POLITEKNIK MALAYSIA

SULTAN SALAHUDDIN ABDUL AZIZ SHAH

RFID GROCERY CART

TEAM MEMBERS:	**MATRIX NO.**
LAU WE ZHE	08DKM18F1078
ATHANAIUS MCKENNZY DUAT	08DKM18F1079
JEROME GIOVANIE ANAK ASAP	08DKM18F1080

SUPERVISOR:

DR .NORASIAH BINTI MUHAMMAD

JABATAN KEJURUTERAAN MEKANIKAL

JUN 2020

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DEPARTMENT OF MECHANICAL ENGINEERING

DECLARATION OF ORIGINALITY AND COPYRIGHT

TITTLE : RFID GROCERY CART

SESSION : JUNE 2020

1. We, **1. LAU WEI ZHE 08DKM18F1078**
2. ATHANAIUS MCKENNZY DUAT 08DKM18F1079
3. JEROME GIOVANIE 08DKM18F1080

Are fifth semester students of **Diploma in Mechanical Engineering** at **Politeknik Sultan Salahuddin Abdul Aziz Shah, Persiaran Usahawan, Seksyen U1, 40150 Shah Alam, Selangor Darul Ehsan** (hereinafter referred ad "PSA")

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b) ATHANAIUS MCKENNZY DUAT	)	…….
(NRIC NO : 000829-13-1169)	)	ATHANAIUS MCKENNZY DUAT
c) JEROME GIOVANIE	)	…….
(NRIC NO : 000218-13-0263)	)	JEROME GIOVANIE
Afformed before me, NORASIAH BT MUHAMMAD (NRIC NO. 770510-03-6216)	)	…….
Project supervisor on: …….	)	NORASIAH BT MUHAMMAD

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ABSTRACT

In this project, the scope of this study focuses on developing and improvising current existing sell and purchase process that uses grocery cart to be quicker and more efficient for both seller and customers. Nowadays, consumers at local grocery store are facing long queues at the payment counter, standing and waiting for a long period at the counter during payment session especially during peak hours. This has been very troublesome to consumers especially those elderly who have health issues, are in a rush or those who are carrying toddler. To solve this problem, a grocery cart attached with an RFID Scanning System Device was created. This product is fully designed and created to make consumers shopping and paying process faster hence, reducing time consumed by consumers at the payment counter. In this study, feasibility study which is intending to be a preliminary review of the facts to see if it is worthy of proceeding to the analysis phase are done. Further, the system programming was designed using Arduino IDE, Laragon and NodeJs Software. Next, the design of device casing was designed using Autodesk Inventor Professional 2019 Software. As for its system, the system is implemented into two section which is the customer section and the retailer section. The result of experiment emphasized that RFID Grocery Cart reduce time consumed by consumer during shopping and paying process. Also, to improve this product there are some future-plan recommendation, one of it is to make the device more user friendly especially toward elderly

Keyword: develop, customer, NodeJs, RFID, recommendation

ABSTRAK

Skop kajian projek ini adalah tertumpu kepada mengembangkan dan memperbaiki troli pasaraya yang sedia ada supaya menjadi lebih mudah dan efisien kepada pengguna. Kini, pengguna di setiap pasaraya tempatan mengalami masalah dimana mereka perlu berbaris panjang dan menunggu untuk tempoh yang lama di kaunter pembayaran,ketika hendak membuat pembayaran.Ini boleh dilihat dengan jelas terutama sekali pada waktu perayaan dan ia telah menjadi satu beban yang berat terutama kepada golongan warga tua yang mengalami masalah kesihatan, mereka yang sedang bergegas dan golongan yang membawa bayi. Untuk mengatasi masalah ini, troli pasaraya dilengkapi dengan peranti RFID telah dicipta. Produk ini telah direka dan dicipta khususnya untuk memudahkan para pengguna dengan mengurangkan masa diambil ketika membeli belah dan semasa proses pembayaran serta mempercepatkan proses pembayaran ketika berada di kaunter pembayaran. Seterusnya, sistem peranti telah diprogram menggunakan perisian Arduino IDE, Laragon and NodeJs. Manakala, bingkai peranti RFID telah direka sendiri menggunakan perisian Autodesk Inventor Proffesional 2019. Selain itu, sistem peranti ini terbahagi kepada dua iaitu bahagian pengguna, dan bahagian pemilik pasaraya.Ujian yang telah dijalankan juga membuktikan produk ini dapat mengurangkan masa yang digunakan pengguna ketika proses membeli-belah dan pembayaran.Seterusnya, untuk memperbaiki produk ini di masa hadapan, terdapat beberapa cadangan telah diusulkan,antaranya adalah untuk menjadikan produk ini lebih mesra pengguna,terutama kepada golongan warga tua.

(*Kata Kunci*): mengembangkan,pengguna,NodeJs,RFID,cadangan

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CHAPTER 1

INTRODUCTION

1.1 **RESEARCH BACKGROUND**

Grocery trolley, also called as shopping cart, shopping trolley might as well being called as carriages, buggies or wagon (depending on particular region), is a wheeled cart supplied by a shop or store, especially supermarkets, for use by customers inside the premises for transport purposes of merchandise as they move around the premises, while shopping, prior to heading to the checkout counter or cashiers. They're used everywhere in almost every grocery store, department store, and bulk item superstore. The used of grocery cart nowadays is very crucial as it lessen consumers burden while carrying huge amount of goods while moving around premises and allow consumers to purchase more amount, bigger size and heavier load of item at once.

RFID Grocery Cart are applicable to all kind of store and supermarket and are most compatible to be used in busy supermarket during peak hours, weekends and festive season where the number of people visiting supermarket during this period are extremely huge. It is compatible as RFID Grocery Cart with the aid of radio frequency identification (RFID) technology are able to reduce time used by consumer during purchasing activity (particularly during payment/checkout session), get rid of long queues at checkout counter issue and making shopping process easier, faster and also systematically better.

RFID Grocery Cart are also specifically design to operate as durable, convenient and flexible as current conventional grocery cart. Only slight modification are added in order to have a better grocery cart handling and movement. In addition, as people are entering the Industrial Revolution 4.0 (IR4.0) era, having a grocery cart with a RFID Technology and system fulfil the requirement of IR 4.0 component where it consist 2 out of 4 IR4.0 major components which is Internet of Things (IoT) and Cloud Computing.

1.2 PROBLEM STATEMENT

Main issue that are being confront by consumer all over the country is that they need to face a very long queues and wait for a long period during the checkout session at the payment counter. This is due to the number of people who went to grocery store and supermarket per day are extremely huge. This can witness clearly in our country where grocery stores and supermarket in Malaysia are relentlessly being crowded by civilian per day and this number get enormous during festive season. This has been very troublesome to a lot of consumer especially those elderly who have health issues, those who are in a rush and family who are carrying toddler.

1.3 RESEARCH OBJECTIVES

The objectives to this research are:

i. To create a grocery cart with RFID system, install in it to solve long queues at paying counter issues.

ii. To create a grocery cart with a RFID price scanner to make consumer shopping process faster.

1.4 RESEARCH QUESTIONS

This study will answer the following research questions:

i. Is it possible to create a grocery cart that is more systematic with the aid of RFID system?
ii. How does RFID system make payment process faster?
iii. How does the price scanning system work?

1.5 SCOPE OF RESEARCH

RFID Grocery Cart is specifically fabricated to help to make consumers shopping session faster and get rid of long queues and long period of waiting during the checkout session at the payment counter.

The scopes and limits to this research are:

I. The grocery cart able to reduce timed used during payment and checkout session.
II. This grocery cart able to eliminate long queues at payment counter issues during items payment session.
III. The grocery cart is able to fulfil the IR 4.0 trend requirement.

1.6 SIGNIFICANCE OF RESEARCH

It is a fact that the conventional grocery cart used nowadays are rapidly evolving in term of design, dimension and mechanism. For instance, various type of grocery cart can be found at any store with numerous kinds of features build to fulfil consumers need. There is grocery cart that is created environmentally friendly, grocery cart specifically builds for the handicapped, also grocery cart builds for kids and many more. But above all, none of them are able to fix the issue of long queues at payment counter and help to make consumer shopping period shorter. Hence, this project will bring a lot of benefit not just to the consumers, but also will benefit store and supermarket retailer as it will attract more customer by eliminating these problems. In addition, as IR 4.0 are still at an early stage, people are struggling to adapt and understand the revolution concept of IR 4.0. Thus, this project will be a crucial way to introduce IR 4.0 technologies to the people, helping them to understand, adapt and learn these new ways to execute work.

1.7 DEFINITION OF OPERATIONAL TERMS

RFID: Radio frequency identification is a tag system that enable object to be identify automatically by using electromagnetic field.

Industrial Revolution 4.0(IR4.0): Refers to a new phase in the Industrial Revolution that focuses heavily on interconnectivity, automation, machine learning, and real-time data

Internet of Thing (IoT): a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs).

Cloud Computing: An on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user.

1.8 CHAPTER'S SUMMARY

In this chapter, the studies were explaining about the origin of the project ideas and inspirations. All the objectives were conceived out of all the problem statements. The main objective that will be focus more on this project is grocery cart with RFID system install in it to solve long queues at paying counter issues and the scope of this project will only be focusing more on RFID Technology system capabilities, how it helps consumer during shopping session and is able to fulfil IR 4.0 requirement. Thus, this new prosthetic could be beneficiary to not just consumers, but also store retailer and enhance the knowledge regarding IR 4.0 technologies to the peoples.

CHAPTER 2
LITERATURE REVIEW

Literature review is a body of text that aims to review the critical points of current knowledge and/or methodological approaches on particular topic. This chapter is about the explanation and description of the studies that have been made by using scholarly sources such as reference books, written articles, internet and journals. This chapter will elaborate on conventional shopping cart, self-checkout counter and the advantages and disadvantages of the RFID shopping cart.

2.1 CONCEPT

RFID Grocery Cart is a conventional shopping cart that is equipped with a radio frequency identification (RFID) system. It works by attaching an RFID reader on the trolley and an RFID tag on the item. Both of which, produce radio wave. When the item is brought near the reader, their radio waves will collide upon each other and produce responds with the information written in its memory bank. The interrogator will then transmit the read results to an RFID computer program. This system could speed up the check-out process due to customer won't have to scan each of their items at the registry as they have done it in the trolley.

2.2 SHOPPING CART ACROSS THE TIME

2.2.1 1937 Foldable Basket Carriage for Self-Service Stores

The first trolley was introduced in the year 1937 by Sylvan Nathan Goldman, the owner of Humpty Dumpty Supermarket in Oklahoma. He, Goldman noticed that his customers often carried their groceries in heavy, hand-held baskets. Their purchases were limited to what would fit in the basket and how much they could carry. Goldman

naturally wanted his customers to visit more frequently and to buy more groceries. One evening, Goldman noticed two folding chairs in the room and came up with the idea for the shopping cart. With the help of his employee, Goldman devised a prototype trolley, based on the folding chair, wheels at the bottom of the chair legs and two metal baskets on top of each other in place of the chair seat [1]. Figure 2.1 below showed the 1937 trolley introduced by Sylvian Nathan Goldman.

Figure 2.1 Foldable Basket Carriage for Self-Service Stores

2.2.2 1946 Telescoping Cart

Orla Watson, an American engineer [2] introduced a system which he invented called telescoping. Telescoping is a system which enables a trolley to fit into another trolley for a compact storage via a swinging one-way rear door. Just like Goldman, Watson employing a similar trolley design. While Goldman's design had two removable baskets and a foldable trolley, Watson had two built-in baskets with each has one-way swinging door at the back. That is where, Watson applying his telescoping system. Instead of having the trolley folded, Watson's idea was to make the trolley fitted into each other for storage [1]. Figure 2.2 below showed Telescoping Cart invented by Watson.

Figure 2.2 1946 Telescoping Cart

2.2.3 1949 Nest-Cart

In the year 1949, Goldman with the advice of his trusted business partners, Fred Taylor, a grocery store owner and George O'Donnell, a grocery store refrigeration salesman modified the trolley [3]. Incorporating Watson's swinging door mechanism, they designed the trolley in a way that it could nest another trolley in it. The trolley was a single large basket trolley with a rear one-way swinging door. Figure 2.3 below showed 1949 Nest-Cart modified by Goldman, Taylor and Donnell.

Figure 2.3 1949 Nest-Cart

2.2.4 2012 Smarter Cart

In 2012, a driverless shopping trolley was made by Chaotic Moon Labs. The device, called "Project Sk8" or "Smarter Cart" was basically a cart fitted with Windows Kinect (to detect obstacles), and an electric drivetrain, and used in conjunction with a Windows 8 tablet. For smaller stores, shopping baskets with wheels can be used either as a large basket or a small cart. These carts are designed for indoor use only [4]. Figure 2.4 below showed 2012 Smarter Cart invented by Chaotic Moon Labs equipped with Windows Kinect.

Figure 2.4 2012 Smarter Cart

2.3 DEFINE RFID TECHNOLOGY

RFID is an acronym for “radio-frequency identification” and refers to a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves. RFID is similar to barcoding in that data from a tag or label are captured by a device that stores the data in a database [5]. Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. An RFID tag consists of a tiny radio transponder; a radio receiver and transmitter. When triggered by an electromagnetic interrogation pulse from a nearby RFID reader device, the tag transmits digital data, usually an identifying inventory number, back to the reader [6].

2.3.1 The working principle of RFID Technology

A RFID system is made up of two parts: a tag or label and a reader. RFID tags or labels are embedded with a transmitter and a receiver. The RFID component on the tags have two parts: a microchip that stores and processes information, and an antenna to receive and transmit a signal. The tag contains the specific serial number for one specific object. To read the information encoded on a tag, a two-way radio transmitter-receiver called an interrogator or reader emits a signal to the tag using an antenna. The tag responds with the information written in its memory bank. The interrogator will then transmit the read results to an RFID computer program [7]. Figure 2.5 below illustrate a simple RFID circuit.

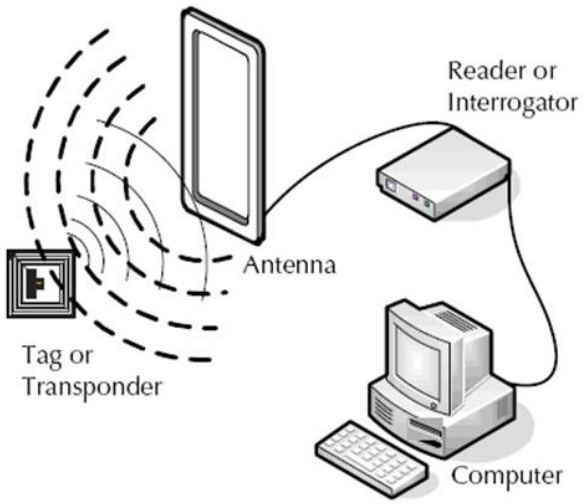


Figure 2.5 an RFID circuit

2.3.2 Advantages & Disadvantages of RFID Technology

Radio Frequency Identification (RFID) is one of most exciting technologies [6] but it also has some issue with it. Table 2.1 below showed the advantages and the disadvantages of RFID technology.

Advantages	Disadvantages
• High speed	• Inference
• Multipurpose and vary in format	• High cost
• Reduce man power	• Some material might create signal problem
• High accuracy	• Overhead reading
• Complex duplication	
• Multiple reading	

Table 2.1 advantages and the disadvantages of RFID technology.

2.3.3 Application of RFID Technology in Self-Checkout Counter

The RFID counter simplifies product scanning and shortens the time consumers spend at the self-checkout counters. The customers simply place their shopping bag/basket on the counter, all the products get scanned at once and the counter monitor displays a full list of the products together with the final bill. This improves the self-checkout experience, as customers no longer have to scan each product individually, which is time consuming and sometimes requires several scans till the product's code is read [8]. Figure 2.6 below showed a self-checkout counter with RFID technology installed.

Figure 2.6 RFID Self-Checkout Counter

2.4 RFID SHOPPING CART

The creation of RFID grocery cart began to grow when time consumed during checkout became a problem. When customers are paying for their items at the registry, they need to scan their items one by one. Even with a self-checkout counter that is equipped with an RFID technology, customer will need to take the time near the RFID reader. This is very time consuming considering when some customers are only buying one or two items meanwhile, another customer in front of them are buying 10 items. RFID shopping cart has an RFID technology installed in it. By this, customer only need to scan their item in their while doing the shopping process through RFID Device attached to their trolley. These data will then be sent to cloud(internet), and will be downloaded by the cashier prior to payment. This will surely cut off the long queue and waiting time. Unfortunately, this will also require an overhaul to manufacturing department as all the label on the items need to be equipped with an RFID tag. It also high in cost in term of maintenance as the hardware for the RFID technology is fragile.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, the progress of producing RFID System for Grocery Cart will be explain with more detail. The programming of the system was designed by using Arduino IDE Software, Laragon Software and NodeJs Software. Next, the design of the system casing was designed by using Autodesk Inventor Professional 2019 Software. As for the component and all material needed for the project will also be explained briefly.

Other than that, a Gantt's Chart of our project will also be included where it will show and explain all the process and planning regarding the project during the 13weeks given.

Figure 3.0 showed the flowchart of the project methodology.

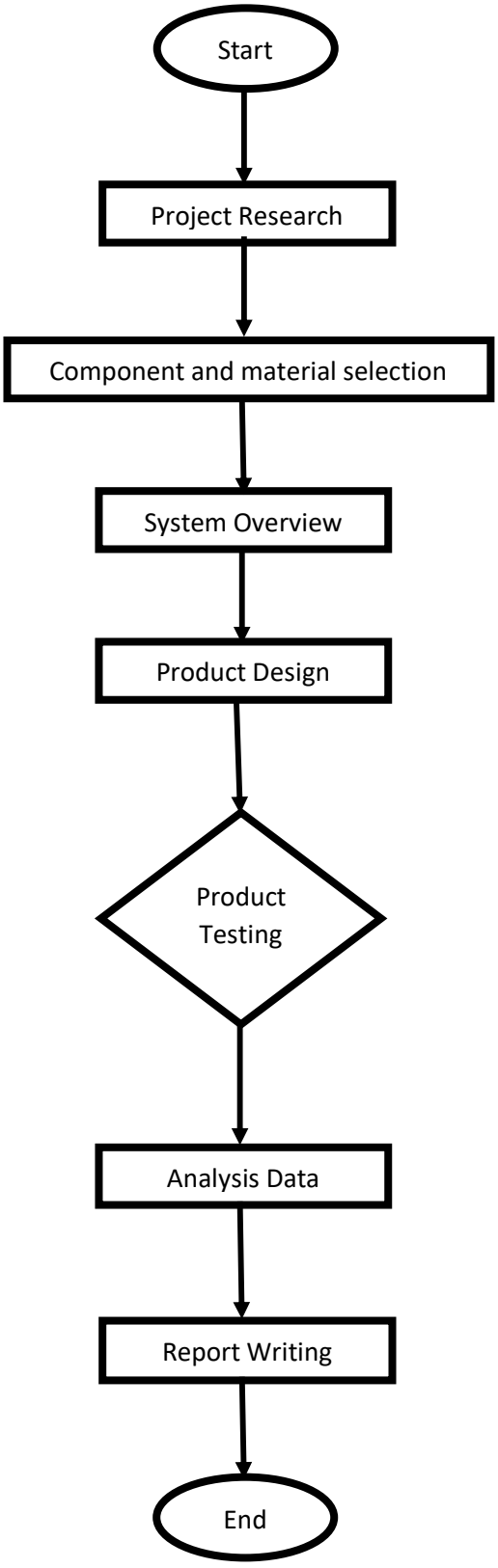


Figure 3.1 Flowchart of Methodology

3.2 PROJECT RESEARCH

In this section, the first step taken was to do the feasibility study which is intending to be a preliminary review of the facts to see if it is worthy of proceeding to the analysis phase. It is because the feasibility analysis is the primary tool for recommending whether to proceed to the next phase or to discontinue the project.

The aims of the RFID System for Grocery cart are:

i. Will solve long queues at counter issues,

ii. To be user friendly and safe to use,

iii. Convenience for the consumer, and

iv. To add up RFID technology to the process of shopping.

Next, the second step in designing the project is by answering the question of 4W1H (What, Who, Where, Why and How) question.

No.	Question and Answer
1.	Q: What does the current supermarket need to solve the issue? A: A grocery cart combine with a RFID System Devices.
2.	Q: Who will use this grocery cart? A: Supermarket customers and consumers.
3.	Q: Where is this product most needed? A: In crowded shopping environment supermarket.
4.	Q: Why does this project important? A: To solve customer current problem at supermarket.

Table 3.1 The Question and Answer Based Method of Project

3.3 FUNCTION OF PRODUCT

RFID (Radio Frequency Identification) System for Grocery Cart was made mainly to help eliminate current supermarket or store common problem regarding long queues at the cashier's counter during payment process. The basic ideas were, by having this product, consumers will no longer need to waste time, queuing for a long period at the cashier's counter as they no longer need to take out and hand over items from their grocery cart to the counter one by one. In addition, they also don't need to wait for the cashier to scan their purchased item once at a time and no longer waiting for the cashier to put their item into plastic bag and waiting for the payment process to be completed.

By having this product, all they need to do is when entering the supermarket premises, a RFID card or tags will be given to them (can also be owned by consumers through membership card) and whilst taking the grocery cart that is attached with a RFID System Devices, before proceeding with their shopping activity, they will need to scan the RFID card/tags to the RFID Devices attached with the grocery cart. When moving around the premises, consumers is able to scan the item they wish to purchase with the same RFID Device attached to the cart. All the data is recorded and when they are done with their shopping activity, at the counter, all the need to do is hand their RFID card/tags to the cashier and all the items purchased data will be transferred to the counter with the total amount that the consumer need to pay. Figure 3.2 showed the Design Concept of Grocery Cart attached with RFID System Device.

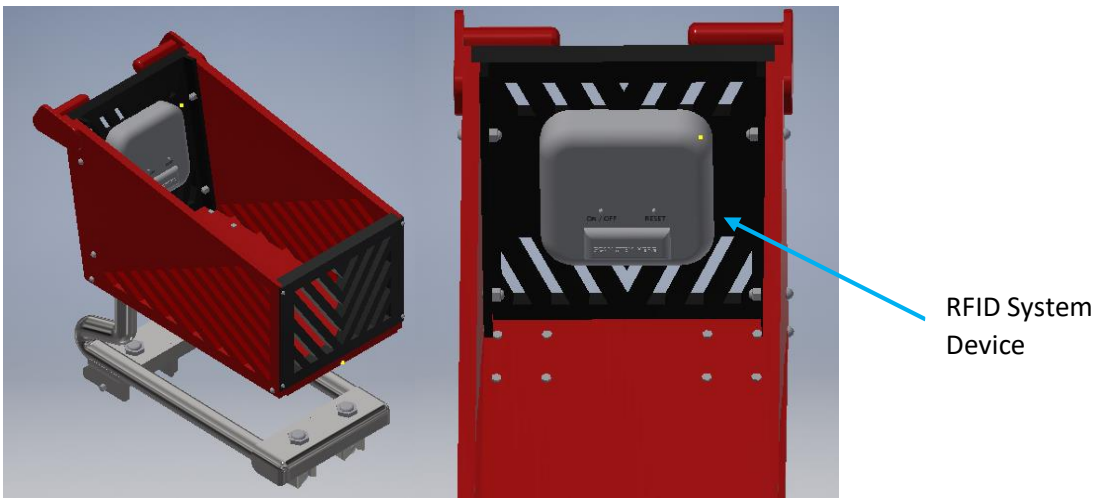


Figure 3.2 Design concept Grocery Cart Attached with RFID System Device

3.4 RFID SYSTEM COMPONENTS AND MATERIAL SELECTION

To ensure an effective product are being made, the study of every part and material used need to be done. This is so that the best solution to the main problem can be develop and so that other kind of product error that can lead to new kind of problem can be avoided. The purpose of the study in this section is to gain information on the foundation component of the device that will make the RFID System Device to work accordingly. The components of the RFID System Device for Grocery Cart are as follows;

i. RFID RC522 Module for Arduino
ii. NodeMCU Microcontroller
iii. Breadboard 800 Holes
iv. Dupont Jumper Wires M/M
v. RFID Passive Tags
vi. Rechargeable Battery
vii. Screw
viii. Spring-coil
ix. Polylactic Acid (PLA)

3.4.1 RFID RC522 Module for Arduino

RFID stands for Radio-frequency identification and can be used for many applications that require an identification mechanism. In this tutorial, it is shown how to use the RFID-RC522 module with the Arduino Uno. The RFID-RC522 module is an RFID reader, which can read RFID tags in close-range. In order to read an RFID tag, the reader and the tag must have the same frequency. The RFID-RC522 module can only reads tag that emits High radio frequency travelling at 13.56 MHz. In order to demonstrate the RFID-RC522 module, a simple application is programmed which identifies a user based on an RFID tag. [9]

Figure 3.3 RFID RC522 Module with a RFID tag

3.4.2 NodeMCU Microcontroller

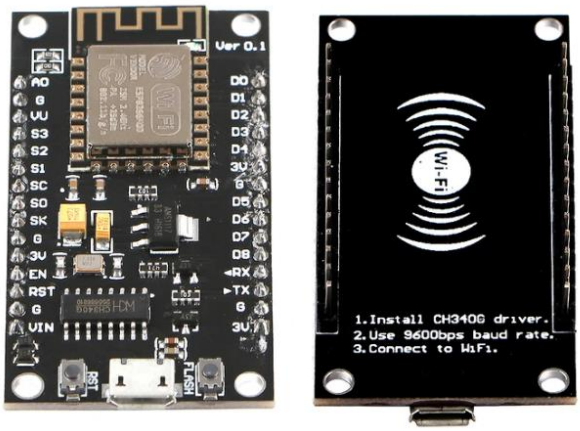


Figure 3.4 NodeMCU Microcontroller

NodeMCU is an eLua based firmware for the ESP8266 WiFi SOC from Espressif. The firmware is based on the Espressif NON-OS SDK and uses a file system based on spiffs. The code repository consists of 98.1% C-code.

The NodeMCU firmware is a companion project to the popular NodeMCU dev kits, ready-made open-source development boards with ESP8266-12E chips.

ESP8266 Arduino Core

As Arduino.cc began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate tool chains to allow Arduino C/C++ to be compiled down to these new processors.

Some creative ESP8266 enthusiasts have developed an Arduino core for the ESP8266 WiFi SoC that is available at the GitHub ESP8266 Core webpage. This is what is popularly called as the “ESP8266 Core for the Arduino IDE” and it has become one of the leading software development platforms for the various ESP8266 based modules and development boards, including NodeMCUs. [13]

Advantages of NodeMCU platform relative to the Arduino

- Low cost
- Integrated support for WIFI network
- Reduced size of the board
- Low energy consumption

Disadvantages

- Need to learn a new language and IDE
- Reduced pin out
- Scarce documentation

The NodeMCU programming can be as easy as in Arduino. The only difference is in the pinning of the board as described below:

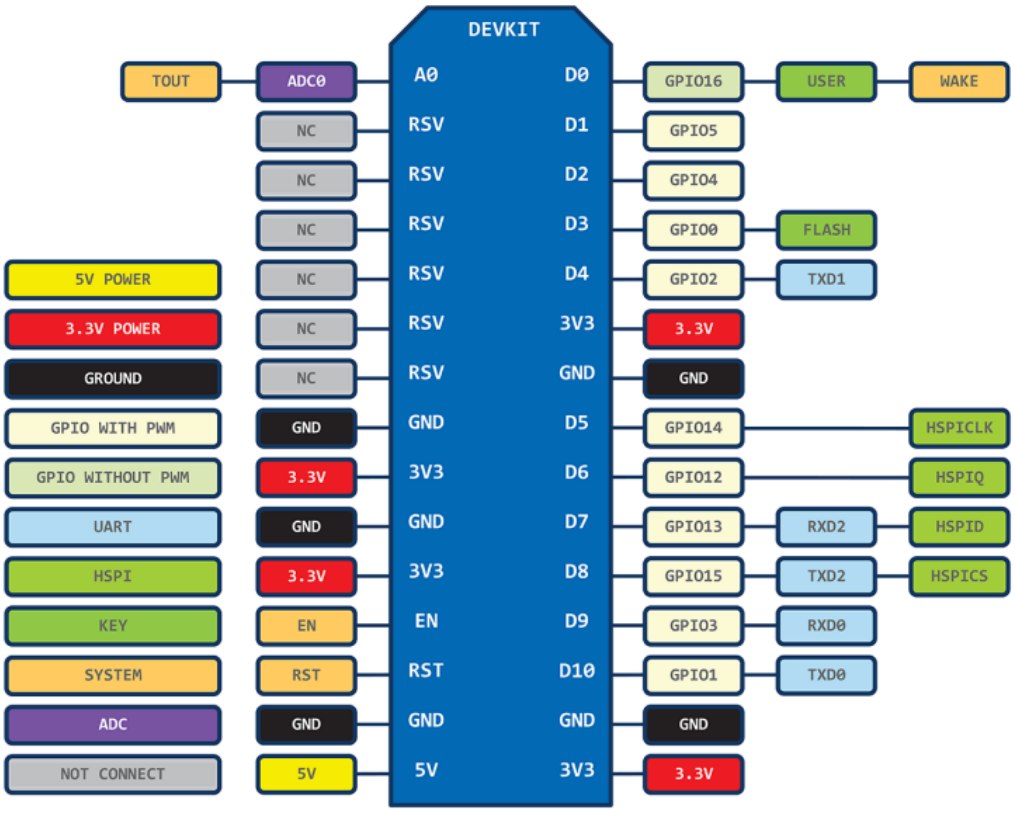


Figure 3.5 Show the Schematic diagram of NodeMCU Programming description.

There are 6 extra GPIOs. All of them can be programmed as PWM, I2C, 1-wire, except for GPIO16 (D0).

3.4.3 Breadboard 800 Holes

A modern solderless breadboard socket consists of a perforated block of plastic with numerous tin-plated phosphor bronze or nickel silver alloy spring clips under the perforations. The clips are often called tie points or contact points. The number of tie points is often given in the specification of the breadboard.

The spacing between the clips (lead pitch) is typically 0.1 inches (2.54 mm). Integrated circuits (ICs) in dual in-line packages (DIPs) can be inserted to straddle the centreline of the block. Interconnecting wires and the leads of discrete components (such as capacitors, resistors, and inductors) can be inserted into the remaining free holes to complete the circuit. Where ICs are not used, discrete components and connecting wires may use any of the holes. Typically, the spring clips are rated for 1 ampere at 5 volts and 0.333 amperes at 15 volts (5 watts). The edge of the board has male and female dovetail notches so boards can be clipped together to form a large breadboard. [14]

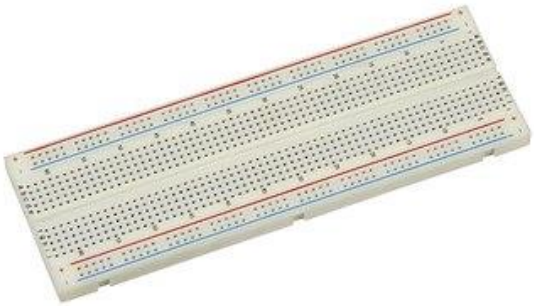


Figure 3.6 Breadboard 800 Holes

3.4.4 Dupont Jumper Wires M/M

Jump wires (also called jumper wires) for solderless breadboarding can be obtained in ready-to-use jump wire sets or can be manually manufactured. The latter can become tedious work for larger circuits. Ready-to-use jump wires come in different qualities, some even with tiny plugs attached to the wire ends. Jump wire material for ready-made or homemade wires should usually be 22 AWG (0.33 mm2) solid copper, tin-plated wire - assuming no tiny plugs are to be attached to the wire ends. The wire ends should be stripped 3⁄16 to 5⁄16 in (4.8 to 7.9 mm). Shorter stripped wires might result in bad contact with the board's spring clips (insulation being caught in the springs). Longer stripped wires increase the likelihood of short-circuits on the board. Needle-nose pliers and tweezers are helpful when inserting or removing wires, particularly on crowded boards. [15]

Applications:

- Connect sensors to your Arduino board.
- Connect a breadboard to your Arduino board.
- Connect other hardware PCB's together.
- Wire hardware in a final product.

Figure 3.7 Dupont Jumper wire

3.4.5 RFID Passive Tags

Passive tag is an RFID tag that does not contain a battery. The power is supplied by the reader. When radio waves from the reader are encountered by a passive RFID tag, the coiled antenna within the tag forms a magnetic field. The tag draws power from it, energizing the circuits in the tag. The tag then sends the information encoded in the tag's memory. [16]

Applications

- Admittance Management
- Data Tracing,
- Contest Scheduling,
- Supply chain management

Figure 3.8 RFID Passive Tag

3.4.6 Rechargeable Battery

A rechargeable battery is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use. It is composed of one or more electrochemical cells. The term "accumulator" is used as it accumulates and stores energy through a reversible electrochemical reaction. Rechargeable batteries are produced in many different shapes and sizes, ranging from button cells to megawatt systems connected to stabilize an electrical distribution network. Several different combinations of electrode materials and electrolytes are used, including lead–acid, nickel–cadmium (NiCd), nickel–metal hydride (NiMH), lithium-ion (Li-ion), and lithium-ion polymer (Li-ion polymer).

Rechargeable batteries typically initially cost more than disposable batteries, but have a much lower total cost of ownership and environmental impact, as they can be recharged inexpensively many times before they need replacing. Some rechargeable battery types are available in the same sizes and voltages as disposable types, and can be used interchangeably with them. [17]

Figure 3.9 Rechargeable Batteries

3.4.7 Screw

Screw is a type of fastener, in some ways similar to a bolt typically made of metal, and characterized by a helical ridge, known as a male thread (external thread). Screws are used to fasten materials by digging in and wedging into a material when turned, while the thread cuts grooves in the fastened material that may help pull fastened materials together and prevent pull-out. There are many screws for a variety of materials; those commonly fastened by screws include wood, sheet metal, and plastic. [18]

Figure 3.10 Collection of screws.

3.4.8 Spring-Coil

A coil spring is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded. A coil spring may also be used as a torsion spring: in this case the spring as a whole is subjected to torsion about its helical axis. The material of the spring is thereby subjected to a bending moment, either reducing or increasing the helical radius. Metal coil springs are made by winding a wire around a shaped former - a cylinder is used to form cylindrical coil springs. [20]

Figure 3.11 Collection of spring coils.

3.4.9 Polylactic Acid (PLA) 3D Printer Filaments

Polylactic Acid (PLA) is different than most thermoplastic polymers in that it is derived from renewable resources like corn starch or sugar cane. Most plastics, by contrast, are derived from the distillation and polymerization of non-renewable petroleum reserves. Plastics that are derived from biomass (e.g., PLA) are known as "bio plastics."

Polylactic Acid is biodegradable and has characteristics similar to polypropylene (PP), polyethylene (PE), or polystyrene (PS). It can be produced from already existing manufacturing equipment (those designed and originally used for petrochemical industry plastics). This makes it relatively cost efficient to produce. Accordingly, PLA has the second largest production volume of any bio plastic (the most common typically cited as thermoplastic starch).

PLA is one of two common plastics used on FDM machines (3D printing) and is commonly available as a 3D printable filament; the other common 3D printer plastic is ABS. PLA filament for 3D printing is typically available in a myriad of colours. Polylactic Acid could be CNC machined but it is typically not available in sheet stock or rod form. It is, however, typically available as a thin film for thermoforming or in the form of plastic pellets for injection moulding. To adjust material properties, plastic injection mold pellets are typically produced and/or blended together. [19]

Figure 3.12 PLA 3D Printer Filaments

3.5 SYSTEM OVERVIEW

In this section, the working operation of the RFID System will be explained with more detail. A description on how each of the system components such as RFID RC522 Module and NodeMCU Microcontroller interface with each other will also be explain and so does the function of each components toward the working operation of the RFID System. And also, the working on system programming development will be showed in this section where it consists the usage of Arduino IDE Software, Laragon Software and NodeJs Software.

3.5.1 Basic Operation of the RFID System

The main basic working operation of this system consist of three main part which is a purchase database management system software, a microcontroller and a RFID Reader Module, interfacing with each other.

A microcontroller is a computer present in a single integrated circuit which is dedicated to perform one task and execute one specific application. It contains memory, programmable input/output peripherals as well a processor. They run one specific program and are dedicated to a single task. They are low power devices with dedicated input devices and small LED or LCD display outputs. Microcontrollers can take inputs from the device they controlling and retain control by sending the device signals to different parts of the device. A good example is a TV's microcontroller. It takes input

from a remote control and delivers its output on the TV screen.[10] In this project, as stated in chapter 3.4 (RFID System Components), the system will be using a NodeMCU Microcontroller as after further research, it was the most reliable in cost and relevance in function, suitable for this project compare to any others microcontroller.

Next, a RFID reader is Radio Frequency module and an antenna which generates high frequency electromagnetic field. It read code which is embedded in a passive generates an electromagnetic field which causes electrons to move through the tag's antenna and subsequently power the chip. The powered chip inside the tag then responds by sending its stored information back to the reader in the form of another radio signal. This is called backscatter. The backscatter, or change in the electromagnetic/RF wave, is detected and interpreted by the reader which then sends the data out to a computer or microcontroller.[9] In this project, the module that will be used is RFID RC522 Module.

Finally, a database management system software. A database is an organized collection of data, generally stored and accessed electronically from a computer system. This collection data will be managed by a management system software that interacts with end users, applications, and the database itself to capture and analyse the data.[11] The DBMS software additionally encompasses the core facilities provided to administer the database. The sum total of the database, the DBMS and the associated applications can be referred to as a "database system". Often the term "database" is also used to loosely refer to any of the DBMS, the database system or an application associated with the database. [12] In this project, the database management system that will be used are Node.JS Software as it is an open-source, cross-platform, JavaScript runtime environment that executes JavaScript code outside of a browser and is easier to use.

To make things short, to make the whole system work it require all three components to interface with each other by;

1. RFID reader read information embedded in passive RFID tags then send signal of information to NodeMCU Microcontroller.

2. NodeMCU Microcontoller receive input of information, translate this information and send them to Database Management System Software.

3. Node.Js Database Management System collect these inputs and organize these data and sum up the total of these database wirelessly. Figure 3.13 below showed a Block Diagram for the RFID System

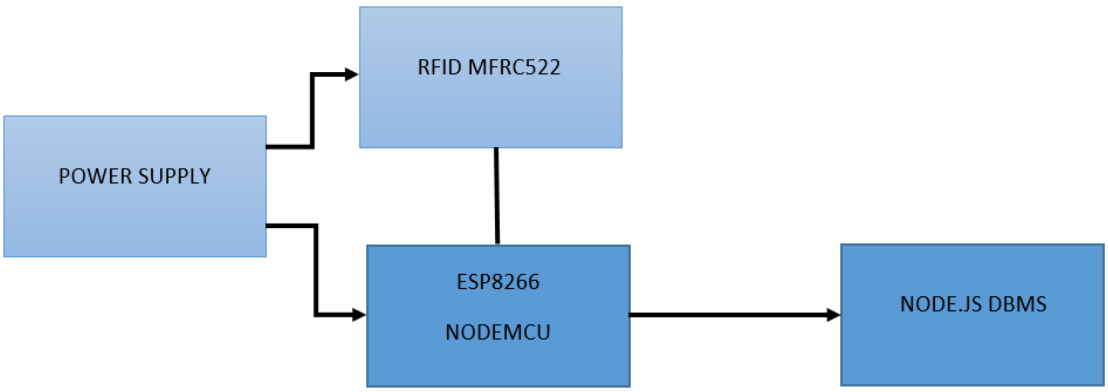
Figure 3.13 Block Diagram for the RFID System.

3.5.2 Detailed Working Principle for RFID System Device for Grocery Cart.

This section will be focusing mainly toward how the system of our product operate. For our product, the system will be implemented into two section which is the customer section (system at grocery cart) and the retailer section (system at the cashier counter).

Figure 3.14 showed flowchart of RFID System Device for Grocery Cart interface process.

Customer Section;



Retailer Section;

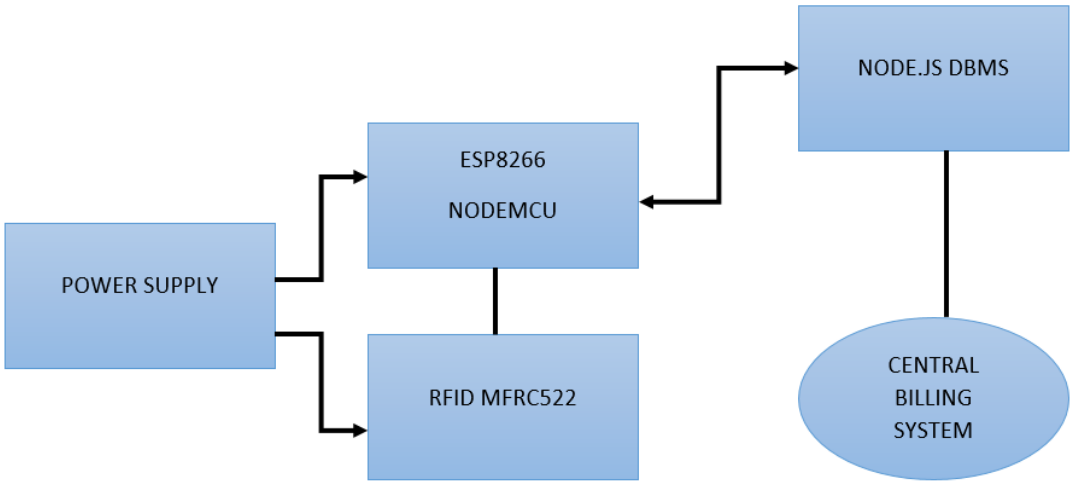


Figure 3.14 Flowchart of RFID System Device for Grocery Cart interface process.

Operational Procedure of RFID System Device for Grocery Cart

Customer Section;

1. Customer enter premises with RFID tags (can also be provide by store retailer).

2. Whilst taking grocery cart before begin with shopping activity, customer scan their RFID tag through RFID scanner that is attached to the grocery cart.

3. RFID Reader scan information embedded in the tags and send this information to NodeMcu Microcontroller.

4. NodeMcu Microcontroller translate the information and send this information to Node.Js Database Management System Software.

5. This set up an item purchased database site which is set up exclusively for that particular customer only.

6. While moving around premises during shopping activity, customer can scan the item they wish to purchase (that have been attached with RFID adhesive tags) through the same RFID reader attached at the grocery cart.

7. Data of customers purchased item will be collected in the items purchased database and is organize and also sum up with a total price.

8. As customer are done with their shopping activity, customer can head to the cashier counter directly.
   Figure 3.15 showed flow chart of Operational Procedure of RFID System Device for Grocery Cart (Customer Section)

Grocery Cart (Customer Section).

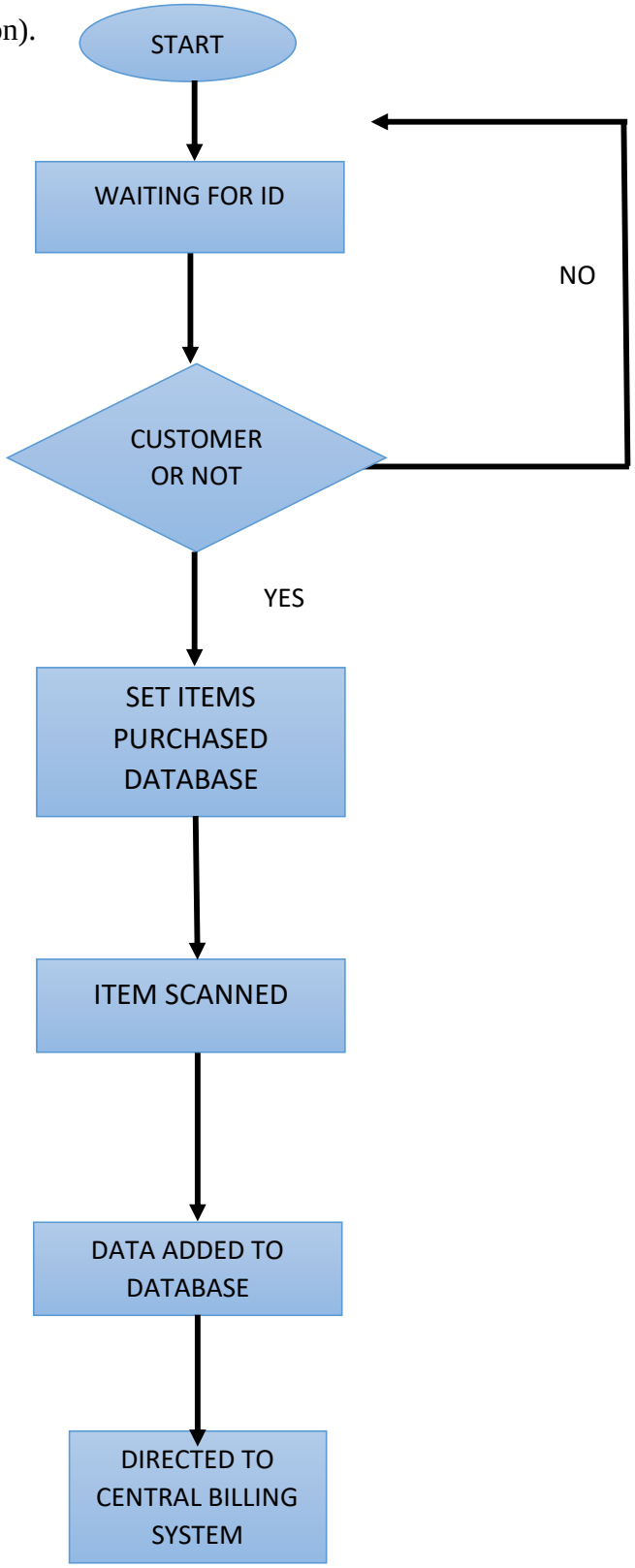


Figure 3.15 Flow chart of Operational Procedure of RFID System Device for Grocery Cart

Retailer Section;

1. Customer reaches cashier counter and hand-over their RFID tags to the cashier.

2. Cashier will scan the RFID tags through a RFID reader located at the cashier counter.

3. This will command the supermarket central billing system to receive input of database from the customer's Item purchased Database.

4. Sum up of collective data with a total price that the customer need to pay will pop out at the counter screen.

5. Customer pay total amount of purchased item through cash or online services.

Figure 3.16 showed flow chart of Operational Procedure of RFID System Device for Grocery Cart (Retailer's Section).

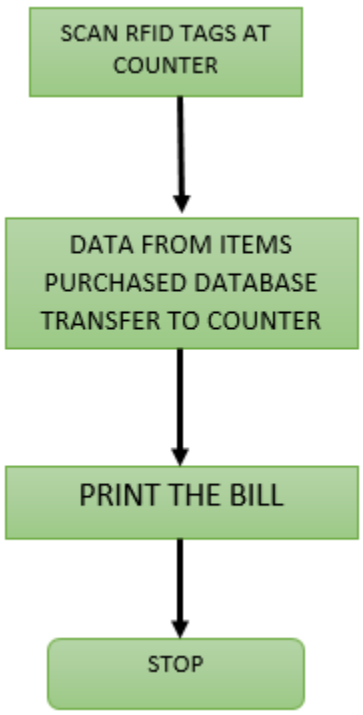


Figure 3.16 Flow chart of Operational Procedure of RFID System Device for Grocery Cart (Retailer's Section).

3.6 PRODUCT DESIGN

This section is specifically about the project design. A 3D, Isometric, Orthographic Projection, Part Assembly and Exploded drawing has been drawn fully by using Autodesk Inventor Software. This step is very crucial, as it determine the specification of our RFID Device and determine how the finishing of our project would look like.

3.6.1 RFID Device Casing Drawing

The drawing that has been constructed is a drawing of RFID Device casing. This casing was designed primarily as a case that will store all of RFID Device electrical circuit and component such as bread board, NodeMcu, RFID reader and rechargeable battery. Refer figure 3.17 below showed Isometric drawing of the RFID Device casing.

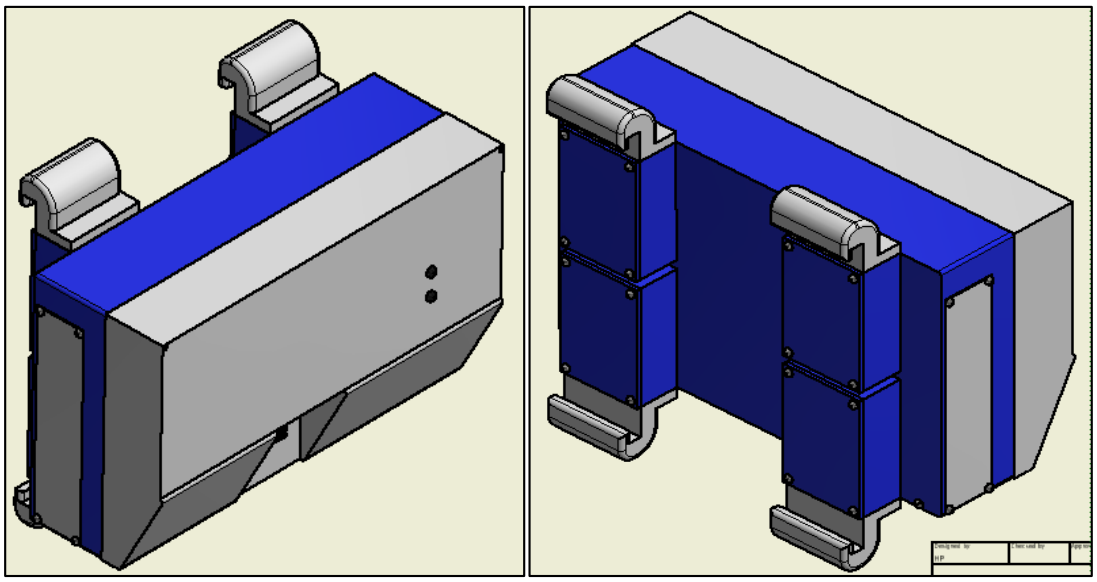


Figure 3.17 Isometric drawing of the RFID Device casing.

Next, the RFID device casing was designed accordingly to the real dimension. As further planning was to build the whole casing by using 3D-printing method, the dimension was calculated precisely to avoid any error during the printing process in the future. With a total dimension of 200mm length, 94mm width and 122mm height, this casing contains a total of 13 parts which consist of;

1. Device Bottom Part x1
2. Device Top Cover x1
3. Device Hook x4
4. Battery Cover x1
5. Hooks Cover x4
6. Button Parts x2

The device casing also contains an additional of 24 pieces fasteners (various screw) and 16 pieces of 2mm spring-coils. Figure below showed Exploded Drawing for RFID Device and Part list for RFID Device

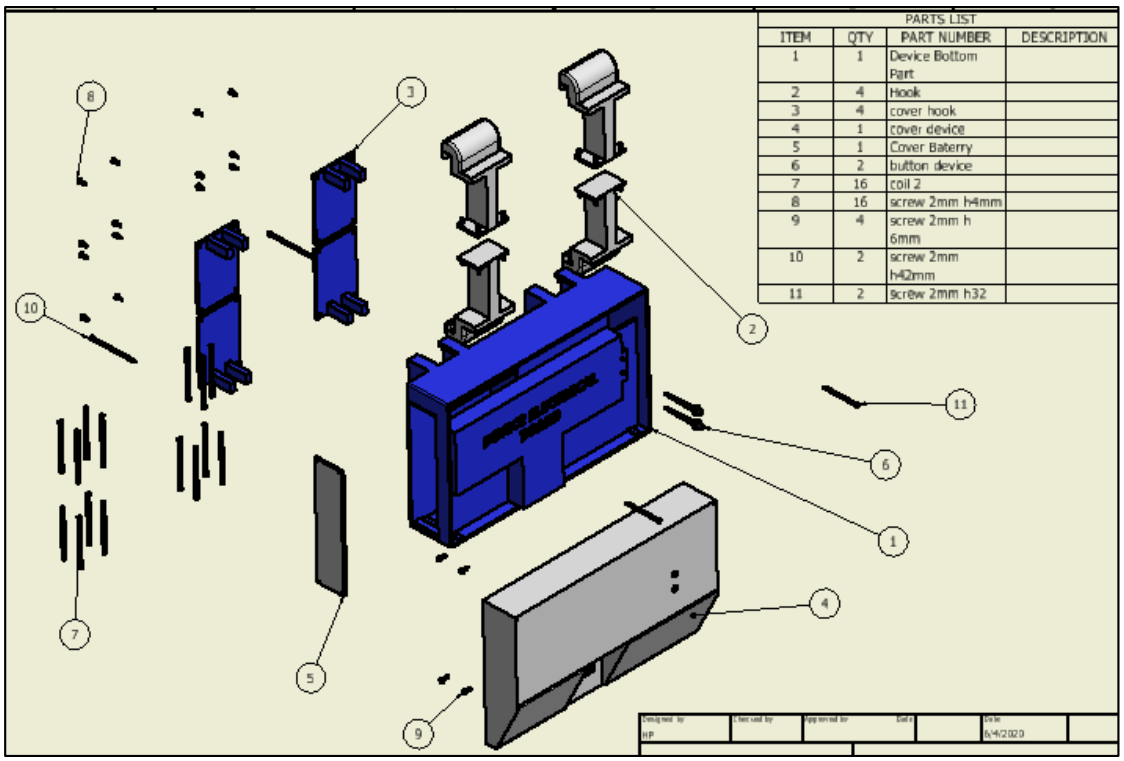


Figure 3.18 Exploded Drawing for RFID Device.

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Device Bottom Part	
2	4	Hook	
3	4	cover hook	
4	1	cover device	
5	1	Cover Baterry	
6	2	button device	
7	16	coil 2	
8	16	screw 2mm h4mm	
9	4	screw 2mm h 6mm	
10	2	screw 2mm h42mm	
11	2	screw 2mm h32	

Figure 3.19 Part list for RFID Device.

Other than that, the RFID Device was also designed so that it can be install nor remove easily from its main medium which is the grocery cart. By using the concept of 'Hook Locking" mechanism, this device case was included with four section of rectangular cavity slot positioned at the back of the device bottom casing. Each off the slot will be installed with a custom-made hook and 4 pieces of spring-coil in it. Figure 3.20 below showed device hooks locking mechanism.

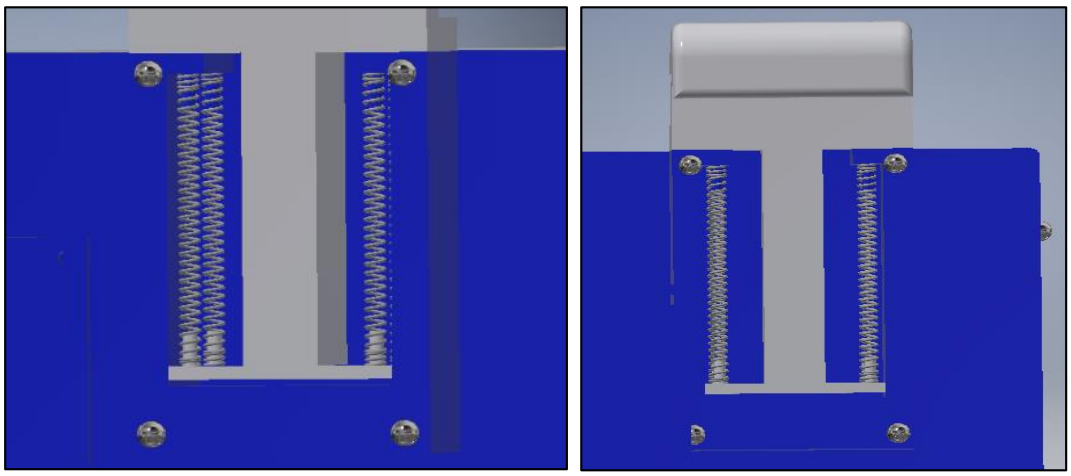


Figure 3.20 RFID Device Hooks Locking Mechanism

3.6.2 RFID Device Casing Specification

In this section, specific part dimension will be shown with more detailed. An orthographic projection drawing that has been drawn by using Autodesk Inventor Software will also be included.

Device Bottom Part

This part will act as the main base for the device casing where all the device electrical circuit and components will be store inside of it. Notice that there was a purple compartment in this drawing below (Figure3.), that purple compartment is a replacement for device's electrical board for this drawing which indicate that electrical board will be place at that purple compartment.

Also, this device bottom part was attached with four section of rectangular cavity slot at the back of this case where hook locking mechanism will be attached in it. Figure below showed Orthographic Projection of the RFID Device bottom part.

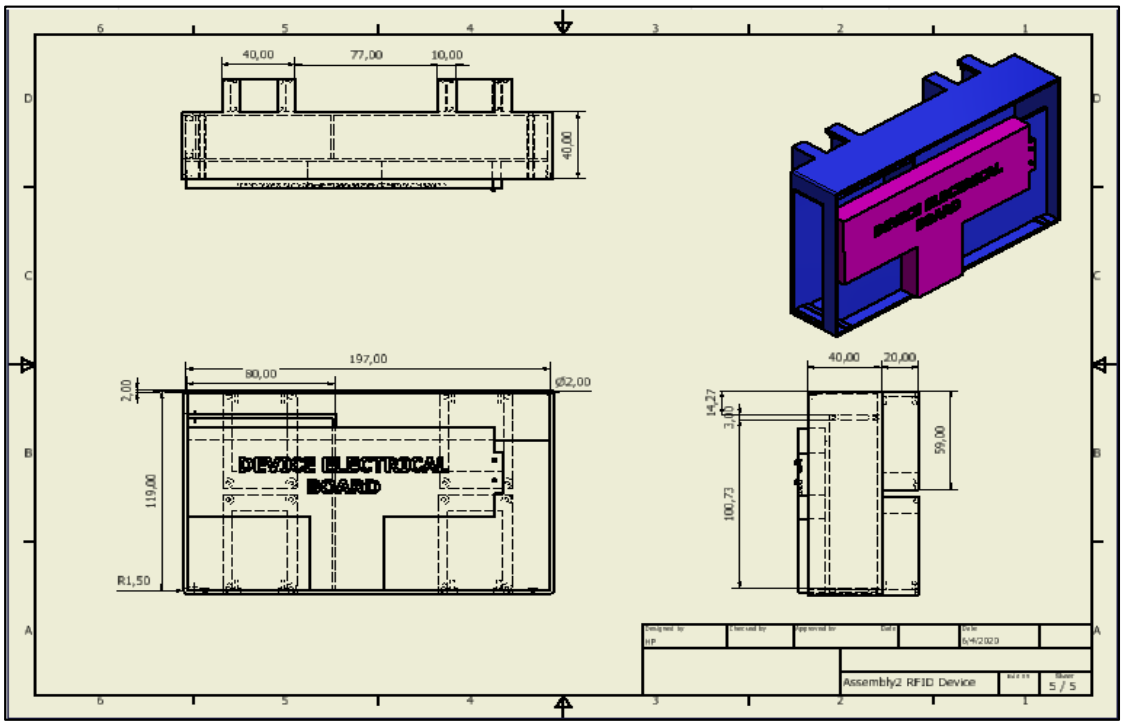


Figure 3.21 Orthographic Projection of the RFID Device bottom part with its full dimensions.

Device Top Cover

This part will act as the top cover for the RFID Device. There was two 5mm holes at the top of this cover where two buttons will be insert in it. Next there is also a small rectangular section at lower-middle part of this cover, where item scanning process will be done at. Figure 3.22 below showed Orthographic Projection of the device top cover.

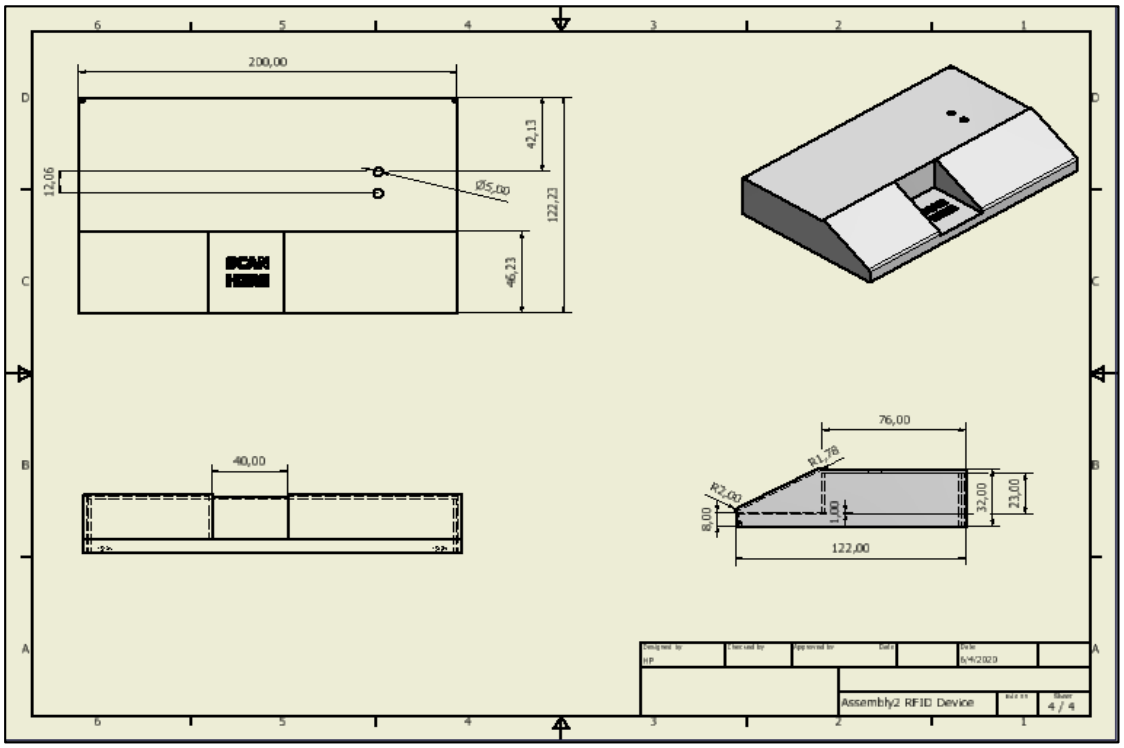


Figure 3.22 Orthographic Projection of the RFID Device top cover with its full dimensions.

Device Battery Cover

This part will act as the device batter slot cover which is located at side part of the device bottom part. Figure 3.23 below showed Orthographic Projection of the RFID Device battery cover.

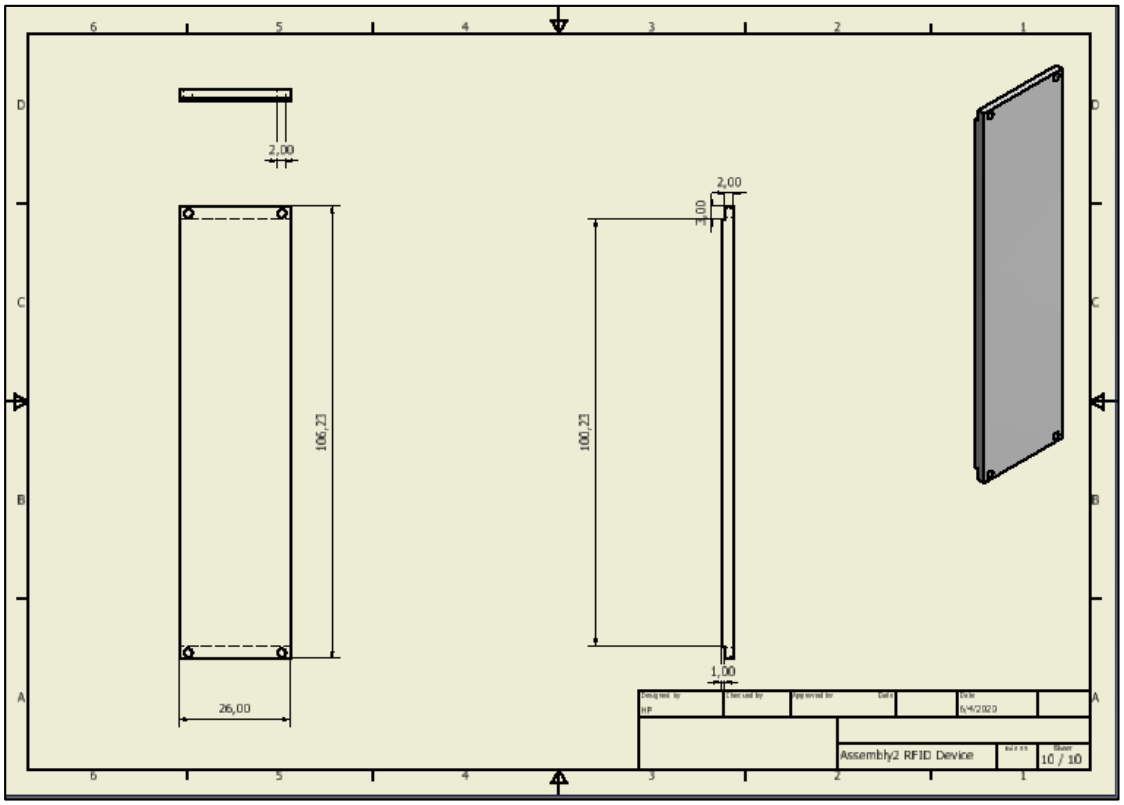


Figure 3.23 Orthographic Projection of the RFID Device battery cover with its full dimensions.

Device Custom-made Hook for Hook Locking Mechanism

This is a custom-made hook that will be attached inside four section of rectangular cavity slot at the back side of the device bottom part that will functioned as a Hook Locking mechanism. Figure 3.24 below showed Orthographic Projection of the RFID Device custom-made hook.

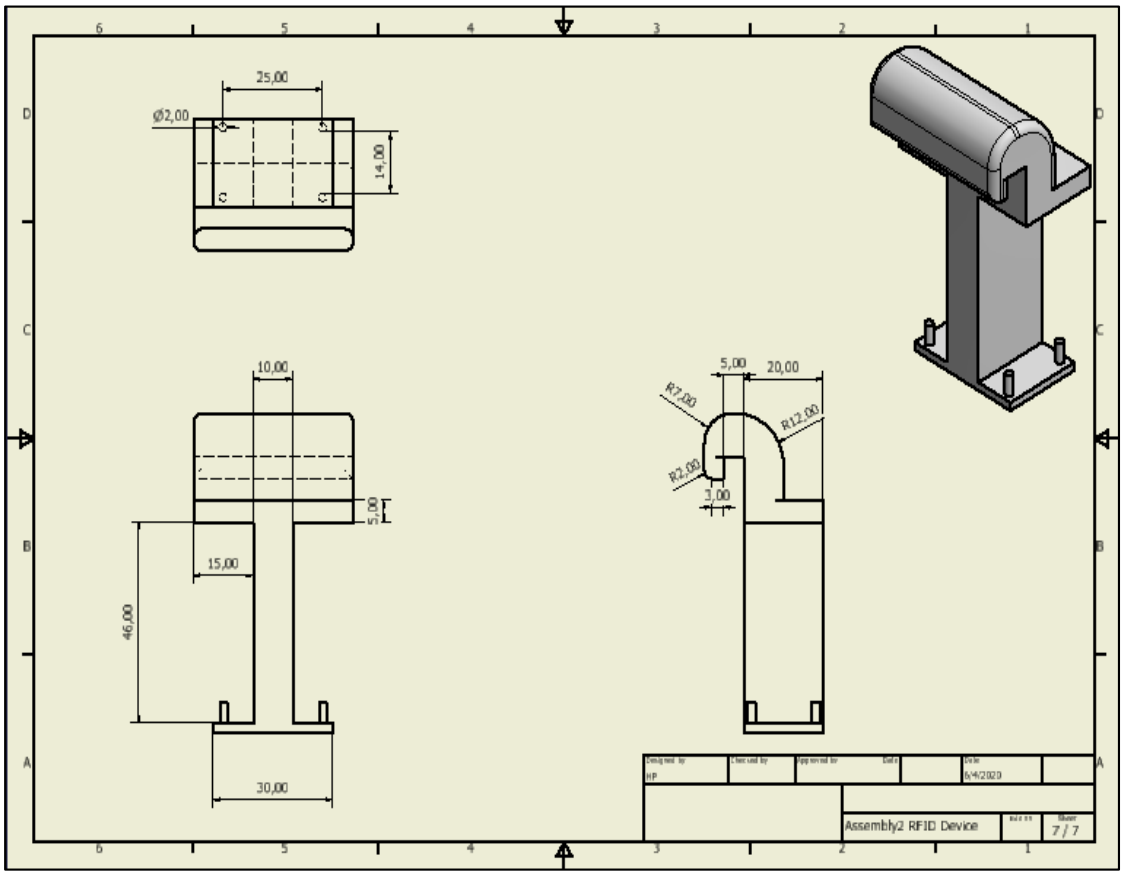


Figure 3.24 Orthographic Projection of the RFID Device custom-made hook with its full dimensions.

Cover for Hook Locking Mechanism

This part will be functioned as a cover for the four section of rectangular cavity slot of the device hook locking mechanism. Figure 3.25 below showed Orthographic Projection of the RFID Device hook locking mechanism cover.

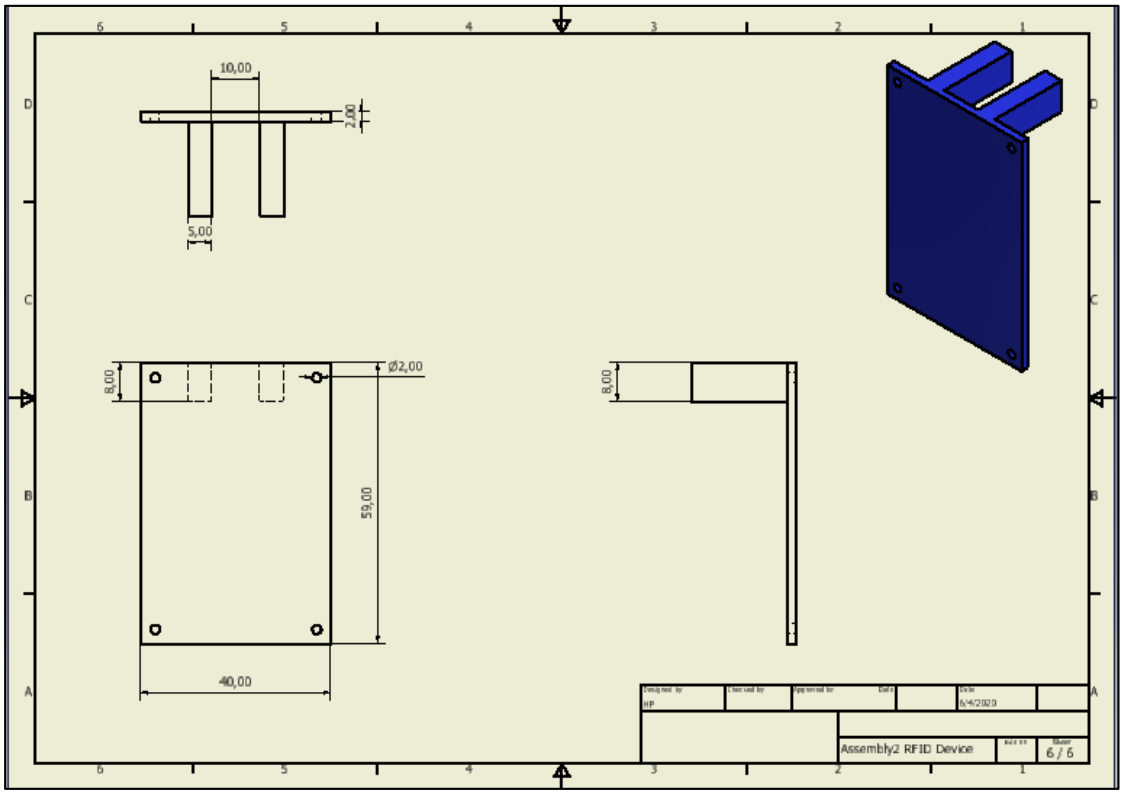


Figure 3.25 Orthographic Projection of the RFID Device hook locking mechanism cover with its full dimensions.

Device Button

This component work as pushing-mechanism that is attached to an electronic push button on the device electronic board inside of the RFID device. Figure 3.26 below showed Orthographic Projection of the RFID Device button part with its full dimensions.

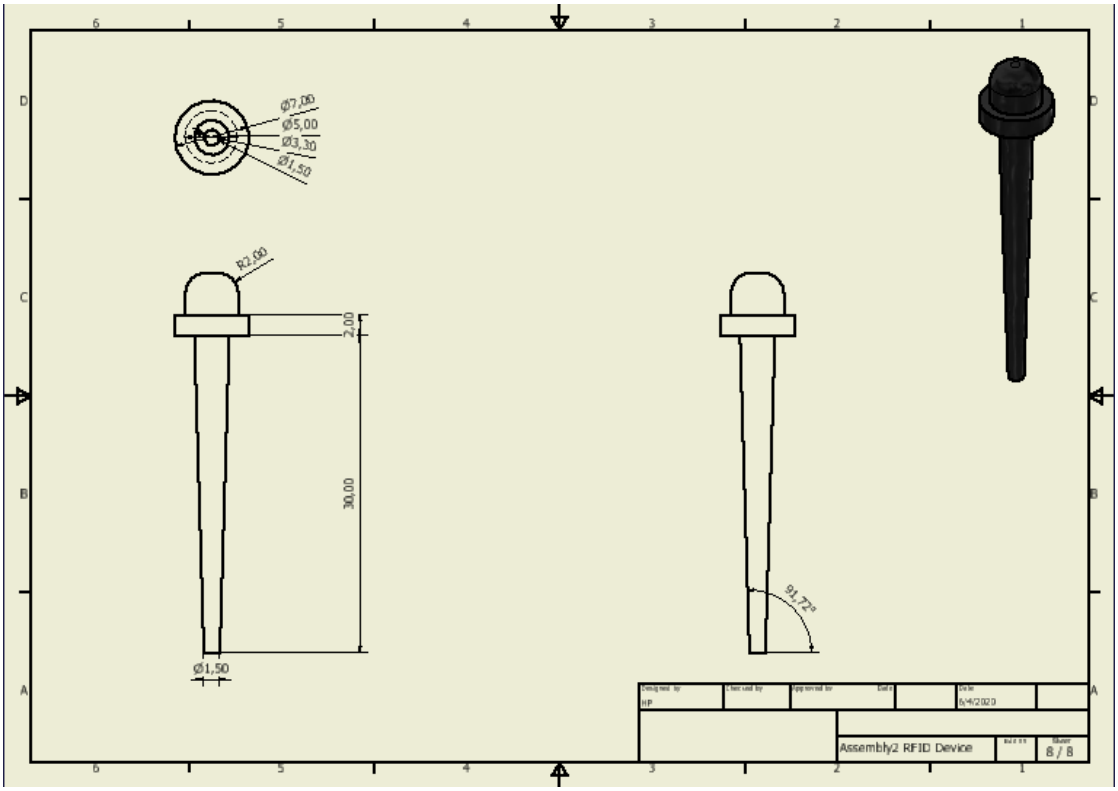


Figure 3.26 Orthographic Projection of the RFID Device button part with its full dimensions.

Fasteners and Spring Coil Used In This Device

This is a drawing of fasteners used to joint all of the device part and spring coil that will make the Hook Locking Mechanism work.

This device uses 2mm x 4mm screw, 2mm x 6mm screw, 2mm x 30mm screw, and 2mm x 43mm screw. As for the spring-coil, this device uses a 32mm length, 0.5mm thick, 0.7mm pitch and 30 revolution stainless steel spring-coil. Figure 3.27 below showed isometric drawing of the connectors and spring coil used in this RFID Device with its full dimensions.

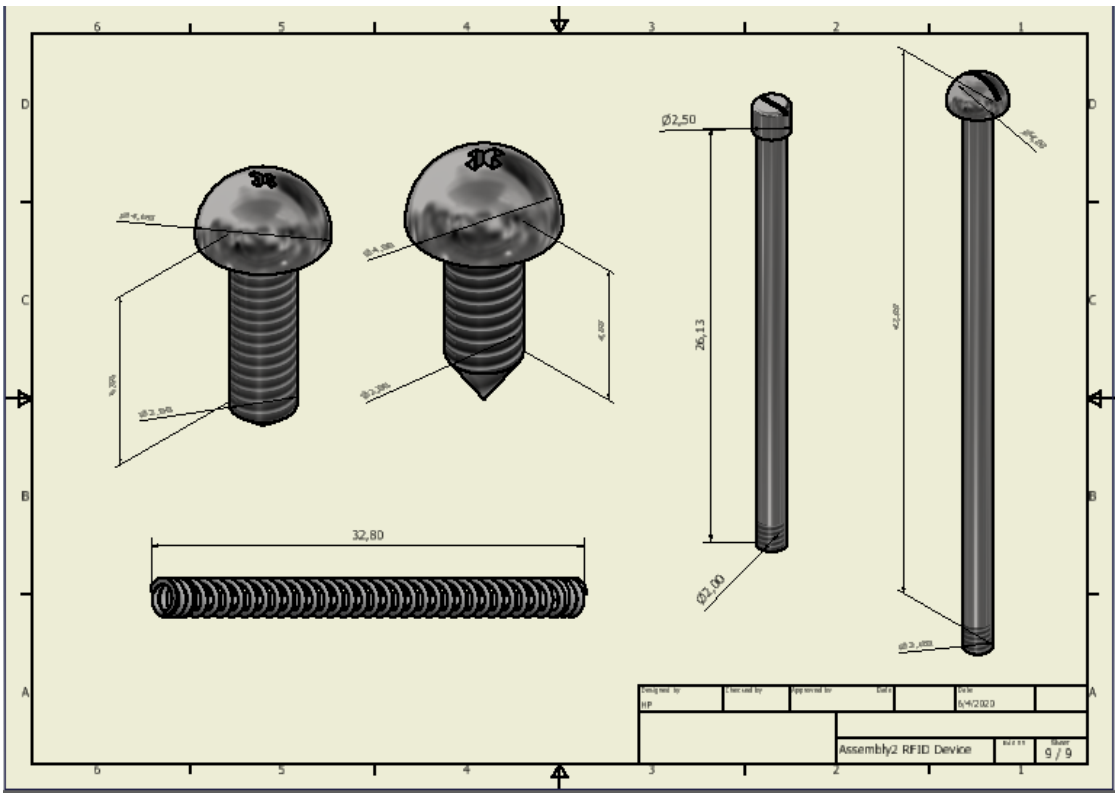


Figure 3.27 Isometric drawing of the connectors and spring coil used in this RFID Device with its full dimensions.

3.7 SYSTEM PROGRAMMING

In this segment, the elaboration about step taken to develop the system programme will be described briefly. For a start, as explained earlier in previous section, the programme was develop using several computer programming software such as Arduino IDE Software, Laragon Software and NodeJs Software. Figure 3.28 below showed software used to develop system programme.

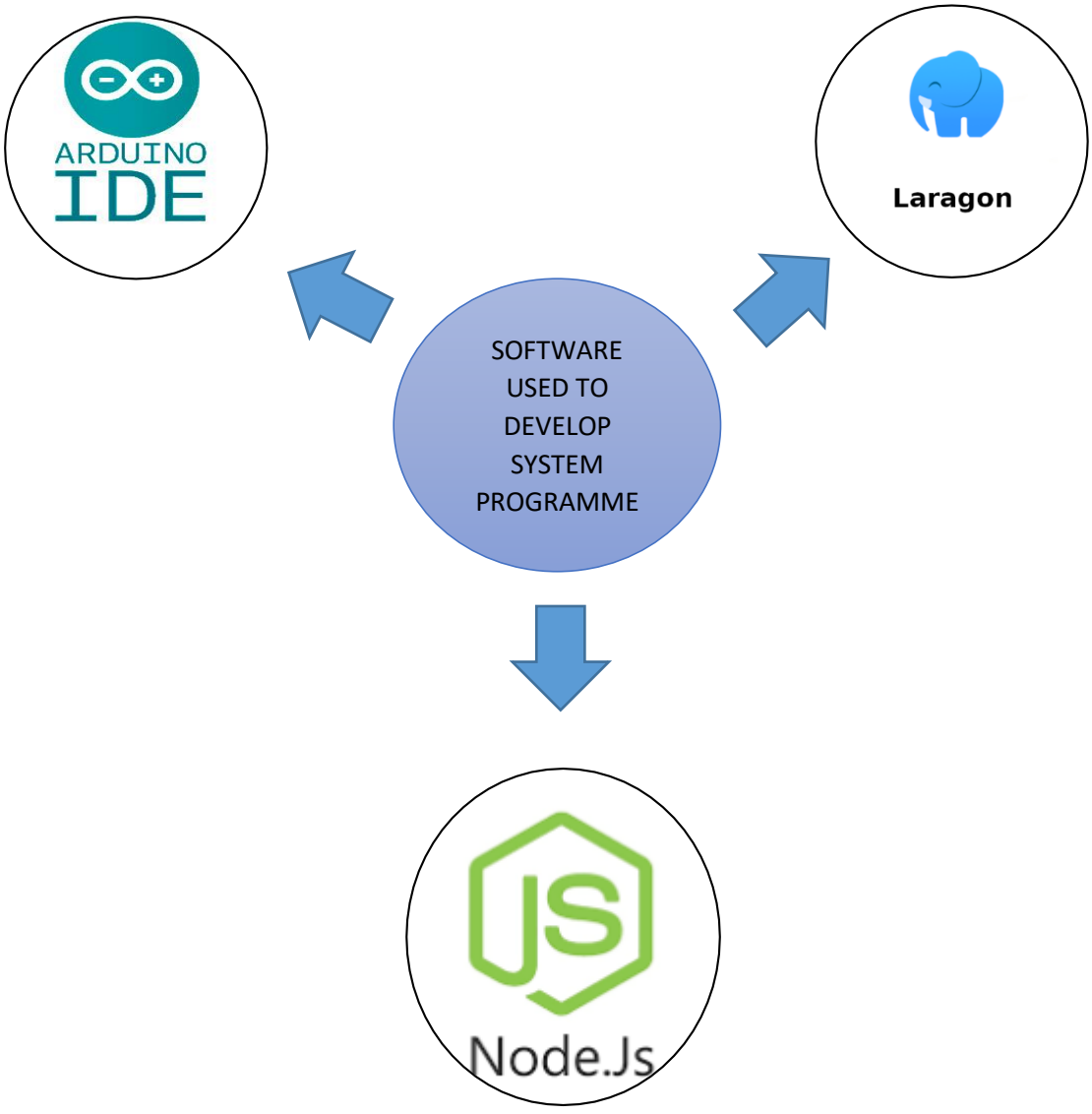


Figure 3.28 Software used to develop system programme.

Also, as a student studying in purely mechanical engineering stream, our knowledge about computer programming were shallow and only limited to ourselves and general knowledge. Thus, it is one of our incentive where we seek help from Mr Mohd Ariffin Zulkifli, a professional IOT consultant and trainer which own a company that provide a consultation and training service regarding IOT programming called 'MyInvent Technologies Sdn Bhd" nearby to our place. There we learn a lot and were consulted by Mr Mohd Ariffin with a precise knowledge.

"MyInvent Technologies Sdn Bhd" details;

Name of Consultant –	Mohd Ariffin Zulkifli
Phone Number –	+60 17-7875232
Address –	No.7A, Jalan Badminton 13/29, Tadisma Business Park,Section 13, 40100 Shah Alam, Selangor.
Office Number –	+603 5523 5321
Website –	https://myinvent.com.my
Facebook –	MyDuino.com

Figure 3.29 Picture of Mr Ariffin.

Figure 3.30 MyInvent Technologies Business card.

As for the system programming, there were several phases of developing as shown in figure below. Figure below showed flowchart for phases of developing system programme.

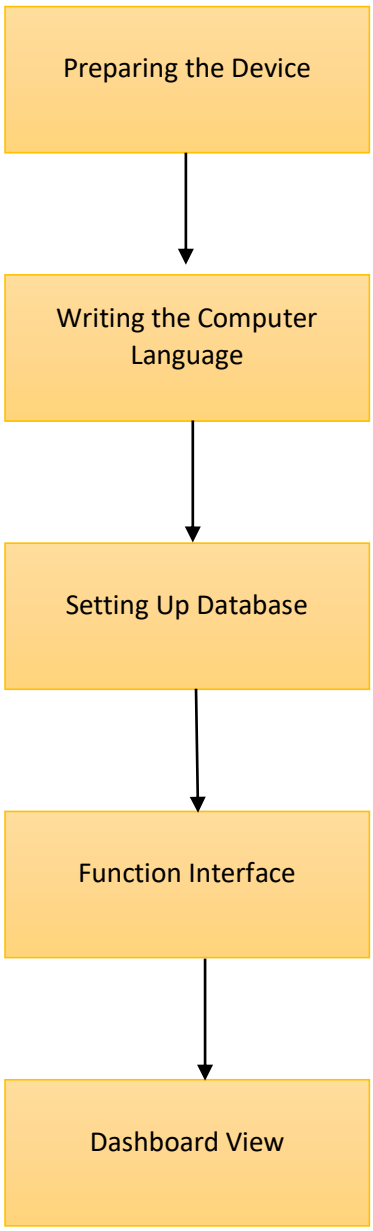


Figure 3.31 Flowchart for phases of developing system programme.

3.7.1 Preparing the Device

The first step was to prepare our device by downloading all the needed software. All of the necessary's software were easy to download as all of them is an open-source/cross-platform, meaning, it is free and easy for everyone to download through internet.

1. Arduino Ide Software

Link: https://www.arduino.cc/en/software

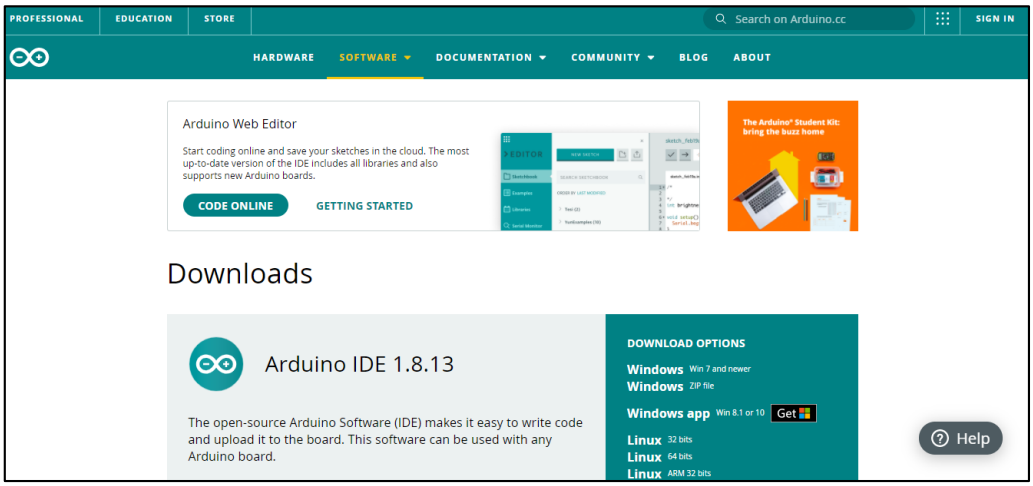


Figure 3.32 Arduino Ide Software webpage.

2. Laragon Software

Link: https://laragon.org/download/index.html

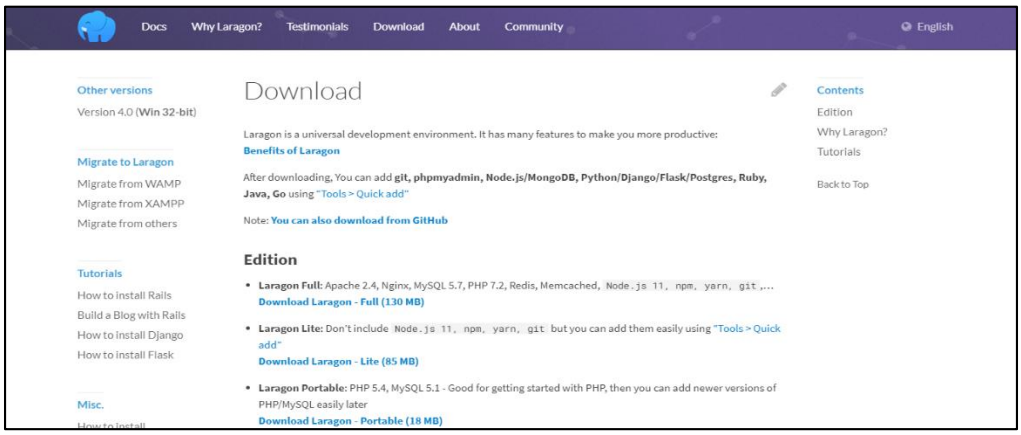


Figure 3.33 Laragon Software webpage.

3. NodeJs Software

Link : https://nodejs.org/en/download/

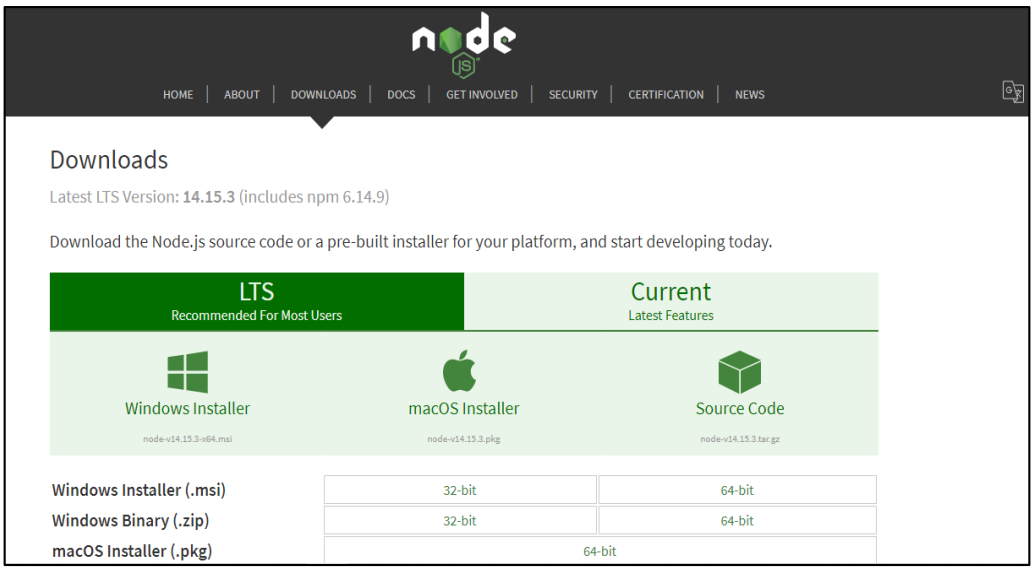


Figure 3.34 NodeJs Sotware webpage.

3.7.2 Writing the Computer Language.

This phase was done through the Arduino Ide Software. This consist of writing computer language for three of the main system which is NodeMcu RFID Reader, NodeMcu RFID Counter Reader and NodeMcu RFID Reader Wifi. Figure below showed three main system of RFID Device.

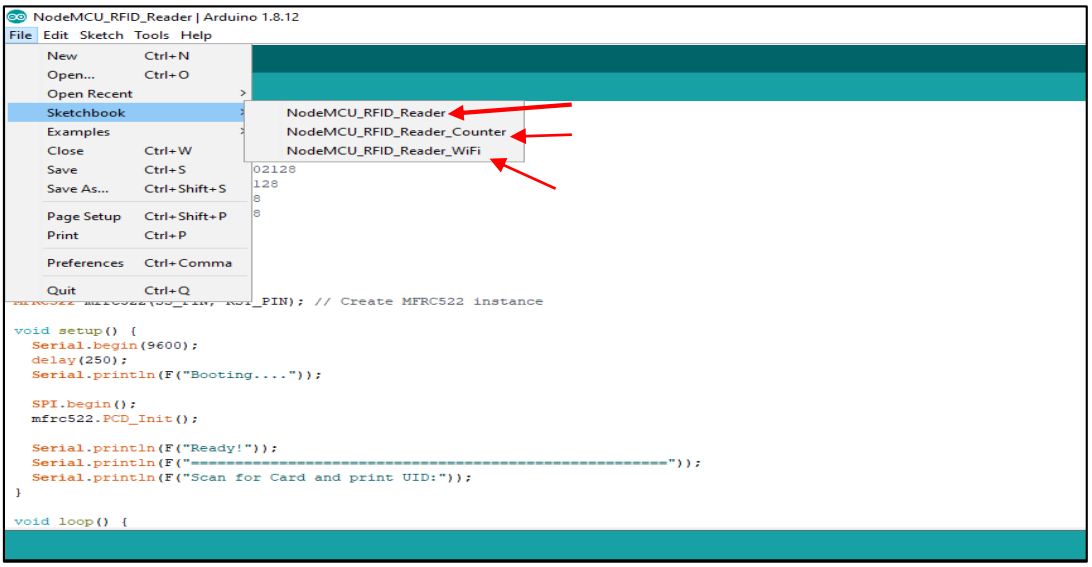


Figure 3.35 Three main system of RFID Device.

Since our RFID Device used NodeMCU Microcontroller as its main components, thus the main objective in this computer language writing was to construct a computer language which in this case was “Javascript. C Language” which act as an instruction when translated by the NodeMcu Microcontroller. This will set up a chain of command for the microcontroller to give it direction on what needed to be done after one’s action. For example, when the RFID reader detect a RFID Tags, it creates a database management system. Figure below showed sketch sheet for NodeMcu RFID Reader, NodeMcu RFID Reader counter and NodeMcu RFID Reader wifi system programming

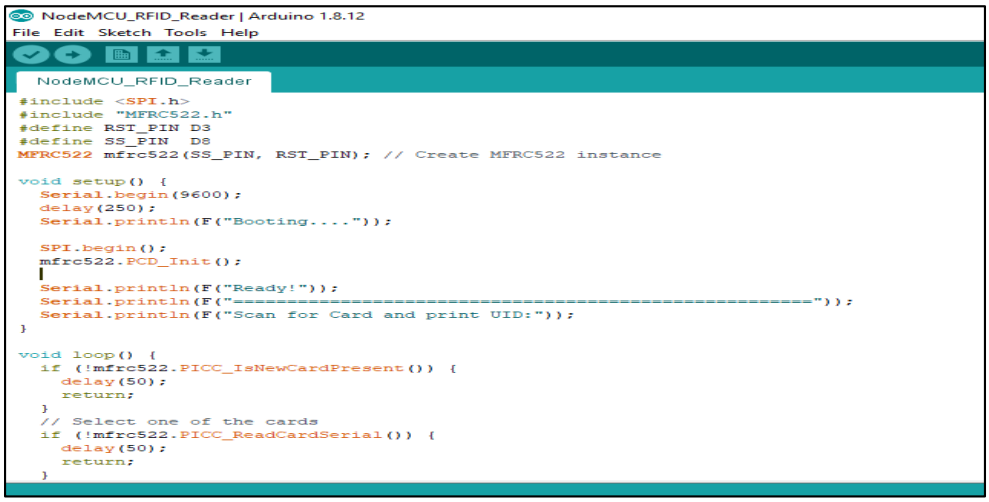


Figure 3.36 Sketch sheet for NodeMcu RFID Reader system programming.

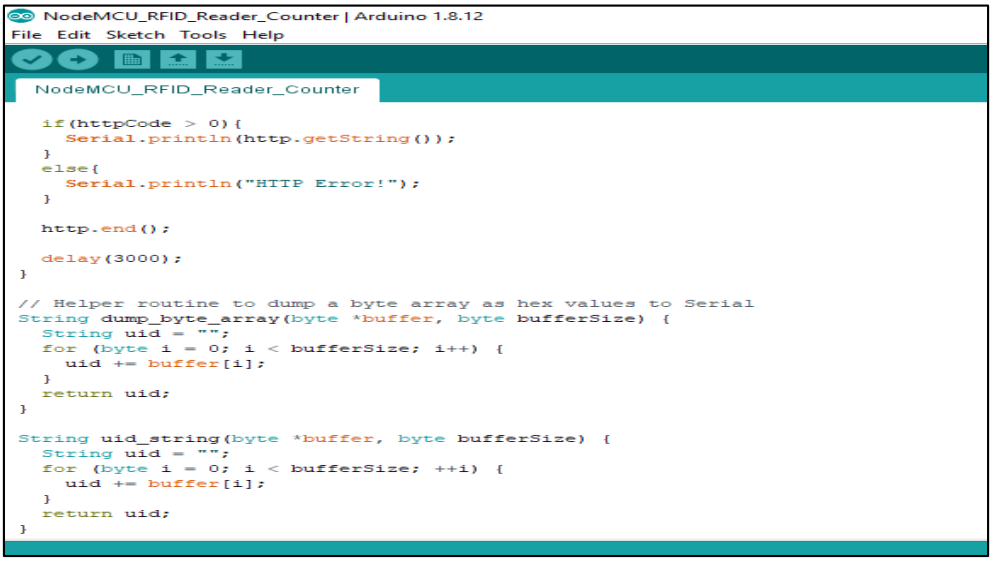


Figure 3.37 Sketch sheet for NodeMcu RFID Reader counter system programming.

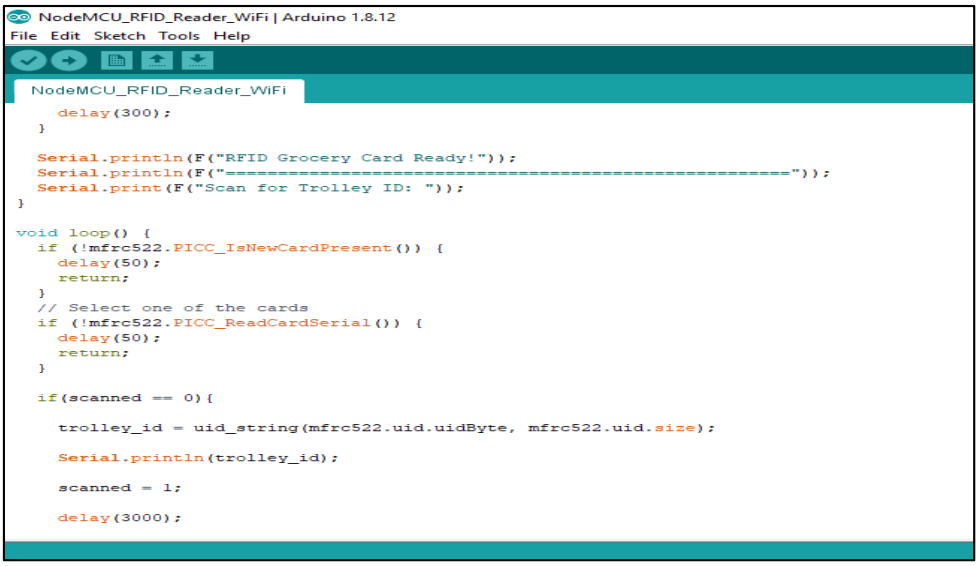


Figure 3.38 Sketch sheet for NodeMcu RFID Reader wifi system programming.

3.7.3 Setting up the Database

A database management system is a software designed to store, retrieve, define, and manage data in a database. This was also a crucial application for our project as it stores all the data such as customers detail, items list and items price. To set up the database, it can only be access through the programme's writer device, which in this case was our device.

To have access, an ip address that can be retrieved from Laragon Software on programme's writer device is needed. Once retrieved, a database editor can be access through online web browser. There, a database can be creating and edited independently. Figure 3.39 below showed red circle to indicate Laragon Software 'Terminal' toggle.

1. Open Laragon Software and click on the ‘Terminal’ toggle.

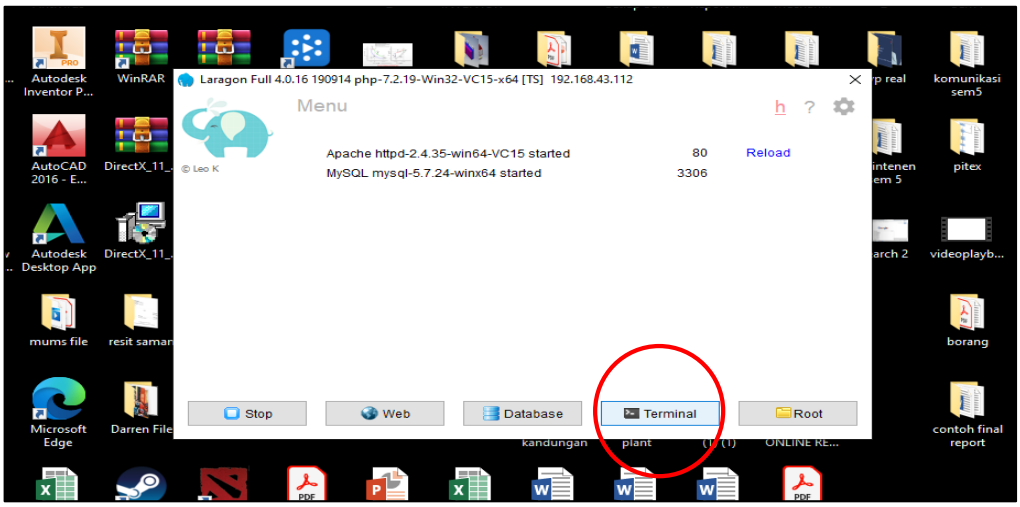


Figure 3.39 Red circle to indicate Laragon Software ‘Terminal’ toggle.

2. A sheet of command and a highlighted i.p address will appear. Copy and paste the ip address in the web search engine. Figure below showed sheet of command and a highlighted i.p address.

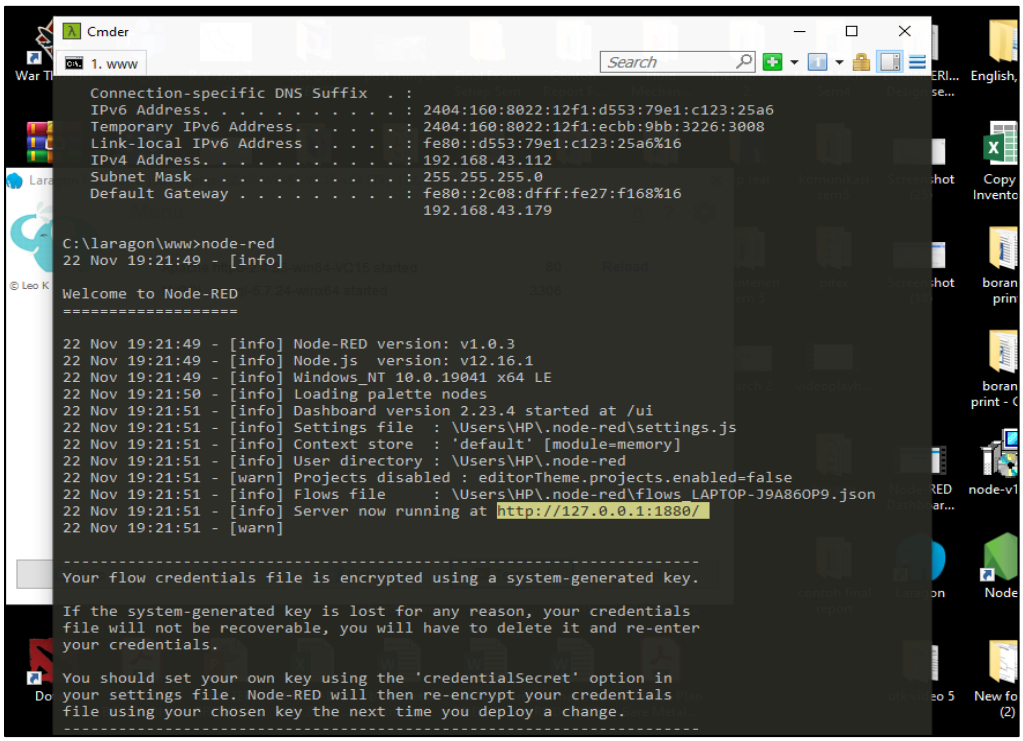


Figure 3.40 Sheet of command and a highlighted i.p address.

3. The ip address will redirect to an adminer page where database set up and editing activity can be completed. Here is list of databases belong to RFID Grocery Cart's Device. Figure below showed an adminer page where database set up and editing activity can be completed.

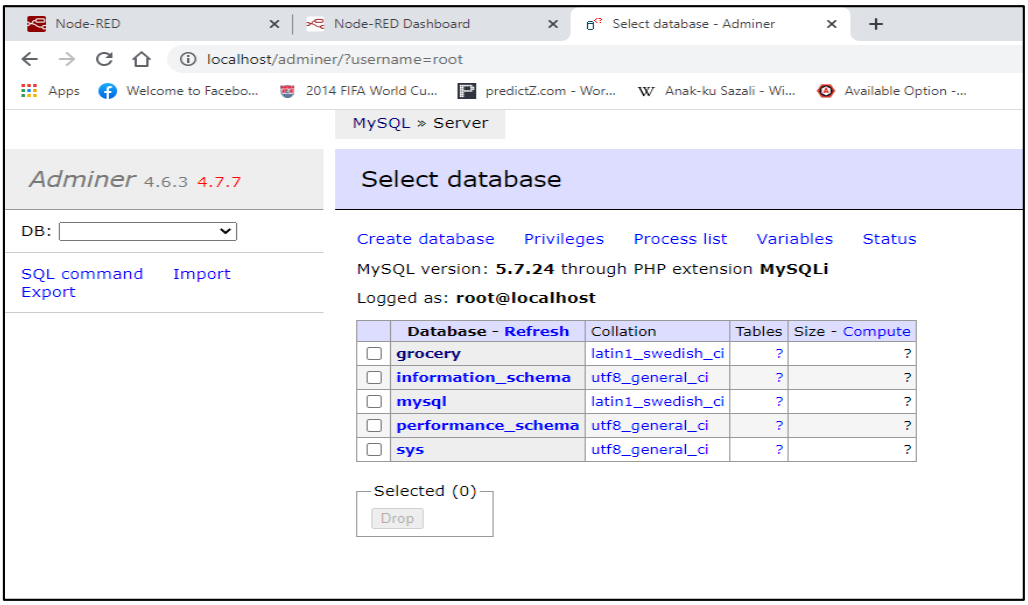


Figure 3.41 Adminer page where database set up and editing activity can be completed.

4. List of customers detail can be store or withdraw. Each of customer will have their own unique id number according to their RFID Tags. Figure below showed customer detail in the database.

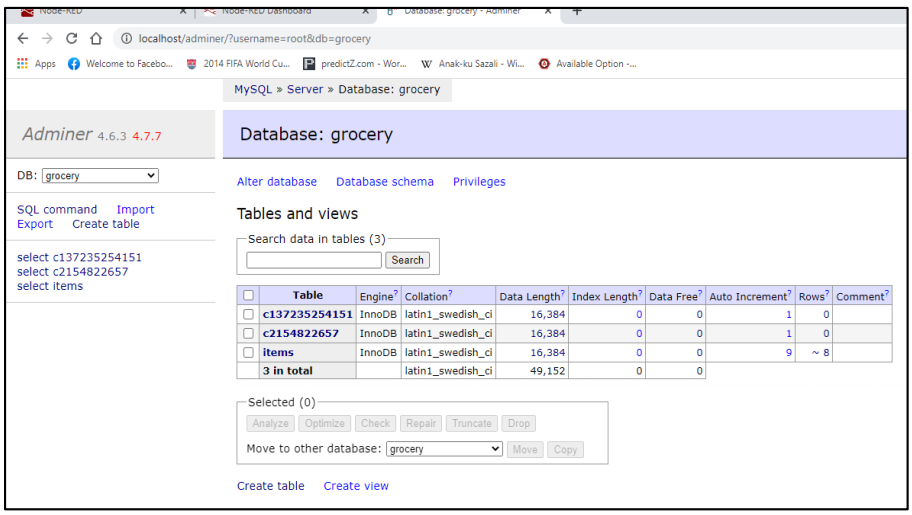


Figure 3.42 Customer detail in the database.

5. List of registered items are also being stored in this database.

   Figure below showed List of registered items in the database.

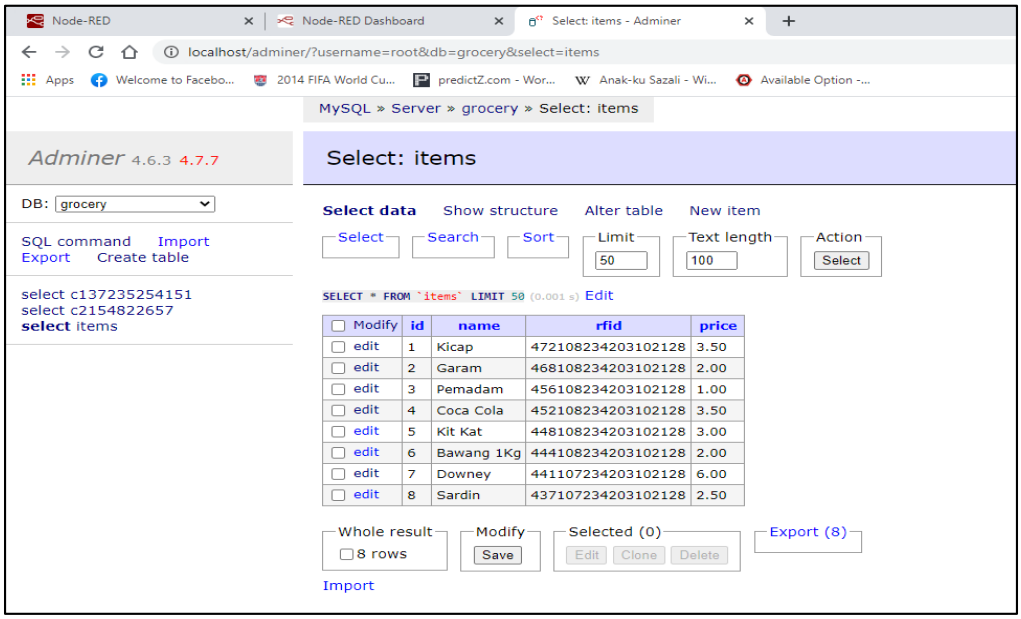


Figure 3.43 List of registered items in the database.

3.7.4 Function Interface

This step was accomplished through NodeJs Software. Since the computer language/instruction have been develop using Arduino Ide Software in previous chapter, in this section, the main objective was to determine and arrange when and where will those command is needed. Also, this section arranges and enable the interfacing between Database Managemenet System, ESP 8266 NodeMCU and RFID MFRC 522 to happen wirelessly. Figure below showed NodeJs Software editing sheet page.

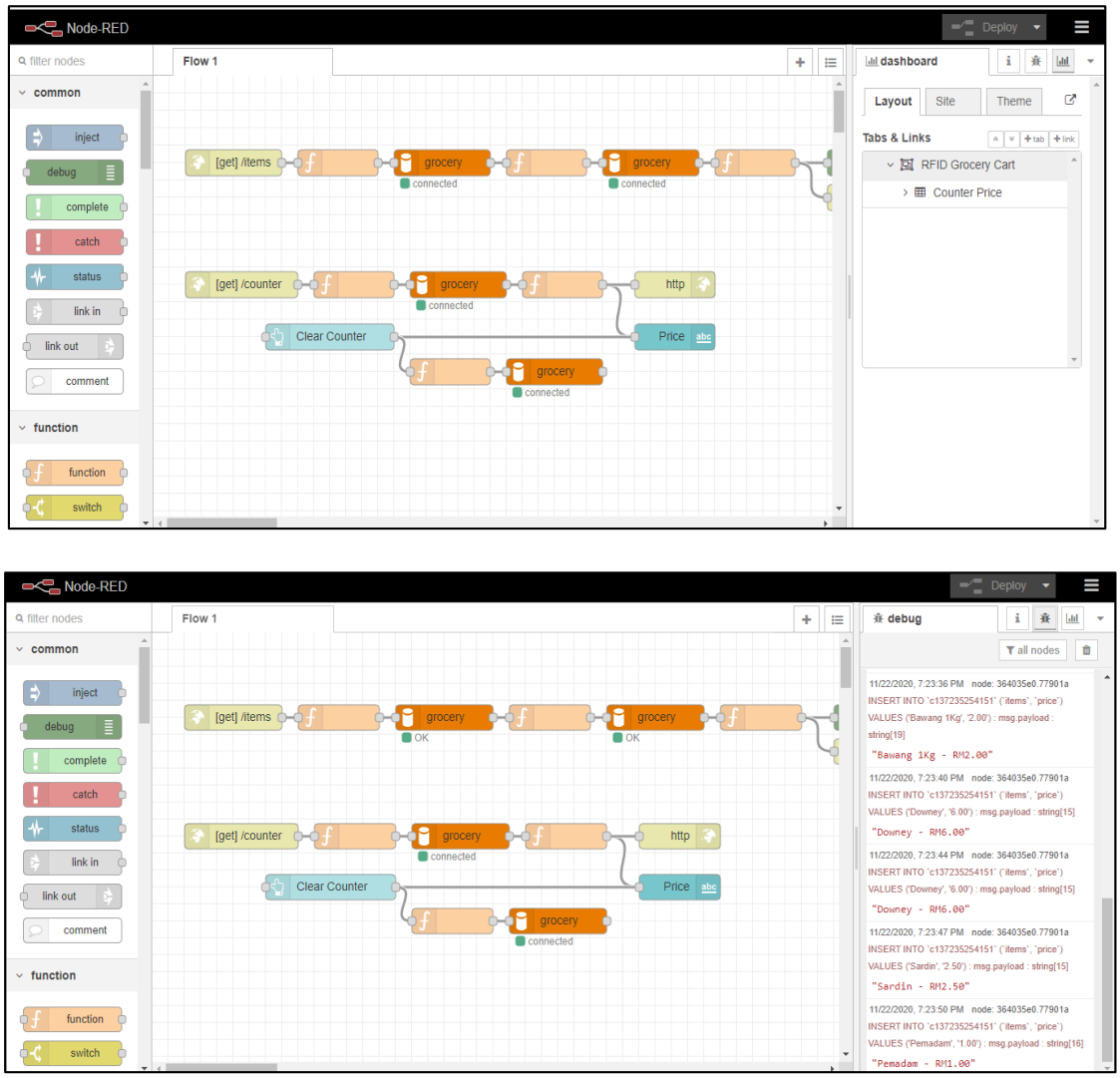


Figure 3.44 NodeJs Software editing sheet page.

3.7.5 Dashboard View

The last step was to develop the dashboard view for cashier to use when it come to the paying session with the customer. The main function of the dashboard is to show the total price that need to be pay by the customer that will appear on the cashier monitor at the counter when cashier scan customer's RFID tag through RFID reader at the counter.

This application was also developed through NodeJs Software by clicking the dashboard indicator. Figure below showed red circle to indicate dashboard indicator and Dashboard View of NodeJs Software.

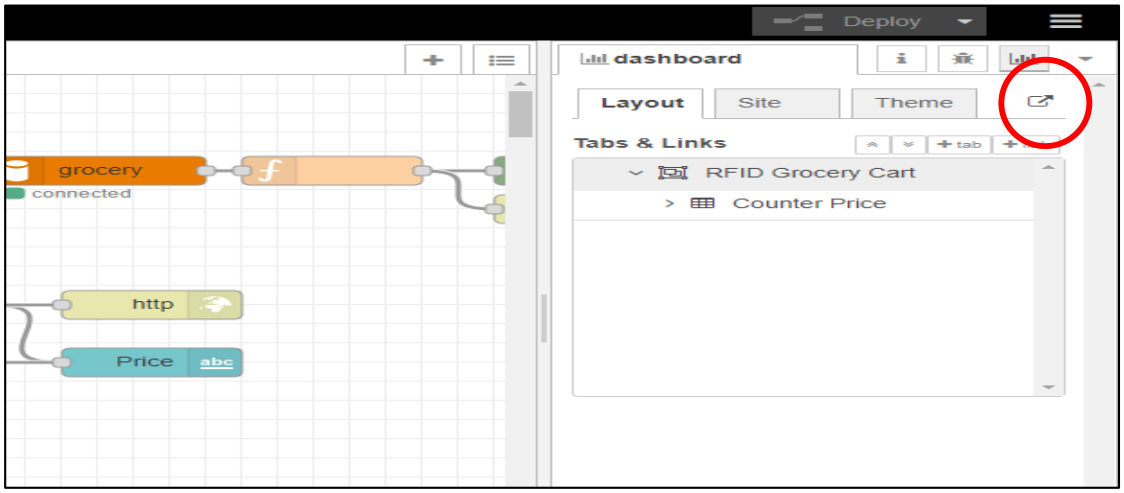


Figure 3.45 Red circle to indicate dashboard indicator.

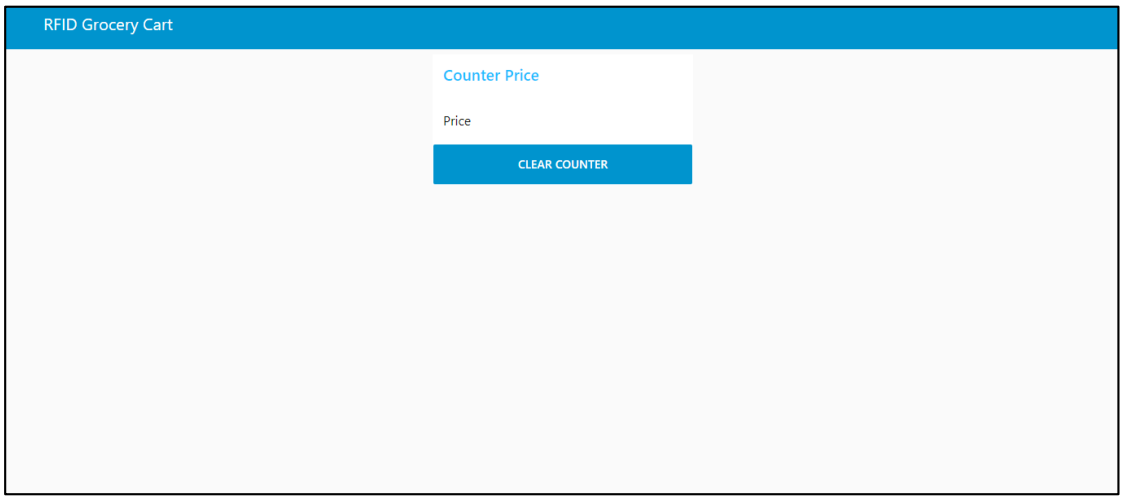


Figure 3.46 Dashboard View of NodeJs Software.

3.8 3D PRINTING

After a long discussion on how should we fabricate the RFID Device Casing part fabricated, we finally unanimously agree to go with 3D Printing. The discussion goes long as there were various ways and choices that we can use to produce the casing such as plastic inject moulding, plastic resin casting, plastic extrusion and many more. But after further research, only 3D printing makes senses for us in term of expenses, which is cheaper than others method, and availability, which places that provide 3D printing service growing drastically and easy to find in Malaysia. Table below showed differences between choices that we can use to produce the casing.

Types / Characteristics	Plastic Inject Moulding	Plastic Resin Casting	3D Printing	Plastic Extrusion
Availability	Low	Low	High	Low
Cost	Expensive	Cheap	Cheap	Expensive
Complexity	High	High	Low	High
Quality	High	Low	High	High

Table 3.2 Differences between choices that we can use to produce the casing.

Hence, we found a self-own business company named “Elmi 3D CAD Designing and Printing Expertise” through Facebook which provide consultation, 3D Design, 3D Scan & 3D Print service nearby. It was run by a guy called Mr Mohammad Razzif. Figure below showed Elmi 3D CAD Designing and Printing Expertise facebook page and picture with Mr Mohammad Razzif.

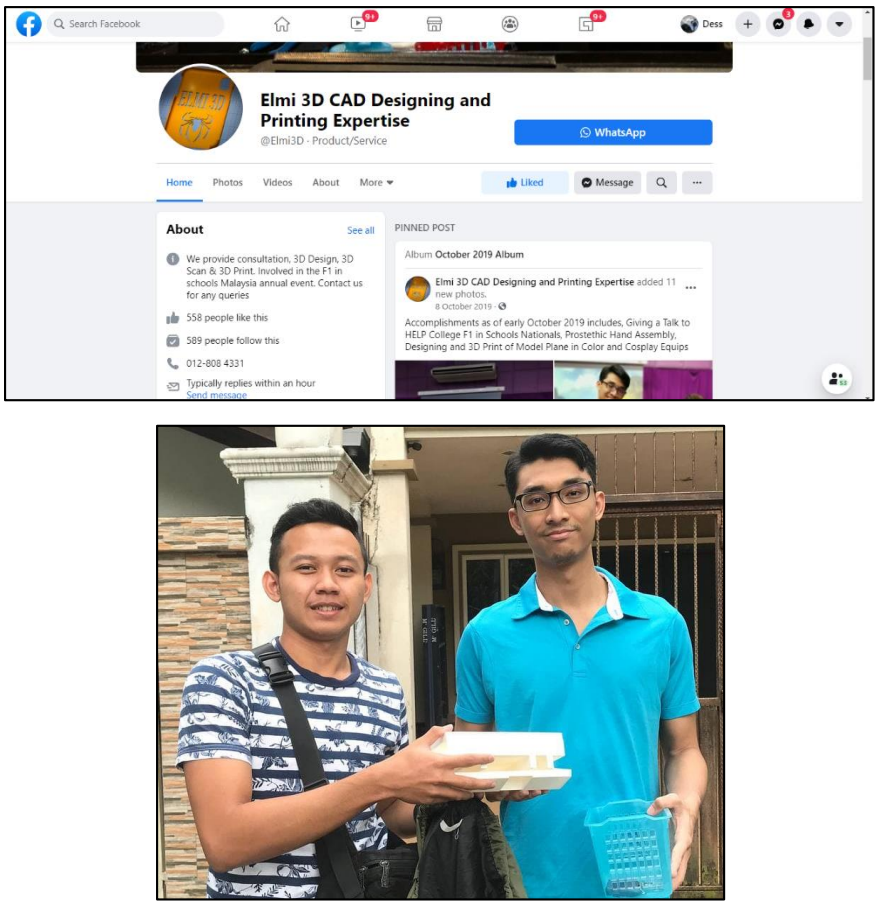


Figure 3.47 Elmi 3D CAD Designing and Printing Expertise facebook page and picture with Mr Mohammad Razzif.

“Elmi 3D CAD Designing and Printing Expertise” details;

Name of Consultant –	Mohammad Razzif
Phone Number –	+60 12-8084331
Address –	N0.49, Jalan UP 5/6, 68000 Ulu Kelang, Selangor, Malaysia.
Email –	nov96i@gmail.com

3.8.1 Machine Used

The fabrication of the RFID Device casing was made using ‘Creality CR10s Pro v2’ 3D printer. Although, this model is not as squandering as others model such as ‘Ultimaker S3’, ‘Makerbot Replicator Plus’ and ‘Prusa i3 MK3’, but this highly developed machine which is packed with useful features and efficient is more than enough to get the job done. Manufactured by a company based in Shenzhen, China, this model come fully packed with some admirable features such as Dense Matrix Measurement Point Precise and Automatic Levelling, Excellent, Hotbed for Rapid Heating-up, Intelligent Detection, Independently Developed Motherboard for Stable Performance and High Precision, Two-Step Quick Assembly and Double Screw Rod-driven More Stable Synchronous Operation. Figure below showed Creality CR10s Pro v2’ 3D printer.

3D Printer Model Details;

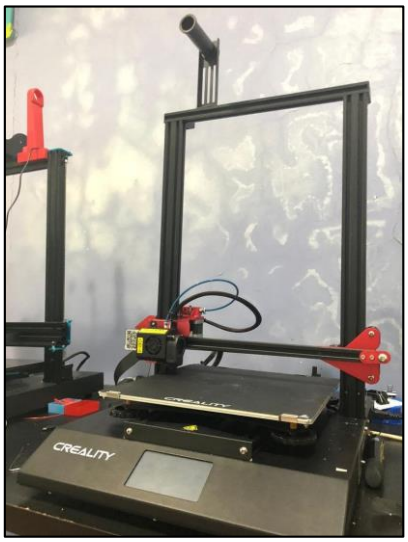


Figure 3.48 Creality CR10s Pro v2’ 3D printer.

Model: Creality CR10S Pro V2

Brand: Creality

Type: FDM (Fused Deposition Modelling)

3.8.2 Finishing Fabricated Part

Although it was printed with a highly develop and admirable feature printer machine, there were still some small flaw such as stepping lines between the printed layers, incomplete layers and filaments offset. These tiny flaws if left unfix, can cause a measurement error and left a groove on the printed part surfaces which can altered the quality of the fabricated parts. Thus, a finishing process were needed where 400,600 and 800 grit sand paper and several aerosol spray paints were used to fix and repaint the printed part surface. Figure below showed finishing process of the fabricated part.

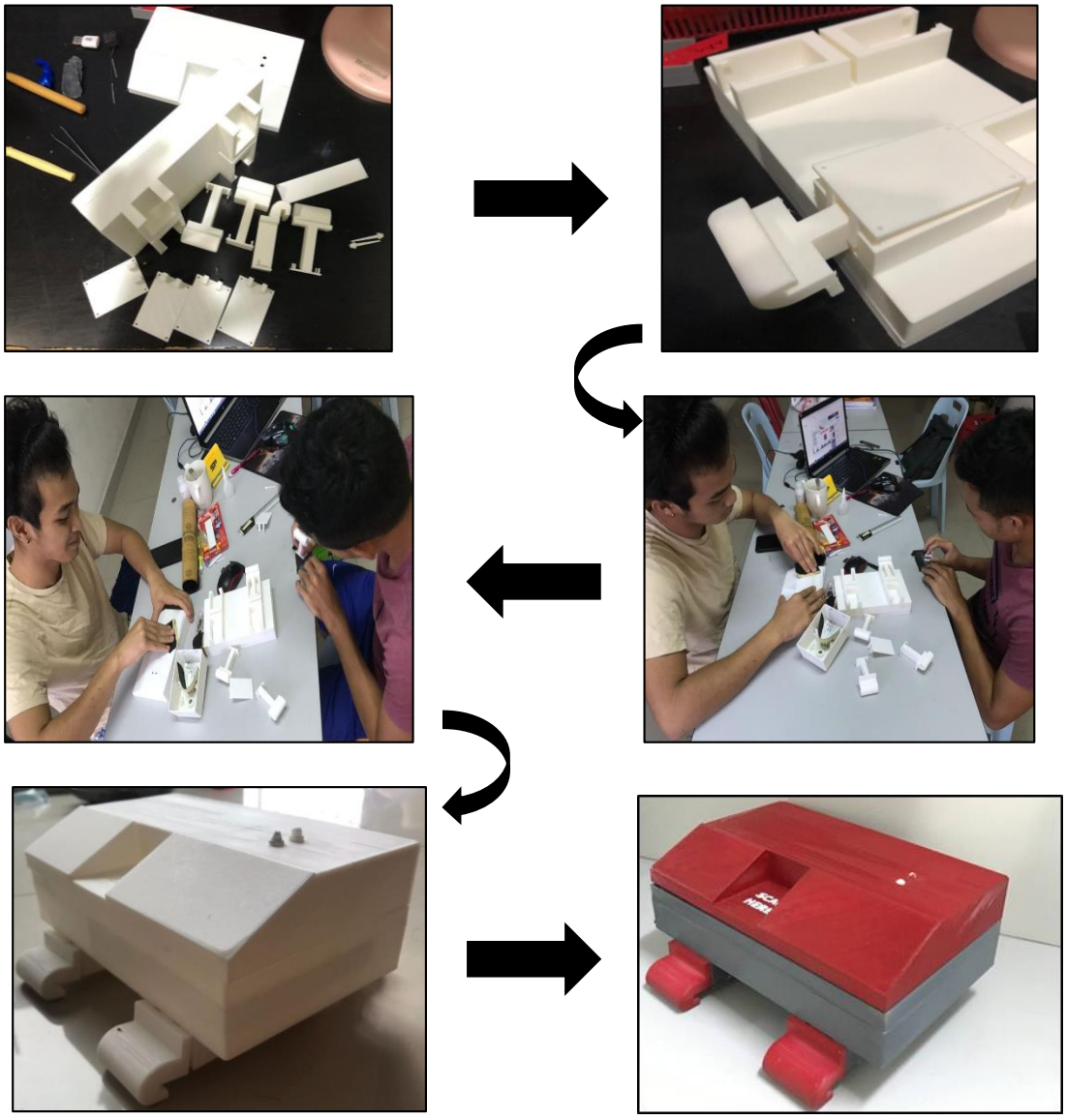


Figure 3.49 Finishing process of the fabricated part.

3.9 FINISHED PRODUCT

In this section, the main objective is to show the final result of our own fabricated RFID Grocery Cart. An idea that initially were only a concept were finally actualize. Through the figures projected below, can be observe that almost all of the fabricated part was accurate and similar to its drawing which mean the final product were exactly how it was planned to be. Figure below showed finished product of RFID Device.

- RFID Device

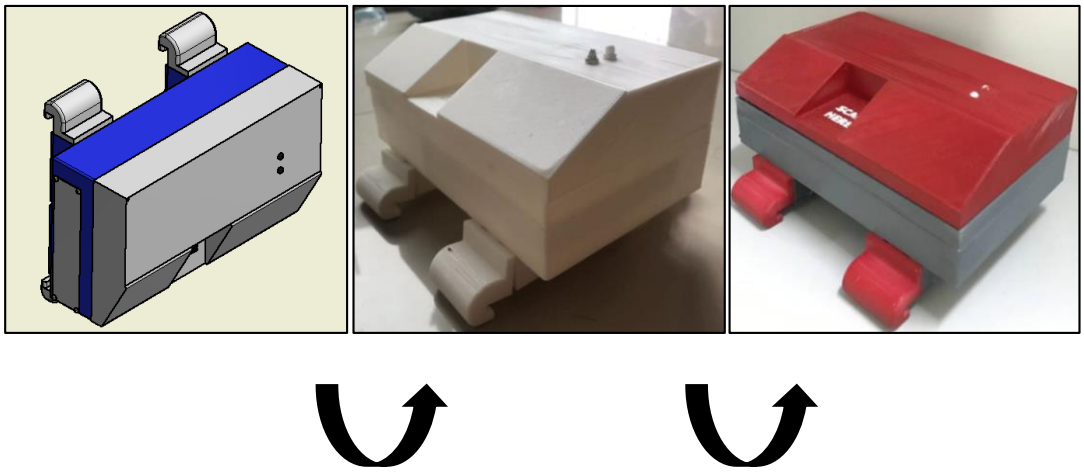


Figure 3.50 Finished product of RFID Device.

- RFID Device Internal View (Electronic Component)

  Figure below showed RFID Device Internal view.

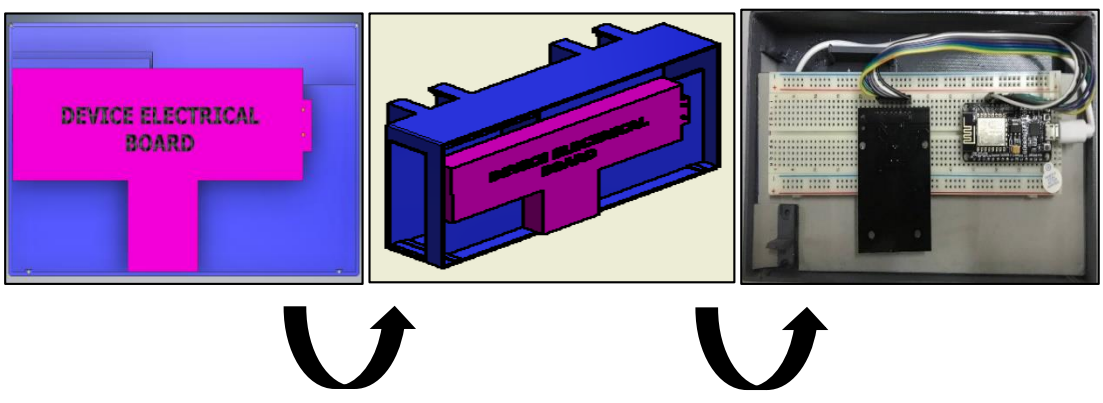


Figure 3.51 RFID Device Internal view.

- Rear Side of RFID Device

  Figure below showed the rear side of RFID Device.

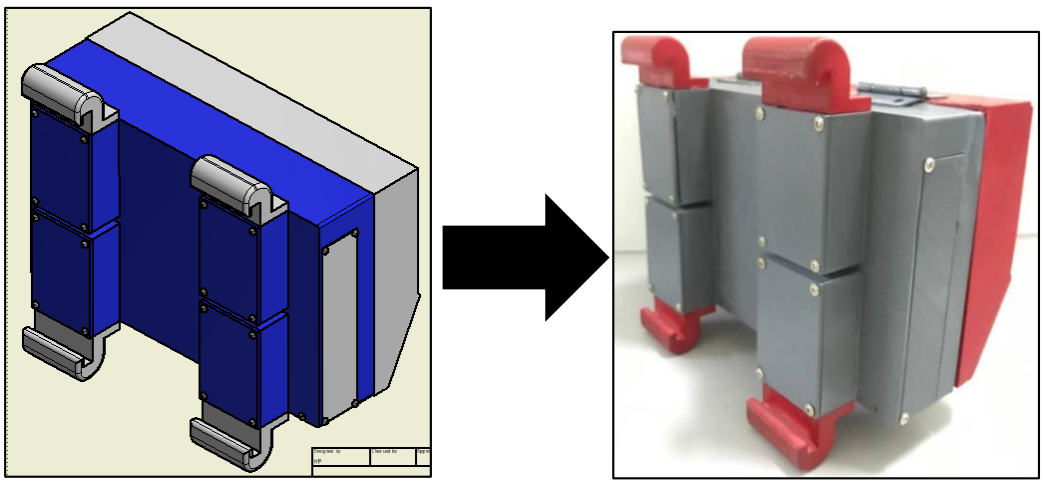


Figure 3.52 the rear side of RFID Device.

- RFID Device Hook

  Figure below showed RFID Device hook.

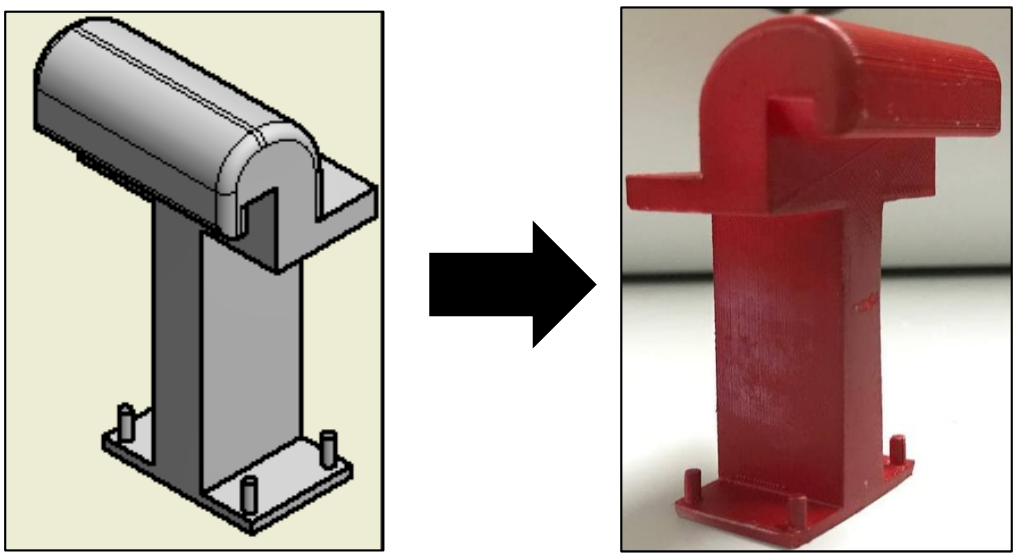


Figure 3.53 RFID Device Hook.

- RFID Device Hook Locking Mechanism

  Figure below showed RFID Device Hook Locking Mechanism.

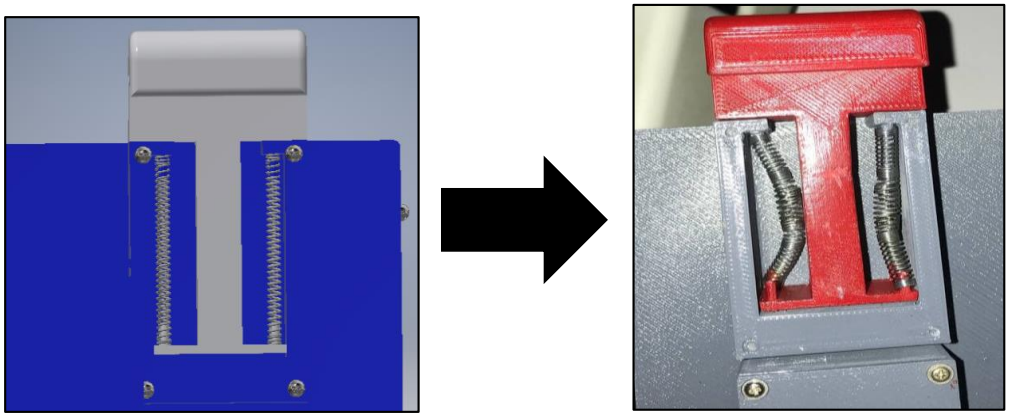


Figure 3.54 RFID Device Hook Locking Mechanism.

- RFID Grocery Cart

  Figure below showed the end product of RFID Grocery Cart.

Figure 3.55 The end product of RFID Grocery Cart.

3.10 BUDGET CALCULATION

Below is our table of expenses.

No	Materials / Equipment	Amount	Price	Total
1.	100 Litre Grocery Cart	1 unit	RM 340	RM 340.00
2.	NodeMCu Microcontroller	2 unit	RM 30 each	RM 60.00
3.	RFID RC522 Module for Arduino	2 unit	RM 32 each	RM 64.00
4.	Bread Board 830 Holes (16.5x5.5 cm)	2 unit	RM 13 each	RM 26.00
5.	30cm 40 ways Dupont jumper wire	1 unit (40 pieces)	RM 5.50	RM 5.50
6.	3.70V Lithium-Ion Rechargeable Battery	1unit	RM 15	RM 15.00
7.	30 cm Micro usb	2 unit	RM8 each	RM 16.00
8.	400,600,800Grit Sand Paper	6 unit	RM 2.16 each	RM 13.00
9.	Aerosol Spray Paint (Red & Grey)	2 unit	RM 5.50 each	RM 11.00
10.	2x4 mm Screw	16 unit	RM 0.20 each	RM 3.20
11.	2x6 mm Screw	4 unit	RM 0.25 each	RM 1.00
12.	(2x30mm), (2x43mm) Screw	4 unit	RM 0.40 each	RM 1.60
13.	32x0.7x0.7 mm spring coil	4 unit	RM 0.50 each	RM 2.00
14.	3D Printing	760 g	RM 0.50 per gram	RM 380
Grand Total			RM 938.30	

Table 3.3 Table of expenses.

Overall, we were glad that we were able to complete the project within our estimated budget, which was RM 1000.

3.11 PROJECT ACTIVITY (GANTT CHART)

Projected table below illustrates the activity schedule for RFID Grocery Cart project.

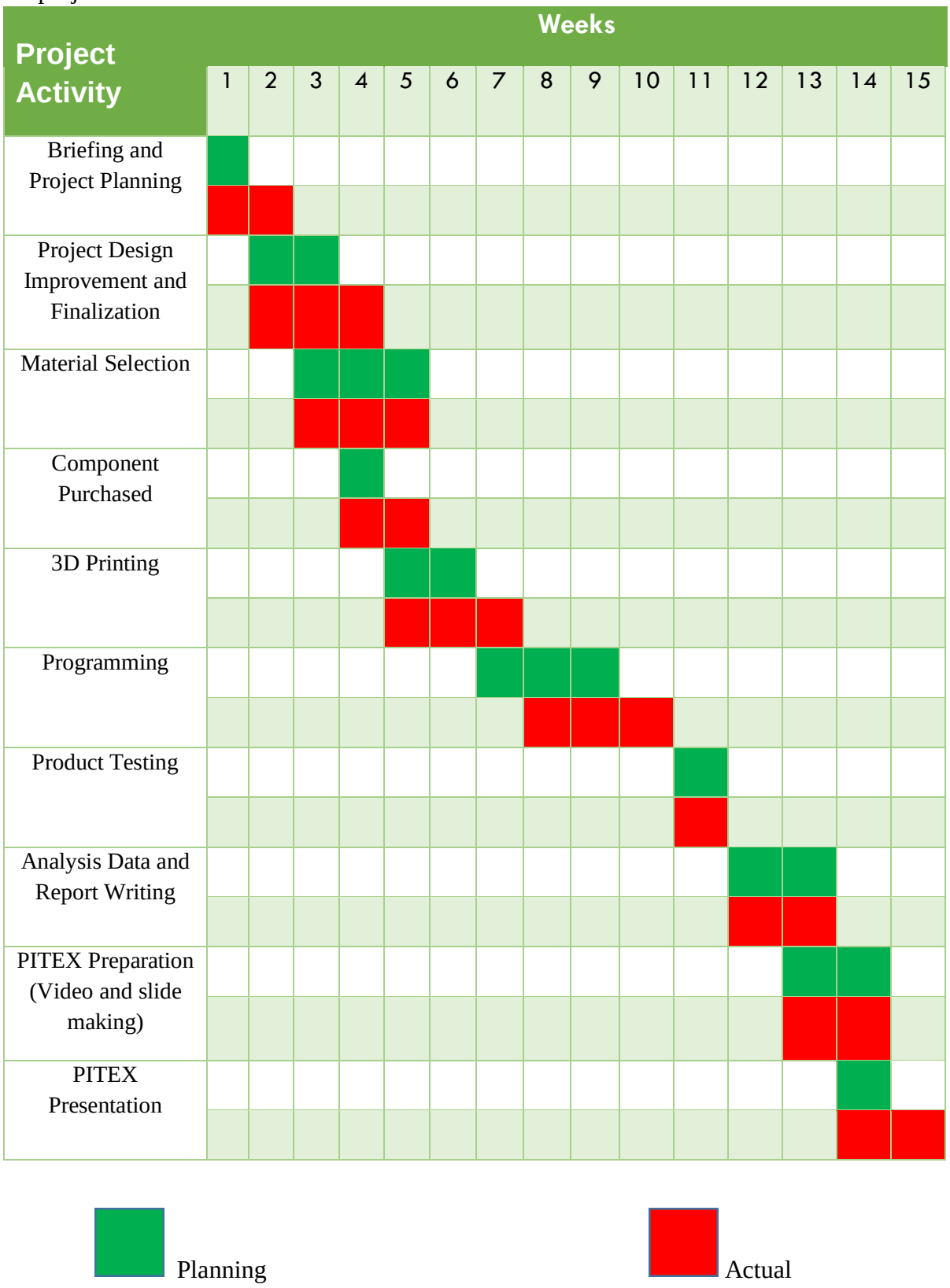


Table 3.4 Gantt chart of project activity.

3.12 SUMMARY

In conclusion, throughout this chapter, the progress of developing the RFID Grocery Cart were explained in fine detail. From the first step of feasibility study as the preliminary review, to the process of contriving the product design and developing the system programming, all the way to the last process which is the finishing process were able to be interpreted adequately. Also, all process in this chapter were done systematically and were accordingly to the methodology flow which proved that the contextual framework of the research for RFID Grocery Cart was a success. We were also glad and no word can express how delighted we were to acknowledge that we were able to complete the project just how we planned it to be.

CHAPTER 4
FINDING AND ANALYSIS

4.1 INTRODUCTION

In this chapter, it describes the finding of our studies, based on the research objectives and question, and explain briefly the operational of the RFID Grocery Cart. Also, this chapter specify the impact of this project, challenges faces and advantages and disadvantages of this project.

4.2 PROJECT OPERATIONAL/APPLICATION

This sub-chapter explained the operational of RFID Grocery Cart in the simplest term. Refer figure below;

1) Figure below showed customer scanning RFID tag through RFID Scanner.

Figure 4.1 customer scanning RFID tag through RFID Scanner.

Customer enter premises with RFID tags (can also be provide by store retailer). Whilst taking grocery cart before begin with shopping activity, customer scan their RFID tag through RFID scanner that is attached to the grocery cart.

Figure below showed the interface between RFID scanner, Microcontroller and Database.

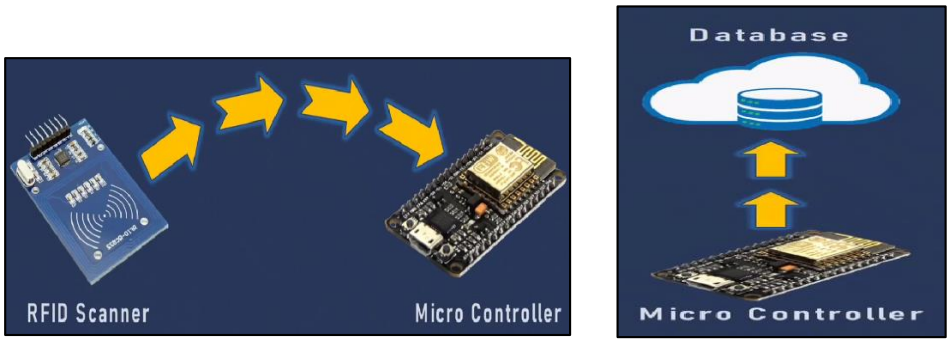
2) 

Figure 4.2 the interface between RFID scanner, Microcontroller and Database.

RFID Reader scan information embedded in the tags and send information to NodeMcu Microcontroller.

Which translate the information and send this information to Database Management System Software. This set up an item purchased database site which is set up exclusively for that particular customer only.

Figure below showed customer scanning item through RFID Device.

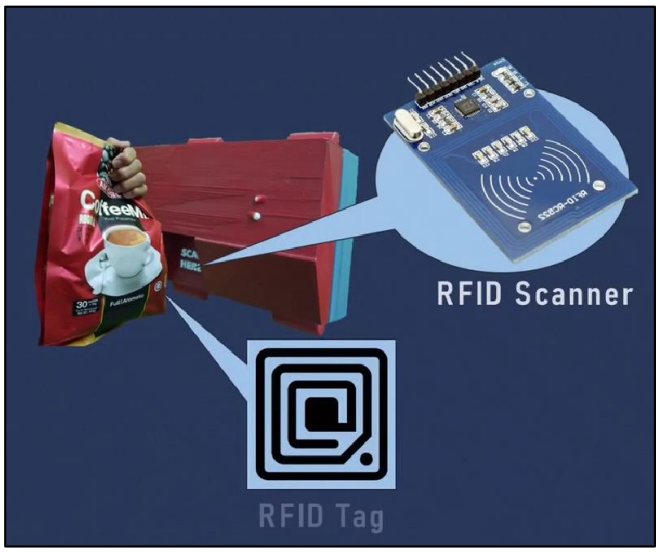
3) 

Figure 4.3 customer scanning item through RFID Device.

While moving around premises during shopping activity, customer can scan the item they wish to purchase (that have been attached with RFID adhesive tags) through the same RFID reader attached at the grocery cart.

Figure below showed cashier scanning RFID tags through RFID scanner at counter.

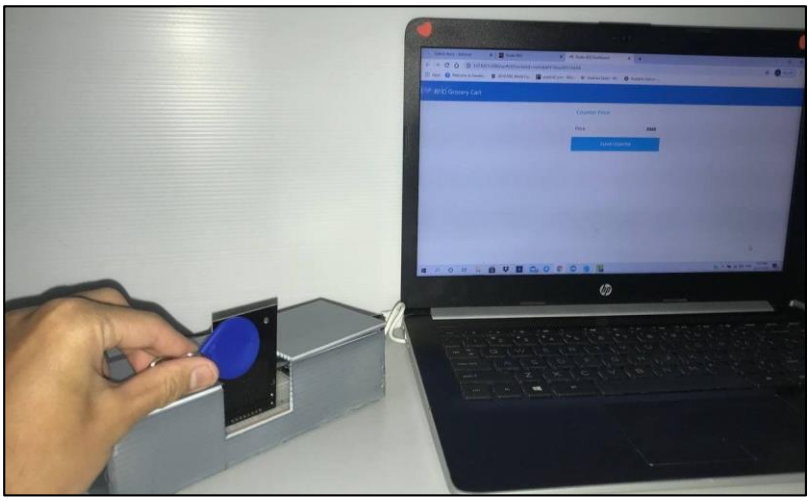
4) 

Figure 4.4 cashier scanning RFID tags through RFID scanner at counter.

As customer are done with their shopping activity, customer can head to the cashier counter and hand-over their RFID tags to the cashier. Cashier will scan the RFID tags through a RFID reader located at the cashier counter. This will command the supermarket central billing system to receive input of database from the customer's Item purchased Database.

Figure below showed Sum up of collective data with a total price that the customer need to pay

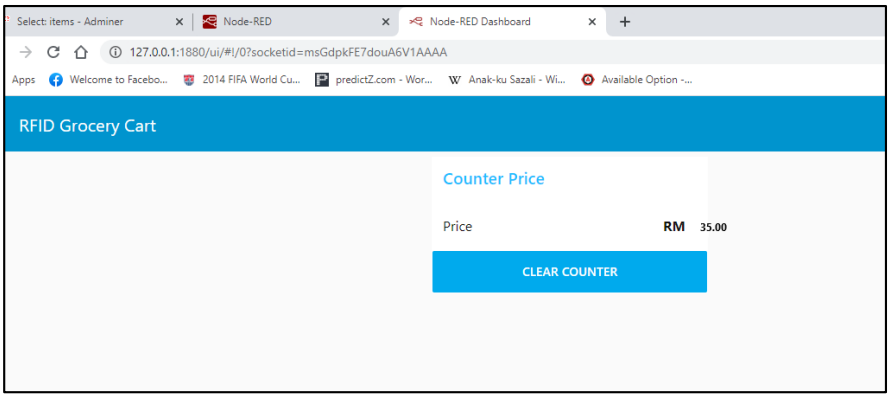
5) 

Figure 4.5 Sum up of collective data with a total price that the customer need to pay

Sum up of collective data with a total price that the customer need to pay will appear at the counter screen. Customer then pay total amount of purchased item through cash or online services.

4.3 PRODUCT TESTING

A test was conducted to compare time consumed when paying at payment counter between using conventional paying method with using advance paying method with the help of RFID Grocery Cart. First, a total of 7 items were picked. During payment, when using the conventional grocery cart and method, time taken was recorded. It recorded a total time of 1 minute 35 second/81 second for a single customer to complete all the transaction needed to buy and pay all 7 items. Then, a simulation of buying and paying process at counter were conducted using RFID Grocery Cart. Similarly, time taken was also recorded. The result came out was excellent as it manage to reduce time taken to approximately 24.69% which is only 20 second compare to when using conventional grocery cart (81 second). This mean by using RFID Grocery Cart, it was able to save about 75.31% of consumer's time. Also, when using conventional grocery cart, if 1 customer need 81 second to complete all the transaction, then if there were 4 customers buying the same amount of 7 items, the fourth customer would need to wait for 5.4 minute/324 second to finally complete his/her transaction. By using RFID Grocery Cart, he or her is reduce to 1.3 minute/80 second and this absolutely solve long queues at paying counter issues and make consumer shopping process faster**.**

4.4 FINDINGS

This section justifies several findings regarding RFID Grocery Cart which consist of impact of the project, advantages and disadvantages of the RFID Grocery Cart, and Challenges.

- IMPACT OF THE PROJECT

    I. Customer no longer have to queue long.
    - By having this product, consumers no longer need to waste time, queuing for a long period at the cashier's counter as they no longer need

to take out and hand over items from their grocery cart to the counter one by one. This is very crucial as it help a lot of customers especially those elderly who have health issues, those who are in a rush and family who are carrying toddler.

II. Less interaction between cashier and customers especially during this pandemic outbreak.

- This project resulted in customers to have less interaction with cashier or other worker and perhaps less interaction among other customer as well. Both mentioned above will become a significant impact toward community especially during this COVID-19 pandemic era.

III. Society will indirectly be exposed to the advancement of IR 4.0 technologies.

- As IR 4.0 are still at an early stage, people are struggling to adapt and understand the revolution concept of IR 4.0. Thus, this project will be a crucial way to introduce IR 4.0 technologies to the people, helping them to understand, adapt and learn these new ways to execute work.

IV. Creating new job scopes.

- This product will help to generate new job scope and provide more job opportunities for the community. It is to be speculate that once the RFID Grocery Cart are being apply, the job position as a cashier would be reduce but at the same time open others new job scope for instance computer programmer for the maintenance of the RFID Device, general worker to maintain the life of device casing and many more.

- CHALLENGES

I. Complication with the programming process.

- Being students developing product that consist a scope of basic element (Computer programming) which have a huge difference from studied

course element (Mechanical engineering) was not easy. Even with the help of a professional IOT consultant and developer, still we faced a hard time to interpret and understand the computer language and arithmetic code.

II. Struggle with the process of designing the RFID Device Casing.

- Since our product is the first of its kind, we face obstacles when designing the RFID Device casing as we have no cross-references to look up for when planning and drawing design.

CHAPTER 5
DISCUSSION AND CONCLUSION

5.1 INTRODUCTION

All research reports seem to end with a set of conclusions. Therefore, you cannot have those before having it to be discussed. Just like in this chapter, we will take a short recap of the entire project with all its content. Having cycled painfully to the top of the hill, the great temptation at this point is to relax and freewheel down to the finish.

5.2 DISCUSSION

There is no doubt that Radio Frequency Identification (RFID) technology and Internet of Things (IoT) system can work together as one system that could help the society making grocery shopping more efficient. Though these benefits are limited to certain aspect such as places where there is no internet coverage and the usability of the technology. As we all know that this technology cannot scan data on metal surfaces as this technology uses radio waves as its medium in transferring and collecting data and metal repel radio waves.

Currently, the usual grocery cart at other related supermarkets/ hypermarkets is mainly used to store goods in the cart after shopping. But the real situation that is faced by the customers is they are when making payment. Customer need to transfer their item one by one on the checkout counter and scan them one by one. This will take a lot of time considering some items need to be checked manually (typing in the check digit). By having this new RFID Grocery Cart, it carries the purchasing data in an RFID card which then will be scan by the cashier. This way, there’s only one item needed to be scan thus, cutting the checkout time short.

Nonetheless, there are still rooms for improvement such as having an LCD monitor on the grocery cart. This way, the customer can easily navigate through their purchase and making it easier for them to edit the purchase.

5.3 CONCLUSION

In conclusion, the main idea behind this project is to help the society by cutting short the time spent on queuing when making grocery shopping. The usual grocery cart at other related supermarkets/ hypermarkets is mainly used to store goods in the cert after shopping. By having RFID technology applied on the grocery cart, it can help both the customer and cashier when making payment, thus making the checkout process faster. We believe that RFID technology are not limited only to access card, tolls, clothing but also grocery. Of course, with the implementation of this project, we will need time to adapt to this technology. As it was mentioned in earlier chapter, elderly will find it difficult to adapt to this technology. At the moment, the grocery cart is not equipped with any monitor, but rather buzzer sound. Thus, making it difficult for elderly and people with hearing disability.

Nonetheless, it is a huge step in the progression of the mankind as we are now in the fourth industrial revolution era. Through this project, we hope to contribute in making Malaysia a great nation that can compete with other nation such as China and Japan in STEM. We believe our project; RFID Grocery Cart will be the face of the future due to its purpose in everyone's life. We hope that our project will be an inspiration to anyone who's interested to take this project to another level.

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APPENDIX

APPENDIX A RFID GROCERY CART POSTER

APPENDIX B PITEX 2020

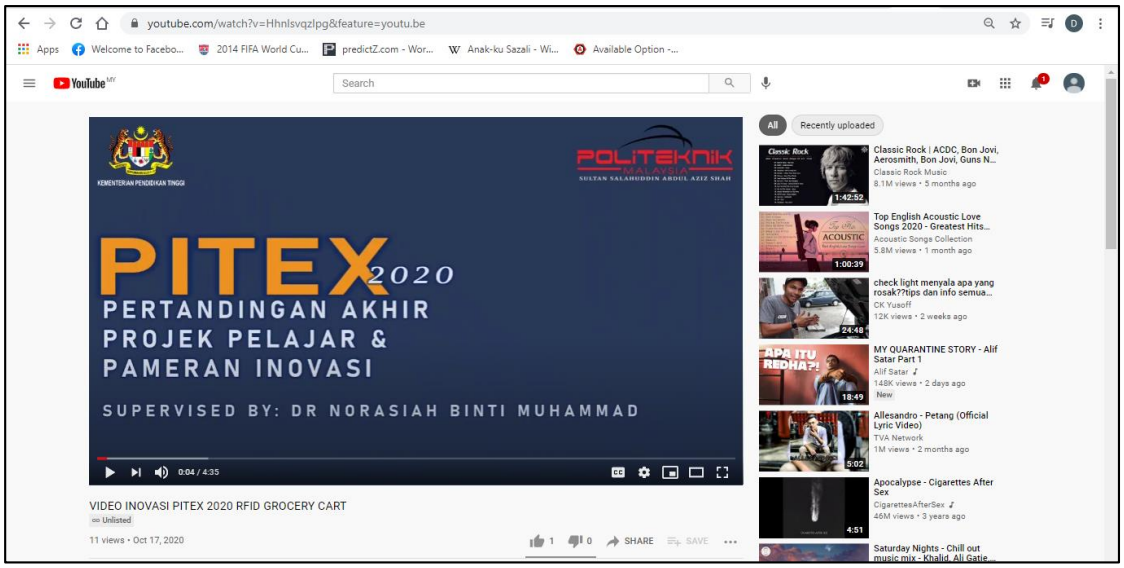
APPENDIX C PROJECT RELATED PICTURE

APPENDIX D MYIPO COPYRIGHT

APPENDIX A

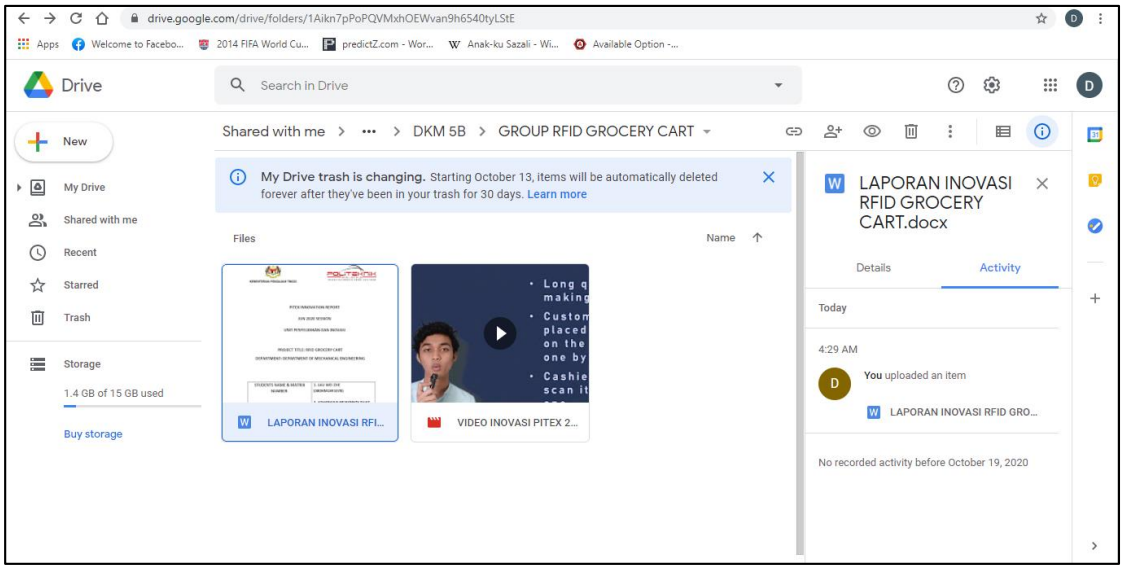
RFID GROCERY CART POSTER

PITEX 2020



RFID Grocery Cart PITEX innovation video uploaded through youtube.

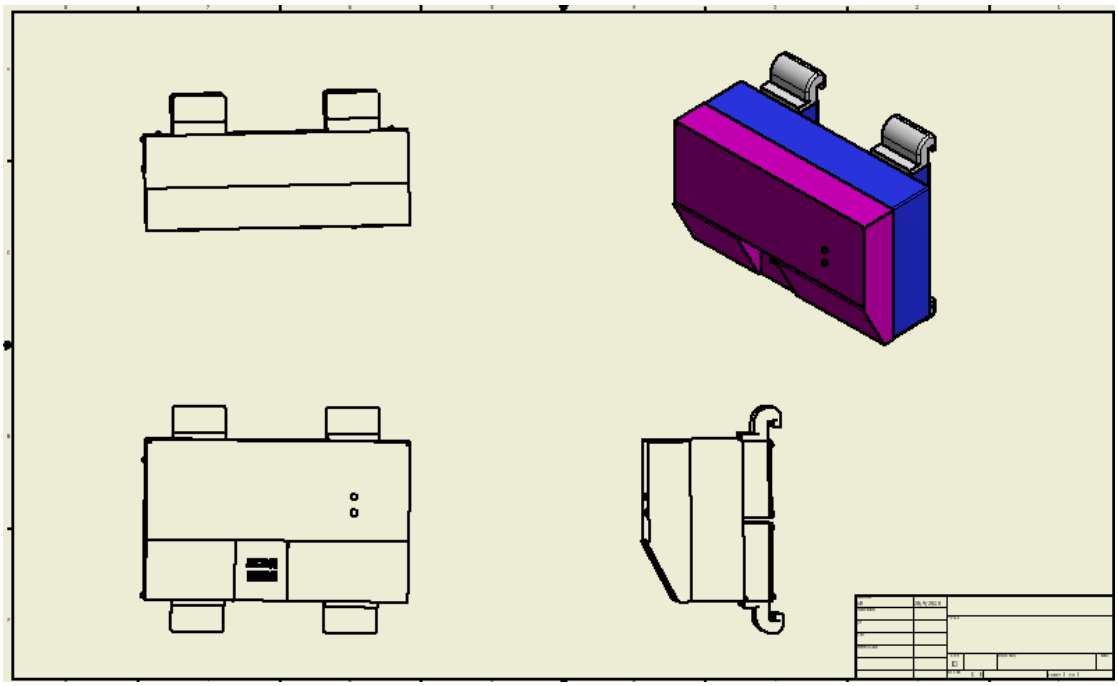
Link ; https://youtu.be/HhnIsvqzIpg

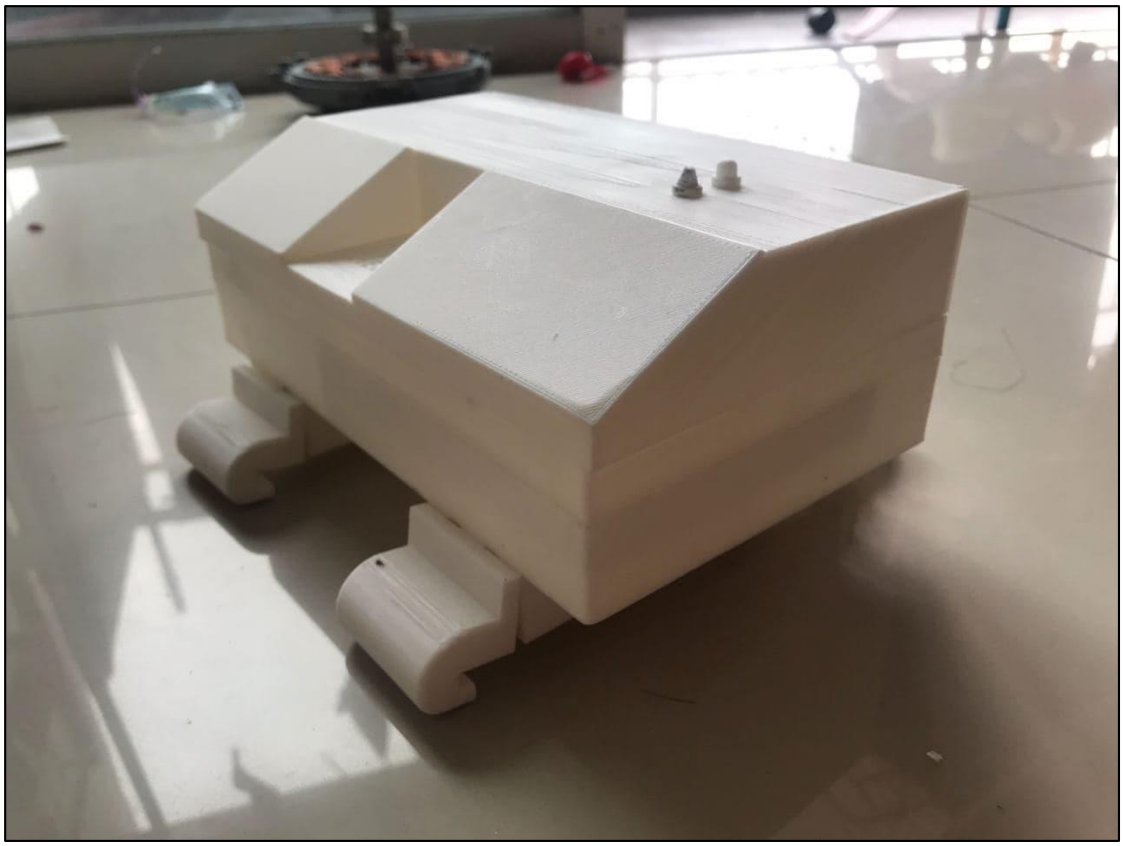


Submission of RFID Grocery Cart PITEX 2020 innovation report and video through Google Drive.

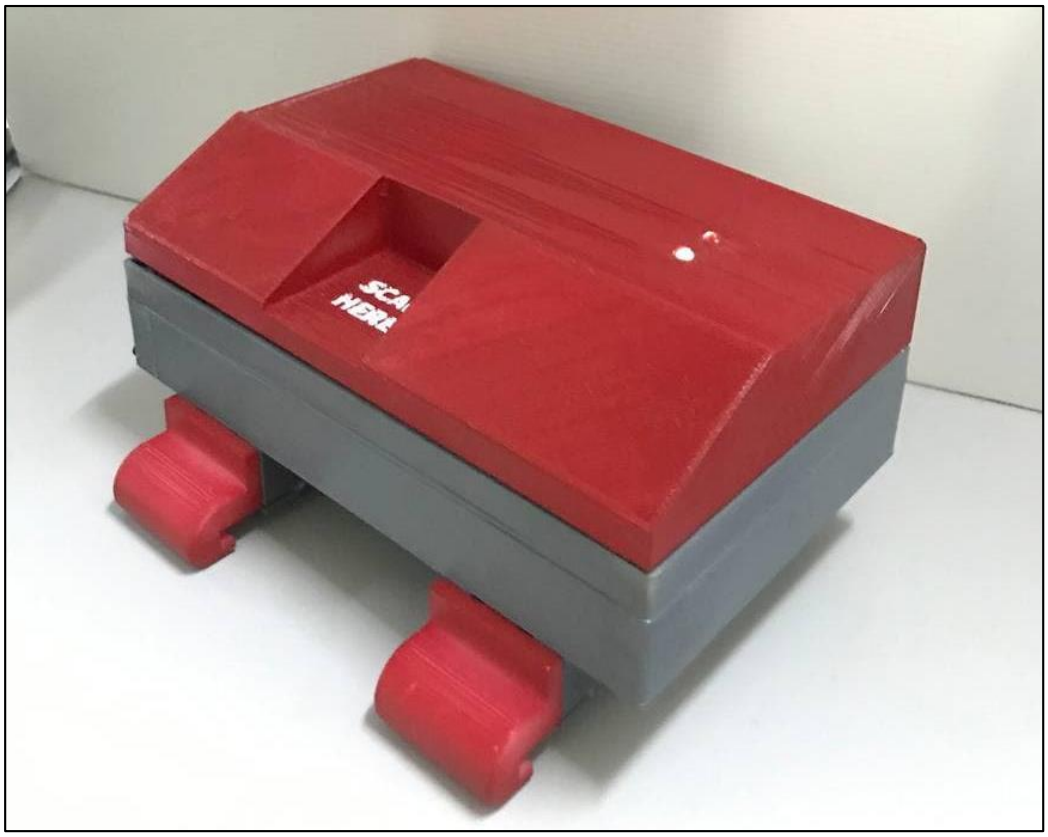
APPENDIX C

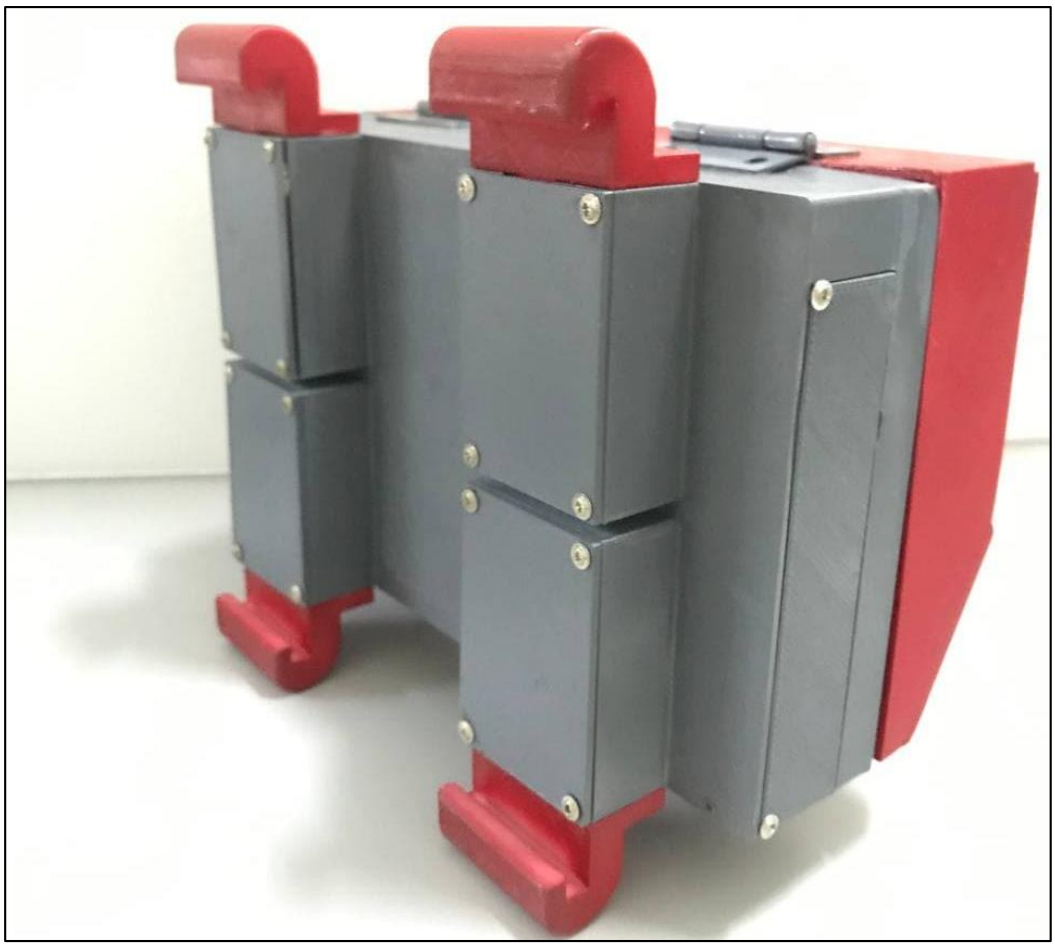
PROJECT RELATED PICTURE





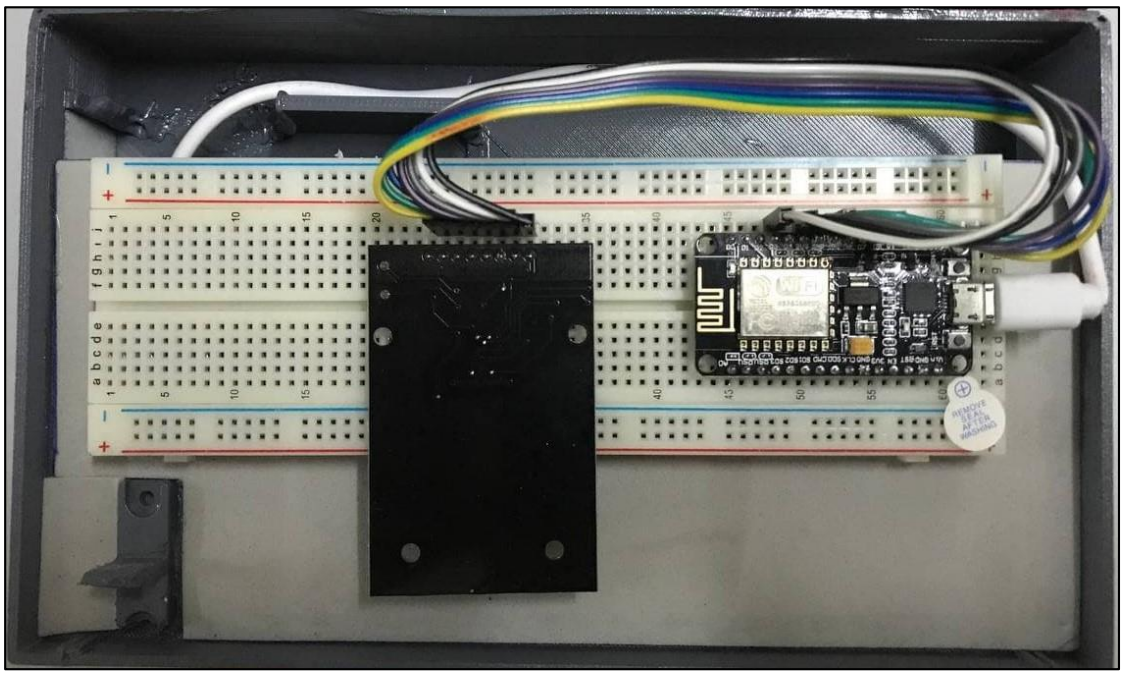
RFID Device Orthographic Drawing and Printed Device Casing.





Finished RFID Device Casing.

RFID Grocery Cart's RFID Device main Components.



RFID Device Components.

RFID Grocery Cart End product.

APPENDIX D

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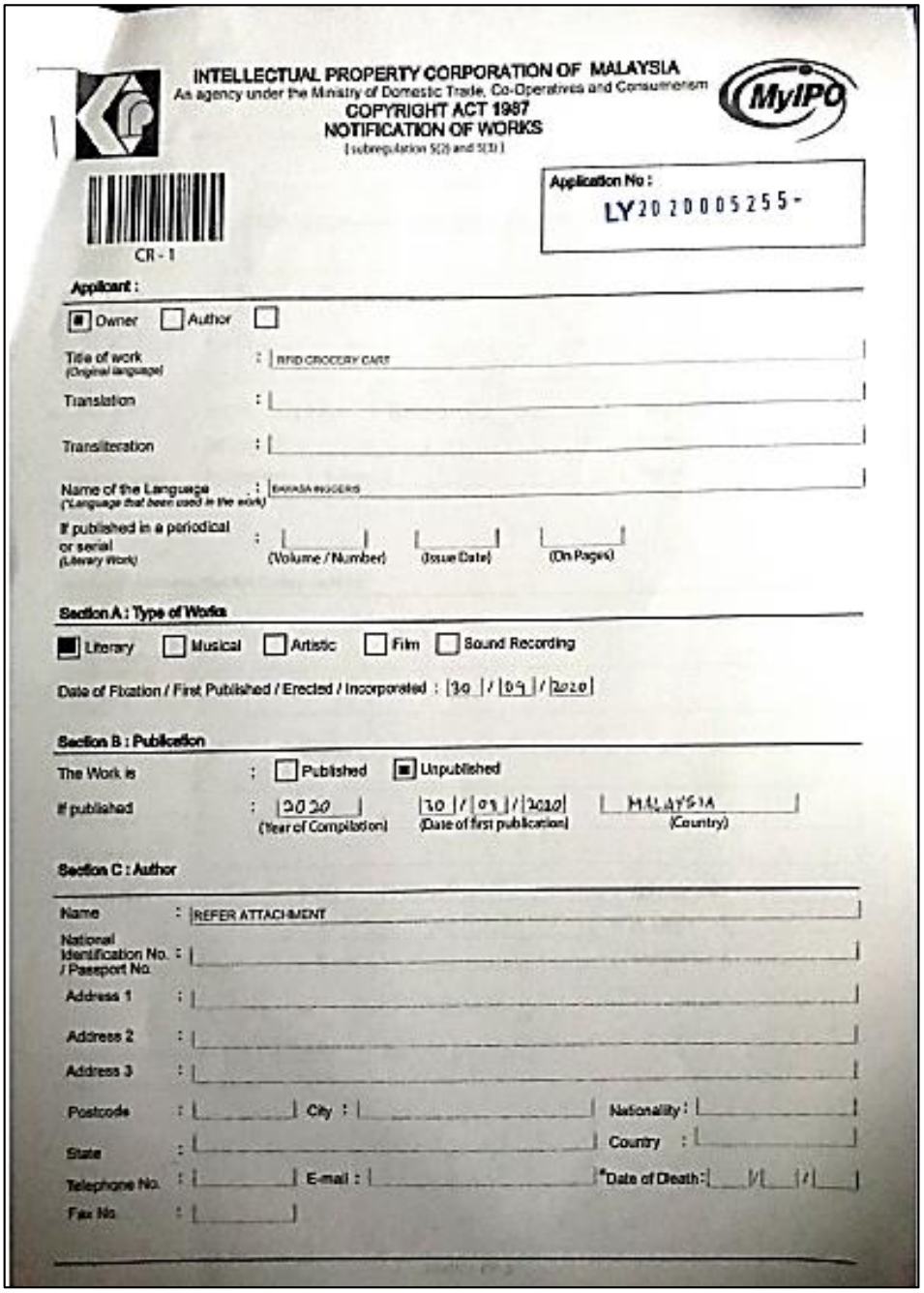

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Application No : LY2020005255

Applicant :

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Title of work (Original language) : RFID GROCERY CART

Translation :

Transliteration :

Name of the Language (*Language that been used in the work) : BAHASA INGGERIS

If published in a periodical or serial (Literary Work) : (Volume / Number) (Issue Date) (On Pages)

Section A : Type of Works

[■] Literary [ ] Musical [ ] Artistic [ ] Film [ ] Sound Recording

Date of Fixation / First Published / Erected / Incorporated : 30 / 09 / 2020

Section B : Publication

The Work is : [ ] Published [■] Unpublished

If published : 2020 (Year of Compilation) 30 / 09 / 2020 (Date of first publication) MALAYSIA (Country)

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Address 1 :

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Section F : Contact Person

Name : DR. HJH WAN ROSE MEHAH BINTI WAN OMAR

National Identification No. / Passport No. : 742606-03-6083

*Company Name : RESEARCH AND INNOVATION UNIT, POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

*Company Registration No. :

Address 1 : PERSIARAN USAHAWAN, SEKSYEN U1

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