UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FACULTY OF ELECTRONICS AND COMPUTER TECHNOLOGY AND ENGINEERING

DEVELOPMENT OF RFID TECHNOLOGY IN A PETROL PUMP AUTOMATION SYSTEM

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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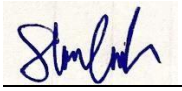
Signature : 

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APPROVAL

I thus declare that I have checked this project report and, in my opinion, it is suitable in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunication) with Honours.

Signature : 

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Date : 21/2/2024

DEDICATION

I would like to dedicate my Bachelor Degree project to my parents, who instilled in me the values of self-reliance and perseverance. Both individuals provide me with encouragement to persevere in life and have also exerted significant effort to offer me guidance and financial assistance in completing my studies. They consistently provide me with support and consistently teach me the invaluable lesson of learning from our experiences and finding the bright aspects in any unpleasant situation. My supervisor, Dr. Suraya Binti Zainuddin, provided guidance and advise throughout this research, ensuring its successful completion. Lastly, I would want to express my gratitude for my friends who have provided unwavering support throughout my entire academic journey, from the very beginning of my degree till now.

ABSTRACT

In many existing systems, almost all petrol pumps have a controlling unit to perform duties like managing the electrical pump, driving the display, measuring the flow and turning OFF the electrical pump accordingly. However, a person is still required to perform a manual process, such as collecting money, and there is a possibility of many human errors. Thus, this petrol pump automation system uses radio frequency identification (RFID) cards to access or purchase fuels at different petrol stations of various companies. The system consists of a microcontroller, RFID module, liquid crystal display (LCD), keypad, direct current (DC) motor, green LED and a buzzer. In order to fill the tank from the fuel dispenser, a user has to position the RFID card near the RFID reader. Then, the microcontroller reads the data from the reader and executes the action according to the customer's requirement. The outcome of the proposed project is a development of a prototype or a conceptual project of the petrol pump automation system by utilising RFID technology. This digital petrol pump system is hoped to provide better security to customers by minimizing human error, while reducing the danger of carrying cash every time.

ABSTRAK

Dalam kebanyakan sistem sedia ada, hampir semua pam petrol mempunyai unit kawalan untuk melaksanakan tugas seperti menguruskan pam elektrik, memandu paparan, mengukur aliran dan mematikan pam elektrik dengan sewajarnya. Walau bagaimanapun, seseorang masih perlu melakukan proses manual, seperti mengumpul wang, dan terdapat kemungkinan banyak kesilapan manusia. Oleh itu, sistem automasi pam petrol yang dicadangkan ini akan menggunakan kad pengenalan frekuensi radio (RFID) untuk mengakses atau membeli petrol di stesen minyak yang berbeza dari pelbagai syarikat. Semua stesen minyak disambungkan menggunakan pelayan web tunggal. Sistem yang dicadangkan terdiri daripada mikropengawal, modul RFID, paparan kristal cecair (LCD), pad kekunci, pam arus terus (AC), LED hijau dan buzzer. Untuk mengisi tangki dari dispenser bahan api, pengguna perlu meletakkan kad RFID berhampiran pembaca RFID. Kemudian, mikropengawal akan membaca data daripada pembaca dan akan melaksanakan tindakan mengikut keperluan pelanggan. Hasil jangkaan projek yang dicadangkan ialah pembangunan prototaip atau projek konsep sistem automasi pam petrol menggunakan teknologi RFID dan mengesahkan projek yang dibangunkan. Sistem pam petrol digital ini diharap dapat memberikan keselamatan yang lebih baik kepada pelanggan dengan meminimumkan kesilapan manusia, di samping mengurangkan bahaya membawa wang tunai setiap masa.

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First and foremost, I would like to express my deep and sincere gratitude to my supervisor, Dr. Suraya Binti Halim for giving me an opportunity to do this project on my topic (Development Of Rfid Technology In A Petrol Pump Automation System). Thanks for guiding me with your precious guidance, words of wisdom and patient throughout this project.

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Finally, I would like to thank all my friends and classmates for being there for me supporting this degree journey since day 1. Thanks for the advice along the way on the completion of this degree and project.

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CHAPTER 1

INTRODUCTION

1.1 Background

A petrol fuel station is an essential component of the distribution and sale of petroleum products. It provides a convenient location for consumers to refuel their vehicles. However, gas stations face numerous obstacles and difficulties. Fuel theft is a major issue that can occur through a variety of means, including dishonest payment practices. Theft of fuel costs gas station owners money, damages their reputation, and diminishes consumer confidence. In addition, efficient inventory management presents a challenge for gas stations. Complex tasks include maintaining an accurate inventory, monitoring stock movements, avoidance of stock outs and overstocking. Inaccurate inventory records and manual monitoring methods can lead to inconsistencies, which can negatively impact operational efficiency and customer satisfaction. To address these issues, gas station managements frequently implement technological innovations and solutions, such as RFID technology in petrol pump automation systems, to improve security, speed up operations, and enhance inventory management. RFID technology offers benefits such as increased operational efficiency, precise monitoring, enhanced security, and efficient data capture.

Using RFID (Radio Frequency Identification) technology in gas station dispensing systems offers numerous benefits. RFID technology enables efficient and automated processes, thereby enhancing operations and consumer satisfaction. By implementing RFID IDs on users and RFID readers on fuel dispensers, the system can identify and authenticate users precisely without requiring manual input or barcode scanning. In addition, RFID technology enables

real-time monitoring of petroleum inventory levels, enabling gas station owners to maintain optimal stock levels and minimize stock-outs. Incorporating RFID technology into payment systems enables secure and error-free transactions, thereby improving consumer convenience and decreasing transactional errors.

1.2 Relationship with environmental, society & global issue

The RFID technology in petrol pump automation system has a significant impact on issues covering environmental, social and global. It contributes to environmental sustainability by enabling precision fuel pouring during refuelling operations. The automated system enhances consumer convenience and safety from a societal perspective. It eliminates the requirement for cash transactions and decreases the chances of fraud or error. This technology also improves queue management and decreases wait periods, which increases customer satisfaction and enhances the overall fuelling experience. The RFID technology petrol pump system improves the overall effectiveness of fuel distribution networks. It contributes to addressing energy security concerns and mitigating the effects of petroleum shortages by optimizing operations and reducing operational inefficiencies. In addition, it facilitates improved monitoring and management of fuel reserves, thereby aiding efforts to prevent fuel theft and other activities with global economic repercussions. The RFID-based automation system for gas stations is environmentally friendly, increases societal ease, and contributes to the global optimization and safety of fuel.

1.3 Problem Statement

Traditional petrol pumping is a multi-step manual procedure that calls for human involvement and introduces opportunities for human mistakes and delays. For instance, the customer and the petrol station attendant must manually input the desired fuel type and quantity before the pump delivers the fuel. Long wait periods and accidental gas dispensing could occur from such an inefficient and time-consuming process.

Existing security vulnerabilities are a further cause for concern. Due to the presence of cash transactions, petrol stations are at risk of theft and fraud. The reliance on cash payments and manual record keeping strengthens the possibility of misappropriation or mismanagement of funds. Without thorough security measures, such as surveillance cameras or advanced payment systems, petrol stations may also be liable to fuel and money transaction theft. During peak hours or busy times, gas stations frequently have extensive lines of vehicles waiting to refuel. Existing systems may lack effective strategies for queue management, resulting in dissatisfied customers, lengthier wait times, and traffic congestion.

A radio frequency identification (RFID) system for automating petrol station pumps is explored and presented as an alternative solution. The system automatically identifies a user and proceeds to prompt them to select on fuel requirements using RFID identifiers and scanners and dispenses fuel accordingly.

1.4 Project Objective

The purpose of this project is to develop an RFID-based automation system for petrol stations that includes the following features:

a) To design a conceptual framework for the developed project.
b) To develop the basic prototype of an automated petrol pump utilising RFID technology.
c) To evaluate the functionality of the developed RFID technology in petrol pump automation to ensure accuracy, security, fault tolerance, user experience, compliance, interoperability, and performance.

1.5 Scope of Project

The proposal to create an RFID-based system for automating petrol pumps entails the creation and development of a conceptual project system capable of automating every aspect of a petrol pump. Utilising RFID technology, the system will trace inventory, process payments, and monitor fuel dispensing in real time. The scope of this project are as follows:

a) System analysis and design: During this stage, the needs of the automation system will be studied. The stage involves exploration of the system architecture and system configuration requirements.
b) Software development: This phase entails the creation of the necessary software for controlling RFID readers, maintaining stock, and handling transactions. The programme needs to be easy to use, reliable, and secure.
c) Integration and testing: In this step, the hardware and software components will be assembled to form a complete prototype system, which will then be tested to ensure that it works, is accurate, and dependable.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

One of the most important aspects of the petroleum distribution system is the service provided by the gas station sector. The increasing need for automation and efficiency has brought a lot of attention to the use of Radio-Frequency Identification (RFID) technology in gas injector systems in recent years. This literature analysis investigates the development of RFID-based gasoline outlet automation systems and highlights the most important developments, obstacles, and potential advantages of this technology. The study also examines the evolution of RFID-based petrol pump automation systems.

2.2 Previous Recent Projects

Previous recent projects that employed almost identical software to create and develop the new project were selected to develop a plan for improving and reducing the drawbacks of the new project. Besides that, these projects were picked because they were completed relatively recently. After reviewing these studies, we will be able to improve upon or eliminate certain aspects of the project.

2.2.1 IOT Based Petrol Bunk Management for Self – Operation using RFID and Raspberry PI [1]

The block diagram shown in Figure 2.1 shows the system with quality safety aspects in a petrol pump system. This investigation aims to devise a safe and error-free system of RFID technology in an automated petrol pump system. The user enters the desired quantity of fuel via the keypad, and the system then calculates the operating time for the electrical fuel pump and initiates fuel dispensing. The system will autonomously turn off the pump once the user-specified value is reached. It is coupled with a Raspberry Pi module that notifies the user via a mobile application. In addition, this system is equipped with a fire sensor to detect fire accidents and a purity sensor to monitor the fuel's purity. Consequently, this work will result in a management system for petrol station refuelling stations that is limitless and requires fewer employees.

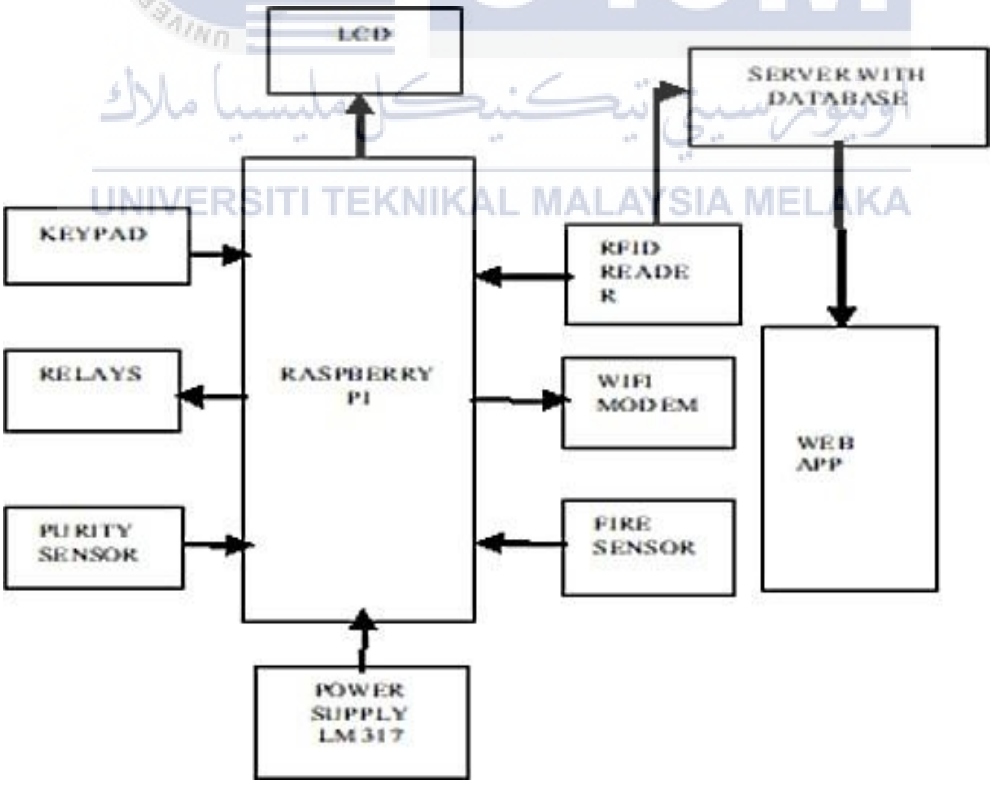


Figure 2.1: IOT Based Petrol Bunk Management for Self – Operation using RFID and Raspberry PI

2.2.2 Smart Waste Management System using RFID [2]

The system is designed to oversee and regulate inventory, evaluate data in real-time, and enhance the efficiency and transparency of supply chain operations. The utilisation of ultrasonic sensors is employed in the sorting process of this system. The system is capable of acquiring knowledge regarding the condition of the container. The system continuously monitors the status of unoccupied containers and can provide relevant information regarding occupied receptacles to sharing vehicles, thereby enabling an efficient collection of waste from filled bins. Undoubtedly, this is expected to decrease the amount of human labour and time required. Furthermore, it will maintain the cleanliness and sanitation of society.

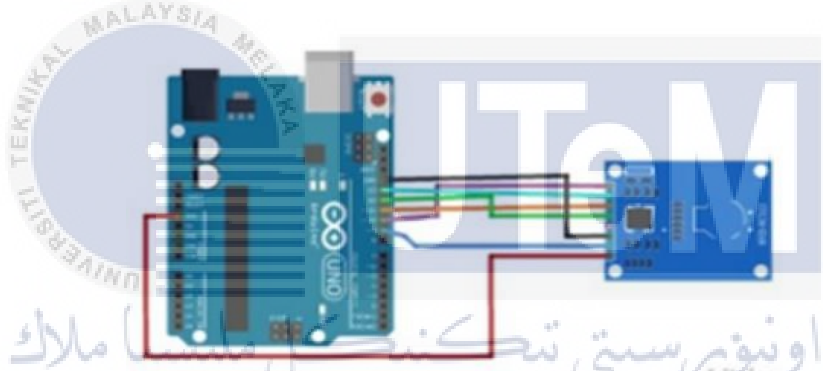


Figure 2.2: Smart Waste Management System using RFID

2.2.3 Implementation of RFID – based Fuel Dispensing System [3]

Figure 2.3 is the working model of implementing RFID – based Fuel Dispensing System. The use of RFID in a fuel delivery system is investigated in this study. The method has the potential to make the process of refuelling significantly less complicated, safer, and more reliable. An unauthorised filling is prevented by assigning a certain type of petrol to registered vehicles, depending on the vehicle's make and model. It makes use of passive tags along with an EM18 RFID reader. This system's hardware component comprises a

microcontroller, relay, LCD, speaker module, as well as a zigbee transmitter and transceiver for automobiles. These components are attached to conventional solenoid valves in order to make them compatible with RFID technology.

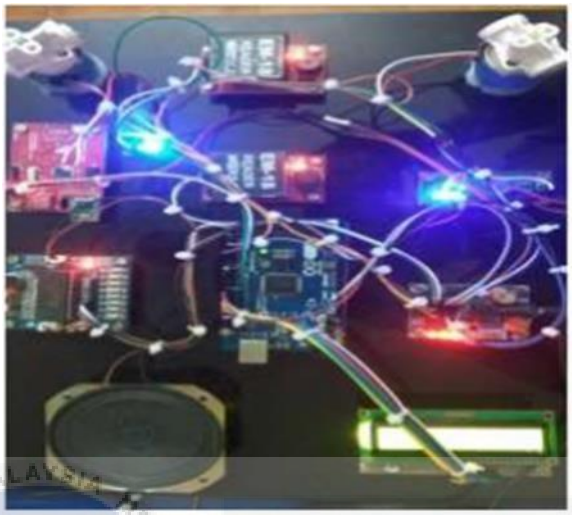


Figure 2.3: Implementation of RFID – based Fuel Dispensing System

2.2.4 Smart Water Vending machine Using RFID Reader [4]

The block diagram of an RFID reader integrated into a smart water vending machine is depicted in Figure 2.4. The purpose of this study is to investigate the feasibility of employing a relay in the process of water distribution from a system. Once the RFID reader has finished reading the user's RFID card, the system evaluates the inputs and triggers the relay, which in turn calculates and commands the Arduino to toggle the operation of the DC motor. This process is identical to that of any other RFID-based dispenser system. However, because there will be a relay present, it will be possible to manage the water flow and prevent any of it from being wasted.

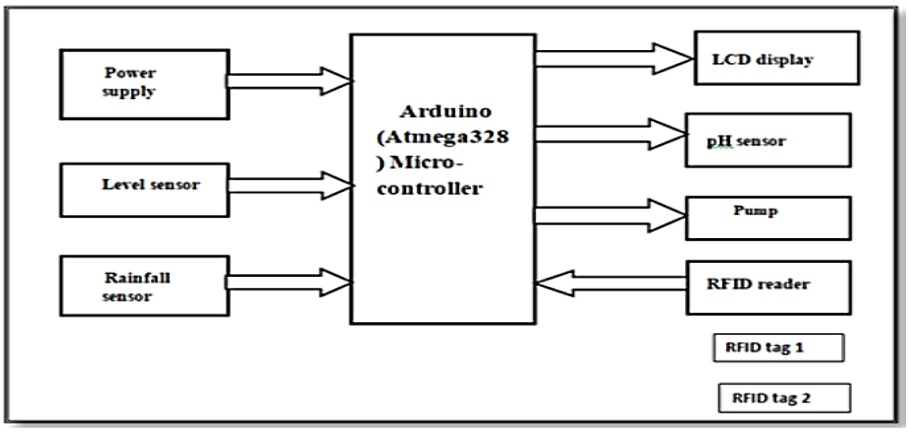


Figure 2.4: Block Diagram of Smart Water Vending Machine Using RFID Reader

2.2.5 Application of the RFID technology in logistics [5]

RFID (Radio Frequency Identification) technology used in logistics revolutionizes tracking and managing of products and assets throughout the supply chain. This includes placing RFID tags to products and strategically placing RFID readers throughout the logistics network at various locations. When an RFID tag passes by an RFID reader, it transmits a unique signal or data recorded in its memory, which is captured by the reader and transmitted to a central database or system. Provides visibility and clarity, enabling movement tracking number of products, delivery status verification, and route optimisation. By automating data processing and reducing the need for manual counting and scanning, RFID technology also facilitates inventory management. It prevents theft and unauthorised access to products and assets by facilitating real-time detection and authentication, thus promoting productivity, reducing costs, and enhancing security.

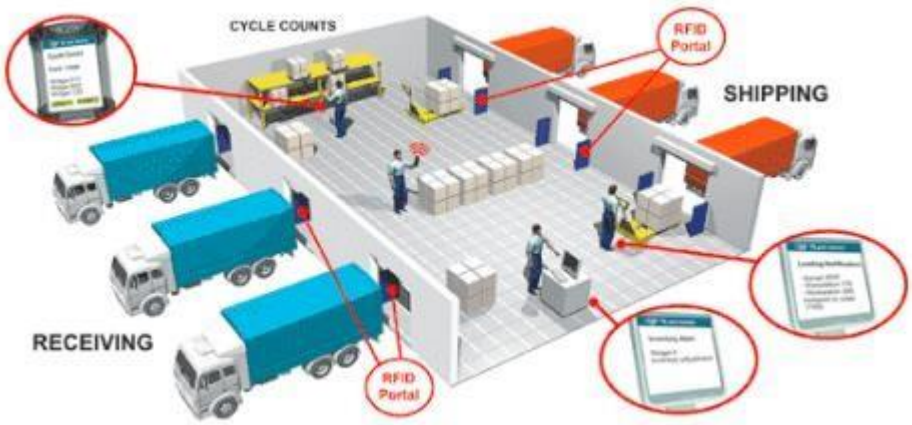


Figure 2.5: Scheme of implementing the RFID technology in a warehouse

2.2.6 Contactless Smart Thermometer using RFID [6]

The circuit diagram of an RFID-based contactless body temperature test is presented in Figure 2.6. The present study investigates the functionality of an RFID module that enables users to scan their RFID tags. Upon scanning, the module retrieves the unique number that is stored on the tag and transmits it to the accompanying system for further processing. In previous studies, it has been noted that during ultrasonic sensing experiments, participants are instructed to stand with their hands positioned in front of the sensor. This positioning allows for accurate measurement and detection of ultrasonic waves. The process of taking an individual's temperature without physical contact has been explored in various studies. One such method involves the use of a temperature sensor, which can be positioned at a safe distance from the individual. The sensor captures the temperature reading, which is then transmitted to a NodeMCU device. The data is subsequently stored in a webpage database for further analysis and use. The database is typically stored in a PHP file within the XAMPP environment. This approach is commonly used in web development to manage and store data in a structured manner. The data is conveniently stored in CSV file format, which allows for efficient backup and user

accessibility. In subsequent stages, the database is designed to enable remote access by the administrator, regardless of location or device. The system under consideration has been deemed reliable due to its ability to prevent data loss and facilitate easy accessibility.

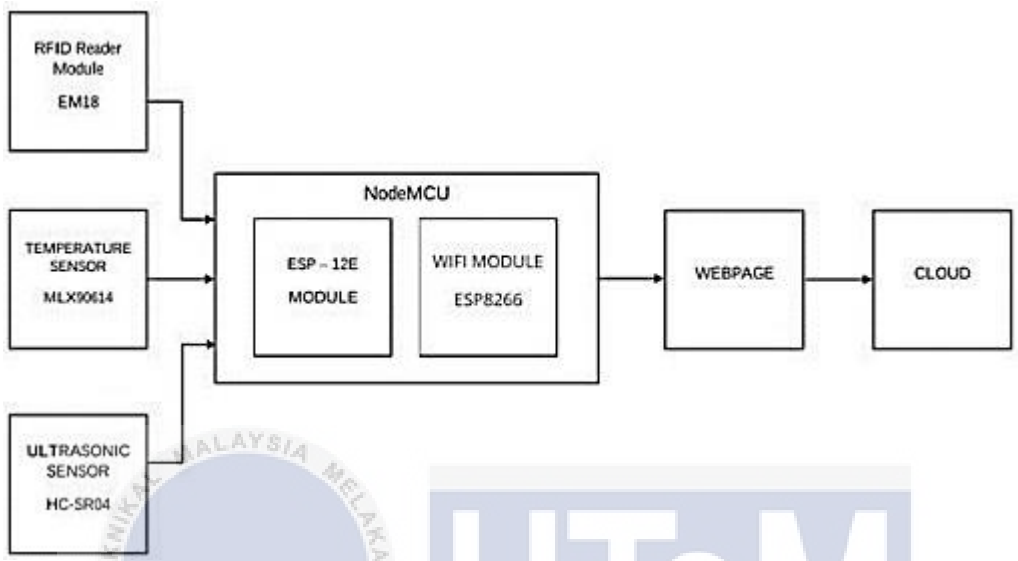


Figure 2.6: Circuit diagram of RFID Based Contactless Body Temperature Screening

2.2.7 RFID – Based Digital Door Locking System [7]

This project's circuit comprises three distinct components a reader, a controller, and a mechanical door lock. This experiment evaluates a circuit consisting of an RFID reader, a controller, a door lock, and three RED, GREEN, and YELLOW LED lights. The RFID reader reads the tags, while the controller scans the door locks and LED lighting after receiving data from the RFID reader. In the context of door lock installation, it is common practice to test the functionality of the lock by applying a battery to the mechanism. The door lock system employs an electromagnet that is powered by a 12-volt DC supply. Upon activation, the electromagnet causes a plate in the door lock to disengage, thereby allowing for easy manual opening of the door.

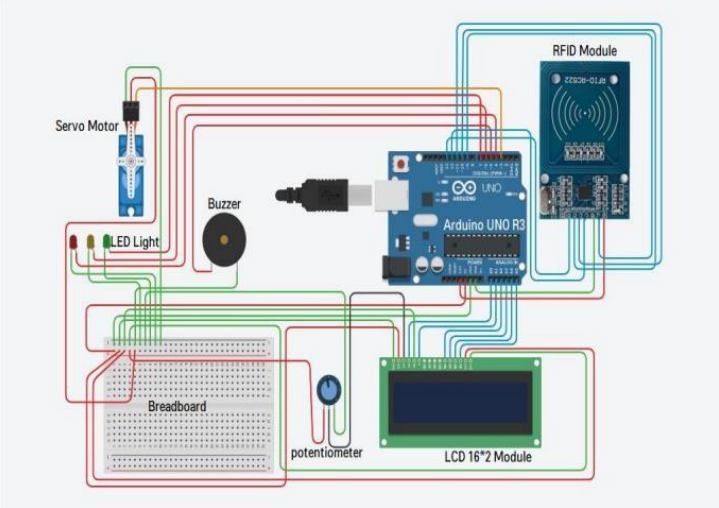


Figure 2.7: Circuit Diagram of Door Lock System

2.2.8 RFID based Smart Parking System [8]

The presented circuit diagram depicts the development of a smart car parking system utilizing RFID technology and Arduino Uno. When the circuit is activated, the LCD quickly displays information about available slots. A crucial step towards secure parking is the process of comparing the card number to the number stored in the database. The Arduino system gives the vehicle authorization to park at the specified area once the signal is validated. . The LCD displays spots that provide quick information on parking that is available, particularly the associated parking lot number upon car entry. A technique for preventing the use of a single card for multiple entries is the use of RFID readers and exit gates at the parking lot's entrance. As a required measure to ensure smooth and safe traffic flow in transport systems, traffic blocking was seen entering at the exit ramp. As the car moves away from the parking area, the LCD is updated with the number of parking spaces.

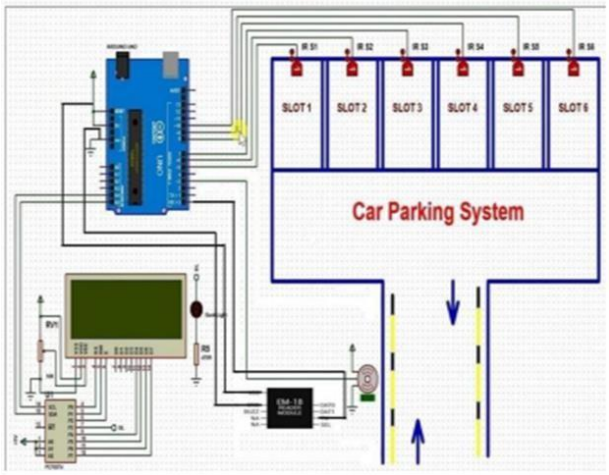


Figure 2.8: RFID based Smart Parking System

2.2.9 Automated Toll Collection System Based on RFID Sensor [9]

The aim of the system depicted in Figure 2.9 is to establish a digital toll collection mechanism that can reduce the issue of traffic congestion and delays on toll roads, bridges, and other related infrastructure. The system functions as an independent mechanism that prohibits the need for recharging, or that can bring a vehicle to a complete stop. The utilisation of RFID technology has been suggested as a means of identifying vehicles, whereby devices may be attached to the number plates of said vehicles. These badges contain text, accessible to RFID readers. This research investigates the viability of a system that could potentially reduce the necessity for automobile owners and tax authorities to manually furnish and gather taxes.

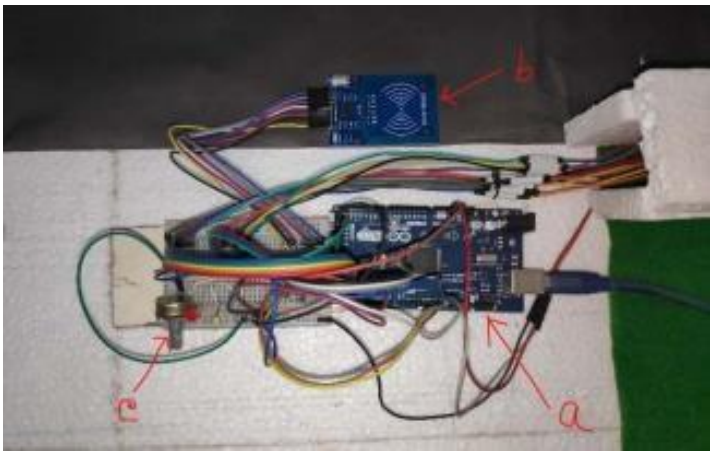


Figure 2.9: Circuit of Automated Toll Collection System Based on RFID Sensor

2.2.10 RFID based Student Attendance System [10]

Figure 2.10 depicts a system that records the attendance of a user. Students must present their RFID IDs to the RFID reader at the entrance upon entering the classroom or designated area. This system is designed to ensure accurate attendance control and is becoming more prevalent in educational institutions. In the process of RFID technology, the reader is responsible for capturing the identification code from the RFID tag. This code is then transmitted to a central database or system for further processing. In the present study, the authors describe a system that matches the code with the student's record, thereby marking the student as present for the specific session. The implementation of an automated attendance system has been shown to effectively eliminate the need for manual attendance taking, thereby reducing administrative burdens and the potential for errors.

Figure 2.10: RFID based Student Attendance System

2.3 Comparison of previous research and projects based on method, component used, advantages and disadvantages.

Previous works by other researchers were compared for benchmarking and guide for the proposed project. By studying the method, components used, disadvantages and disadvantages, it was found that RFID is widely implemented in various applications and minimized error introduced by human. From the literatures, it can be concluded that RFID technology is widely used in today applications. It brings the benefit to the applications in terms of accuracy, visibility, traceability, speed, security and effective management. Thus, this proposed project will employ RFID in petrol pump automation system. Table 2.1 tabulates the comparison of previous works.

Table 2.1: Comparison of previous research

Title	Method	Hardware / Software	Advantages	Disadvantages
RFID-Based Petrol Pump Automation Using Raspberry Pi [1]	RFID technology dispenses petrol, preventing unwanted scenarios and error. It captures data and notifies consumers via SMS to track petrol pump transactions.	• LCD • Keypad • Relays • Purity sensor • Power supply • Raspberry pi • RFID module	❖ Streamlined Method for Fuel Dispensing ❖ Secure and Reliable Transactions ❖ Remote Access and Management	• Metal, EMI, and RF noise can impair RFID systems. These factors can affect RFID reader reliability and tag detection accuracy. • Raspberry Pi and RFID system support may be needed periodically. Updates, hardware troubleshooting, and system dependability are included.
Smart Waste Management	optimise route planning, and automate bin emptying processes for sustainable waste management using	• Microcontroller • Ultrasonic sensor • RFID module • GSM module	❖ Greater efficiency in the collection and disposal of waste. ❖ Optimise collection	• RFID tags used in trash cans may have limitations such as a limited read range, susceptibility to injury in

System using RFID [2]	RFID technology		arrangements	harsh waste environments, or poor performance. • Requires regular service and maintenance, including replacement of damaged or malfunctioning badges
Implementation of RFID-based Fuel Dispensing System [3]	Enables automated and secure fuel dispensing processes through vehicle identification and transaction approvals.	• LCD • Relay • Microcontroller • RFID Module • Buzzer • Zigbee	❖ Effective and Precise Fueling Process ❖ Rapid and Convenient Transactions	• Issues of Confidentiality and Data Protection
Smart Water Vending machine Using RFID Reader [4]	Fatigued people will benefit from this module. Water is dispensed by three buttons on this device. After the user chooses, the system calculates the total. Stages are shown by	• Arduino Mega 2560 • Wi-Fi Module (ESP8266) • Push button • LED • 16x2 LCD	❖ It can accurately monitor and measure the quantity of water a person consumes.	• It lacks a hot water option, despite the fact that some individuals may want to use hot water to prepare coffee. Consequently, humans can only consume cold water.

	coloured LEDs.	• Water pump • Relay		
Application of the RFID technology in logistics [5]	Utilizes RFID tags and readers to track and monitor the location, movement, and condition of products throughout the supply chain, allowing for real-time visibility, enhanced inventory management, and efficient logistics operations.	• RFID module	❖ Reading tags without human intervention reduces the number of mistakes induced by the human element. ❖ giving real-time information on business events, allowing the "just-in-time" principle to be implemented	• High cost of RFID tags • Potential hacking, when any person who received a product with a tag can gain access to the database
Contactless Smart Thermometer using RFID [6]	The idea behind the project is that each person will have a unique RFID tag, which will be read by the RFID reader. The thermometer will then be used to read the person's temperature. That temperature will be written down on a site,	• Ultrasonic sensor • Temperature Sensor • RFID Module	❖ Lowers the risk of cross-contamination and the spread of germs or illnesses. ❖ Useful in places with a lot of people or when quick screening is needed, like airports, hospitals, or public events.	• The distance between the thermometer and the object being measured can affect the accuracy and effectiveness

	which will be saved in the cloud later.			• interference from other electronic devices or metal items nearby.
RFID – Based Digital Door Locking System [7]	This device helps a business owner manage his office and who gets in. It's safe too. The door lock is open when the green LED is on and locked when the yellow LED is on. Red LEDs indicate incorrect cards.	• Arduino Uno • Servo Motor • RFID Module • LCD • LED • Buzzer	❖ Uses unique identification codes encoded on RFID tags to provide a high level of security ❖ Enables monitoring and accountability, making it simpler to identify and investigate security violations or attempts to gain unauthorized access.	• RFID-based digital door securing systems can be expensive to implement. • Power outages or system failures can cause transient loss of access control, necessitating the use of backup power or manual intervention.
RFID based Smart Parking System [8]	The system is designed to restrict access to the parking lot solely to authorized individuals possessing a valid RFID card.	• Arduino Uno • RFID Module • IR Sensors • Servo Motor • LCD	❖ Enables real-time surveillance of parking spaces. ❖ Monitors vehicle entry and departure, providing a record of parking activity. ❖ Drivers can access parking	• For successful detection, RFID-tagged vehicles must be in close proximity to the receiver. • Interference can compromise the accuracy of tag detection and leads to invalid readings,

			facilities without needing to purchase tickets or explore for available spaces.	resulting in inefficiencies in parking management.
Automated Toll Collection System Based on RFID Sensor [9]	The implementation of automated toll payment systems has been found to enhance transparency while minimizing manual labour and associated human errors.	• Arduino Mega R3 2560 • LCD • RFID Module • Servo Motor	❖ RFID tags allow vehicles to pass through toll booths at normal speeds, thereby reducing traffic congestion and wait periods. ❖ Identifies and authenticates vehicles precisely, reducing cases of toll evasion and fraud.	• RFID tags attached to vehicles are susceptible to degradation over time, which could impair their readability.
Student Attendance Using RFID System [10]	Automate the process of documenting student attendance in educational institutions, thereby improving its precision and efficacy.	• Microcontroller • LCD • RFID Module	❖ Eliminates the need for manual attendance taking by automating the process of monitoring attendance. ❖ Provide precise and dependable information on attendance.	• There is a large volume of students entering or exiting a location, attendance recording may be delayed or inaccurate.

2.4 Comparison between RFID card detection and RFID drive-through car sensor

2.4.1 RFID Card Detection:

Pros:

1. User Proficiency: A significant number of users are already well-acquainted with card-based systems.
2. Vehicle type: Only cars are able to use this system.
3. Security: Depends on the security capabilities of RFID cards to authenticate users.

Cons:

1. User Interaction: Users are required to pause and engage with the system, which may potentially cause a delay in transactions.
2. Speed of interaction: Transaction speed may be hindered by the necessity of manual interaction.

2.4.2 RFID Drive-Through Car Sensor

Pros:

1. Enhanced User Convenience: Provides a smoother and uninterrupted experience for users.
2. Transaction Speed: Enables quicker transactions by detecting them in real-time while driving through.

3. User Authentication: Implementing passive authentication helps simplify the process for users as they pass through, minimizing their required effort.

Cons

1. Vehicle type: Only cars are able to use this system.
2. Compatibility Challenges: Compatibility issues may arise across different sensor technologies.

2.5 Summary

This chapter describes the research and initiatives conducted by others in the past. The literature evaluation provides a clearer picture of the project flow, experiment setup, and required components. Then, they are transferred to a table to compare the employed method, components, benefits, and drawbacks. According to the available literature, RFID technology provides enhanced security measures, which reduce fuel theft and unauthorised access. RFID readers with centralised systems enables real-time monitoring and reporting, thereby facilitating the analysis and optimisation of petrol station operations. The literature review discusses the implementation of RFID technology in fuel pumps, which enables automatic operation. RFID technology is a useful tool for automatic vehicle identification and simplifying fuel and payment processes. The real-time monitoring of fuel inventory, connection information, and operating status has been found to enhance data-driven decision-making and improve inventory management. This chapter provides a literature review of prior research and work conducted by other scholars which offers an overview of the project's progression, dimension, and materials. The process, features, advantages, and disadvantages of the subject are compared in a table.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The development of an RFID-based fuel pump automation system is one of the solution towards enhancing the efficiency, precision, and safety of fuel pump operations. Using RFID technology, the system automates a number of processes, including reducing human error and the need for manual intervention. Customer identification, petroleum delivery, and payment processing are included in these channels. A strategic planning procedure is required to create such a system, beginning with a requirements analysis and finishing with maintenance and upgrades. These operations include analysis of the system, system design and interface design, and development and testing of the system. The implementation of an RFID-based petrol pump automation system could benefit both fuel pump owners and consumers by increasing operational efficiency, limiting errors, and enhancing the overall customer experience.

To develop the proposed RFID-based fuel station automation system, below work plan is identified:

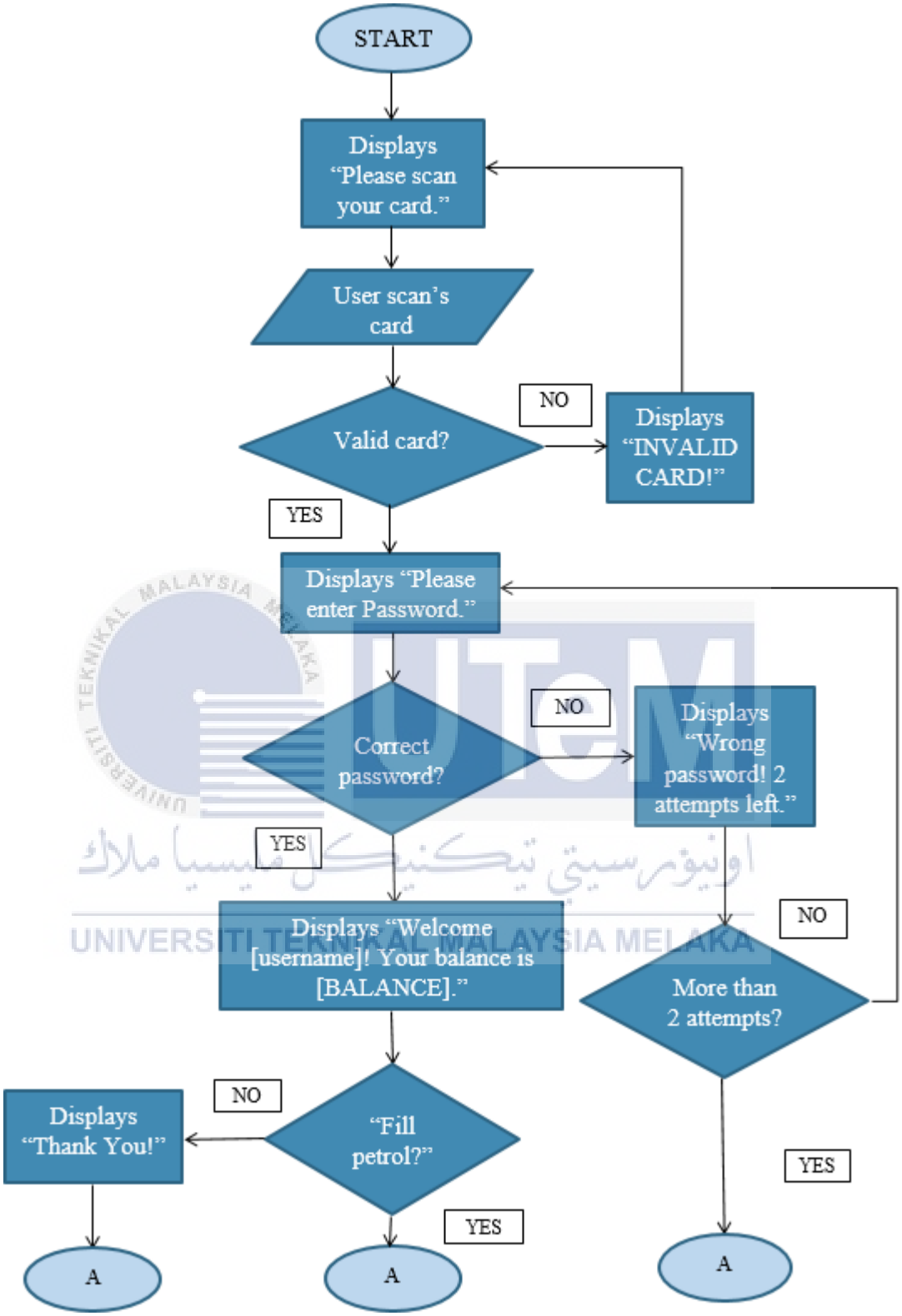
i. **Identify the requirements:** The first step is determining what the automation system needs. This phase identifies jobs to be automated, the primary participants and the system's overall goals.

ii. **Research on existing systems:** The next step is to look into current systems that perform similar activities. It helps to identify the strengths and limitations of existing systems and determine which critical aspects must be included in the new system.

iii. **Design the system:** Next step is to build the RFID-based petrol pump automation system after analysing the requirements and investigating existing systems. This comprises creating a system architecture, designing the user interface, and determining which hardware and software components are required.

iv. **Develop the system:** After completing the system's design, the system must be developed. This entails writing the code for the software components, integrating the hardware components, and evaluating the system to ensure it meets the specifications.

v. **Test and validate the system:** Following system development, it must be tested and validated to ensure it meets the requirements and performs as expected. This include utilizing the system in various settings, looking into and resolving any issues, and making sure it is user-friendly and satisfies consumer needs.



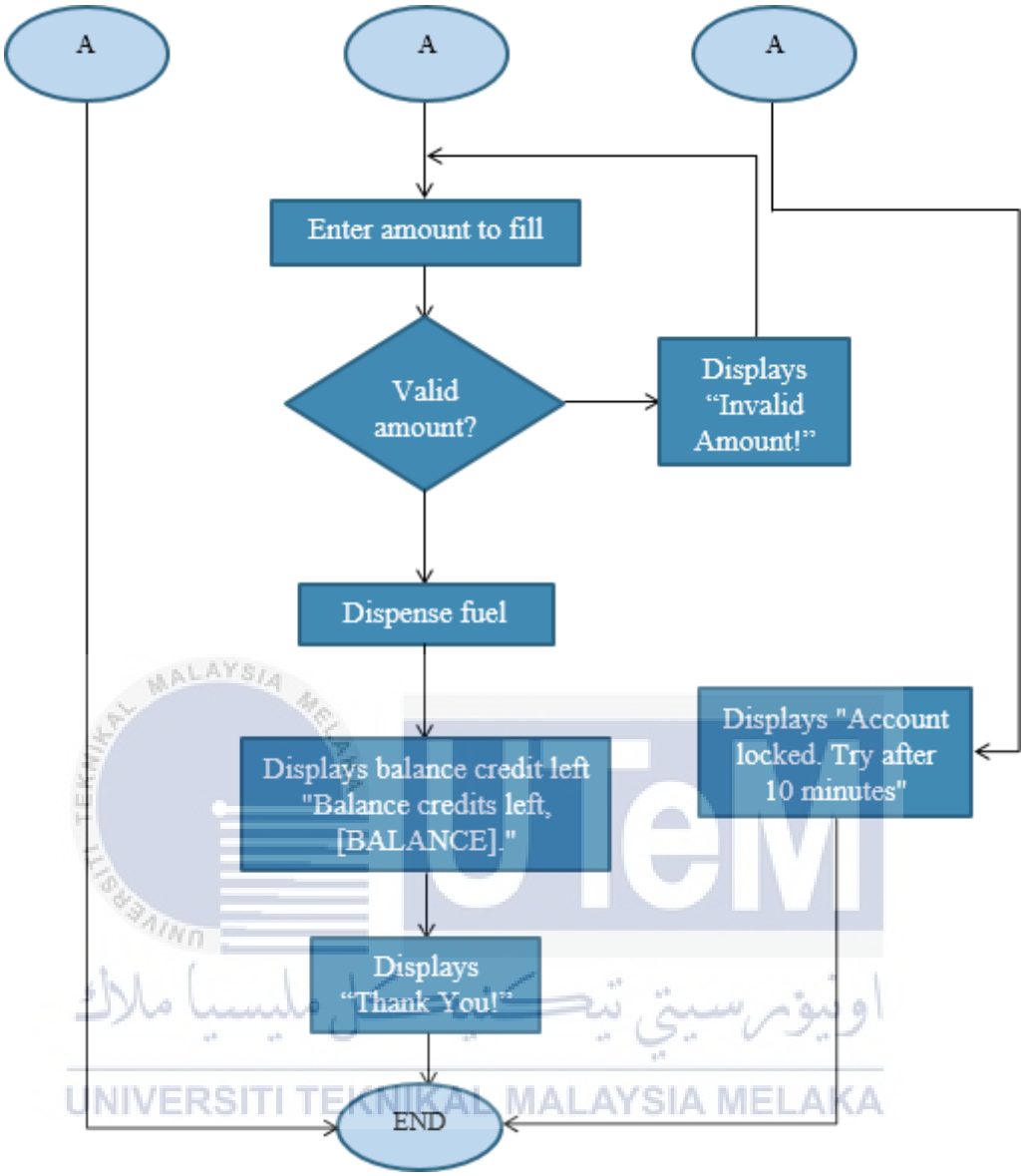


Figure 3.1: The Proposed System's Flowchart

3.2 Conceptual Framework Block Diagram of the Proposed Project

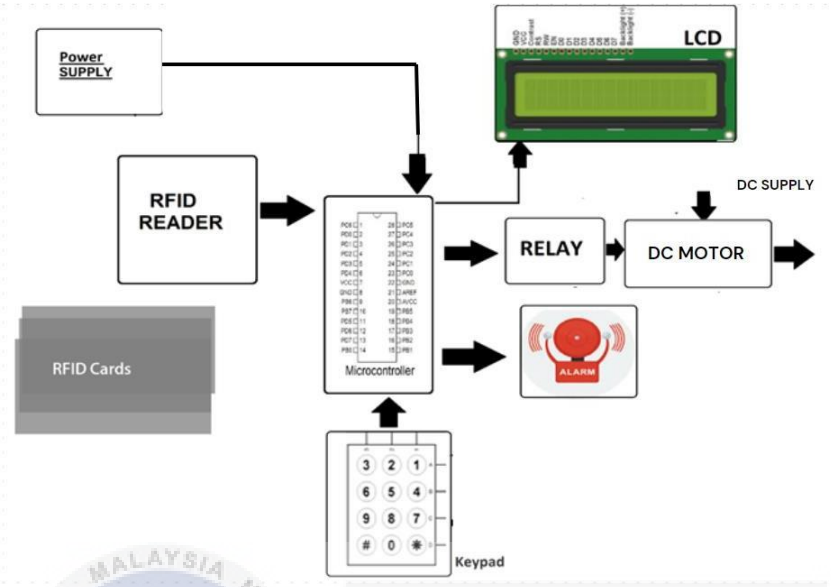


Figure 3.2: Block Diagram of the Proposed Project

RFID and the Arduino Uno are used in the proposed method to construct an automated gas station. The proposed methodology is divided into two distinct sections, analog and digital. Utilizing an analog component, the procedure measures the time, quantity, and amount of the identified product. In addition, a digital component is used to operate the vacuum and pump unit (SUMP). This methodology involves assessing the efficiency of the model with various user-entered financial amounts. Each user is allocated a unique RFID tag in order to keep track of its information. The RFID reader is used to monitor the respective RFID tag frequencies. RFID technology employs electromagnetic pulses with a frequency spectrum between 125 kHz and 2.4 GHz. Once the frequency is matched with the tag, the reader gathers the customer-specified number and instructs the arduino Uno to calculate the time and number for the customer-specified number. Dispensing occurs in response to the Arduino Uno activating the motor. This concept ensures that:

a) Customers' vehicles and fuel requirements can be automatically determined using RFID tags and scanners.

b) Dispensing petrol automatically according to the customer's requirements.

c) Real-time inventory and monitoring of fuel distribution systems.

d) By integrating with payment processing systems, financial transactions can be made in a safe and efficient manner.

e) Fuel station employees and customers alike will appreciate the intuitive interface.

f) Distributing and keeping track of petroleum stockpiles with unmatched accuracy and dependability.

3.3 The Proposed Components Specification

This artwork demonstrates that numerous hardware and software to be utilised to accomplish the desired project outcome. The proposed components and modules as follows:

Table 3.1: The Proposed Hardware

Components	Description
1. RFID Module 	The RC 522 RFID Reader is equipped with a radio transponder that functions as an antenna, has a frequency range of 125 HKZ to 2.4 GHZ and uses electromagnetic fields to identify signals corresponding to RFID tags.

2. Relay 	There are five relays in the relay block. With numeric logic, the four relays are used to turn on the numbers. First, the user has the choice to type in an amount. Arduino Uno runs the fifth switch that was left out. Finally, the Arduino uno figures out how much fuel will be dispensed and for how long. It then sends a message to the relay. This relay controls the reasoning for turning the DC motor on and off.
3. AA Battery 	An AA battery is a conventional cylindrical electrochemical cell that is frequently employed in portable electronic devices. The battery usually possesses a nominal voltage of 1.5 volts and is readily accessible in both disposable and rechargeable variations.
4. Keypad array 	The 4x3 keypad array is connected to the Arduino UNO and relay circuits, and is used to input the amount.

5. 5V DC Motor 	A pump AC motor is an alternating current (AC) motor that turns electrical energy into mechanical energy to power a pump that moves fluids or gases. Pump AC motors are often used in pumping systems, such as water supply systems, irrigation systems, and the oil and gas business. These motors are made to work in rough conditions, high temperatures, and under heavy loads. They come in many sizes and power ratings, depending on the purpose and requirements.
6. Arduino Uno 	Arduino Uno is a recognised ATmega328P-based microcontroller board used extensively in prototyping and Do-It-Yourself (DIY) electronics projects. It provides a straightforward and flexible framework for programming and administering an extensive range of electronic devices and sensors.

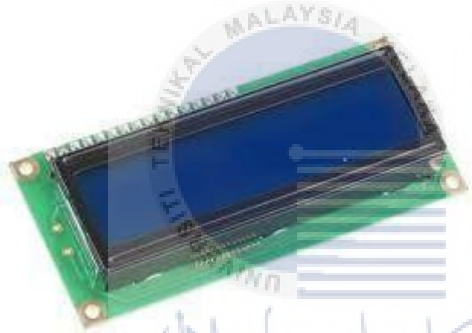
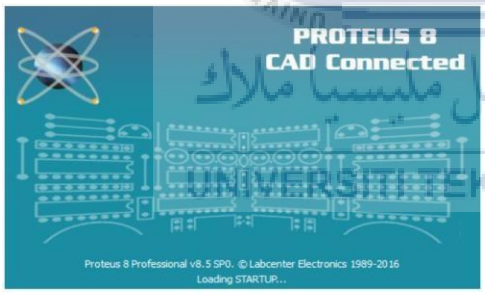
7. Green LED 	A green LED, or Light-Emitting Diode, is a semiconductor device that emits green light when an electric current passes through it. Widely used in electronics and indicator applications, the green LED is energy-efficient, durable, and commonly employed for status and signaling purposes.
8. Liquid Crystal Display 	Liquid Crystal Display (LCD) is a type of flat-panel technology that use liquid crystals positioned between two layers of glass or plastic to generate visual representations. Liquid crystal displays (LCDs) are extensively utilised in various devices, including televisions, computer monitors, and digital screens, due to their ability to provide high-quality pictures and operate with energy efficiency.

Table 3.2: The Proposed Software

Software	Description
1. Arduino UNO compiler 	Arduino UNO is a popular microcontroller board. It simplifies programming and electronics interface. Arduino IDE is the Arduino UNO compiler. The Arduino IDE makes writing, modifying, and uploading code easy. The IDE lets developers write and upload Arduino code using a text editor, compiler, and debugger. The Arduino UNO board's firmware allows USB programming without hardware.
2. Proteus 8 Professional 	Proteus 8 Professional is a software tool commonly used by electronics engineers and designers for circuit design, simulation, and PCB layout. It provides a comprehensive set of features, including a vast library of components, virtual testing capabilities, and seamless integration between schematic capture and PCB design modules.

3.4 Flow Chart

Figure 3.3 shows the flowchart of the proposed system's process. The flowchart for this project illustrates the logical sequence of steps involved in the RFID-based automation system at a gas station. It provides a graphical representation of the system's process flow and decision-making points.

The key components of the flowchart are as follows:

1. **Start:** The flowchart commences with the "Start" symbol, denoting the inception of the automation system.

2. **Initialize:** The initialization process of the system involves the activation of essential components, including the RFID reader, LCD display, keypad, and other peripherals that are necessary for the system's proper functioning.

3. **Wait for RFID Tag:** The system remains in a state of readiness until the proximity of an RFID tag is detected by the RFID reader. This stage usually entails the ongoing verification of the RFID tag through suitable functions or methods.

4. **RFID Tag Detected:** When an RFID tag is detected, the flowchart is divided into two paths: one for valid tags and one for incorrect tags.

5. **Invalid/ Valid RFID Tag:** If the RFID tag is determined to be invalid, the system will display an error message on the LCD stating that the tag is not recognized or approved. Upon validation of the RFID tag, the system initiates a prompt for the user to input their

password. The flowchart then breaks into two distinct paths, one for successful password authentication and the other for unsuccessful password authentication.

6. **Wrong/ Correct password**: In the event of an incorrect password input, the user will be granted two additional attempts. Should these attempts prove unsuccessful, the system will be automatically locked for a duration of 10 minutes. Conversely, in the event that the password is accurate, the system will proceed to exhibit the remaining credit balance in the user's account and will prompt the user to input fuel details. Subsequently, the user will have the option to either terminate the transaction or continue with the fuel filling process.

7. **Input Fuel Details:** The user is prompted to enter the fuel type and amount using the keypad or any other input method. The system validates the inputs to ensure they are within acceptable ranges. If the inputs are not within the range, the system displays invalid amount and goes back to the fuel input details screen.

8. **Dispense Fuel:** Once the fuel details are entered, the system initiates the fuel dispensing process. This step may involve activating pumps, calculating the amount of fuel dispensed, and updating the inventory or transaction records accordingly.

9. **Display Confirmation:** The LCD display show a confirmation message to the user, indicating that the fuel dispensing process is complete.

10. **End:** The "End" symbol at the end of the flowchart indicates the end of the automated system.

3.5 Summary

In conclusion, the development of an RFID technology petrol pump automation system for petrol stations has the potential to significantly benefit the gas station industry. The methodology described above helps to design dependable, efficient, and user-friendly system capable of performing duties such as recognition, fuelling, and executing payments itself. RFID technology can reduce errors, eliminate the need for manual data entry, and enhance the customer experience overall. Therefore, the development of an RFID technology in automation system for petrol pumps is a way towards modernizing the gas station and enhancing both efficiency and safety.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and analysis on the development of RFID Petrol Pump Automation System. All the results are obtained and analysed from the final prototype built based on the research and methodology done. All the manual inputs of this system performed by the students or teachers are performed through keypad inputs and RFID cards while all the output data will be shown in the Liquid Crystal Display, motor, buzzer, green LED and buzzer. These results are important as they can prove the functionality of this system.

4.2 Simulation Results and Analysis

Figure 4.1 shows the prototype of this project. The entire system is developed using the C++ programming language within the Arduino IDE software. Initially, the system exhibits the message "Petrol Pump Automation System" and awaits the user toposition their card at the MFRC522. Following that, it operates according to the programmed sequence defined by the Arduino IDE software. The green LED and buzzer serve as indicators, functioning to signal the detection of an invalid card or dispensing of fuel by the system, respectively. The 5V DC motor functions as a petrol pump, activating specifically during the refuelling procedure.

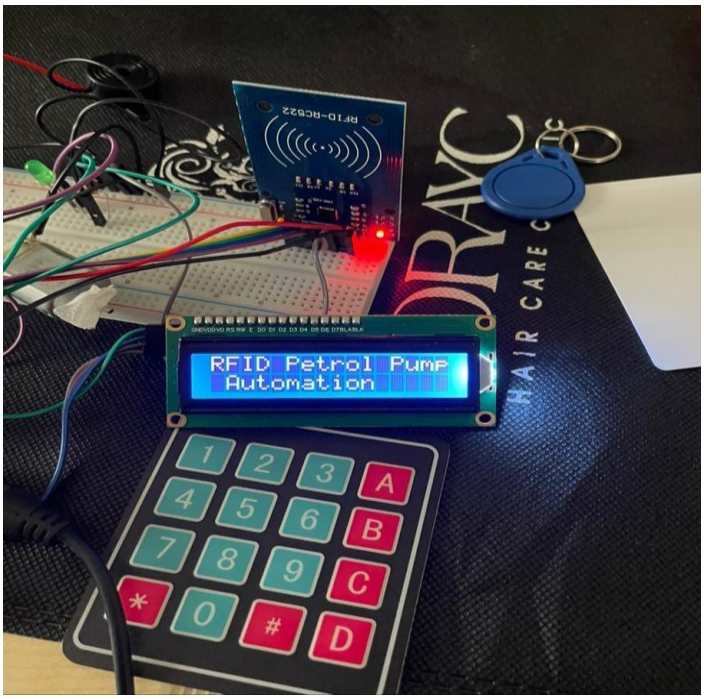


Figure 4.1: Prototype circuit

Various conditions were simulated. The prototype results are as follows:

4.2.1 Condition 1: Authorised RFID Card detected with valid PIN

Upon detecting a valid card, the system requests the user to input their account password. Keypad is used to input the keys. Then, the system extends a greeting to the user and exhibits the remaining amount in the account prior to offering the user the choice to either proceed with refueling or terminate the process.

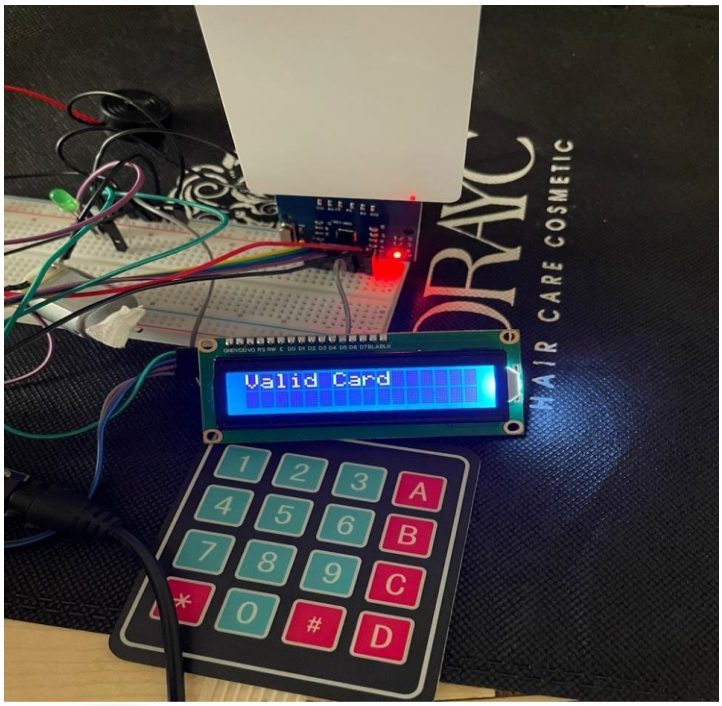


Figure 4.2: Displays valid card

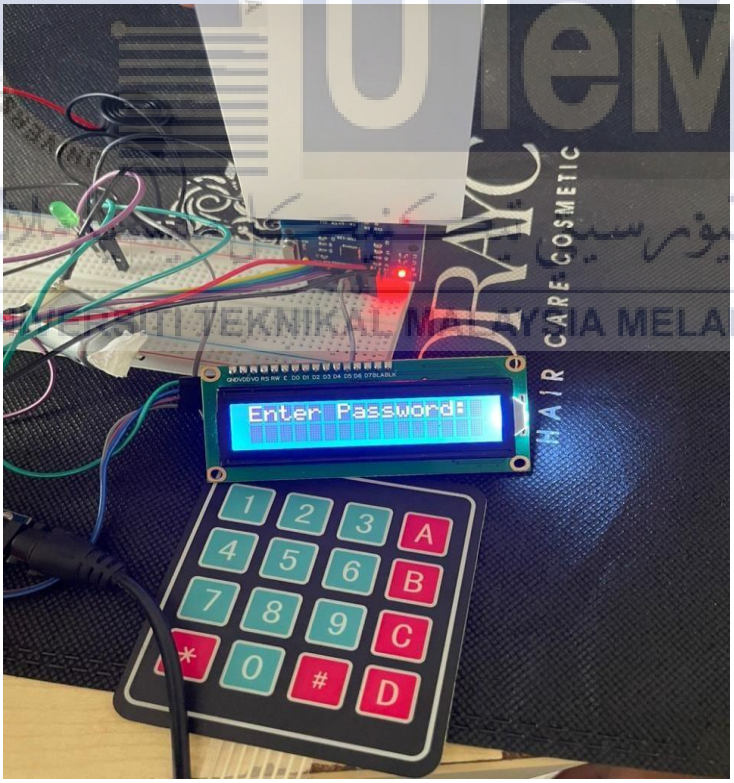


Figure 4.3: Prompts user to enter password

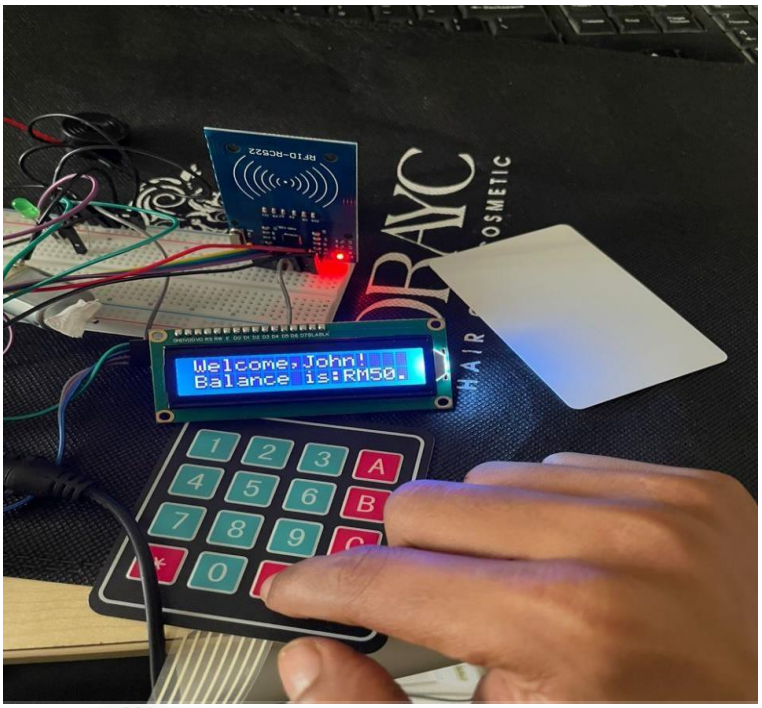


Figure 4.4 : Greets user and displays account balance

Figure 4.5: Gives option to fill petrol or no

4.2.2 Condition 2: User proceed with refuelling

Once the user is presented with the refuelling choice, selecting "yes" will prompt the system to proceed and request the user to input the desired quantity of petrol. Upon entering a valid amount, the system initiates the dispensing of fuel by activating the green LED and a 5V DC Motor. The motor remains active until the dispensing process is complete. Subsequently, the buzzer emits a brief tone to indicate that the dispensing has finished. Ultimately, the LCD screen exhibits the user's current balance and conveys gratitude by saying "Thank you."

Figure 4.6: Prompts user to enter an amount

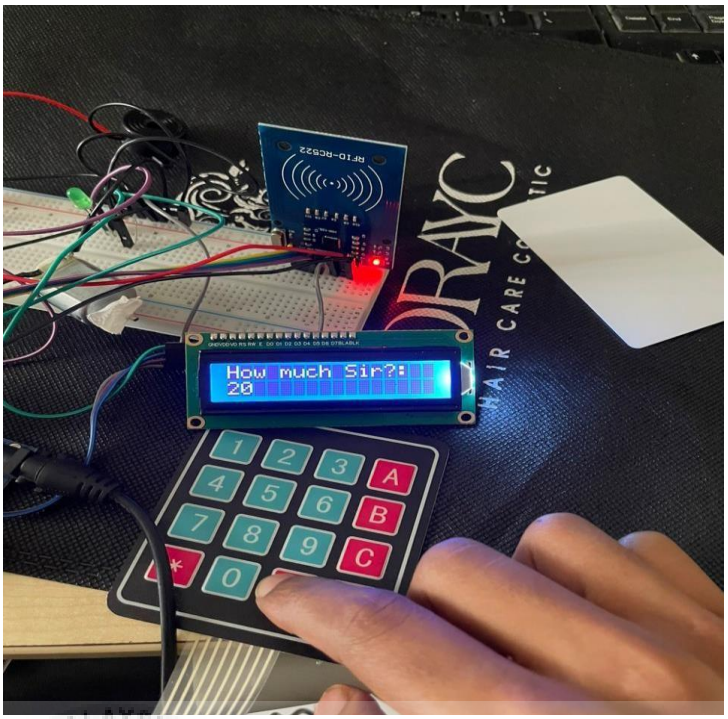


Figure 4.7 : User enters an amount

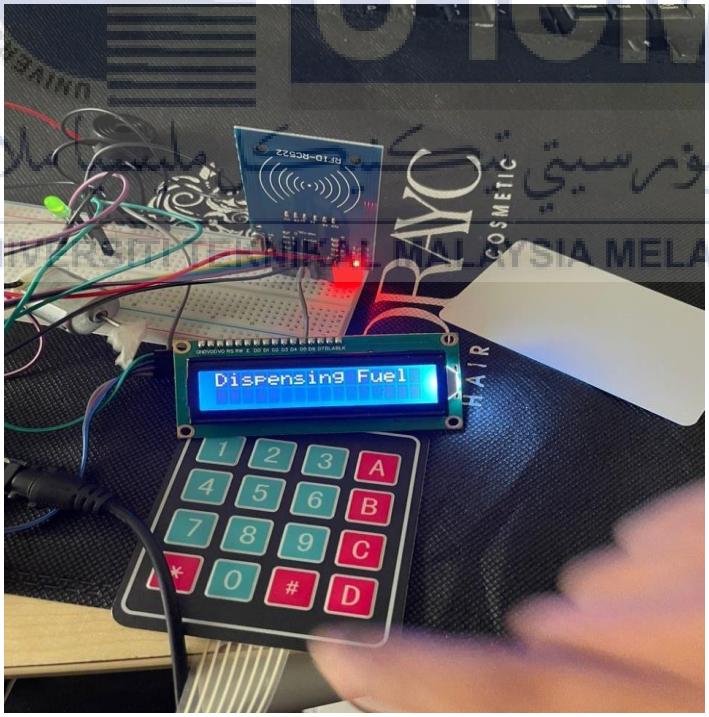


Figure 4.8: Dispensing Fuel, Motor and LED activates

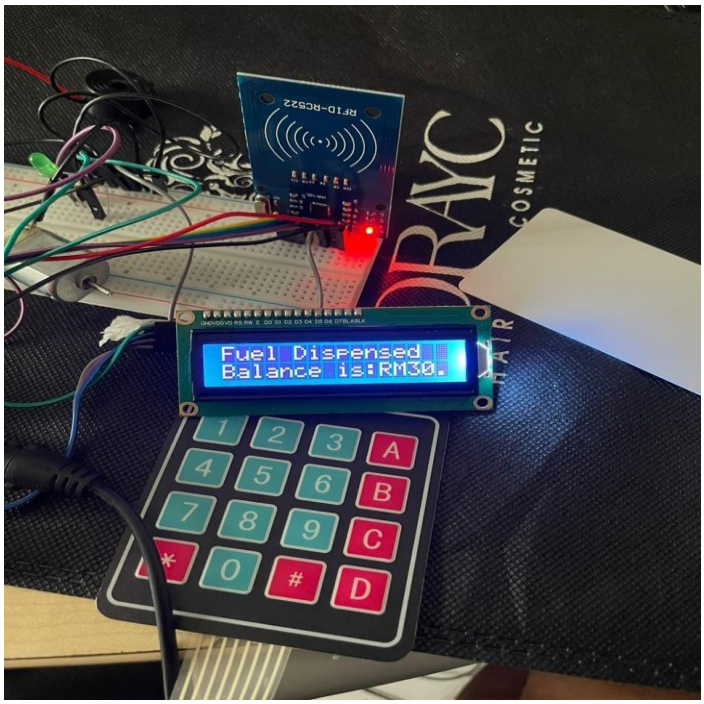


Figure 4 9: Displays Balance

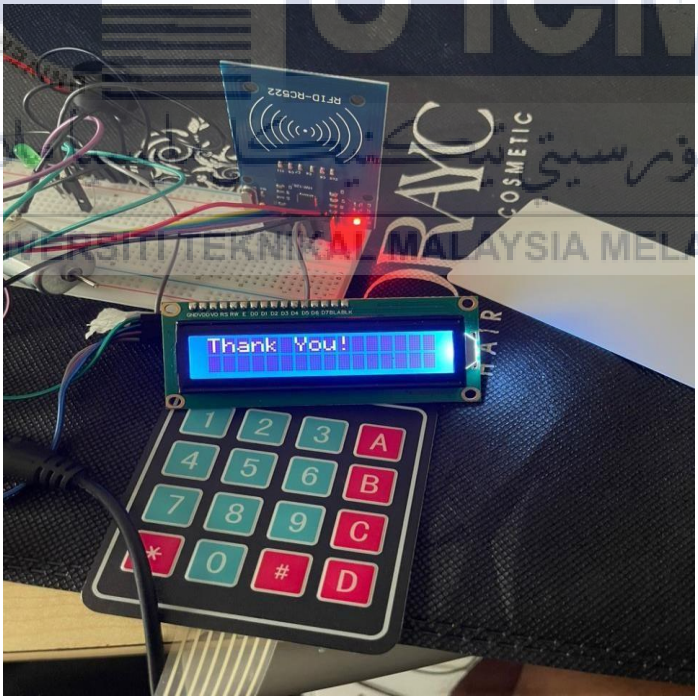


Figure 4.10: Wishes Thank You!

4.2.3 Condition 3: User does not proceed refuelling

Figure 4.11 explains that, if the user chooses not to proceed after checking his balance by choosing “No”, the system ends by saying “Thank You! Have a good day”.

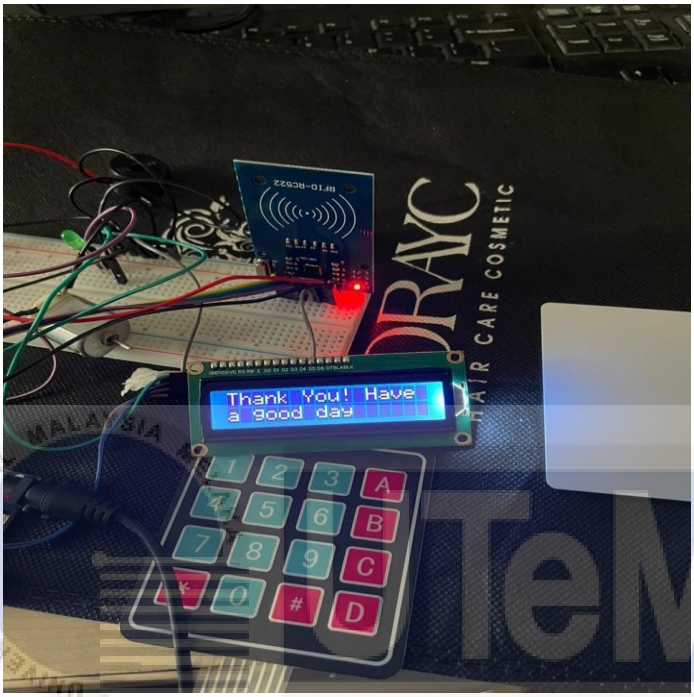


Figure 4.11: Displays Thank You! Have a good day

4.2.4 Condition 4: Invalid ID detected

When the system detects an invalid card ID, it displays “Invalid Card” and does not proceed to ask for the user’s password until the correct card is detected.

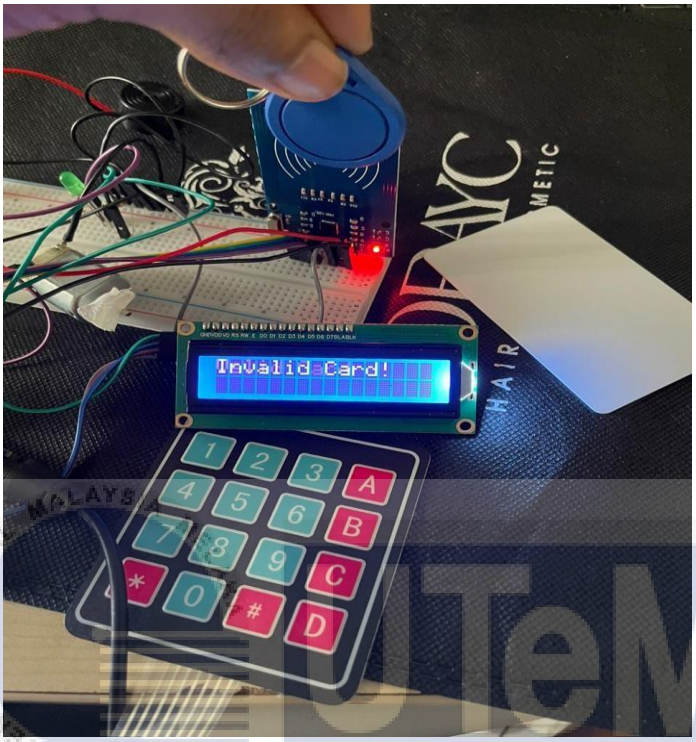


Figure 4.12: Invalid Card

4.2.5 Condition 5: Authorised ID detected with invalid PIN

Figure 4.13 shows that if the wrong pin is entered, the system displays “Wrong Password! Attempts left:2” and the user will have 2 more attempts to enter his pin. Figure 4.14 and 4.15 shows that if he fails both the attempts, his account will be locked for 10 minutes.

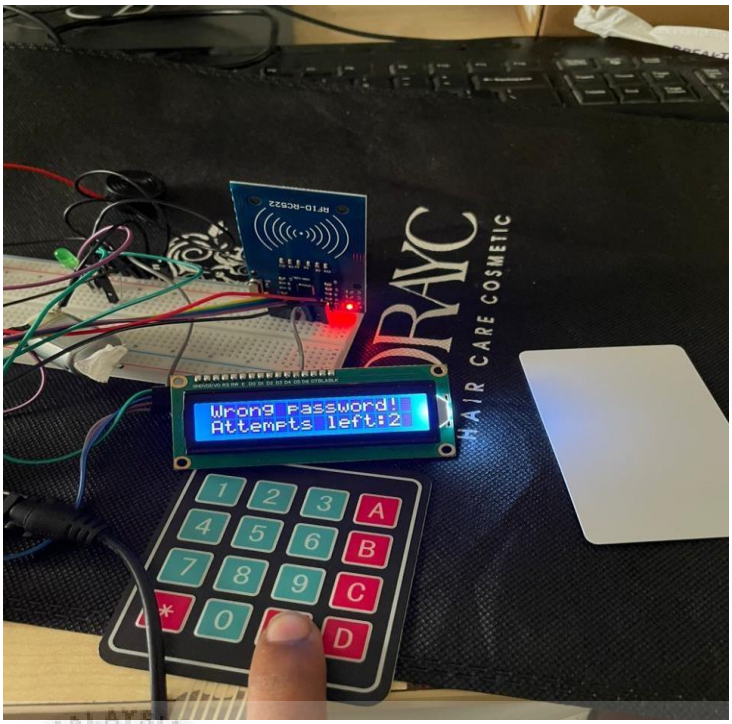


Figure 4.13: After First attempt

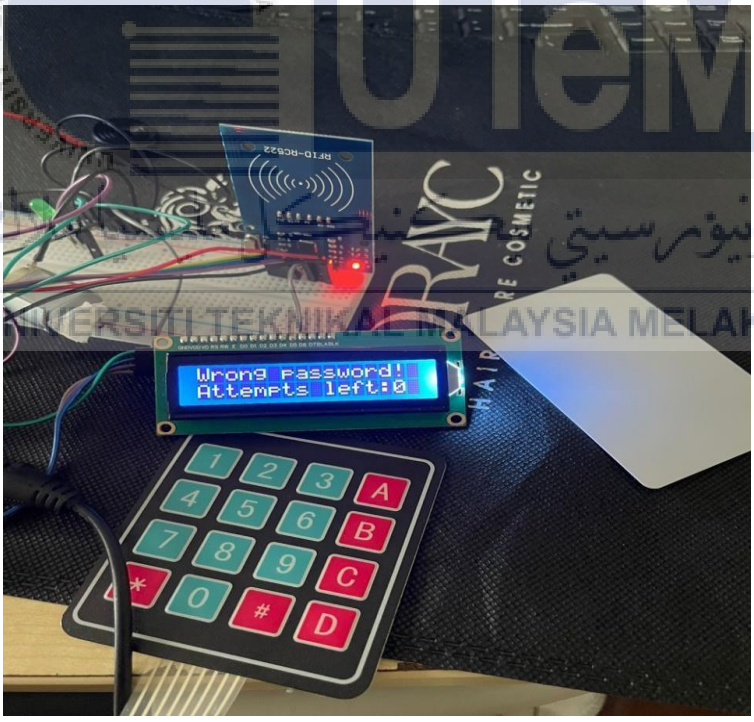


Figure 4.14: Zero attempts left

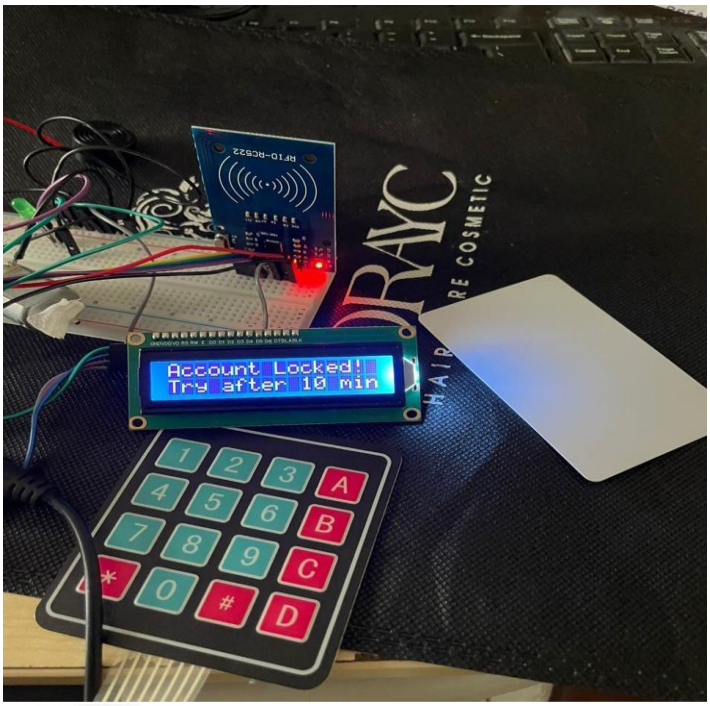


Figure 4.15: Account will be locked

4.2.6 Condition 6: Invalid Amount

Figure 4.16 depicts that if user inserts an invalid amount, the LCD displays "Invalid Amount" and goes back to enter amount screen .

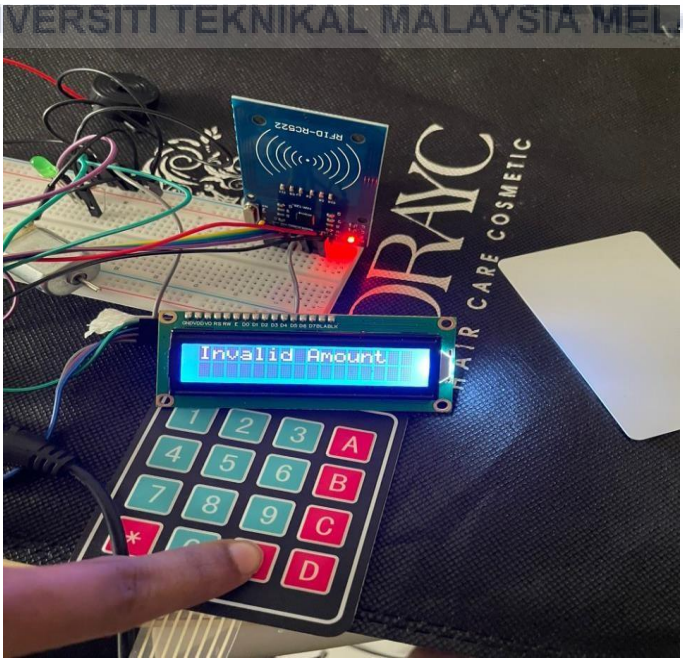


Figure 4.16: Invalid amount

4.3 Summary

In summary, the simulation results have been successfully obtained for all system features through the utilisation of appropriate code developed via Arduino IDE, as depicted in the attached figures. Based on the findings, I have established the functionality of the prototype in this PSM, including extra features into the system.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The research presented in this project has succeeded in contributing to understanding the concept of this RFID Petrol Pump Automation System. The presented method utilizes a reasonable type of data input and output, by using simple equipment and requires fundamental knowledge in the C++ program, yet, capable to produce quick, credible and reasonably accurate output. From BDP I, the simulation of the system is done by using Proteus 8 Professional. Allthe results obtained from the circuit built in Proteus 8 and Arduino IDE could be successfully obtained using the prototype with some added features. With numerous human error that occursat petrol pumps which leads to unwanted events, this project could reduce and make it more convenient for users to carry out their transactions and manage their spending at petrol pumps.

Through systematic planning and execution, the project has successfully realized its objectives. Initially, a comprehensive conceptual framework was established to guide the integration of RFID technology into petrol pump automation, portraying essential components and operational procedures. Subsequently, the project advanced to the development phase, working in the creation of a prototype of an automated petrol pump leveraging RFID technology, thereby exemplifying its practical implementation. Following this, an evaluation of the functional efficacy of the implemented RFID technology in petrol pump automation was conducted, enclosing assessments of precision, security robustness, fault tolerance, user interface design, regulatory compliance, interoperability with existing infrastructure, and

operational performance. This achievement underscores the project's commitment to technological innovation, marking a significant advancement in the application of RFID technology within the automative sector.

5.2 Recommendations

For future improvements, enhancement for this RFID Petrol Pump Automation System can be done as below:

i. Creating a separate database that handles every user's transactions using their respectives RFID card for petrol which users can view their transactions more detailed through an app.

ii. Making this method an alternate solution on making transactions like another 'TNG' brand for petrol pumps.

iii. Integrating a web server with an RFID petrol pump automation system for inventory and transactions review involves connecting the petrol pump system to a web-based platform where users, administrators, or system operators can monitor and manage inventory and transaction data.

5.3 Project Potential

The RFID Petrol Pump Automation System project signifies an innovative method to upgrade and optimize efficiency in petrol station operations. By utilizing Radio-Frequency Identification (RFID) technology, the system provides a user experience that is both smooth and secure. RFID cards or tags facilitate efficient and dependable user verification, enabling automatic fuel dispensing and instantaneous payment processing. By including a web-based

dashboard, station operators and administrators gain immediate access to vital information such as gasoline inventory levels, transaction histories, and alarms, thereby enhancing their capabilities. This platform centralizes operations, enabling well-informed decision-making and effective monitoring to meet the changing requirements of the fuel station industry.

Although there may be difficulties regarding system compatibility and user adoption, the project's objective is to address these obstacles by emphasizing a user-friendly interface, strong security measures, and compliance with regulatory standards. The system guarantees the security and confidentiality of user data and transactions through the implementation of role-based access controls and encryption methods. In addition, the project acknowledges the significance of analytics tools, offering stakeholders vital insights for strategic planning, inventory management, and overall operational efficiency. This project aims to revolutionize the conventional fuelling process by smoothly incorporating RFID technology into the petrol pump environment. The integration of this technology is expected to bring about a new era of intelligent, secure, and data-driven operations at petrol stations.

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APPENDICES

Appendix A Gantt Chart PSM 2

Project Gantt Chart	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
INTRODUCTION															
Subject briefing by lecturer															
Project briefing by supervisors															
DEVELOPMENT															
Idea Brainstorming															
Literature review															
SIMULATION FOR POST PROCESSING															
Programming Arduino Coding Writing															
Complete the simulation															
Check for the error															
OUTDOOR EXPERIMENT															
EXPERIMENT FOR ACTUAL DATA															
Complete the simulation for actual data															
Comments and Improvements															
REGIONAL EVALUATION															
Evaluation															
Final Poster															
Presentation Project															

Appendix B Gantt chart PSM 1

Task	MAR			APR				MAY				JUN			
	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14	WEEK 15
INITIATION															
Student registration															
PSM title selection via ePSM															
PLANNING															
Chapter 3: Methodology															
Conduct research for literature review															
Tabulated all research projects in Chapter 2: Literature Review															
Started designing systems flowchart and psm flowchart															
EXECUTION															
Design simulation and code using proteus and Arduino IDE compiler															
CLOSING															
Formatting Final report															
Report Submission/Presentation															

Appendix C System Code

```
#include <Wire.h>
#include <MFRC522.h>
#include <LiquidCrystal_I2C.h>
#include <Keypad.h>

#define RST_PIN         9
#define SDA_PIN         10
#define BUZZER_PIN      8
#define MOTOR_PIN       6
#define GREEN_LED_PIN   7  // Change this to the appropriate pin for your
green LED

MFRC522 mfrc522(SDA_PIN, RST_PIN);
LiquidCrystal_I2C lcd(0x27, 16, 2);

const byte ROWS = 4;
const byte COLS = 4;
char keys[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8','9','C'},
  {'*','0','#','D'}
};
byte rowPins[ROWS] = {A0, A1, A2, A3};
byte colPins[COLS] = {5, 4, 3, 2};
Keypad keypad = Keypad(makeKeymap(keys), rowPins, colPins, ROWS, COLS);

int maxAttempts = 3;
int lockoutDuration = 600000; // 10 minutes in milliseconds
unsigned long lockoutEndTime = 0;
float balance = 50.0;
String correctPassword = "1234";
byte correctCardID[] = {0x93, 0x25, 0x8F, 0x11};
byte invalidCardID[] = {0xC3, 0xC1, 0xC1, 0x0B}; // Invalid RFID card ID
String userName = "John"; // User name associated with the RFID card
bool thankYouDisplayed = false; // Track if "Thank You!" has been displayed

void setup() {
  Serial.begin(9600);
  lcd.begin();
  lcd.backlight();
  SPI.begin();
  mfrc522.PCD_Init();
  pinMode(BUZZER_PIN, OUTPUT);
  pinMode(MOTOR_PIN, OUTPUT);
  pinMode(GREEN_LED_PIN, OUTPUT);  // Initialize green LED pin
}
```

```
void loop() {
  if (millis() < lockoutEndTime) {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("or save my");
    lcd.setCursor(0, 1);
    lcd.print("number ;)");
    delay(100);
    thankYouDisplayed = false; // Reset flag when the system is locked
  } else {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("RFID Petrol Pump ");
    lcd.setCursor(0, 1);
    lcd.print(" Automation ");

    if (mfrc522.PICC_IsNewCardPresent() && mfrc522.PICC_ReadCardSerial()) {
      if (validateRFID()) {
        lcd.clear();
        lcd.setCursor(0, 0);
        lcd.print("Valid Card");
        delay(2000);

        lcd.clear();
        lcd.setCursor(0, 0);
        lcd.print("Enter Password:");
        lcd.setCursor(0, 1);
        String enteredPassword = getEnteredPassword();

        if (validatePassword(enteredPassword)) {
          lcd.clear();
          lcd.setCursor(0, 0);
          lcd.print("Welcome,John!");
          lcd.setCursor(0, 1);
          lcd.print("Balance is:RM" + String(balance));
          delay(2000);
          promptToFillPetrol();
          delay(1000); // Add a delay to stay on the prompt screen for 10
seconds
          displayThankYou(); // Display "Thank You!" message
          resetRFID(); // Reset RFID module
          thankYouDisplayed = true; // Set the flag after displaying "Thank
You!"
          delay(1000); // Add a delay for "Thank You!" message
        } else {
          lcd.clear();
          lcd.setCursor(0, 0);
```

```
          lcd.print("Wrong password!");
          lcd.setCursor(0, 1);
          lcd.print("Attempts left:");
          lcd.print(maxAttempts - 1);

          delay(1000);
          maxAttempts--;
          if (maxAttempts == 0) {
            lockoutEndTime = millis() + lockoutDuration;
            maxAttempts = 3; // Reset attempts for the next lockout
            lcd.clear();
            lcd.setCursor(0, 0);
            lcd.print("Account Locked!");
            lcd.setCursor(0, 1);
            lcd.print("Try after 10 mins");
            delay(3000);
            resetRFID(); // Reset RFID module
            thankYouDisplayed = true; // Set the flag after displaying "Thank
You!"
            delay(2000); // Add a delay for "Thank You!" message
          }
        }
      } else {
        activateBuzzer();
        if (isInvalidCard()) {
          lcd.clear();
          lcd.setCursor(0, 0);
          lcd.print("Invalid Card!");
          delay(2000);
          // Reset RFID module for an invalid card
          resetRFID();
        }
        delay(2000);
      }
    }
  }
}

bool validateRFID() {
  byte readCardID[4];
  for (byte i = 0; i < 4; i++) {
    readCardID[i] = mfrc522.uid.uidByte[i];
  }

  for (byte i = 0; i < 4; i++) {
    if (readCardID[i] != correctCardID[i]) {
      return false;
    }
```

```
  }

  return true;
}

bool isInvalidCard() {
  // Read RFID tag data
  byte readCardID[4];
  for (byte i = 0; i < 4; i++) {
    readCardID[i] = mfrc522.uid.uidByte[i];
  }

  for (byte i = 0; i < 4; i++) {
    if (readCardID[i] != invalidCardID[i]) {
      return false;
    }
  }

  return true;
}

String getEnteredPassword() {
  String enteredPassword = "";
  char key;
  while ((key = keypad.getKey()) != '#') {
    if (key != NO_KEY) {
      enteredPassword += key;
      lcd.setCursor(enteredPassword.length() - 1, 1);
      lcd.print(''); // Mask the password with ""
      delay(200);
    }
  }
  lcd.setCursor(0, 1);
  lcd.print(" ");
  delay(200);
  return enteredPassword;
}

bool validatePassword(String enteredPassword) {
  return (enteredPassword == correctPassword);
}

void displayBalance() {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Balance:RM" + String(balance));
  delay(3000);
}
```

```
void promptToFillPetrol() {
  char key = NO_KEY;
  while (key != 'A' && key != 'B'){
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Fill Petrol?");
    lcd.setCursor(0, 1);
    lcd.print("A: Yes   B: No");

    key = waitForKey();
  }

  if (key == 'A') {
    bool validAmount = false;

    while(!validAmount){
      lcd.clear();
      lcd.setCursor(0, 0);
      lcd.print("How much Sir?:");
      float amount = enterAmountToFill();
      if (amount > 0 && amount <= balance) {
            validAmount = true;
            dispenseFuel(amount);
          }
      else{
            lcd.clear();
            lcd.setCursor(0, 0);
            lcd.print("Invalid Amount");
            delay(2000);
          }
    }
  } else if (key == 'B') {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Thank You! Have");
    lcd.setCursor(0, 1);
    lcd.print("a good day");
    delay(1000);
  }
}

char waitForKey() {
  unsigned long startTime = millis();
  char key = NO_KEY;

  while (millis() - startTime < 10000) {
    key = keypad.getKey();
```

```
    if (key) {
      return key;
    }
    delay(50); // Add a small delay to prevent high CPU usage
  }

  return NO_KEY;
}

float enterAmountToFill() {
  String amountString = "";
  lcd.setCursor(0, 1);

  while (true) {
    char key = keypad.getKey();

    if (key) {
      if (key == '#') {
        break;
      } else if (key == '*') {
        amountString = "";
        lcd.clear();
        lcd.print("How much Sir?");
      } else {
        amountString += key;
        lcd.print(key);
      }
    }
  }

  return amountString.toFloat();
}

void dispenseFuel(float amount) {
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Dispensing Fuel");
  digitalWrite(MOTOR_PIN, HIGH);
  digitalWrite(GREEN_LED_PIN, HIGH);  // Turn on the green LED

  delay(10000); // Simulate fuel dispensing for 10 seconds

  balance -= amount;
  activateBuzzer();

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Fuel Dispensed");
```

```
  digitalWrite(MOTOR_PIN, LOW);
  digitalWrite(GREEN_LED_PIN, LOW);  // Turn off the green LED
  lcd.setCursor(0, 1);
  lcd.print("Balance is:RM" + String(balance));
  delay(4000);
  displayThankYou();
  delay(2000);
}

void activateBuzzer() {
  tone(BUZZER_PIN, 1000, 500);
  delay(1000);
  noTone(BUZZER_PIN);
}

void displayThankYou() {
  if (!thankYouDisplayed) { // Display "Thank You!" only once
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Thank You!");

  }
}

void resetRFID() {
  mfrc522.PICC_HaltA();
  mfrc522.PCD_StopCrypto1();
}
```

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