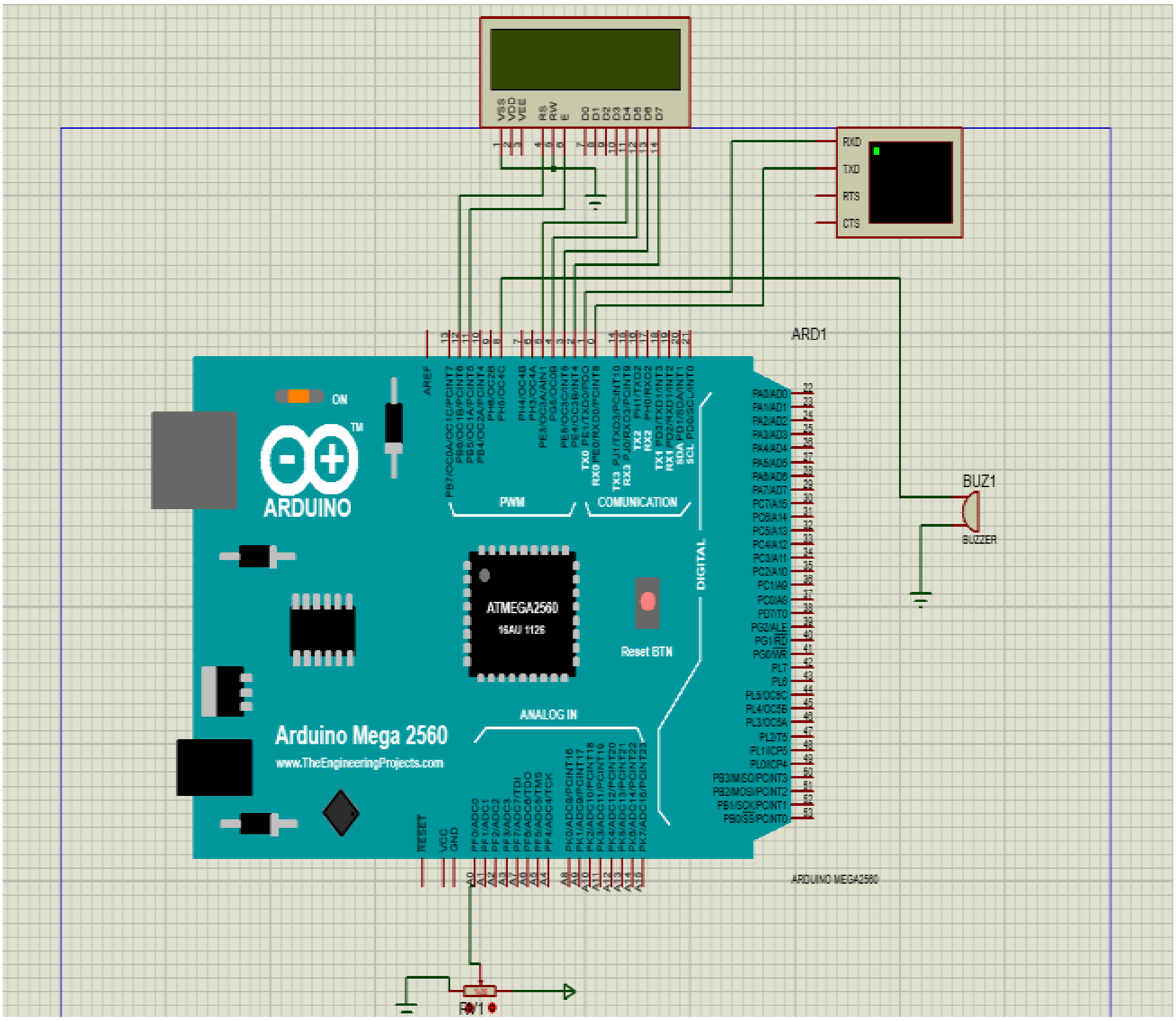


Fig 4.3.3: Schematic diagram

4.3.4: ARDUINO CODE

Code is provided on ANEXTURE 1.

4.4: COST ANNALYSIS

ITEM	COST
Circuit components	10500
Soldering iron 40W	1500
Soldering lead	400
Power supply	1500
Exterior	5000
Net Total	**18900**
Cost of the products considering only circuit components and miscellaneous costs related to the product	17000
Estimated market price	**20000**

Table 2: Cost Estimation

CHAPTER 5: FINAL OUTCOME AND DISCUSSION

I was able to finish the project as I proposed in the project proposal. The following figures show the outcome and the final product prototype.

5.1: FINAL OUTCOME

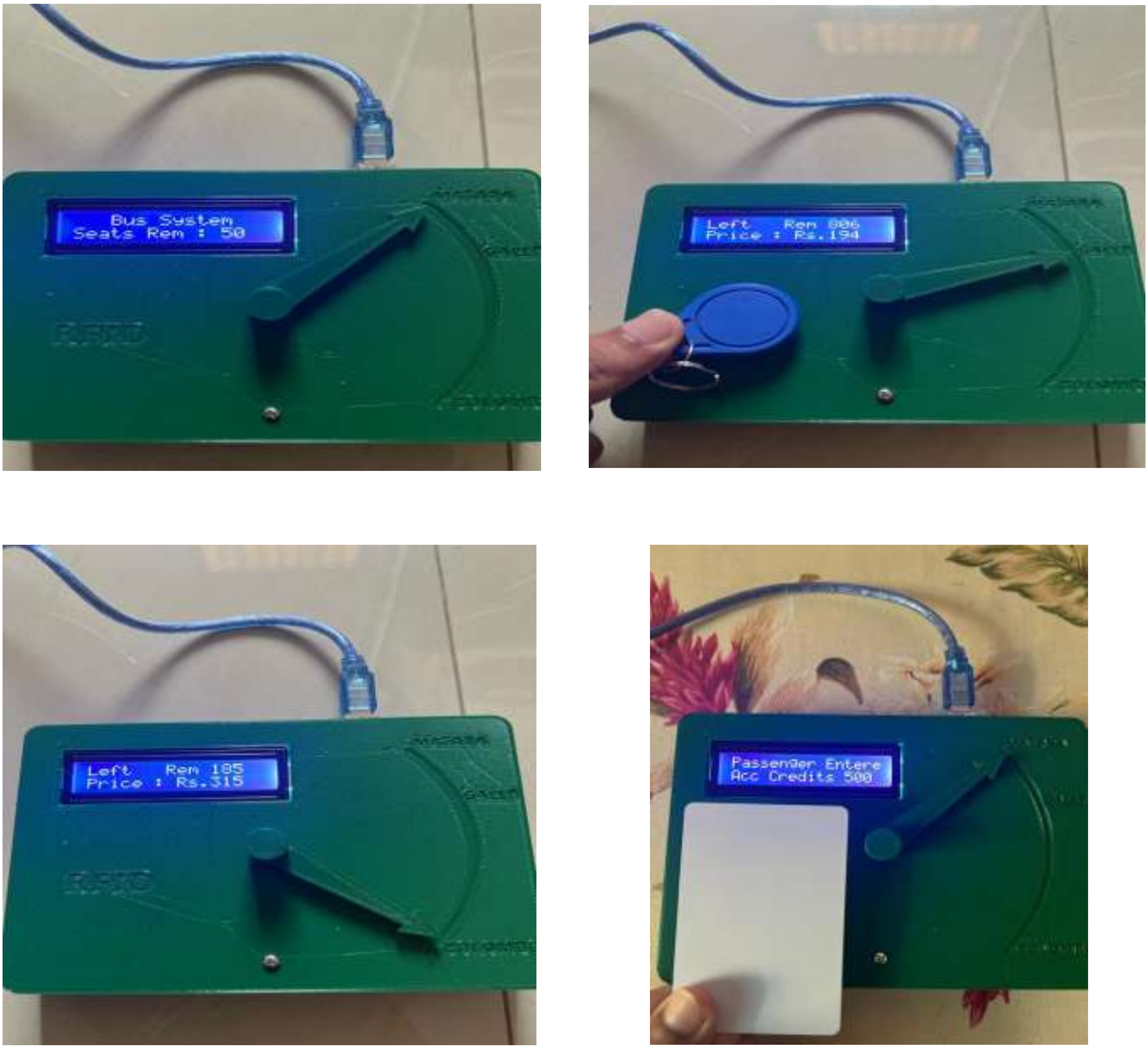


Fig 5.1.1: Final product prototype

5.2: DISCUSSION

This project aims to revolutionize public transportation ticketing systems by implementing RFID technology for seamless and efficient fare collection. RFID (Radio Frequency Identification) offers a contactless solution that enhances user convenience, reduces transaction time, and minimizes operational costs associated with traditional ticketing methods. At the core of the system lies the RFID-enabled smart master card, which serves as a secure and reusable ticketing medium for passengers. Each card is embedded with a unique identifier that can be read wirelessly by RFID readers installed at various entry points and exits of buses and metro stations. This allows for swift and automatic fare deduction upon card presentation, eliminating the need for physical tickets or cash transactions.

The implementation of RFID technology offers several key advantages over conventional ticketing systems. Firstly, it enhances passenger throughput by significantly reducing boarding and disembarking times, thereby improving overall service efficiency and reducing congestion. Additionally, RFID technology facilitates real-time tracking and monitoring of passenger movements, enabling transportation authorities to gather valuable data for route optimization and demand forecasting. Moreover, the smart master card introduces flexibility and convenience for passengers, as it can be easily recharged or topped up through online platforms, kiosks, or designated recharge stations. This eliminates the inconvenience of queuing for tickets and ensures that passengers always have sufficient fare credit for their journeys. From an operational perspective, the RFID-based ticketing system offers cost savings by reducing the reliance on paper-based tickets and manual fare collection processes. It also enhances revenue collection and accountability through automated fare deduction and transaction logging.

However, the successful implementation of the project relies on several critical factors, including the robustness of the RFID infrastructure, the interoperability of the smart cards across different modes of transportation, and the integration with existing ticketing systems. Additionally, ensuring the security and privacy of passenger data is paramount to maintaining public trust and confidence in the system. Overall, the "RFID based smart master card for bus metro ticketing" project represents a significant step forward in modernizing public transportation systems, offering a seamless and user-friendly ticketing solution that enhances efficiency, convenience, and reliability for both passengers and transportation Authorities alike.

5.3: ENCOUNTED PROBLEMS AND IMPLEMENTED SOLUTIONS

Throughout the course of this project, I found several challenges; however, I was able to overcome them by displaying determination and employing effective problem-solving techniques. One challenge was that I couldn't easily find all the components I needed. To solve this, I asked local stores and online communities for help and searched different online shops to find the required parts. Other major challenge was those problems related to my code. Sometimes I was failed to display the required terms correctly in the LCD display because there were some small mistakes in the code. I followed online tutorials to overcome that challenge. Sometimes the LCD display was not turned on as well as the RFID was not able to catch the signals. I overcome that challenge by removing the jumper wires and adding new wires. I checked the wiring connections carefully and made sure the modules had a stable power supply. I also tested them in open areas to get a strong signal connection.

5.4: LIMITATIONS

The power has to be given by a laptop and keeping a laptop in a bus is not practical. Every passenger should have a RFID card with them. Otherwise they are not able to travel in the bus. Passengers have to top up their cards when they don’t have enough money in their cards.

5.5: KNOWLEDGE GAINED

This project has provided invaluable insights and knowledge in various domains crucial for modernizing public transportation systems. I learned how to connect a RFID reader module and a LCD display into an ARDUINO Mega as well as the major concepts of those modules. The implementation of RFID technology has deepened understanding of contactless payment systems, including the design and integration of RFID readers and smart cards into existing infrastructure. Moreover, the project has expanded knowledge in data analytics and real-time tracking, as it involves the collection and analysis of passenger movement data for route optimization and demand forecasting. Additionally, the project has enhanced understanding of user experience design, particularly in designing intuitive interfaces for smart card usage and facilitating seamless transactions for passengers. Furthermore, the project has shed light on operational efficiency and cost-effectiveness in transportation management, demonstrating the potential for automation and digitization to streamline fare collection processes and reduce operational costs. Overall, the project has contributed significantly to the body of knowledge in transportation technology, paving the way for future innovations in public transit ticketing systems. This project greatly enhanced my project management skills. I learned the importance of meticulous planning, efficient organization, and successful execution of tasks and was able to acquire the ability to troubleshoot and overcome any challenges that arose during the project.

CHAPTER 6: CONCLUSION AND FUTURE WORKS

6.1: CONCLUSION

In conclusion, the "RFID based smart master card for bus metro ticketing" project represents a transformative step forward in the evolution of public transportation ticketing systems. By harnessing the capabilities of RFID technology, this project has introduced a contactless, efficient, and user-friendly solution that enhances the experience for passengers while optimizing operations for transportation authorities. Through the implementation of RFID-enabled smart cards, the project has demonstrated the potential to significantly reduce boarding and disembarking times, minimize congestion, and streamline fare collection processes. Furthermore, the project has provided valuable insights into data analytics, user experience design, and operational efficiency, laying the groundwork for future innovations in transportation technology. Overall, this project has not only revolutionized the way passengers interact with public transit systems but also paved the way for a more sustainable, convenient, and accessible future of urban mobility. Further improvements are necessary to enhance the performance and effectiveness of the system, particularly in terms of accuracy.

6.2: FUTURE WORK

The project "RFID based smart master card for bus metro ticketing" lays a strong foundation for future advancements and enhancements in public transportation ticketing systems. Some potential areas for future work include:

1. Integration with Mobile Devices: Explore options for integrating the RFID-based ticketing system with mobile devices, such as smartphones to offer passengers greater flexibility and convenience in managing their fare transactions.

2. Enhanced Security Features: Investigate the implementation of advanced security features, such as encryption protocols or biometric authentication, to ensure the integrity and privacy of passenger data stored on the smart master cards and within the ticketing system.

3. Interoperability with Multi-Modal Transport: Expand the scope of the project to encompass multi-modal transport networks, enabling seamless fare integration across different modes of transportation, including buses, metro, trains, and ferries.

4. Smart Fare Pricing Models: Develop dynamic fare pricing models based on factors such as time of day, distance traveled, or passenger demographics, to optimize revenue generation while incentivizing off-peak travel and reducing congestion during peak hours.

CHAPTER 7: ANNEXTURE 1

7.1: ARDUINO CODE

```
#include <LiquidCrystal.h>
#include <SPI.h>
#include <MFRC522.h>

#define SS_PIN 53
#define RST_PIN 9

const int rs = 30, en = 32, d4 = 34, d5 = 36, d6 = 38, d7 = 40;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

const int buzzer = 22;
int bus_sheets = 50;
int current_price= 0;

int passengerNo = 0;

MFRC522 rfid(SS_PIN, RST_PIN); // Instance of the RFID class

MFRC522::MIFARE_Key key;

// Init array that will store new NUID
byte nuidPICC[4];

int remainingAmount[] = {500,1000};
bool isInBus[] = {0,0};

void setup() {

  lcd.begin(16, 2);
  SPI.begin(); // Init SPI bus
  lcd.print("   Bus System");
  lcd.setCursor(0,1);
  lcd.print("Initializing.");
  delay(1000);
```

```
  pinMode(buzzer,OUTPUT);
  Serial.begin(9600);
  rfid.PCD_Init(); // Init MFRC522

  for (byte i = 0; i < 6; i++) {
    key.keyByte[i] = 0xFF;
  }

  Serial.println(F("This code scan the MIFARE Classsic NUID."
  Serial.print(F("Using the following key:"));
  printHex(key.keyByte, MFRC522::MF_KEY_SIZE);


  lcd.clear();
  lcd.print("   Bus System");
  lcd.setCursor(0,1);

  for(int i=0;i<16;i++){
    lcd.print('.');
    digitalWrite(buzzer,HIGH);
    delay(20);
    digitalWrite(buzzer,LOW);
    delay(40);
  }

  lcd.clear();
  lcd.print("   Bus System");
  lcd.setCursor(0,1);
  lcd.print("Seats Rem : ");
  lcd.print(bus_sheets);
}
```

```
//////////////////////////////// LOOP ///////////////////////////////////
/////////////////////////////////////////////////////////////////////////

oid loop() {

 // Reset the loop if no new card present on the sensor/reader. This saves the entire process when idle.
 if ( ! rfid.PICC_IsNewCardPresent())
   return;

 // Verify if the NUID has been readed
 if ( ! rfid.PICC_ReadCardSerial())
   return;

 Serial.print(F("PICC type: "));
 MFRC522::PICC_Type piccType = rfid.PICC_GetType(rfid.uid.sak);
 Serial.println(rfid.PICC_GetTypeName(piccType));


 // Check is the PICC of Classic MIFARE type
 if (piccType != MFRC522::PICC_TYPE_MIFARE_MINI &&
   piccType != MFRC522::PICC_TYPE_MIFARE_1K &&
   piccType != MFRC522::PICC_TYPE_MIFARE_4K) {
   Serial.println(F("Your tag is not of type MIFARE Classic."));
   return;
 }



 checkRFID();
```

```
if(remainingAmount[passengerNo] < 0){
  lcd.clear();
  lcd.print("Not enough credits");
  lcd.setCursor(0,1);
  lcd.print("You cannot Enter");
  for(int i=0;i<4;i++){
    digitalWrite(buzzer,HIGH);
    delay(500);
    digitalWrite(buzzer,LOW);
    delay(500);
  }
}

else if (isInBus[passengerNo] == 0) {
  isInBus[passengerNo] = 1;
  Serial.println(F("Entered Bus."));
  lcd.clear();
  lcd.print("Passenger Entered");
  current_price = analogRead(A0);
  lcd.setCursor(0,2);
  lcd.print("Acc Credits ");
  lcd.print(remainingAmount[passengerNo]);
  Serial.print("Price - ");
  Serial.println(current_price);
  digitalWrite(buzzer,HIGH);
  delay(1000);
  digitalWrite(buzzer,LOW);
  delay(3000);
  //Reduce bus count
  bus_sheets -= 1;
  lcd.clear();
  lcd.print("   Bus System");
  lcd.setCursor(0,1);
  lcd.print("Seats Rem : ");
```

```
 lcd.print("Seats Rem : ");
 lcd.print(bus_sheets);







lse{


 isInBus[passengerNo] = 0;
 passengerNo = equlizeRFIDid(rfid.uid.uidByte, rfid.uid.size);
 Serial.println(F("Got down from bus."));

 if(bus_sheets == 0){
   lcd.clear();
   lcd.print("   Bus Full");
   digitalWrite(buzzer,HIGH);
   delay(500);
   digitalWrite(buzzer,LOW);
   delay(500);
   digitalWrite(buzzer,HIGH);
   delay(500);
   digitalWrite(buzzer,LOW);
   delay(500);
   digitalWrite(buzzer,HIGH);
   delay(500);
   digitalWrite(buzzer,LOW);
   delay(500);
   lcd.print("   Bus System");
   lcd.setCursor(0,1);
   lcd.print("Seats Rem : ");
```

```
    lcd.print(bus_sheets);
  }
  else{
    lcd.clear();
    lcd.print("Left");

    int tempPrice = abs(analogRead(A1)-current_price);
    remainingAmount[passengerNo] = remainingAmount[passengerNo]-tempPrice;
    lcd.setCursor(7,0);
    lcd.print("Rem ");
    lcd.print(remainingAmount[passengerNo]);
    lcd.setCursor(0,1);
    lcd.print("Price : Rs.");
    lcd.print(tempPrice);
    Serial.print("Price - ");
    Serial.println(tempPrice);

    digitalWrite(buzzer,HIGH);
    delay(3000);
    //Got Down From Bus
    if(bus_sheets == 0){
      lcd.clear();
      lcd.print("   Bus Full");
    }

    bus_sheets += 1;
    lcd.clear();
    lcd.print("   Bus System");
    lcd.setCursor(0,1);
    lcd.print("Seats Rem : ");
    lcd.print(bus_sheets);
```

```
      digitalWrite(buzzer,LOW);
      delay(500);
      digitalWrite(buzzer,HIGH);
      delay(500);
      }
      digitalWrite(buzzer,LOW);
  }

  // Halt PICC
  rfid.PICC_HaltA();

  // Stop encryption on PCD
  rfid.PCD_StopCrypto1();
}
```

```
void printHex(byte *buffer, byte bufferSize) {
  for (byte i = 0; i < bufferSize; i++) {
    Serial.print(buffer[i] < 0x10 ? " 0" : " ");
    Serial.print(buffer[i], HEX);
  }
}



void printDec(byte *buffer, byte bufferSize) {
  for (byte i = 0; i < bufferSize; i++) {
    Serial.print(' ');
    Serial.print(buffer[i], DEC);
  }
}



int equlizeRFIDid(byte *buffer, byte bufferSize){
  Serial.println("equlizeRFIDid");
  Serial.println(buffer[0]);
  Serial.println(buffer[1]);
  Serial.println(buffer[2]);
  Serial.println(buffer[3]);
  Serial.println("equlizeRFIDid end");

  if(buffer[0] == 130 && buffer[1] == 254 && buffer[2] == 44 && buffer[3] == 78){
    Serial.println("Rfid equals passenger 0");
    return 0;
  }
  else if(buffer[0] == 195 && buffer[1] == 25 && buffer[2] == 135 && buffer[3] == 29){
    Serial.println("Rfid equals passenger 1");
    return 1;
  }
```

```
}



oid checkRFID(){
// Store NUID into nuidPICC array
  for (byte i = 0; i < 4; i++) {
    nuidPICC[i] = rfid.uid.uidByte[i];
  }

  Serial.println(F("The NUID tag is:"));
  Serial.print(F("In hex: "));
  printHex(rfid.uid.uidByte, rfid.uid.size);
  Serial.println();
  Serial.print(F("In dec: "));
  printDec(rfid.uid.uidByte, rfid.uid.size);
  Serial.println();
  passengerNo = equlizeRFIDid(rfid.uid.uidByte, rfid.uid.size);
```

REFERENCES

1] Venugopal Prasanth , Hari Prasad R.,K.P.Soman , "Ticketing Solutions for Indian Railways Using RFID Technology," act, pp.217-219, 2009 International Conference on Advances in Computing, Control, and Telecommunication Technologies, 2009

[2] http://rfid.bemrosebooth.com/benefits_of_rfid_tickets.php

[3]http://www.hbeonlabs.com/synopsis/RFID%20Based%20Road%20Toll%20Tax.doc

[4] http://www.gojohnedwards.com/RFIDMontreal.pdfb