DEPARTMENT OF AIRCRAFT MAINTENANCE

FINAL PROJECT E -THESIS

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A REPORT SUBMITTED TO DEPARTMENT OF AIRCRAFT MAINTENANCE
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR A DIPLOMA
ENGINEERING IN AIRCRAFT MAINTENANCE

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ACKNOWLEDGEMENT

We would like to express our heartfelt gratitude to our parents for their unwavering support and sacrifices throughout our journey in completing this end-of-semester project at Polytechnic Banting Selangor. Their dedication to our education has been instrumental in our success.

We would also like to extend our deepest appreciation to our project supervisor, Mr. Muhammad Faez Bin Nordin, for his continuous assistance, support, and guidance. His enthusiasm and professionalism have been a constant source of motivation and inspiration for us, especially during challenging times when we faced difficulties or lacked ideas. Whenever we reached out for help, he was always there to lend a hand and offer words of encouragement, helping us overcome obstacles.

A special thanks goes to our lecturers from the Aircraft Maintenance Department for granting us access to the workshop and providing valuable advice, guidance, and supervision throughout the project. Their input and ideas greatly contributed to the successful completion of our project.

We would like to express our deep appreciation to our team members for their cooperation, dedication, and willingness to contribute their time, energy, and ideas. Without their unwavering commitment, we would not have been able to complete this project. Their support and collaboration have been invaluable, and we are grateful for their relentless efforts.

Lastly, we would like to extend our infinite thanks to everyone involved, especially Polytechnic Banting Selangor, for their support and encouragement throughout the project. We acknowledge that the contributions and assistance received from various parties, whether direct or indirect, have been blessings for our group.

ABSTRACT

The efficient and safe operation of aircraft runways is crucial for ensuring air travel security and minimizing the risk of accidents. Foreign object debris (FOD) poses a significant threat to aircraft during take-off and landing, potentially leading to damage or catastrophic failures. This abstract presents a novel foreign object detection system specifically developed for aircraft runways. The system combines advanced sensing technologies, LCD display, and coding programming, to detect and locate foreign objects on the runway surface. The system's design focuses on real-time monitoring, rapid detection, and accurate identification of FOD, enabling timely mitigation actions to be taken. Experimental evaluations demonstrate the system's effectiveness in different weather conditions and its ability to discriminate between harmless debris and potentially hazardous objects. The proposed foreign object detection system offers airports and aviation authorities a valuable tool for enhancing runway safety and reducing the risk of FOD-related incidents, ultimately improving overall air travel reliability and passenger security.

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LIST OF ABBREVIATIONS

ATC	AIR TRAFFIC CONTROL
FOD	FOREIGN OBJECT DEBRIS
FODS	FOREIGN OBJECT DETECTION SYSTEM
LED	LIGHT-EMITTING DIODE

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Nowadays, aircraft is one of the most chosen transport for those people who want to travel near or far. As an airline company, they must provide a safe and comfortable flight for the customers. Airline company also need to maintain their aircraft is in good condition and can be operated with normal operation. They must have a runway for aircraft landing and take-off and located far from residential area because it might cause noise pollution for those who are in the area.

Figure 1.1: Runway (Source: Boltmethod)

From the figure 1.1, we can see the runway are at open space and enough for aircraft take-off before flying. According to the International Civil Aviation Organization (ICAO), a runway is a defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft. An airline must be aware of the condition runway and alert with presence of Foreign Object Debris (FOD).

Foreign object damage (FOD) is a big problem in aviation maintenance industry that reduces the level of safety for an aircraft. In fact, it can only be controlled and minimized properly by using the right and precise control method. Basically, FOD is known as Foreign Object (FOD) that can cause severity and destruction to the aircraft such as engine failure and loss of human life. Nowadays, there are many cases of FOD that happen due to some reasons and this situation leads to a survey on aviation safety in the aviation industry. The result has indicated that FOD is the most potential ground base destruction because that contributes to catastrophic aviation failure.

FIGURE 1.2: FOD detector (Source: BusinessAviation)

The figure 1.2 shows an example Foreign Object Debris (FOD) detector used to detect foreign object that presence on runway. The detector is connected as to transmit information to Aircraft Traffic Airline (ATC) when detected FOD.

1.2 PROBLEM STATEMENT

FIGURE 1.3: Piper PA-31 Crash (Source: AustralianTransportSafetyBureau)

On 27 November 2018, a Piper PA-31 was operating a charter flight with one pilot and three passengers on board to Palm Island, Queensland.

After landing, the nose wheel tyre was punctured by foreign object debris (FOD)[1] on the runway. The nose wheel began to vibrate resulting in the pilot braking with caution and applying back pressure[2] to alleviate the pressure on the nose wheel. The rubber on the tyre started to disintegrate and the rim of the wheel dug into the soft asphalt, caused by the extremely hot conditions.

The tyre became caught between the rim and the fork of the nose gear, which acted as a brake and rudder causing the aircraft to veer to the right and off the runway resulting in a nose gear failure. The pilot shut down both engines to reduce the possibility of debris becoming projectiles and to minimise damage to the aircraft before both propellers struck the ground unpowered.

Figure 1.4: Australian Governance (Source: AustralianTransportSafetyBureau)

The accidents are happened at Palm Island, Queensland on 27 November 2018. From this article, we can conclude that Foreign Object Debris (FOD) was the main factors for the accident to happen. The pilots cannot control the aircraft when the tires became caught between the rim and the fork of the nose gear. These happened because of the careless Aircraft Traffic Control (ATC) that did not care of the presence of Foreign Object Debris (FOD) on runway.

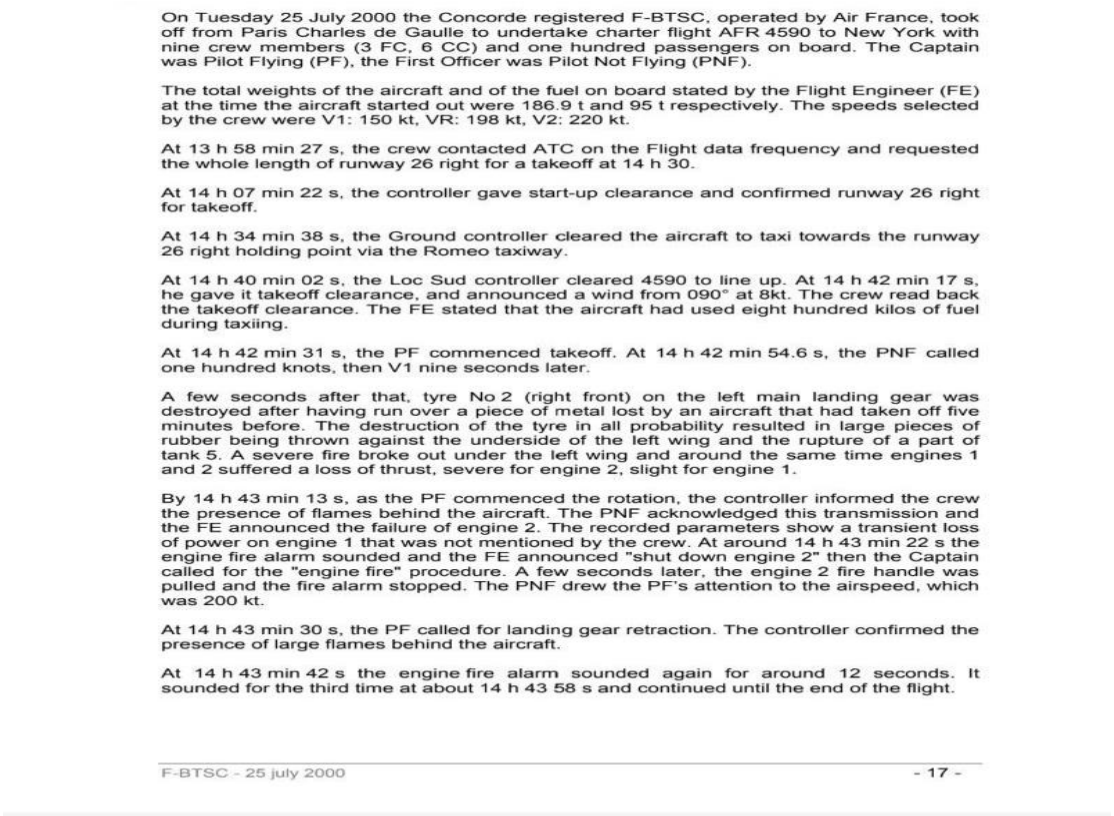
Fortunately, 3 passenger and the pilot were safe and escaped without any severe injuries.

Aircraft Traffic Control (ATC) and airport crew are responsible to check runway clear from Foreign Object Debris (FOD) to make the aircraft to have safe landing and take-off. Most of the Foreign Object Debris (FOD) on runway are from technological factor, human factors and less nature factor. Fuel caps, landing gear, fitting, nuts and metal sheets are example for technological factor. Human factor that has on runway such as mechanic tools, catering supplies and their debris, personnel badges, maintenance and construction equipment.

Figure 1.5: Concorde Air Crash (Source: DevastingDisasters)

Figure 1.5 shows the accidents of Concorde Flight at Gonesse, France on 25 July 2000. The accidents took one hundred and nine life who were one hundred are the passengers and the other nine were crew of the aircraft. Based on the investigation, these happened because of the French authorities did not complete runway inspection before the concord was ready to take-off. The accidents caused the hotel that the aircraft crashed onto and the aircraft destroyed completely.

Based on report made by BUREAU D'ENQUETES ET D'ANALYSES POUR LA SECURITE DE L'AVIATION CIVILE, (page 17, 18):



On Tuesday 25 July 2000 the Concorde registered F-BTSC, operated by Air France, took off from Paris Charles de Gaulle to undertake charter flight AFR 4590 to New York with nine crew members (3 FC, 6 CC) and one hundred passengers on board. The Captain was Pilot Flying (PF), the First Officer was Pilot Not Flying (PNF).

The total weights of the aircraft and of the fuel on board stated by the Flight Engineer (FE) at the time the aircraft started out were 186.9 t and 95 t respectively. The speeds selected by the crew were V1: 150 kt, VR: 198 kt, V2: 220 kt.

At 13 h 58 min 27 s, the crew contacted ATC on the Flight data frequency and requested the whole length of runway 26 right for a takeoff at 14 h 30.

At 14 h 07 min 22 s, the controller gave start-up clearance and confirmed runway 26 right for takeoff.

At 14 h 34 min 38 s, the Ground controller cleared the aircraft to taxi towards the runway 26 right holding point via the Romeo taxiway.

At 14 h 40 min 02 s, the Loc Sud controller cleared 4590 to line up. At 14 h 42 min 17 s, he gave it takeoff clearance, and announced a wind from 090° at 8kt. The crew read back the takeoff clearance. The FE stated that the aircraft had used eight hundred kilos of fuel during taxiing.

At 14 h 42 min 31 s, the PF commenced takeoff. At 14 h 42 min 54.6 s, the PNF called one hundred knots, then V1 nine seconds later.

A few seconds after that, tyre No 2 (right front) on the left main landing gear was destroyed after having run over a piece of metal lost by an aircraft that had taken off five minutes before. The destruction of the tyre in all probability resulted in large pieces of rubber being thrown against the underside of the left wing and the rupture of a part of tank 5. A severe fire broke out under the left wing and around the same time engines 1 and 2 suffered a loss of thrust, severe for engine 2, slight for engine 1.

By 14 h 43 min 13 s, as the PF commenced the rotation, the controller informed the crew the presence of flames behind the aircraft. The PNF acknowledged this transmission and the FE announced the failure of engine 2. The recorded parameters show a transient loss of power on engine 1 that was not mentioned by the crew. At around 14 h 43 min 22 s the engine fire alarm sounded and the FE announced "shut down engine 2" then the Captain called for the "engine fire" procedure. A few seconds later, the engine 2 fire handle was pulled and the fire alarm stopped. The PNF drew the PF's attention to the airspeed, which was 200 kt.

At 14 h 43 min 30 s, the PF called for landing gear retraction. The controller confirmed the presence of large flames behind the aircraft.

At 14 h 43 min 42 s the engine fire alarm sounded again for around 12 seconds. It sounded for the third time at about 14 h 43 58 s and continued until the end of the flight.

F-BTSC - 25 july 2000 - 17 -

At 14 h 43 min 56 s, the PNF commented that the landing gear had not retracted and made several callouts in relation to the airspeed.

At 14 h 43 min 59 s, the GPWS alarm sounded several times. The FO informed ATC that they were trying for Le Bourget aerodrome. The recorded parameters then indicate a loss of power on engine 1. A few seconds later, the aircraft crashed onto a hotel at "La Patte d'Oie" in Gonesse at the intersection of the N17 and D902 roads.

Figure 1.6: Report form (Source: Bureau D'enquetes Et D'analyses Pour La Securite De L'aviation Civile)

As a conclusion for this report, the Aircraft Traffic Control (ATC) was careless about the presence of foreign object debris (FOD) on runway before the aircraft are going to land. The causing of flame under the aircraft's wing and severe loss of thrust on engine 2 and then engine 1 which is the ignition of the leaking fuel by an electric arc in the landing gear bay with the hot parts of the engine with forward propagation.

1.3 PROJECT OBJECTIVES:

1.3.1 General Project Objectives:

This project aimed:

1. To alert Aircraft Traffic Control (ATC) presence of FOD on runway.
2. To make sure the design of the detector similar to the chosen concept.
3. To improve the FOD detection system

1.3.2 Specific Individual Project Objectives:

1.3.2.1 Product Structure

This project aimed:

- To design the FOD detector which comprises 4 different type of design FOD detector.
- To design FOD detector that suitable on airport runway without disturbing aircraft take-off and landing.
- To furnish the FOD detector with the material that can be designed aesthetic look and can withstand when good or bad weather.
- To develop FOD detector that has high quality, stability and durability.

1.3.2.2 Electrical/Electronic Mechanism

This project is aimed:

- To design and embed the electrical and electronic components to the FODS which link to the electrical system.
- To design and develop appropriate software programming which encode Arduino programming language as part of the system.
- To design and develop electrical and electronic component which can be a main mechanism for our project.

1.3.2.3 Software/Programming

This project is aimed:

- To design and embed the electrical and electronic components to the FODS which link to electrical system.
- To design and develop appropriate software programming which encode Arduino programming language as part of the detection system.
- To design and develop electrical and electronic component which can be a detection system for FODS.

1.3.2.4 Design & Finishing

Design

This project aim:

- To design Foreign Object Detection System (FODS) that can withstand the unpredicted weather like sudden rain, hot weather etc.
- To design the case to fit all the electrical component.
- To design a window feature for ultrasonic sensor that can scan 120 degrees.
- To design a roof that can repel water from entering the system.

Finishing

This project aim:

- To have a good anti corrosion and can withstand high temperature.
- To have a bright colour to make the Foreign Object System more vibrant at the tarmac.

1.4 SCOPE OF PROJECT

1.4.1 General Project Scope

First, this project is for runway detector system because its has been designed for open space situation and detect presence of foreign object debris (FOD). The Aircraft Traffic Control (ATC) need to inform line maintenance when the detector had detected foreign object debris (FOD) before aircraft take-off or landing.

Other than that, this product will specifically design at aircraft runway to avoid any accidents for the aircraft. This project also secured the safety of passenger in the aircraft when departure and arrive.

1.4.2 Specific Individual Scope

1.4.2.1 Product Structure

The product is focused on detecting foreign object debris (FOD) and located beside the runway Road. The product structure must be suitable with the condition of the runway which is open area and high possibility of strong winds. So, the product structure must have durability and can withstand in bad weather.

The FODS need to furnish with material that can make the designed look aesthetics and corrosion or rust resistance. The finishing for Foreign Object Detection System (FODS) should be water sealant because it is protecting the detector from water and prevent from rust. The design of our project is trapezium which is suitable design for common detector design.

1.4.2.2 Electrical/Electronic Mechanism

Firstly, this product only applies on aircraft runway only. This product also is design with electrical/electronic component that can be a sensor and rotate mechanism for Foreign Object

Detection System (FODS). All component that FODS used have relation to create a detector.

First component is ultrasonic sensor, the function of this component is to detect any FOD on the runway. Next, LED to indicate which detector that detect the FOD. Besides that, Servomotor which is used to rotate the FODS 120°. Other than that, is buzzer that used to aware ATC personnel about the presence of FOD on the runway. Finally is, Arduino Uno R3, this component is very important for electrical/electronic mechanism because it is the logic board used to programming using Arduino IDE and it is also responsible to make sure other electrical/electronic component work function as programmed.

1.4.2.3 Software/Programming

Firstly, the software in this project is to write code that can detect and determine the FOD on the runway. Arduino IDE software also needs to combine all the electrical component and merge it to become one solid system that can communicate to each other, so when the ultrasonic sensor senses the presence of FOD, it can alert the ATC and maintenance personal about it.

1.4.2.4 Design & Finishing

Since this Foreign Object Detection System (FODS) while be located at aircraft runway, the design must protect the electrical system from the unpredicted weather like sudden rain, hot weather and other unpredicted scenario. The case design also needs to have a sufficient space to accommodate all the electrical component inside. Also, this design should have a window that can allow ultrasonic sensor to scan 120 degrees. Last but not least, this design also need to have a good roofing design to redirect water away from entering the system

This project also needs to have a good anti corrosion finishing and can withstand high temperature because this system will be exposed to all sorts of weather. Also, this project needs to have a bright colour to make it more stand out at the runway or tarmac.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL LITERATURE REVIEW

Foreign Object Debris (FOD) at airports includes any object found in an inappropriate location that can damage equipment or injure personnel. FOD includes a wide range of material, including loose hardware, pavement fragments, catering supplies, building materials, rocks, sand, pieces of luggage, and even wildlife. FOD is found at terminal gates, cargo aprons, taxiways, runways, and run-up pads.

There are 3 main areas that should not presence of FOD which is runway, taxiway and base maintenance. The various FOD on runway is example as object that fallen from aircraft or vehicles, broken ground equipment and birds. Next, the various FOD at base maintenance is example as tools, materials or small parts that are used in maintenance activities aircraft maintenance and construction works while various FOD at taxiway may seem less harmful than the other areas.

The effect of FOD can causes damaging aircraft engines if ingested, cutting aircraft tyres, lodging in aircraft mechanisms preventing them from operating properly and can injuring people after being propelled by a jet blast. The resulting damage is estimated to high cost the aerospace industry and reaching million dollar per years.

FOD prevention and clearance is the responsibility of all airport users. However, the specific responsibility must be allocated to appropriate persons who must be suitably trained and

supervised. Quality assurance is an essential tool to ensure that responsible organisations and personnel carry out their allotted tasks correctly. While the airport authority is responsible for the runways, taxiways and general manoeuvring areas. Airline representatives or handling agents are normally responsible for ensuring that the gate are clear of FOD, including ground equipment. Handling contracts must specify the extent of agents' responsibilities and agents' procedures must specify how these responsibilities are to be exercised.

2.2 Specific Literature Review

2.2.1 Product Structure

The body structures for FOD Detector are commonly made with durability and hardness to maintain the shape of the project and can withstand in any weather. The body structure must be strong and stick to the ground because the location of the FOD detector is at runway and exposes with strong winds and wind from an aircraft that may causes the detector hover. The product structure of fod detector must have stability and not easy swaying that might cause false detection of FOD.

2.2.1.1 Aluminium

Aluminium is a chemical element and has density lower than those of other common metals. Aluminium is lightweight, durable, malleable and corrosion-resistant that make it valuable in engineering material. This metal is widely used for components in the aerospace, transportation and construction industries. One of the most well-known properties of aluminium is the fact that it is a very lightweight metal, though it still retains its strength when combined with other metals. It is also malleable, meaning that it can be easily shaped or formed using pressure or force. This property is part of what gives aluminium its many uses, such as the ability to be shaped into soda cans or foil. Other properties include the fact that aluminium is non-toxic, a great conductor and is resistant to heat and corrosion.

Figure 2.1: Aluminium (Source: LBAluminiumGroup)

2.2.1.2 Perspex

Perspex or also known acrylic is polymethyl methacrylate (PMMA) acrylic sheet which is manufactured from methyl methacrylate monomer (MMA) and produced directly from monomer cast between two sheets of high-quality glass. The advantages of using this material is lightweight, low density and can withstand in any weather. It also one of the strongest and most durable plastic products on the market. Other than that, it is an incredibly versatile material and is used across a wide range of industries and applications. Its also can be used in applications as diverse as signs, visual communication, window glazing, acoustics, design, architecture, furniture, boat and car windows, kitchen and bathroom splash backs.

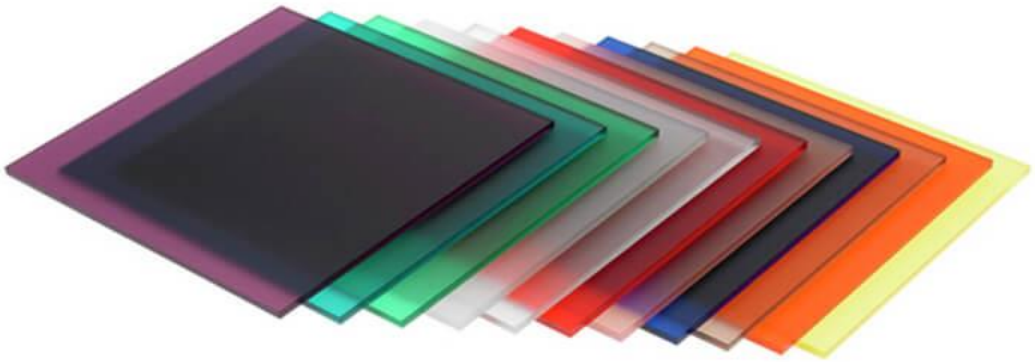


Figure 2.2: Perspex (Source: AllplasticEngineering)

2.2.1.3. Titanium

Titanium is combination of iron, aluminium, vanadium, nickel, molybdenum and other metals to produce high-performance alloys. Titanium is strong as steel but much less dense. It is therefore important as an alloying agent with many metals including aluminium, molybdenum and iron. These alloys are mainly used in aircraft, spacecraft and missiles because of their low density and ability to withstand extremes of temperature.

Figure 2.3: Titanium (Source: Titanium)

2.2.1.4. Stainless Steel

Stainless steel is mixture of iron, chromium and other metals. It is corrosion-resistant because contains chromium and forms chromium oxide which acts as a protective surface to prevent air and moisture from causing rust. Chromium is added in quantities ranging from 10.5 to 30%, depending on the application or environment in which the steel is to be used. The aviation industry also has a preference for stainless steel. It is used in various applications including the frames of airplanes because of its strength and ability to withstand extreme temperatures. It can also be applied in jet engines as it can help prevent against its rusting.

Figure 2.4: Stainless Steel (Source: Cubii.co)

2.2.1.5. Thermoset

Thermoset is a polymer that is irreversibly hardened by heat and cannot successfully be remolded or reheated after initial heat-forming or moulding. It tends to be heat resistant but when high of intensity is applied, they tend to decompose before reach the melting point. It is strong chemical bond between molecules which do not separate on heating and made it hard and brittle. It also highly adaptable design process with ability to thick and thin wall formation and good impact resistance**.** Thermoset components are extraordinary for applications in the automotive industry, daily appliance, electrical industry, lighting industry and energy markets because of excellent heat and chemical stability as well as superior hardness, strength and mold ability. Some common examples of Thermoset plastic components are transmission components, motor houses, valve housings, appliance knobs and handles.

There is difference between Thermoset plastic polymers and thermoplastic polymers. For Thermoset plastic polymers its properties are strong chemical bond between molecules which do not separate on heating, high heat, chemical resistance, hard and brittle. For thermoplastic polymers its properties are weak chemical bond between molecules that can be broken by heating, lower heat, chemical resistance, elastic and flexible. Organic solvents will cause damage to thermoplastic polymers but not for Thermoset plastic polymers.

Figure 2.5: Thermoset and Thermoplastic (Source: MechanicalBooster)

2.2.2 Electrical/Electronic Mechanism

Electrical mechanism is main mechanism for FODD. Electrical mechanism do not involve any mechanical mechanism, it is more to software programming and using electronic component such as Arduino board, LED, buzzer, servo and sensor

2.2.2.1 Type of Arduino Board

Arduino is an open-source platform that can be used to create electronic creations. It is made up of a physical circuit board (also known as a microcontroller) and software (called an IDE) that runs on your computer. It is used to create and upload computer code to the physical board. Type of Arduino is:

2.2.2.1.1 Arduino Uno (R3)

The Arduino UNO is a microcontroller board that can be used to control electronic devices. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, a reset button and ICSP header. It contains everything needed to support the microcontroller and just simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Figure 2.6: Arduino UNO R3 (Source: Wikipedia)

2.2.2.1.2 Arduino Nano

The classic Arduino Nano is the oldest member of the Arduino Nano family boards. It is designed for use on a breadboard, lacks a dedicated power jack, and is similar to the Arduino Duemilanove. Successors of the classic Nano include the Nano 33 IoT, which features a Wi-Fi module, and the Nano 33 BLE Sense, which features Bluetooth Low Energy and several environmental sensors.

Figure 2.7: Arduino Nano (Source: CytronTechnologies)

2.2.2.1.3 Arduino Micro

The Micro is a microcontroller board based on the ATmega32U4, which means it has 20 digital input/output pins and a 16 MHz crystal oscillator. It also includes a micro-USB connection, an ICSP header, and a reset button. The Micro has a form factor that enables it to be easily placed on a breadboard, similar to the Arduino Leonardo. The ATmega32U4 on the Micro board is similar to the ATmega32U4 on the Arduino Leonardo in that it has built-in USB communication, eliminating the need for a secondary processor. This allows the Micro to appear to a connected computer as a mouse and keyboard, in addition to a virtual (CDC) serial / COM port.

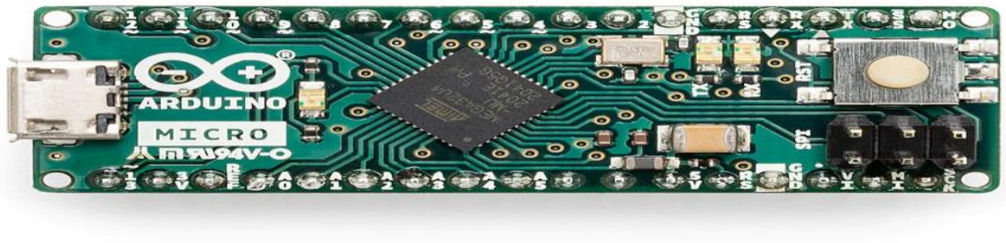


Figure 2.8: Arduino Micro (Source: ArduinoStore)

2.2.2.2 Type of LED

A light emitting diode is a type of semiconductor device that emits light when current flows through it. The color of the light is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device. Type of LED is:

2.2.2.2.1 Dual In-Line Package (DIP) LEDs

DIP LED chips are older versions of LED lighting that are still in use today. They are smaller than their newer counterparts and are commonly found built into electronic devices because of their small size. They are not very powerful, and typically only emit a limited amount of brightness.

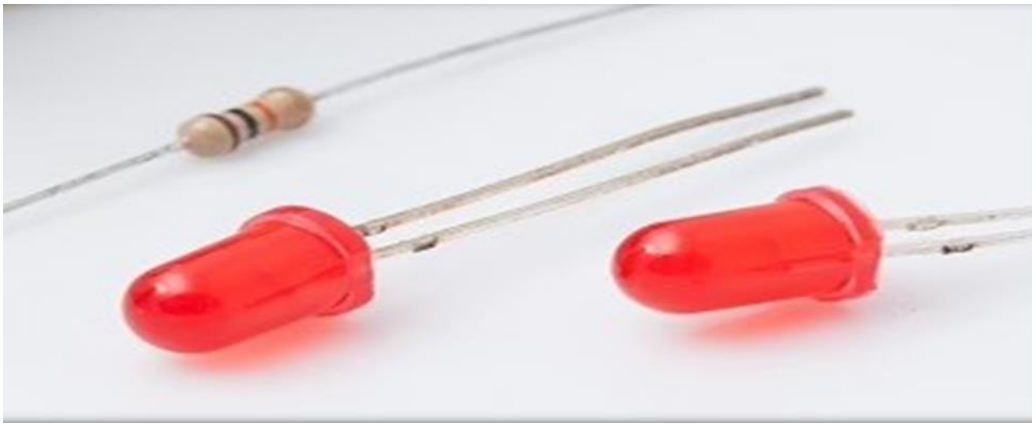


Figure 2.9: Dual In-Line Package (DIP) LEDs (Source: LEDHut)

2.2.2.2.2 Surface Mounted Diode (SMD) LEDs

These chips are attached to a circuit board and are probably the most common type of LED chip available. It is generally brighter and smaller than DIP LED chips. They can create different colors, making them more versatile when it comes to using them in electronics or lighting. There are two most common chip sizes, SMD 3528 and SMD 5050, which are both 3.5mm wide and 5mm wide, respectively.

Figure 2.10: Surface Mounted Diode (SMD) LEDs (Source: LEDHut)

2.2.2.3 Type of Buzzer

A buzzer or beeper is a type of audio signaling device, which may be mechanical, electromechanical, or piezoelectric that can be used for many different purposes, such as alarms, timers, and confirming user input.

2.2.2.3.1 Piezoelectric Buzzer

A piezoelectric element can be driven by an oscillating electronic circuit or other audio signal source, which will produce a sound when the button is pressed. This sound is usually referred to as a 'click', 'ring' or 'beep'.

Figure 2.11: Piezoelectric Buzzer (Source: Wikipedia)

2.2.2.3.2 Magnetic Buzzer

A magnetic buzzer is like a piezo buzzer, but it uses a magnetic field to make noise. Magnetic buzzers are more traditional than piezo buzzers because they work with a magnetic field instead of relying on piezo materials. This makes them sound more like traditional bells or drumheads.

Figure 2.12: Magnetic Buzzer (Source: Element14)

2.2.2.4 Type of motor

A servomotor is a type of rotary actuator or linear actuator that allows you to control its position, velocity, and acceleration very precisely. It needs a motor and a sensor to help keep track of its position, and it often requires a more specialized controller to operate properly.

2.2.2.4.1 180° Servo motor

This type of servo motor will rotate and is limited between 0° and 180°. The rotating direction will be in clockwise and counter-clockwise. Furthermore, the rotating position can be controlled to rotate to specific angle between 0° and 180°. The rotating speed can be controlled but not smoothly. It does not require extra hardware driver. We can just control directly from an Arduino pin but still need extra power supply such as battery.

Figure 2.13: 180° Servo Motor (Source: MYBOTIC)

2.2.2.4.2 Stepper Motor

For this kind of motor, the rotation is unlimited. The rotation direction is same as servo motor which is clockwise and counter-clockwise. Besides that, the rotating speed, acceleration deacceleration and de can be controlled precisely. But, the disadvantages of this motor is need extra hardware driver.

Figure 2.14: Stepper Motor (Source: Element14)

2.2.2.5 Type of Sensor

A sensor is a device that can detect physical events in the environment and send the information to other electronics. Sensors are always used with other electronics to help us understand what is happening.

2.2.2.5.1 Ultrasonic Sensor

The HC-SR04 ultrasound sensor is a sensor that can sends out a sound at 40,000 Hz, which travels through the air. If an object or obstacle is in the way, it will bounce back and the module can measure the distance.

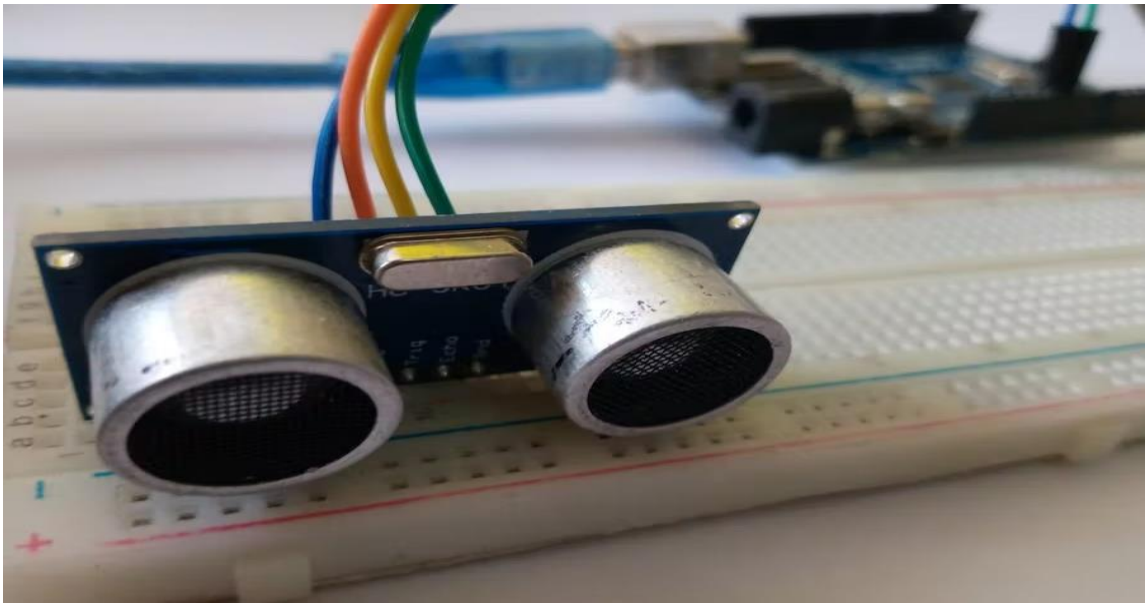


Figure 2.15: Ultrasonic Sensor (Source: ProjectHub)

2.2.2.5.2 IR Sensor (Infrared Sensor)

An infrared sensor is a piece of equipment that is sensitive to radiation in the infrared range, which is between 780 and 50 microns. This sensor is used in things like motion detectors, which are used to turn on lights or activate alarms when people or objects move around.

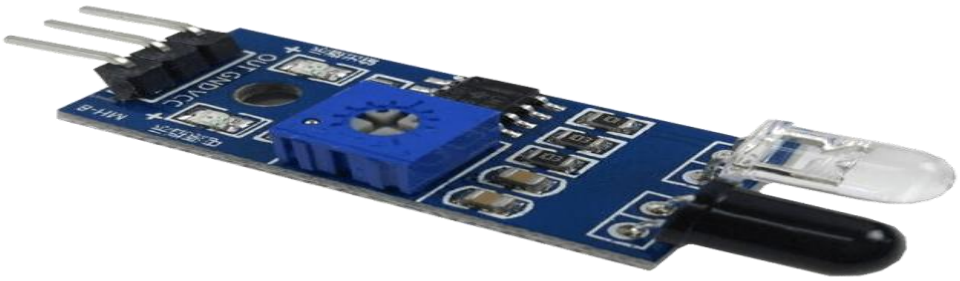


Figure 2.16: Infrared Sensor (Source: Cytron)

2.2.3 Software/Programming

This product is designed to detect and determine any FOD on runway to prevent any unnecessary incident that can happened when there is FOD on runway while an aircraft is taking off or landing. This problem is solved by creating a system that can detect any FOD by using ultrasonic sensor which is embedded in the system and can alert ATC and maintenance personnel. All this will be determined by Arduino IDE

2.2.3.1 Type of Software

A software is a set of instructions, data or programs used to operate computers and execute specific tasks. The software implemented in the FOD Detection system is used to detect and determine any FOD on runway.

2.2.3.1.1 IntelliJ IDEA

IntelliJ Idea is one of the IDE used for Java programming. This IntelliJ Idea UI has makes coding more appealing to many Java developers. Using this IDE, the code can get indexed, can provide the relevant suggestions to help and complete code lines. This IDE can automatically detect and providing relevant suggestions to help and complete code lines that may be repetitive. Apart from supporting web, this IDE also can support enterprise and mobile Java programming. It is also a good option for JavaScript, SQL and JPQL programming.

Figure 2.17: IntelliJ IDEA (source: TechRepublic)

2.2.3.1.2 Xcode

Xcode might be the best IDE tool for Apple product developers because this tool can support iOS app development using numerous iOS tools. Xcode can support programming languages such as Swift, C++ and Object-C. Using Xcode, developers can easily manage their development workflow with quality code suggestion from its interface.

Figure 2.18: Xcode (source: TechRepublic)

2.2.3.1.3 Arduino IDE

Arduino is a open-source, cross-platform IDE that can helps developers to write clean code with an option to share and copy code with other developers. Arduino supports both online and local code editing environments. Developers who want to carry out sophisticated tasks without using a strain on computers resources without putting a strain on computer resource love how Arduino ide is simple to utilize it. Arduino IDE can support the newest Arduino board. Arduino also offers contemporary editor and a dynamic UI with autocompletion, code navigation and even live debuggers features. This IDE is very beginner friendly and can do many projects with it

Figure 2.19: Arduino (source: TechRepublic)

2.2.4 Design & Finishing

This product can first be used on an aeroplane runway. This product also rely on electrical and electronic components, which can support this device's functionalities and ensure they are error-free. The electrical components or internal parts should always be protected in order to retain its operations and quality.

2.2.4.1 Clear Coating

A clear coating is a substance that based on water or solvent. This coating usually uses sophisticated cross-linking process, it gives them an outstanding bonding capability. Clear coating also advantageous for all metal.

Figure 2.20: Clear Coat (Source: CarBuilders)

2.2.4.2 Water Sealant

Water Sealant products protect electronic components from contaminants, overheating, rust, shock, vibration and moisture. The rest, such as circuit boards, strain-sensitive parts, and coils are made with resins.

Figure 2.21: Water Sealant (Source: RaymingPCB&Assembly) 30

2.2.4.3 Conformal Coating

Printed circuit boards is a protected layer of thin polymeric film known as conformal coating (PCB). the coating adheres to the PCB's outlines, it is given the moniker conformal. Electronic circuit is usually coated with conformal coatings from a distance of 25–250 m to protect it from moisture, dust, chemicals, and extreme temperatures.

Figure 2.22: Conformal Coating (Source: Amazon.in)

2.2.4.4 Samurai Hi-Temperature Spray

High Temperature Spray shields lubricated components against rust and corrosion. Its ability to foam allows it to penetrate chains deeply. Chain’s longevity is increased by the Hi-Temperature Spray chemicals. Its paint that dries quickly and can undergo lengthy exposure to temperatures of up to 600 °C. In comparison to traditional paints, paints that contain silicone resin have greater heat resistance and do not tarnish as soon.

Figure 2.23: Hi-Temperature Spray (Source: ATKCaWarehouse)

2.2.4.5 Lithium Grease

White lithium grease is use to guard against corrosion and is for metal-to-metal applications requiring heavy-duty lubrication. Different weather won't cause this mixture to melt, freeze, or run. It is Ideal for lubricating machinery before putting it away for storage. Sprays on effortlessly and leaves a protective layer. Using it safely on metals at temperatures between 0 to 300 degrees Fahrenheit.

Figure 2.24: Lithium Grease (Source: WD-40)

CHAPTER 3

RESEARCH METHODOLOGY

3.1. PROJECT BRIEFING & RISK ASSESMENT

3.1.1 Utilisation of Polytechnic's Facilities

To access and make use of the facilities offered by the Polytechnic, including equipment, consumable materials, and tools, it is necessary to obtain permission from both the supervisor and workshop coordinator. This is done by completing the required form, which will outline the specific tools and equipment needed to successfully carry out the project.

Example of facilities used in Polytechnic:

- Composite workshop
- Engine workshop room

3.2 OVERALL PROJECT GANTT CHART

Figure 3.1: Gantt chart W1

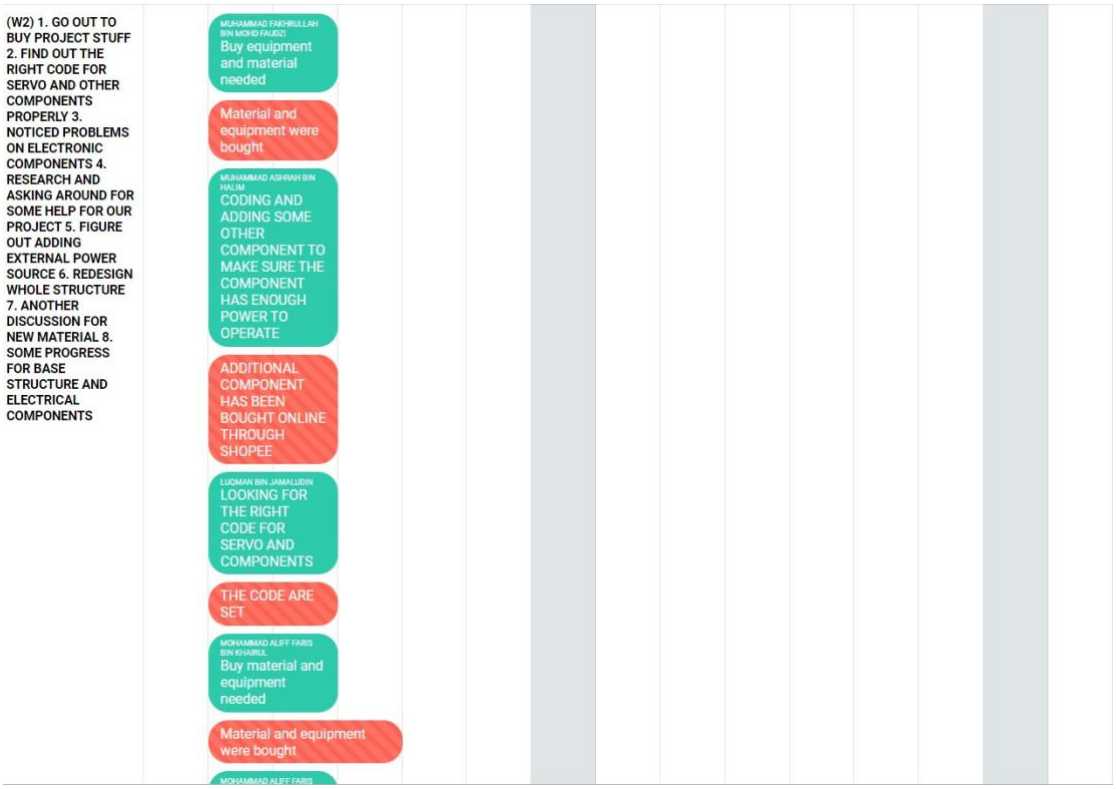


Figure 3.2: Gantt Chart W2

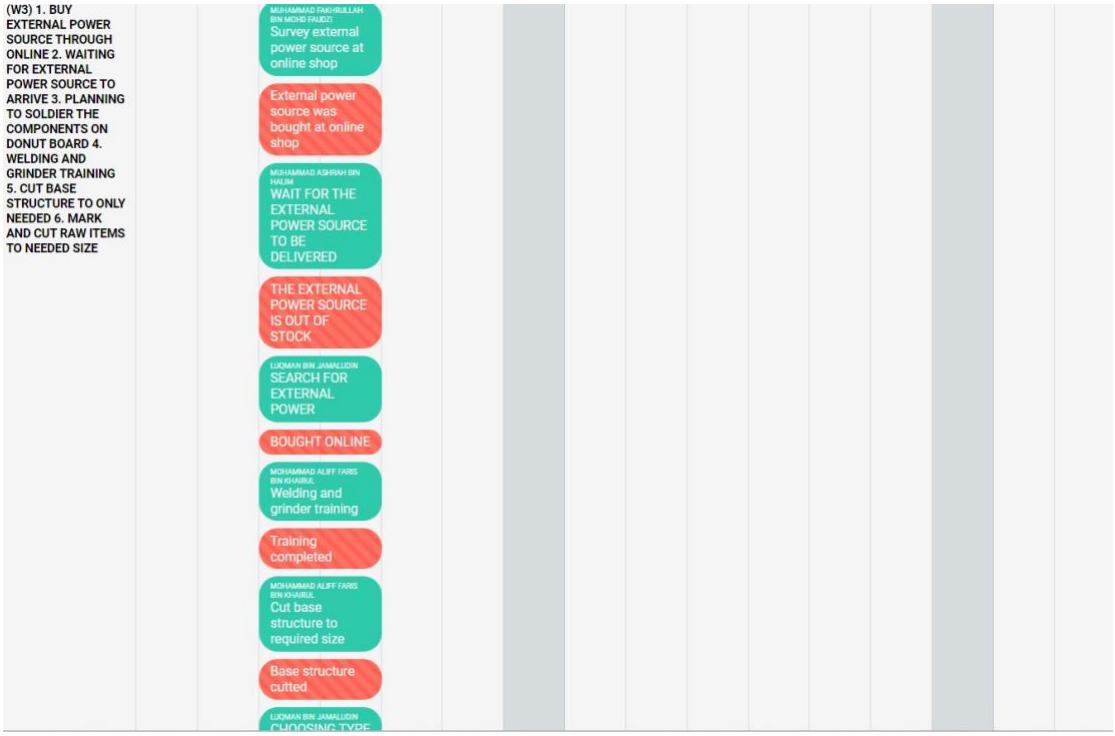


Figure 3.3: Gantt Chart W3

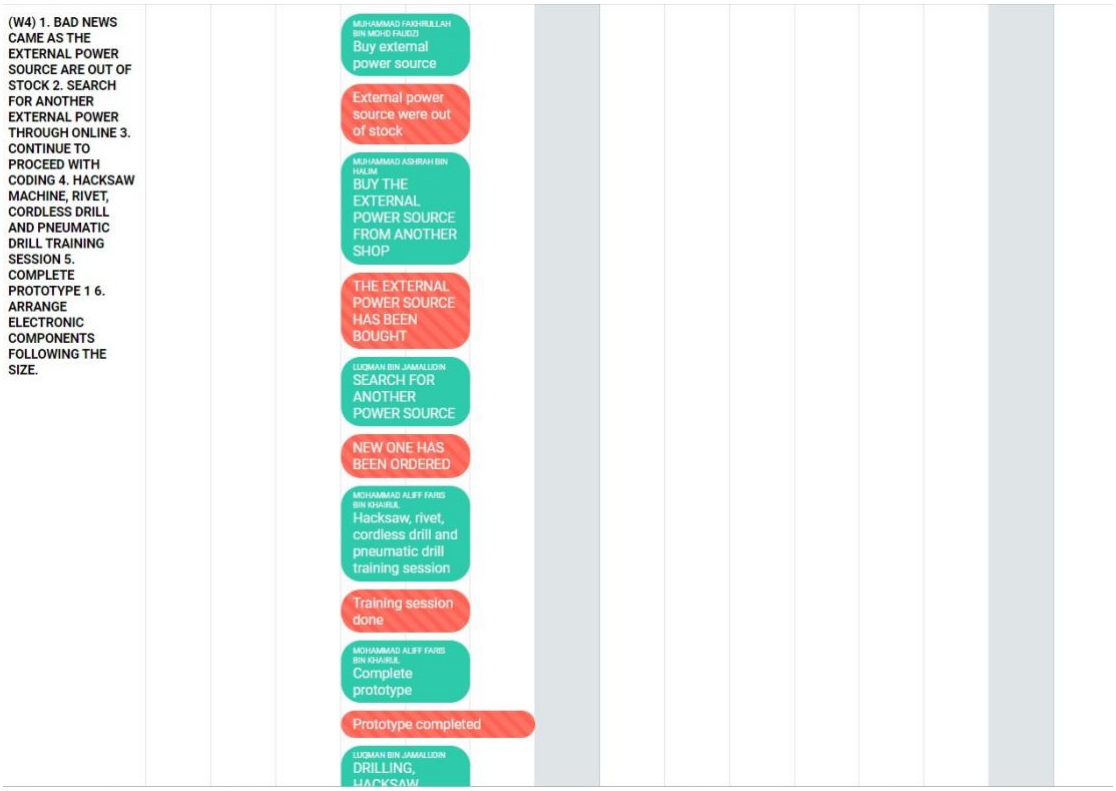


Figure 3.4: Gantt Chart W4

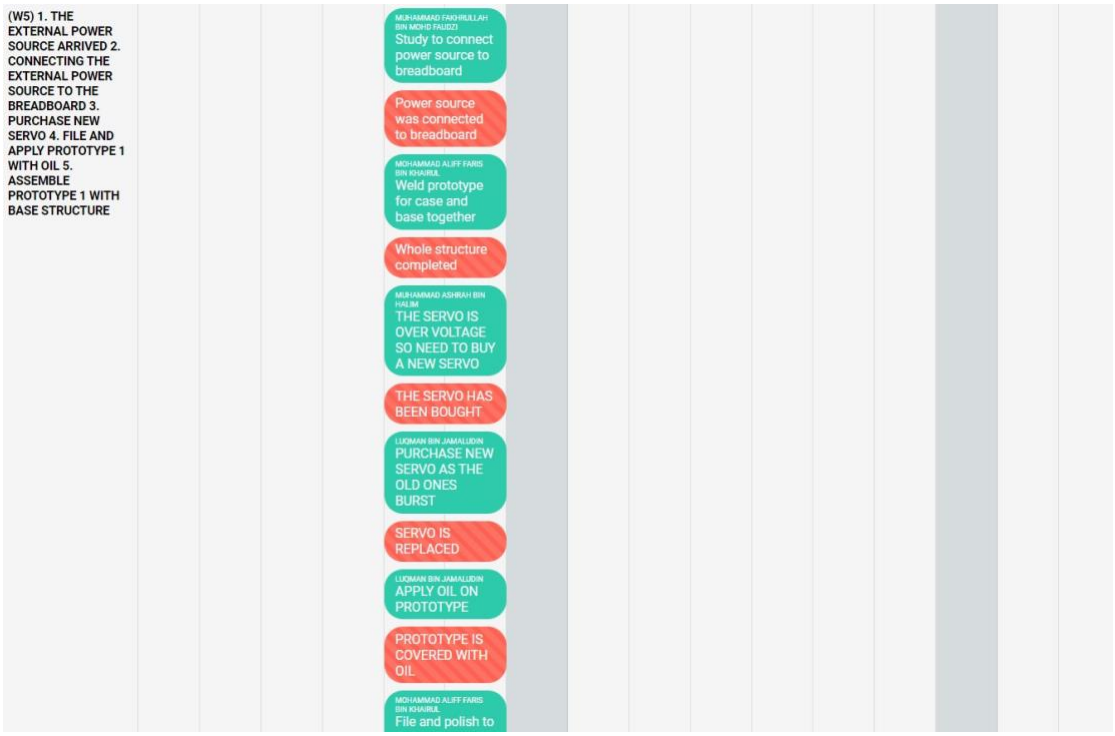


Figure 3.5: Gantt Chart W5

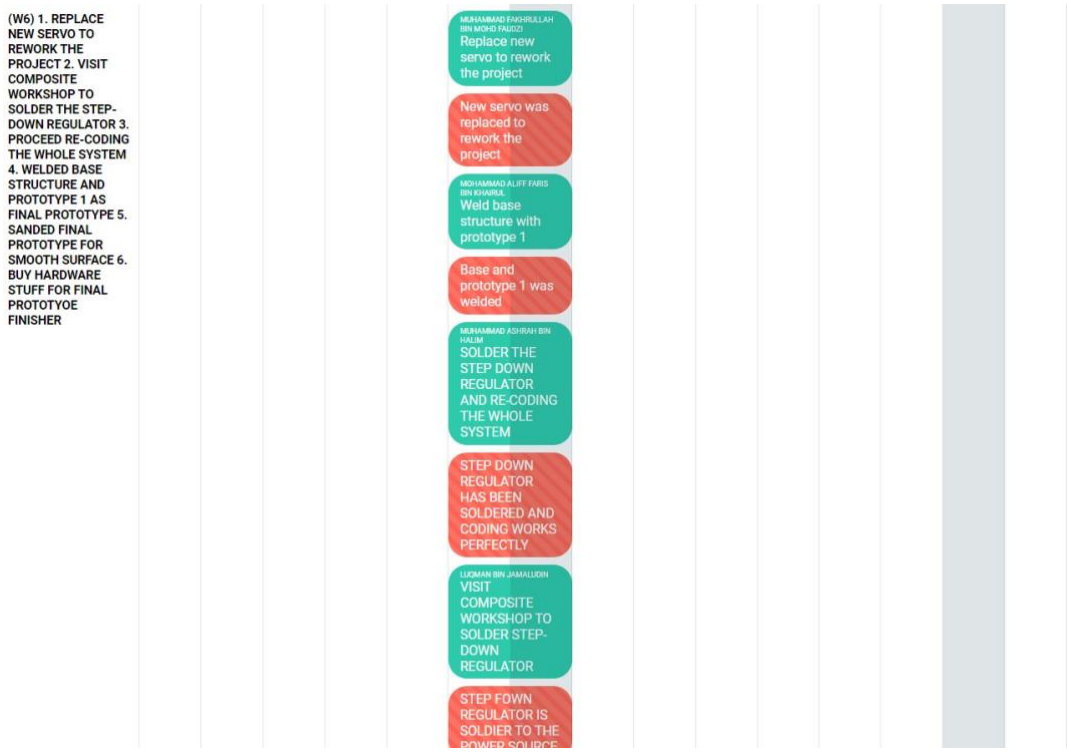


Figure 3.6: Gantt Chart W6

Figure 3.7: Gantt Chart W7

Figure 3.8: Gantt Chart W8

Figure 3.9: Gantt Chart W9

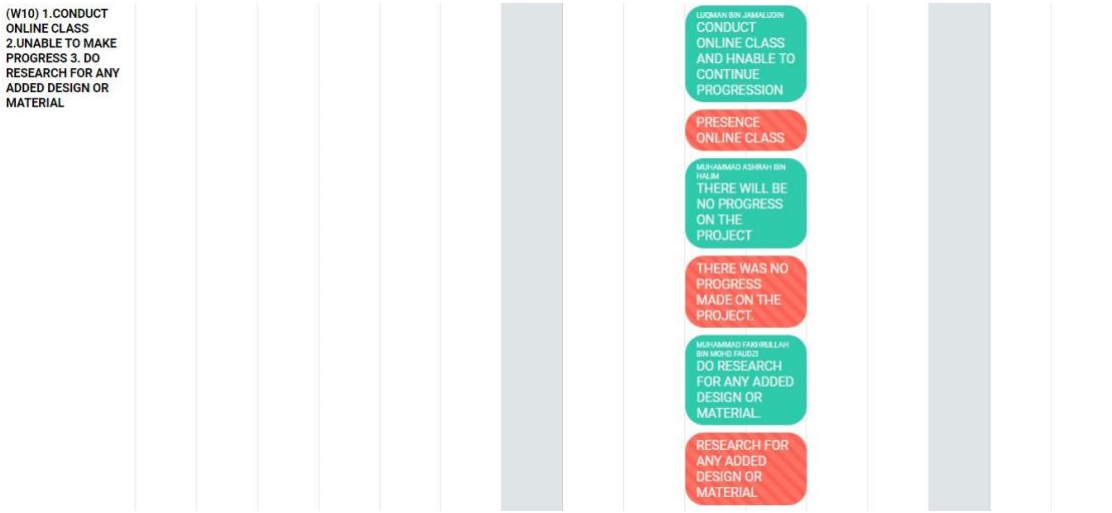


Figure 3.10: Gantt Chart 10

Figure 3.11: Gantt Chart W11

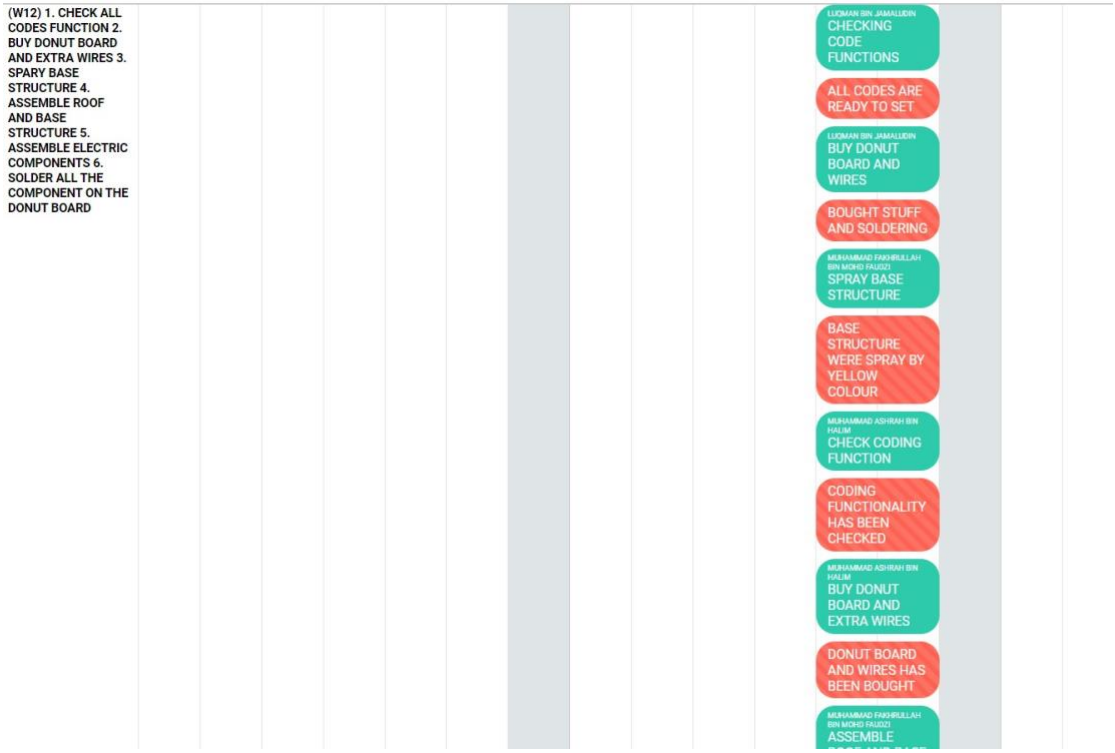


Figure 3.12: Gantt Chart W12

Figure 3.13: Gantt Chart W13

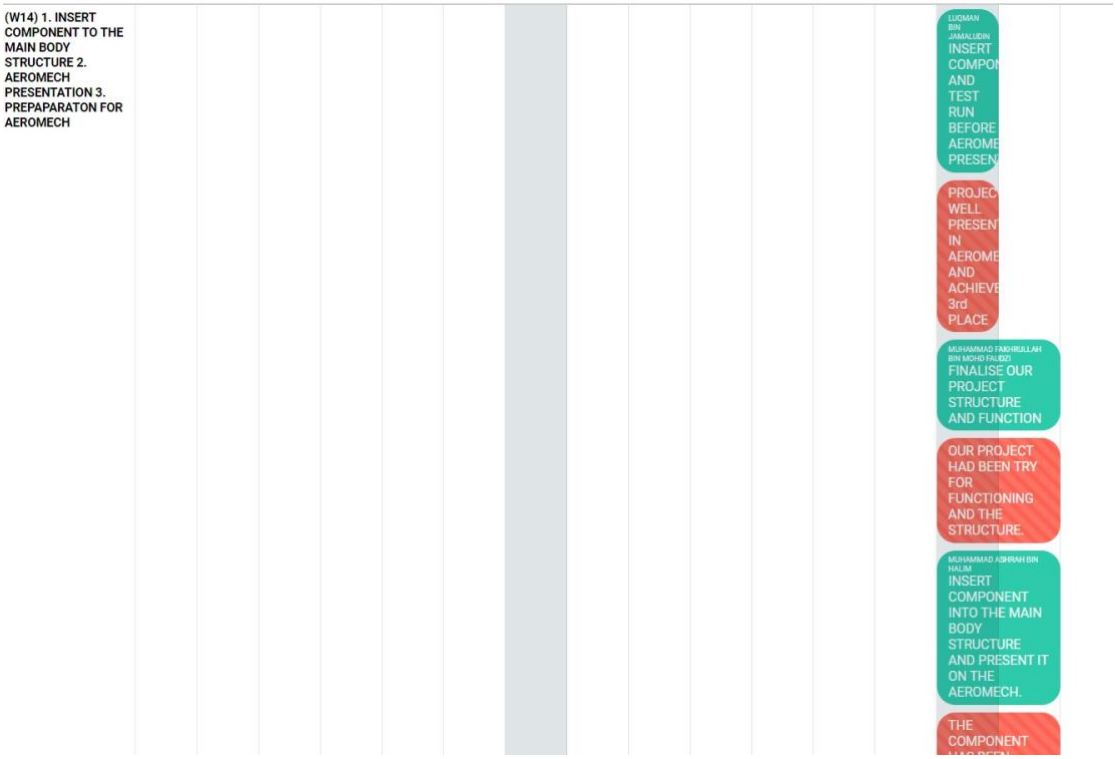


Figure 3.14: Gantt Chart W14

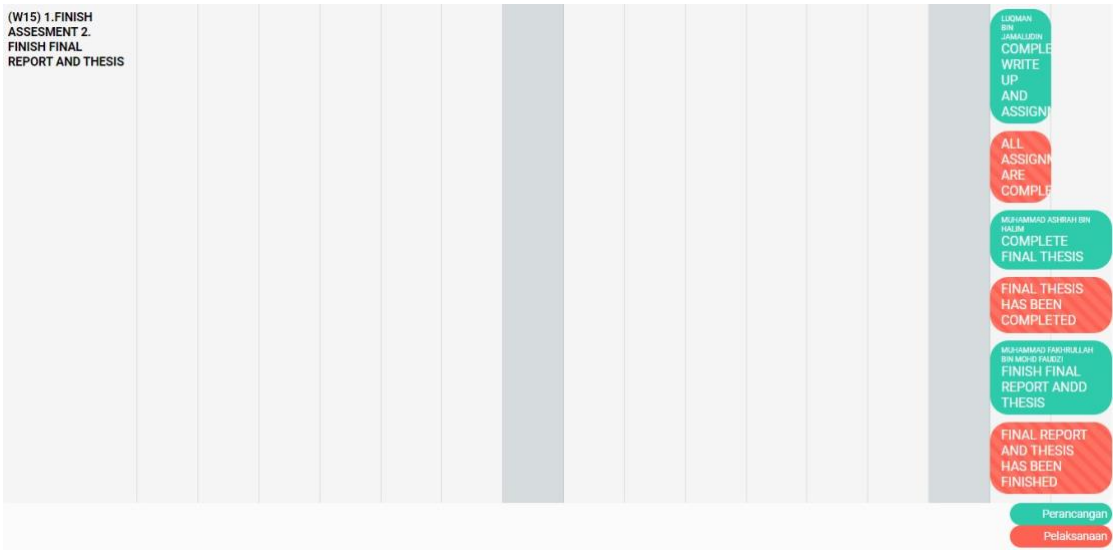


Figure 3.15: Gantt Chart W15

3.3 PROJECT FLOW CHART

3.3.1 Overall Project Flow Chart

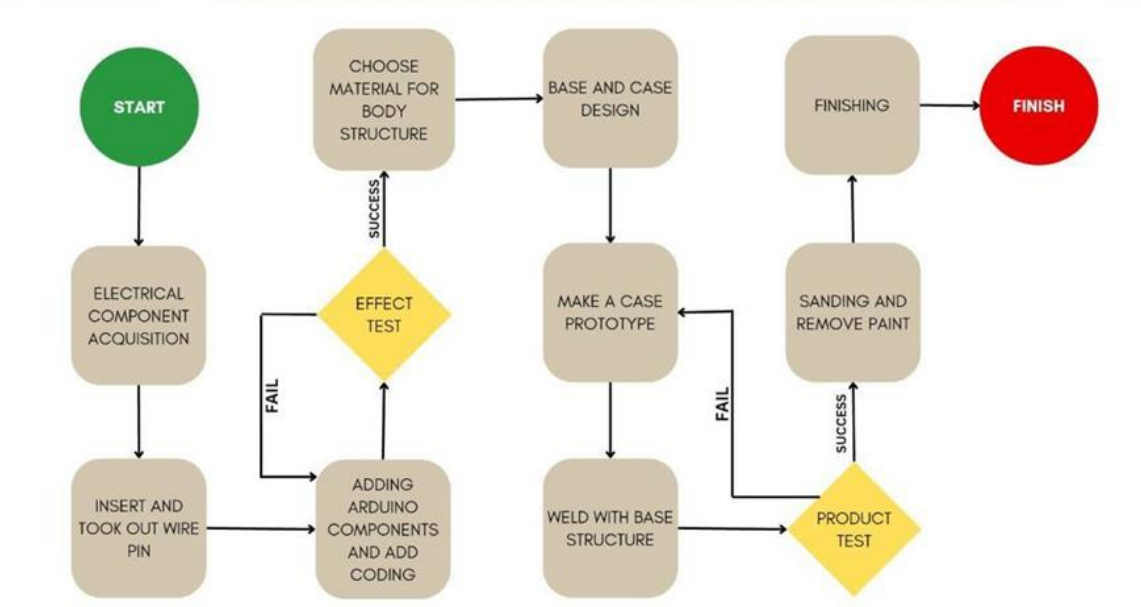


Figure 3.16: Overall Project Flow Chart

3.3.2 Specific Project Design Flow / Framework

3.3.2.1 Product Structure

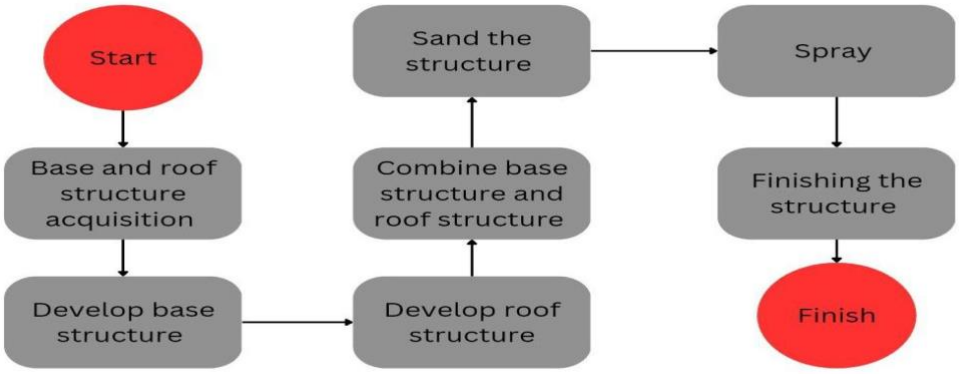


Figure 3.17: Product Structure Flow Chart

3.3.2.2 Electrical / Electronic Mechanism

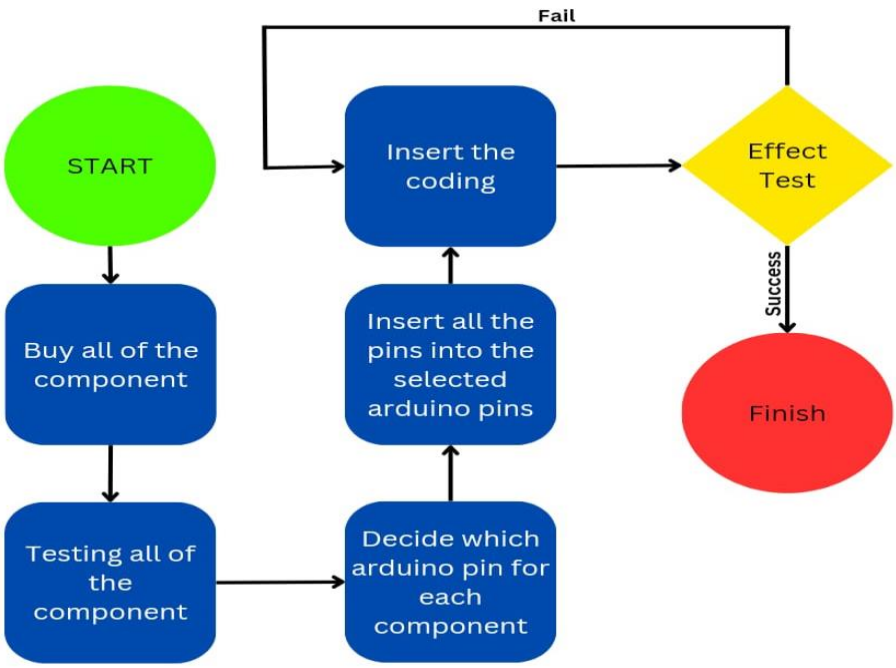


Figure 3.18: Electrical / Electronic Mechanism Flow Chart

3.3.2.3 Software / Programming

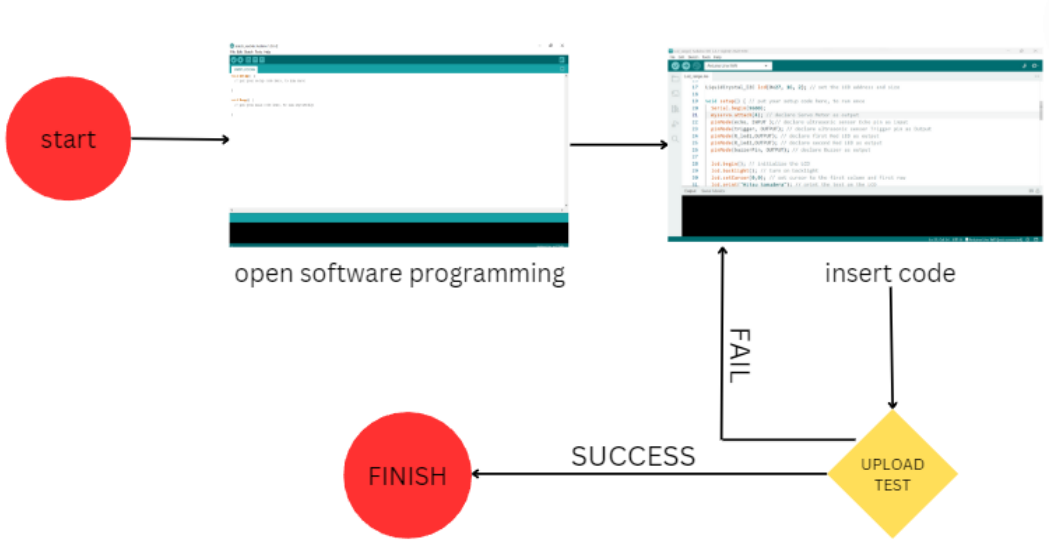


Figure 3.19: Software / Programming Flow Chart

3.3.2.4 Design & Finishing

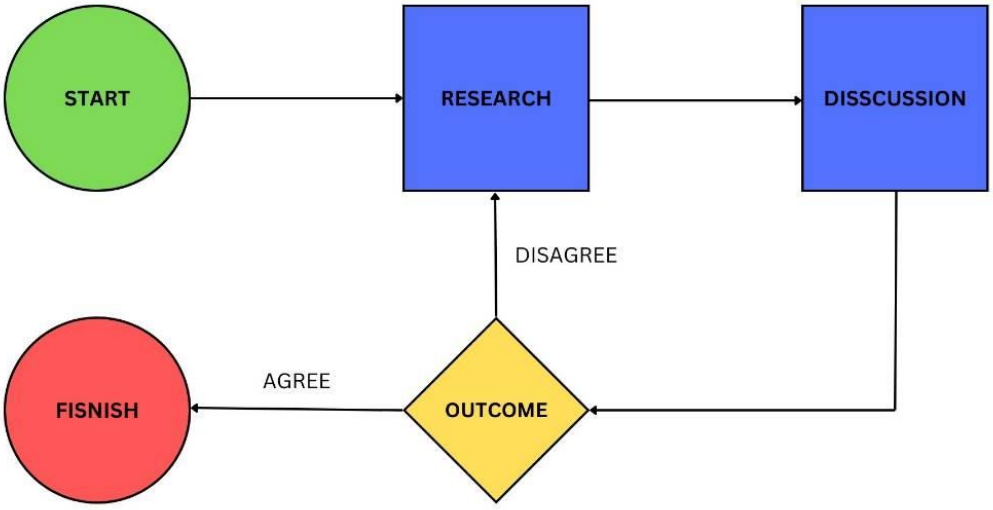


Figure 3.20: Design & Finishing Flow Chart

3.4 LIST OF MATERIALS & EXPENDITURES

3.4.1 Product Structure				
NO.	**ITEMS**	**Unit**	**Price /Unit**	**Total (RM)**
1	Stainless steel	2	-	Free (take from FYP store)
2	Perspex 8 x 15 in	1	8	8
3	Perspex 10 x 4 in	1	8	8
1	Flap grind disk	3	2.30	6.90
2	Epoxy steel adhesive	1	9.90	9.90
3	Cut grind disk	3	2.30	6.90
4	Aerosol spray paint yellow	1	9.90	9.90
5	Aerosol spray paint white	1	9.90	9.90
6	Sun paint removal	1	13.00	13.00
7	Brush	1	2.00	2.00
3.4.3 Electrical/Electronic Mechanism				
NO.	**ITEMS**	**Unit**	**Price /Unit**	**Total (RM)**
1	Arduino Uno R3	1	-	Free (take from FYP store)
2	Breadboard	1	-	Free (take from FYP store)
3	Resistor	1	-	Free (take from FYP store)
4	Servo	1	9.50	9.50
5	Buzzer	1	-	Free (take from FYP store)
6	Wire	4 sets of ten	9.80/10pcs	39.2
7	LCD	1	-	Free (take from FYP store)
8	LED	1	1.4	1.4
9	Ultrasonic Sensor	1	8.5	8.5
10	Ultrasonic Sensor Bracket	1	2.5	2.5

11	Battery Holder 2 Slot	1	4	4
12	Battery 18650	2	2.55	5.10
13	Battery 18650 Charger	1	6.5	6.5
14	Donut Board	1	5	5
15	On/Off Toggle Switch	1	4.5	4.5
Grand Total				**170.6**

Table 3.1: LIST OF MATERIALS & EXPENDITURES

3.5 PRODUCT DRAWING / SCHEMATIC DIAGRAM

3.5.1: General Product Drawing

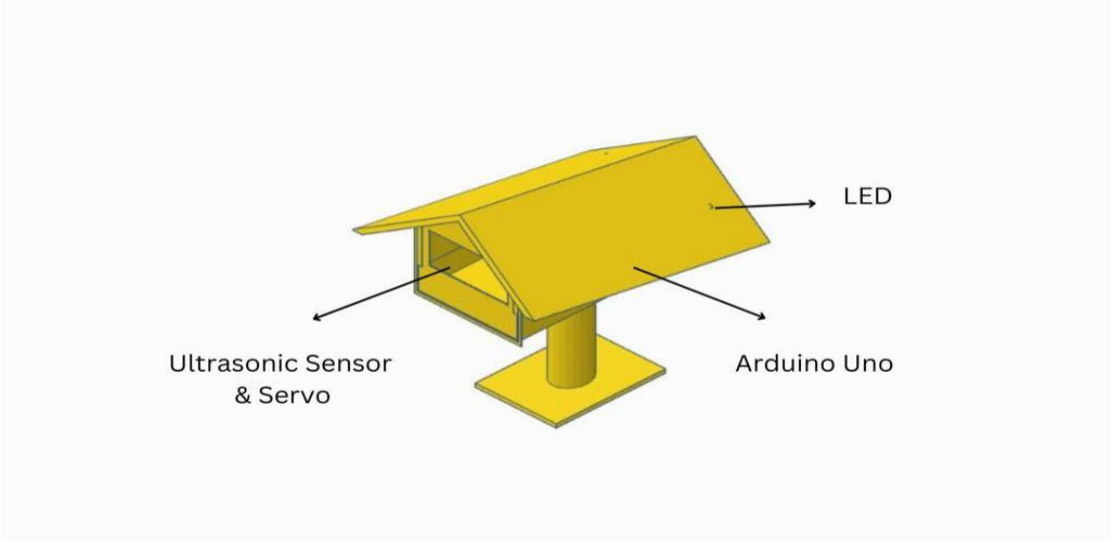


Figure 3.21: General Product Drawing

3.5.2: Specific Part Drawing / Diagram

3.5.2.1 Product Structure

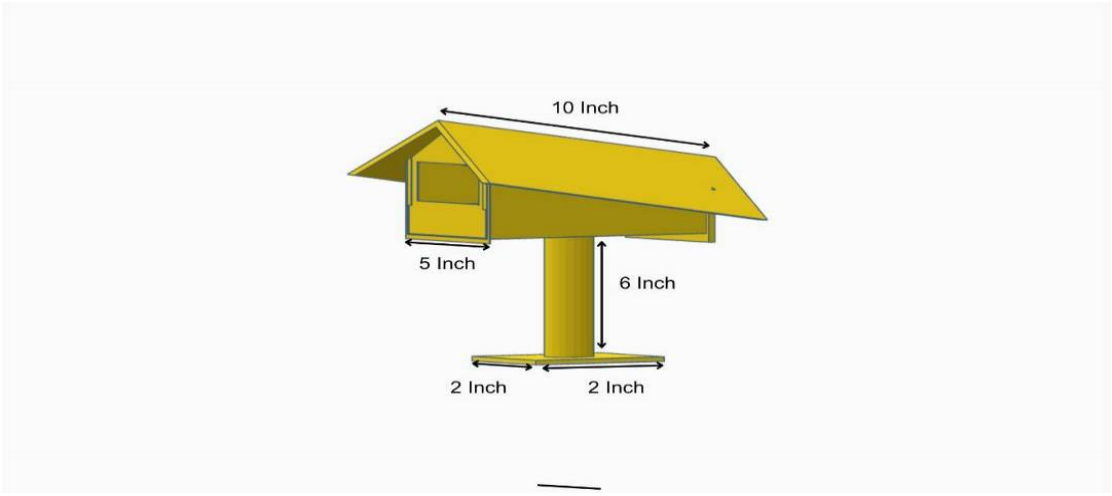


Figure 3.22: Product Structure

3.5.2.2 Electronic / Electrical Mechanism

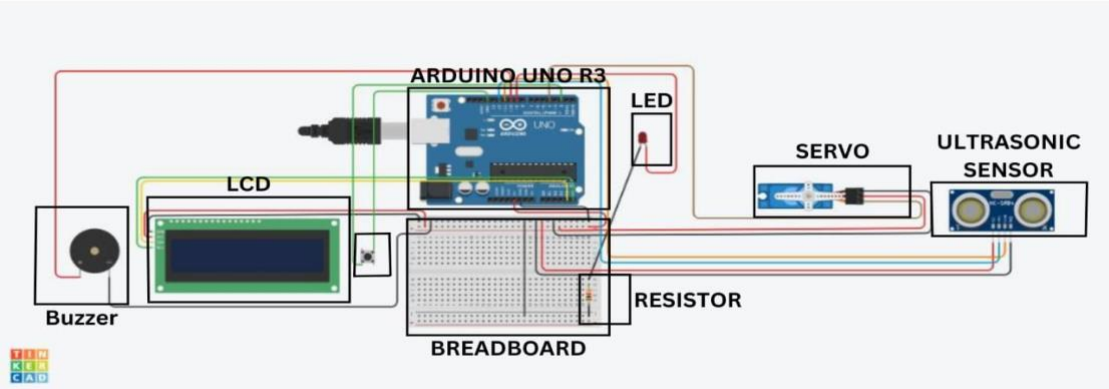


Figure 3.23: Electronic / Electrical Mechanism

3.5.2.3 Software / Programming

Figure 3.24: Software / Programming

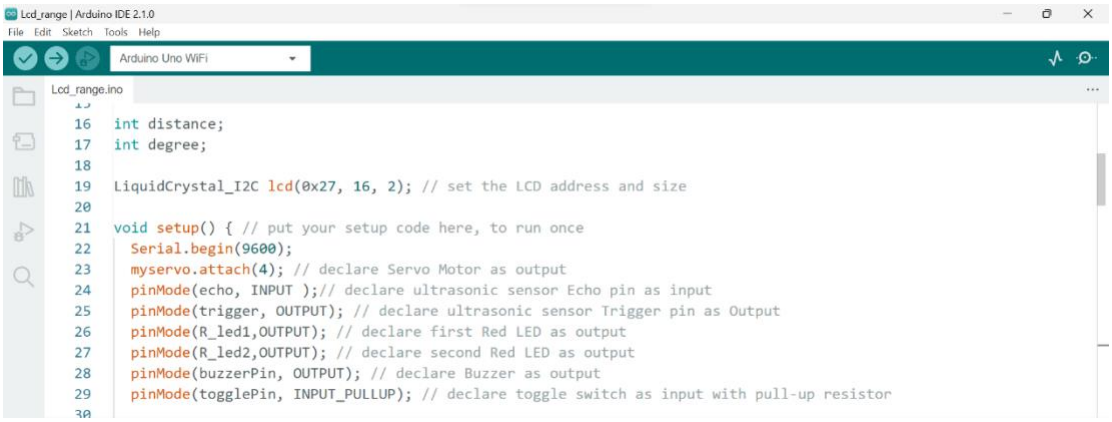


Figure 3.25: Software / Programming

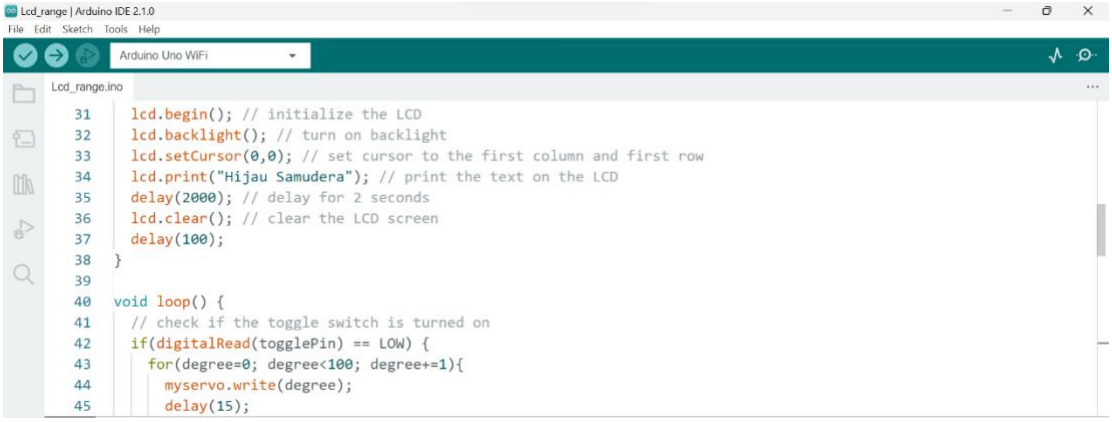


Figure 3.26: Software / Programming

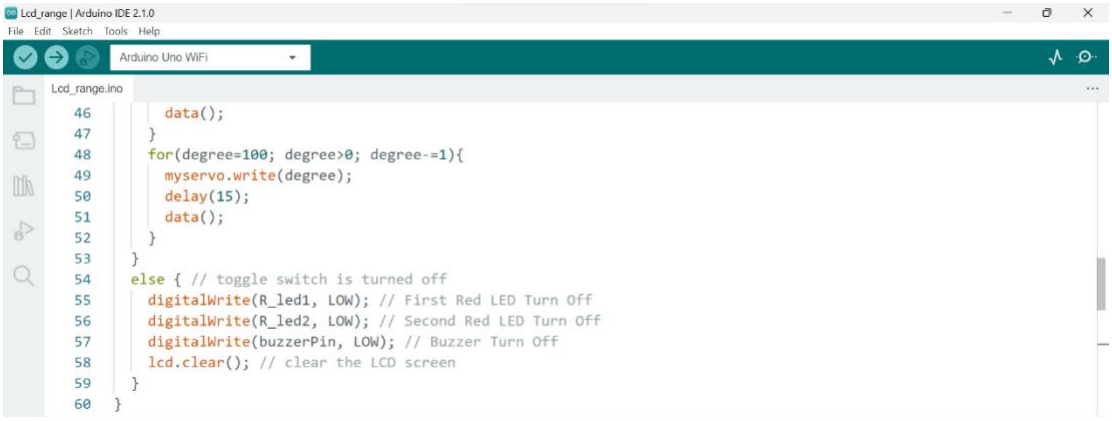


Figure 3.27: Software / Programming

Figure 3.28: Software / Programming

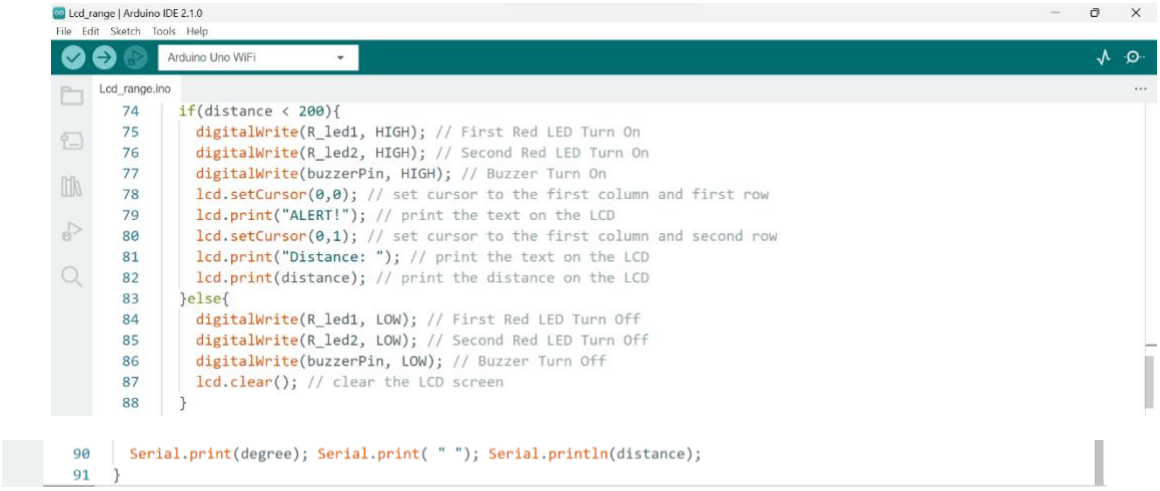


Figure 3.29: Software / Programming

3.6 DEVELOPMENT OF PRODUCT

3.6.1 Material Acquisition

3.6.1.1 Base Structure of FODS

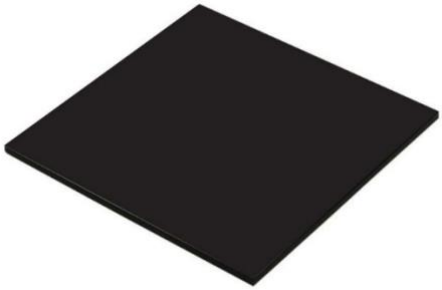
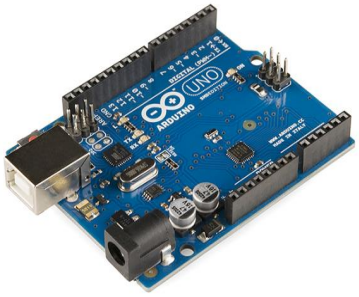
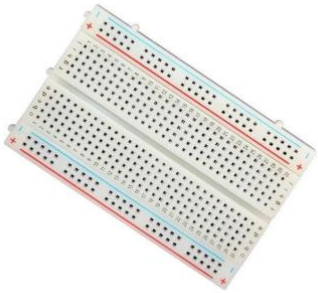
DESCRIPTION	MATERIAL
Stainless steel is used as the base structure and body structure	 Stainless Steel
Perspex are used as roof structure of FODS	 Perspex

Table 3.2: Base Structure

3.6.1.2 Electrical and Electronic Component of FODS

Description	Material
The Arduino Uno is a device that can understand and follow instructions written in code. It can control various electronic components based on those instructions.	 Arduino Uno R3
The breadboard is a tool that helps us connect jumper wires and electronic components together.	 Breadboard
The LED is used to indicate which is the detector that detect the FOD	 Red LED
The resistor is used to reduce current flow and adjust signal levels of the red LED	 Resistor

The buzzer is used for alerting the ATC personnel when detect FOD	 Buzzer
The LCD is used to indicate the distance of FOD from detector	 LCD
The toggle switch is used to turn on and off the entire system	 Toggle Switch
The Ultrasonic Sensor is used for scanning the FOD on aircraft runway	 Ultrasonic Sensor

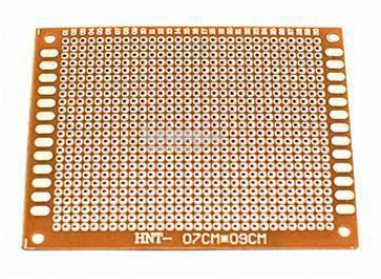
The servo is used to rotate the ultrasonic sensor 100°	 Servo
The jumper wire is used to connect all component	 Jumper Wire
The donut board is used for more solid prototyping after making an early working circuitry on a solderless breadboard	 Donut Board
The battery used to supply power to Arduino and other component	 Battery 3.7V 2 Slot

Table 3.3: Electrical and Electronic Component

3.6.2 Machines and Tools

No.	Machine Description & Usage	Types of Machines
1	• General Purposes: The basic purpose of welding is to join two elements together with a firm connection. • Project Purpose: To join the base and the body structure	 Arc Welding
2	• General Purposes: Used for cutting, grinding and polishing steel, wooden material and other material. • Project Purpose: To smoothest the welding point	 Hand Grinder

3	• General Purposes: Used for drilling hole • Project Purpose: To drill hole for LED and ultrasonic sensor.	 Pneumatic Hand Drill
4	• **General purpose**: Used for joined two materials together by melting and putting a filler metal (solder) into the joint. • **Project Purpose**: Used to solder the connection to the donut board	 Solder

Table 3.4: Machines

No.	Description	Type of Hand Tools
1.	• **General Purposes**: The tool used to remove surplus fine amounts of material from a workpiece • **Project Purpose:** To smoothest the edges of product structure	 File
2.	• **General Purposes**: It used to secure an object to allow work to be performed on it during saw, drilling, filing and others task • **Project Purpose:** It use to hold the structure	 Bench vice
3.	• **General Purposes**: To cut the Perspex • **Project Purpose:** To cut the Perspex for roof structure	 Acrylic Cutter

4.	• **General Purposes:** The instrument used to measure internal and external distances such as diameter and length of the object. • **Project Purpose:** It is used to measure the diameter of hole LED	 Vernier Caliper
5.	• **General Purposes**: The tool suitable for carpenters use. It used for measurement, especially for right-angles • **Project Purpose:** Used for measured length and make a horizontal line	 L Square
6.	• **General Purposes**: Cutting the hard object • **Project Purpose**: To cut the stainless steel	 Hacksaw

Table 3.5: Tools

3.6.3 Specific Project Fabrication

3.6.3.1 Phase 1 (Base & Roof Structure)

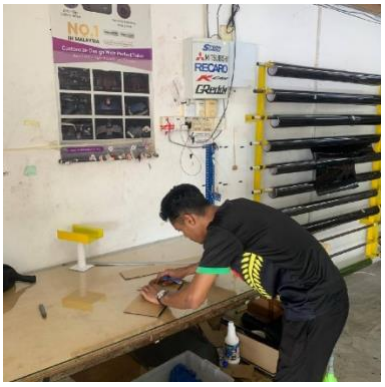
No.	Working Procedure	Illustration
1.	Material Acquisition; Stainless Steel **Base structure**: The base structure was taken from the senior projects. The measurement to cut the project as per design project were marked.	
2	The base of project senior was cut to the length that only needed.	

3	**Body Structure**: The body structure was made from L shape stainless steel. 2 pieces of stainless steel was cut as required the length of design body structure using cutting disc by the grinder.	
4	The stainless steel was welded together using the arc welding.	
5	The sample of body structure.	
6	The base structure and body structure were welded together using the arc welding in composite workshops.	

7	The picture of the body structure and base structure after welded.	
8	The base structure was spray by white colour to make the surface flat before spray yellow.	
9	The picture of base structure after sprayed.	

Table 3.6: Base Structure

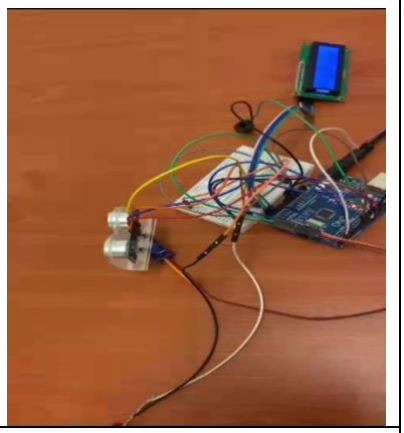
Working Procedure for Roof Structure

No.	Working Procedure	Illustration
1	Material Acquisition: Perspex Roof Structure: The Perspex was cut as per dimension roof structure using acrylic cutter.	
2	The Perspex was glue at the base structure using epoxy adhesive.	
3	The structure was spray by white colour as a primary coat before spray to yellow colour.	

4	The structure of our project was checked for any holes or defect.	

Table 3.7: Roof Structure

3.6.3.2 Phase 2 (Programming & Electrical Circuit)

No.	Working Procedure	Illustration
1	Connected all electronic/electrical component refer to the schematic circuit diagram	
2	Arduino has been connected to the laptop through USB port	

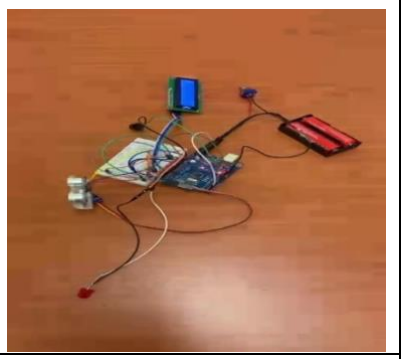
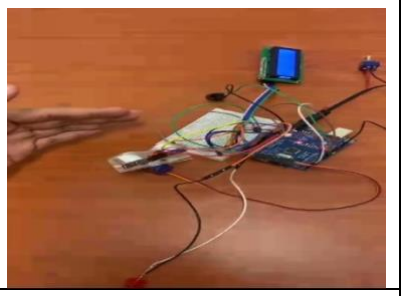
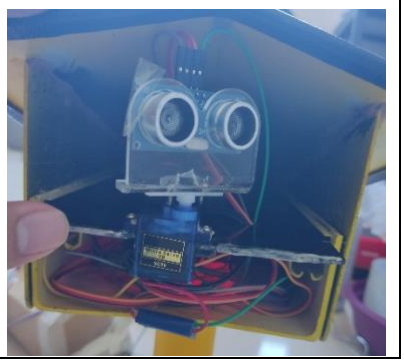
3	Code has been uploaded to the Arduino	
4	3.7v battery is connected to the Arduino for power supply	
5	Sensor has been tested	
6	All component has been assembled into the product structure	

Table 3.8: Programming & Electrical Circuit

CHAPTER 4

RESULT & DISCUSSION

4.1 PRODUCT DESCRIPTION

4.1.1 General Product Features & Functionalities

This product is an innovative solution designed for airports that do not have any detectors in place to identify any foreign object on the runway. Its main purpose is to prevent potential damage during aircraft landing or takeoff. The product uses an Ultrasonic Sensor, which is a device that uses sound wave to detect object within range.

If the Ultrasonic Sensor scans any object on the runway, it triggers an alert system. This alert will be sent to Air Traffic Control (ATC) personnel responsible to monitor and manage the aircraft movements. ATC personnel will get an instant reaction as the buzzer will go off. Other than that, they also will receive a notification “ALERT!” when there is a presence of foreign object via display, such as LCD screen.

4.1.2 Specific Part Features

4.1.2.1 Product Structure

The structure of the Foreign Object Debris System (FODS) detector is designed with durability and functionality in mind. It is primarily constructed using stainless steel, which offers high tensile strength and exceptional durability, allowing it to withstand the demanding conditions on the runway, including extreme temperatures, heavy loads, and exposure to various weather elements.

Stainless steel is chosen for its corrosion resistance, ensuring that the FODS remains intact and functional even in harsh environments. The material's resistance to rust and degradation makes it well-suited for prolonged use on the runway, where it may be exposed to rain, moisture, and other corrosive elements. By utilizing stainless steel, the FODS can withstand these conditions without compromising its structural integrity.

4.1.2.2 Electronic / Electrical Mechanisms

The Inner Part:

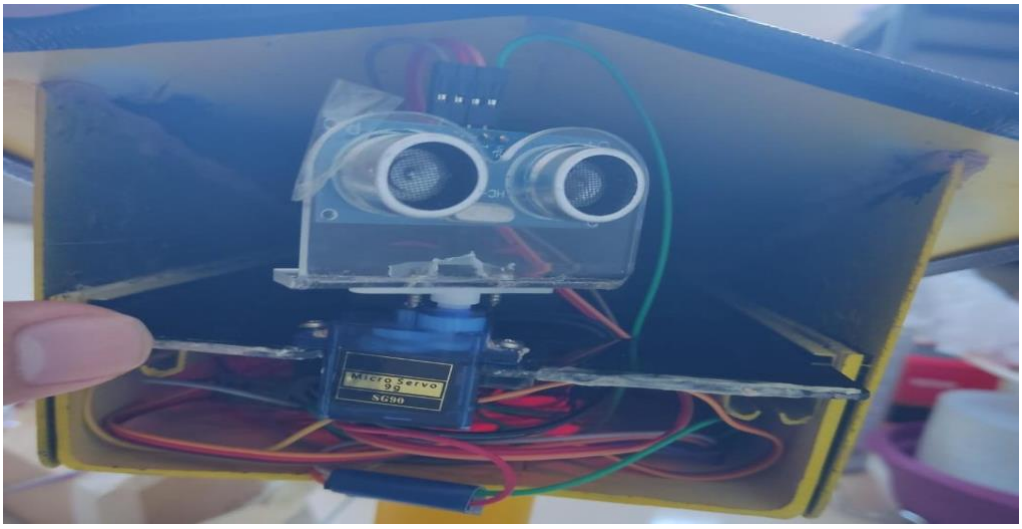


Figure 4.1: Inner Part

The Foreign Object Detection System (FODS) houses the majority of the electrical and electronic components. The main and crucial component within this system is the Arduino UNO. The Arduino UNO's primary function is to store the code created in Arduino IDE software. Additionally, it can send commands to other electrical and electronic components according to the instructions in the program.

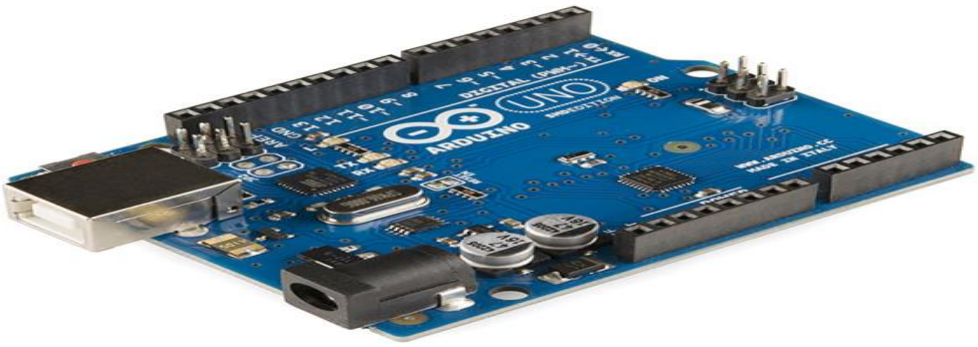


Figure 4.2: Arduino UNO (Source: Wikipedia)

Second, we have the servo, which is responsible for rotating the ultrasonic sensor. Its purpose in this project is to rotate the sensor by 120° within the FODS.

Figure 4.3: Servo (Source: Wikipedia)

Next, we have the ultrasonic sensor, which measures distance using ultrasonic waves. It plays a vital role in detecting foreign objects within the FODS.

Figure 4.4: Ultrasonic Sensor (Source: Wikipedia)

The LED is another component that converts electrical energy into light. It is used to indicate which detector has detected a foreign object on the runway.

Figure 4.5: LED (Source: Wikipedia)

Lastly, two 3.7V batteries are used as the power source for the entire system.

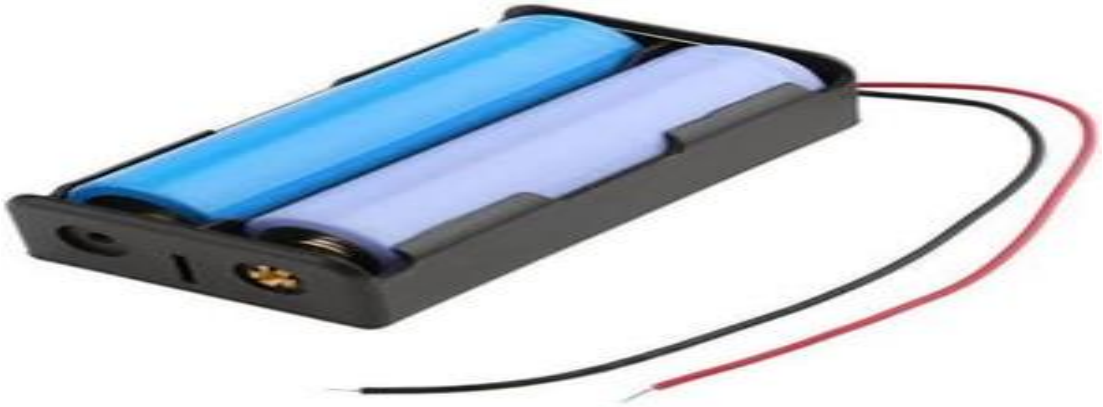


Figure 4.6: Batter Holder (Source: Bukalapak)

At the Air Traffic Control (ATC):

At the Air Traffic Control (ATC). The component involved for this part is firstly, LCD, or liquid crystal display, shows alerts and the distance of the detected foreign object. It is located at the Air Traffic Control (ATC) and provides information to the personnel.

Figure 4.7: LCD (Source: Arduino)

The buzzer produces sound when an electric current is passed through it. Placed beside the LCD at the ATC, it alerts ATC personnel when the FODS detects a foreign object.

Figure 4.8: Buzzer (Source: Wikipedia)

A toggle switch is used at the ATC to turn the FODS on or off. ATC personnel will switch it off once clearance is given for landing or take-off.

Figure 4.9: Toggle Switch (Source: Heschen)

4.1.2.3 Design & Finishing

The bird-house-like design has been carefully chosen due to its ability to comply with our specific purpose. This particular design not only serves its aesthetic appeal but also efficiently repels water, providing a protective shield for the ultrasonic sensor and other electronic components. The incorporation of a front hole in the design serves a crucial role in maintaining the integrity of the system. By preventing any intrusion of water, dirt, or other unwanted debris, it ensures an optimal environment for the ultrasonic sensor to diligently scan and analyze its surrounding environment, facilitating accurate and reliable results.

We have opted for the use of Samurai spray paint, specifically in the fluorescent yellow shade with the code 56**, for our finishing purposes. This choice was made due to its remarkable water-repellent properties, ensuring the longevity and durability of the coated surface. Additionally, the vibrant and bright color serves as a distinctive indicator, making it easily visible even from a considerable distance.

For the initial coating process, we have employed Anchor spray paint, utilizing a white base coat. This selection serves a dual purpose, functioning as both a primer and a preventive measure against uneven material surfaces. Furthermore, it also acts as an effective anti-rust agent, safeguarding the integrity and longevity of the treated surface.

4.1.3 General Operation of the Product

The Foreign Object Debris detection system is strategically positioned alongside the runway. Once in place, the system is turned on, receiving power from a reliable battery source. This initial activation ensures that the system is ready to commence its vital role in maintaining a clear runway environment. The FOD system employs advanced scanning capabilities to detect foreign objects along the runway. Utilizing a 120-degree angle on both the left and right sides, the system thoroughly scans for any debris or objects that could pose a hazard to aircraft. By

covering a wide area, the FOD system maximizes its effectiveness in identifying potential risks promptly.

To facilitate effective management of the detected foreign object, an LCD display is incorporated into the FOD system. The LCD provides essential information such as the distance of the identified object from the FODS. This real-time data allows air traffic control personnel to make informed decisions regarding aircraft landing and take-off clearance, ensuring the safety of the aircraft and passengers.

Upon the detection of a foreign object by the FODS, air traffic control personnel promptly inform the ground staff responsible for maintaining the runway. This clear communication ensures that the necessary measures are taken promptly to remove the identified foreign object, thus minimizing the risks and ensuring a safe operating environment for aircraft.

4.1.4 Operation of the Specific Part of the Product

4.1.4.1 Product Structure, Design and Finishing

The operation of structure of the FODS plays a crucial role in ensuring the proper functioning of the detector. Designed with functionality and organization in mind, the FODS structure serves as a bird house and storage unit for all the necessary electrical components that enable the detector to operate effectively. The FODS structure is carefully engineered to provide a secure and protected environment for the electrical components. The interior of the FODS structure is designed with compartments and mounting systems to securely hold each electrical component in place. This arrangement prevents movement, reducing the risk of damage or disconnection during the detector's operation or transportation. Furthermore, the compartments are strategically positioned to facilitate easy access for maintenance.

Additionally, this project uses a bold color to ensure that this system can be seen from a distance. This can make it easier for maintenance staff to find the system during takeoff or

landing, as well as for pilots. This is a feature to aid any maintenance personnel as well as for the system's own safety.

To ensure that no water or debris may enter the system, we also add a rubber strip to make the compartment door fit more snugly.

4.1.4.2 Electronic / Electrical Mechanism

The electrical/electronic mechanism operates by starting with the Arduino UNO board, which serves as the central control unit. It stores the program code and commands all the electrical/electronic components.

The Foreign Object Detection System (FODS) initiates by rotating 120° to scan the runway. If the FODS detects a foreign object, the LED will light up. Simultaneously, at the Air Traffic Control (ATC), the LCD will display an alert message along with the distance of the object. Additionally, a buzzer will sound to notify the ATC personnel.

For the toggle switch, once the ATC personnel have given clearance for landing or take-off, they need to turn off the FODS. After completion, they should turn the FODS back on for continued operation**.**

4.1.4.3 Software / Programming

The Arduino IDE software is utilized by the Foreign Object Detection System (FODS), providing a user-friendly interface for coding, building, and uploading programs to Arduino microcontrollers.

Key Features of the Arduino IDE:

Code Editor:

The Arduino IDE includes a text editor that allows easy code editing. It supports features like syntax highlighting, automatic error identification, and other helpful functionalities.

Library Manager:

The Arduino IDE incorporates a library manager tool that simplifies library browsing, installation, and management. These libraries offer various functionalities and compatibility options tailored to our project's requirements.

Sketches:

In the Arduino IDE, projects are organized as sketches. A sketch consists of two essential functions: **'setup()'** and **'loop()'.** The **'setup()'** function executes once at the beginning, while the **'loop()'** function runs repeatedly until the board is powered off.

The FODS takes advantage of the Arduino IDE user interface, high effective code editing capabilities, huge library supports, and the idea for structuring and executing code into Arduino Microcontrollers.

4.2 PROJECT IMPACTS / PURPOSE OF PRODUCT

The main objective of this project is to advance safety and prevents accidents by addressing the issue of foreign object causing crashes or damages during aircraft takeoff or landing. There have been accidents where foreign objects entered the aircraft engine, resulting to catastrophic accidents. To prevent this risk, our team has developed a Foreign Object Detection System (FODS)

Our project aims to create a safe environment across multiple airports that do not have the system, relieving the burden on ATC personnel and ground crew. By applying our FODS,

airports can detect and remove foreign objects, reducing the accidents and upgrade overall safety measures

The impact of this project is very good. It reduces the risk of aircraft crashes during takeoff or landing, making airports safer for passengers and aircraft operations. By implementing our FODS, it eliminates the need for expensive detection system. It also makes it more accessible with limited sources. Smaller airports can provide a highly safe environment for travelers, allowing them to travel for short distance instead of travelling long distances to major airports. This helps to instill confidence in passengers.

4.3 ANALYSIS OF PROBLEM ENCOUNTERED & SOLUTIONS

4.3.1 Product Structure

The problem we encountered on constructing the structure is when to welding the L square stainless steel together. This is because the stainless steel cannot withstand the high temperature of arc welding and can turn to melt. We encountered this problem by not put arc welding not to close with the stainless-steel during welding.

Next, the problem that I was encountered on constructing structure is when to cut the Perspex. The Perspex is a fragile material and need a special cutter to cut it. We encountered this problem by using acrylic cutter that we buy from hardware shop.

Lastly, the problem that I was encountered on constructing structure is when to glue the roof structure and base structure. This is because the roof structure was made by Perspex and slippery to glue with base structure. I encountered this problem by apply glue gun to the base structure before using epoxy adhesive.

4.3.2 Electronic / Electrical Mechanisms

During the course of the project, several issues were encountered with the electrical/electronic mechanism. The first problem arose when the ultrasonic sensor obtained for the project turned out to be faulty, necessitating a visit to Aiszzy Electronic in Shah Alam to purchase a replacement.

The second problem arose after uploading the code for the ultrasonic sensor, LED, and servo. The servo did not rotate properly due to insufficient power supply. Despite purchasing a 9V battery, the issue persisted as the power voltage from the battery was inconsistent. To address this, 3.7V batteries with 2 and 4 slots were purchased.

The third problem occurred when the 4-slot 3.7V battery was connected to the breadboard, resulting in over-voltage that caused the servo to malfunction and emit smoke. To rectify this issue, a new servo, a 3.7V battery with 2 slots, and a step-down regulator for external power supply to the servo and LCD were acquired.

The fourth problem was discovered the day after soldering all the components onto the donut board. The step-down regulator wire accidentally made contact with the battery and damaged the component, unbeknownst at the time. The following day, the system exhibited improper functionality, with the servo rotating at varying speeds when the ultrasonic sensor detected an object, and the LCD failing to display any messages despite the backlight being on. This problem was traced back to the inconsistent power supply from the faulty step-down regulator. After several days of troubleshooting, the main issue was identified, and a new step-down regulator was purchased. However, upon attempting to use it, the component was found to be broken, leading to multiple replacements. To overcome this setback, it was decided to use only one external power supply connected to the Arduino to operate all the components.

The fifth problem arose the night before the AEROMECH event when the system was not functioning properly. After hours of troubleshooting, it was discovered that loose wires were

causing the issue. However, spare wires were not available, so an attempt was made to secure the connections with tape to prevent them from disconnecting.

4.3.3 Software / Programming

Common problems that I encountered doing the software programming and coding were,

Compilation Errors:

Encountering compilation errors when trying to compile the codes can occur due to syntax errors, wrong libraries, incorrect board settings and undetected USB port.

Upload Failures:

After numerous failures, we finally identified the issue as a USB connection problem. That might also be the result of the software's inability to connect to the USB port. We managed to connect the USB by installing a CH340 driver for specific USB com reading.

Serial Communication Issue:

This problem could be caused by software reading incorrect data; for instance, the code entered into the software is not formatted in accordance with the specifications of the Arduino IDE. Hardware connections are yet another cause of incorrect communication problems. Possible incorrect wiring connections based on the code. A focus when detailing the wiring connections helped us to get the system works.

Library Compatibility:

Libraries that are used to interact with few components and a lot more functionalities, could be incompatibilities between libraries or library versions. Choosing the right libraries and stay at that one and only to not mix up other libraries.

4.3.4 Design & Finishing

During our precise manufacturing procedure, we encountered a notable obstacle that required immediate attention and careful deliberation. It became evident that the design of the window in our Foreign Object Detector System (FODS) did not possess the desired attributes to effectively prevent the infiltration of water particles into the system. Specifically, the size of the window proved to be inadequate in providing sufficient protection and coverage to safeguard the internal components from potential water ingress. Additionally, our manufacturing process revealed another issue related to the limited space within the system. The insufficient room for cable management presented a significant challenge when it came to organizing and securing the cables, which are crucial for the system's functionality. This space constraint impeded our ability to achieve an orderly and efficient arrangement of the cables, potentially leading to complications such as entanglement or damage.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 ACHIEVEMENT OF AIM & OBJECTIVES OF THE RESEARCH

5.1.1 General Achievements of the Project

We can finally say that the project we have been working on for a year has met all the requirements. Our objectives are to alert Aircraft Traffic Control (ATC) presence of FOD on runway. For this to be done, we need to create our own specific size because size matters in this project. How it could stand, and the effect to be put at the side of aircraft runway. Our team managed to make an FODS according to the AUTOCAD drawing thus follow the height and width required from discussion. For electrical and electronics, we managed to code and install them to the Arduino Microcontrollers after numerous attempts. The systems also work perfectly fine.

5.1.2 Specific Achievement of Project Objectives

5.1.2.1 Product Structure

The objective of a FODS detector that is suitable for airport runways without disturbing aircraft take-off and landing operations has been achieved. The design of FODS has been chosen to the bird house as per in pattern design. The furnishing of FODS was designed aesthetic look and

able to withstand when in good or bad weather. We had developed FODS with high quality, stability and durability.

5.1.2.2 Electronic / Electrical Mechanism

The objective of the project, which was to develop an electrical/electronic mechanism for the Foreign Object Detection System (FODS), has been successfully achieved. The FODS serves as a detector on the runway to identify and prevent the presence of Foreign Object Debris (FOD). It effectively detects any FOD and promptly alerts the Air Traffic Control (ATC) personnel about its presence.

5.1.2.3 Software / Programming

Successfully combine all the codes according to the components used for the project. Other than that, for problems like USB COM port not reading, we installed a driver CH340 to fix it.

5.1.2.4 Design & Finishing

Prioritizing reliability was our first priority when building the Foreign Object Detector System (FODS). We are committed to customizing the design to satisfy the demands of our product, particularly the electrical components used. This guarantees the best results when using an ultrasonic sensor to look for potential debris.

We have coated our goods with a layer of yellow paint spray to increase visibility and maximize the efficiency of our product. This tactical choice adds color and individuality to our FODS when placed on the tarmac and allows for easy recognition from a considerable distance. Such painstaking attention to detail not only improves the product's aesthetic appeal but also makes it easier for it to integrate seamlessly into the operational setting. When necessary, it allows for quick diagnosis and subsequent preventive action.

5.2 CONTRIBUTION OR IMPACT OF THE PROJECT

The impact and contribution of the project are significant. From improving runway safety and crash prevention to cost savings. It is also contributing to higher productivity and increased passengers' confidence. FODS could be consider advances the safety, and operations.

5.3 IMPROVEMENT & SUGGESTIONS FOR FUTURE RESEARCH

5.3.1 Product Structure

The improvement that we seek in future is to change the option of material used for the making of FODS from stainless steel to aluminum steel. This is because aluminums steel is easy to get and easy to shape. Next, the improvement that we will do is to make the roof can open to easier the maintenance to repair the electrical components.

The suggestion for FODS is to make innovation of the detection system which is added a camera to the detector. This will make the Air Traffic Control (ATC) can identify the type of foreign object that presence on runway. The improvement that we seek in future is to change the option of material used for the making of FODS from stainless steel to aluminum steel. This is because aluminums steel is easy to get and easy to shape. Next, the improvement that we will do is to make the roof can open to easier the maintenance to repair the electrical components.

5.3.2 Electronic / Electrical Mechanisms

To enhance the electrical/electronic mechanism, it is recommended to conduct thorough research on the datasheets of each component, particularly focusing on their limitations and voltage requirements. Additionally, it is essential to verify the proper functioning of each component before proceeding with soldering. When soldering, ensure the use of new wires, considering that all components will be inserted into the body. Finally, it is crucial to avoid using high-voltage batteries with the Arduino, as this can lead to over-voltage issues and potentially damage the Arduino board and other components.

5.3.3 Software / Programming

As a starter to Arduino or programming, I highly recommend not to use the easy ways. For example, do not get all the codes from online Chat GPT and connect. That will not help in understanding the concept of coding and their connections. Instead do more research on YouTube, google or browser and Chat GPT to really get the work of the system. Other than that, user may need to really focus on coding. For example, there must be any error in the code written if there is software errors. Lastly, make sure the software is connected to the Arduino.

5.3.4 Design & Finishing

We aim to enhance the design of the system itself by implementing specific key aspects that will strengthen its functionality and effectiveness. For example, our goal is to develop an improved window design that can effectively shield the system from potential threats like debris or water particles. This enhancement will provide an extra layer of protection, ensuring the integrity of the sensitive components housed within the FODS.

Additionally, we understand the significance of optimizing the internal space of the system. By increasing its capacity, we can better manage cables, leading to a more organized and efficient arrangement. With more space, we can neatly route and secure cables, minimizing the risk of entanglement or damage. This upgrade will greatly streamline maintenance and troubleshooting processes, ultimately improving the reliability and longevity of the FODS.

In summary, our forward-thinking approach drives us to continuously seek ways to enhance the performance and capabilities of our product. By implementing these envisioned improvements, we strive to create a Foreign Object Detector System that excels in both durability and functionality, meeting the evolving needs and demands of our industry.

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APPENDIX A: DECLARATION OF TASK SEGREGATION

SUB-CHAPTERS	DESCRIPTION
MUHAMMAD ASHRAH BIN HALIM	
1.1	BACKGROUND OF STUDY
1.2	PROBLEM STATEMENTS
1.3.1	GENERAL PROJECT OBJECTIVES
1.3.2.2	ELECTRICAL/ELECTRONIC MECHANISMS
1.4	PURPOSES OF PRODUCT
1.5.1	GENERAL PROJECT SCOPES
1.5.2.2	ELECTRICAL/ELECTRONIC MECHANISMS
2.1	GENERAL LITERATURE REVIEW
2.2.2	ELECTRICAL/ELECTRONIC MECHANISMS
3.1.1	UTILISATION OF POLYTECHNIC'S FACILITIES
3.1.2	PROJECT COLABORATION & TRANSFER OF TECHNOLOGY
3.2	OVERALL PROJECT GANTT CHART
3.3.1	OVERALL PROJECT FLOW CHART
3.3.2.2	ELECTRICAL/ELECTRONIC MECHANISMS

3.4	LIST OF MATERIALS & EXPENDITURES
3.5.1	GENERAL PRODUCT DRAWING
3.5.2.2	ELECTRICAL/ELECTRONIC MECHANISMS
3.6.1	MATERIAL ACQUISITION
3.6.2	MACHINE & TOOLS
3.6.3.2	PHASE 2 (PROGRAMMING & ELECTRICAL CIRCUIT)
4.1.1	GENERAL PRODUCT FEATURES & FUNCTIONALITIES
4.1.2.2	ELECTRICAL/ELECTRONIC MECHANISMS
4.1.3	GENERAL OPERATION OF THE PRODUCT
4.1.4.2	ELECTRICAL/ELECTRONIC MECHANISMS
4.2	PROJECT IMPACT / PURPOSE OF PRODUCT
4.3.2	ELECTRICAL/ELECTRONIC MECHANISMS
5.1.1	GENERAL ACHIEVEMENTS OF THE PROJECT
5.1.2.2	ELECTRICAL/ELECTRONIC MECHANISMS
5.2	CONTRIBUTION OR IMPACT OF THE PROJECT
5.3.2	ELECTRICAL/ELECTRONIC MECHANISMS

MOHAMMAD ALIFF FARIS BIN KHAIRUL	
1.1	BACKGROUND OF STUDY
1.2	PROBLEM STATEMENTS
1.3.1	GENERAL PROJECT OBJECTIVES
1.3.2.4	DESIGN & FINISHING
1.4	PURPOSES OF PRODUCT
1.5.1	GENERAL PROJECT SCOPES
1.5.2.4	DESIGN & FINISHING
2.1	GENERAL LITERATURE REVIEW
2.2.4	DESIGN & FINISHING
3.1.1	UTILISATION OF POLYTECHNIC'S FACILITIES
3.1.2	PROJECT COLABORATION & TRANSFER OF TECHNOLOGY
3.2	OVERALL PROJECT GANTT CHART
3.3.1	OVERALL PROJECT FLOW CHART
3.3.2.4	DESIGN & FINISHING
3.4	LIST OF MATERIALS & EXPENDITURES
3.5.1	GENERAL PRODUCT DRAWING

3.5.2.1	PRODUCT STRUCTURES
3.6.1	MATERIAL ACQUISITION
3.6.2	MACHINE & TOOLS
3.6.3.1	PHASE 1 (BASE & ROOF STRUCTURE)
4.1.1	GENERAL PRODUCT FEATURES & FUNCTIONALITIES
4.1.2.3	DESIGN & FINISHING
4.1.3	GENERAL OPERATION OF THE PRODUCT
4.1.4.1	PRODUCT STRUCTURE, DESIGN AND FINISHING
4.2	PROJECT IMPACT
4.3.4	DESIGN & FINISHING
5.1.1	GENERAL ACHIEVEMENTS OF THE PROJECT
5.1.2.4	DESIGN & FINISHING
5.2	CONTRIBUTION OR IMPACT OF THE PROJECT
5.3.4	DESIGN & FINISHING

LUQMAN BIN JAMALUDIN	
1.1	BACKGROUND OF STUDY
1.2	PROBLEM STATEMENTS
1.3.1	GENERAL PROJECT OBJECTIVES
1.3.2.3	SOFTWARE / PROGRAMMING
1.4	PURPOSES OF PRODUCT
1.5.1	GENERAL PROJECT SCOPES
1.5.2.3	SOFTWARE / PROGRAMMING
2.1	GENERAL LITERATURE REVIEW
2.2.3	SOFTWARE / PROGRAMMING
3.1.1	UTILISATION OF POLYTECHNIC'S FACILITIES
3.1.2	PROJECT COLABORATION & TRANSFER OF TECHNOLOGY
3.2	OVERALL PROJECT GANTT CHART
3.3.1	OVERALL PROJECT FLOW CHART
3.3.2.3	SOFTWARE / PROGRAMMING
3.4	LIST OF MATERIALS & EXPENDITURES
3.5.2.3	SOFTWARE / PROGRAMMING
3.6.1	MATERIAL ACQUISITION
3.6.2	MACHINE & TOOLS
3.6.3.2	PHASE 2 (PROGRAMMING & ELECTRICAL CIRCUIT)

4.1.1	GENERAL PRODUCT FEATURES & FUNCTIONALITIES
4.1.3	GENERAL OPERATION OF THE PRODUCT
4.1.4.3	PROGRAMMING / SOFTWARE
4.2	PROJECT IMPACT
4.3.3	SODTWARE / PROGRAMMING
5.1.1	GENERAL ACHIEVEMENTS OF THE PROJECT
5.1.2.3	SOFTWARE / PROGRAMMING
5.2	CONTRIBUTION OR IMPACT OF THE PROJECT
5.3.3	SOFTWARE / PROGRAMMING
MUHAMMAD FAKHRULLAH BIN MOHD FAUDZI	
1.1	BACKGROUND OF STUDY
1.2	PROBLEM STATEMENTS
1.3.1	GENERAL PROJECT OBJECTIVES
1.3.2.1	PRODUCT STRUCTURE
1.4	PURPOSES OF PRODUCT
1.5.1	GENERAL PROJECT SCOPES
1.5.2.1	PRODUCT STRUCTURE
2.1	GENERAL LITERATURE REVIEW
2.2.1	PRODUCT STRUCTURE

3.1.1	UTILISATION OF POLYTECHNIC'S FACILITIES
3.1.2	PROJECT COLABORATION & TRANSFER OF TECHNOLOGY
3.2	OVERALL PROJECT GANTT CHART
3.3.1	OVERALL PROJECT FLOW CHART
3.3.2.1	PRODUCT STRUCTURE
3.4	LIST OF MATERIALS & EXPENDITURES
3.5.1	GENERAL PRODUCT DRAWING
3.5.2.1	PRODUCT STRUCTURES
3.6.1	MATERIAL ACQUISITION
3.6.2	MACHINE & TOOLS
3.6.3.1	PHASE 1 (BASE & ROOF STRUCTURE)
4.1.1	GENERAL PRODUCT FEATURES & FUNCTIONALITIES
4.1.2.1	PRODUCT STRUCTURE
4.1.3	GENERAL OPERATION OF THE PRODUCT
4.1.4.1	PRODUCT STRUCTURE, DESIGN AND FINISHING
4.2	PROJECT IMPACT

4.3.1	PRODUCT STRUCTURE
5.1.1	GENERAL ACHIEVEMENTS OF THE PROJECT
5.1.2.1	PRODUCT STRUCTURE
5.2	CONTRIBUTION OR IMPACT OF THE PROJECT
5.3.1	PRODUCT STRUCTURE

APPENDIX B: TURNIT-IN REPORT

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