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ORIGINAL ARTICLE

Preventive Maintenance Data Logger Monitoring System

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ABSTRACT – This research presents the Preventive Maintenance Data Logger (PMDL) Monitoring System and the process of how it has been manufactured. Preventive Maintenance Data Logger Monitoring System is a device which will collect the data from vehicle's sensor for prevention maintenance and then save the data to other storage for future analysis. Preventive Maintenance Data Logger Monitoring System also can send notification to user for crash prevention. This project comprises of mechanical system, electronic system, and software system. The methodology of the Preventive Maintenance Data Logger system and prototype development is discussed in this paper on the manufacturing processes. The software is programmed using C language in Arduino software and the notification for preventive are develop using BLYNK application. Manufacturing processes involves in making this project, including additive manufacturing, welding and cutting. Several test case studies were conducted to verify the capability of the device in term of the vehicle speed, location, crash point data, distance between other vehicles detection and reliability.

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INTRODUCTION

There will be various road traffic accidents around the world by vehicles such as car, motorcycle, lorry, van, bus and other road users. Road accidents are a serious issue in many nations across the world. In fact, according to the World Health Organization (WHO), road accidents are the ninth most prevalent cause of death. Per year, roughly 1.35 million number of fatalities recorded because of road traffic accidents [1]. Non-fatal injuries affect between 20 and 50 million more individuals, with many of them resulting in disability because of their injury. According to the Ministry of Transportation (mot.gov.my), collaborate with Royal Malaysian Police (RMP) and Malaysian Institute of Road Safety Research (MIROS) revealed that with ten-years in the number of road accidents, 2019 was the most hazardous year since 2010. Meanwhile, the number of deaths has been steadily decreasing from a high of 7,152 in 2016 to a low of 6,167 in 2019 during the previous 10 years as shown in Figure 2 [2].

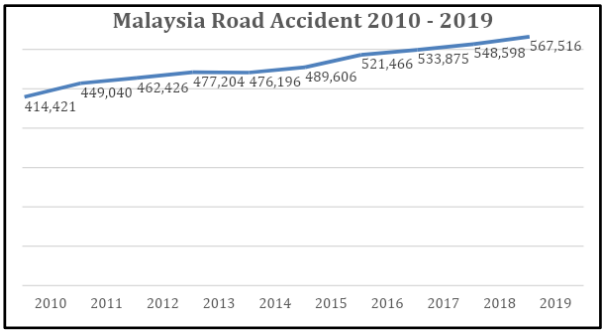

Figure 1: Malaysia Road Accident 2010 – 2019

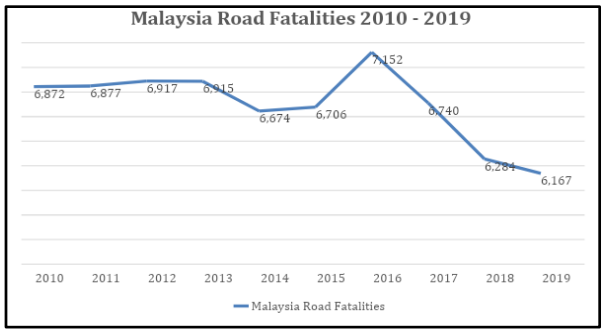

Figure 2: Malaysia Road Fatalities 2010 - 2019

On the same time, based on The Malaysian Institute of Road Safety Research (MIROS) has published road fatality data for 2020, which showed a 24.9 % decrease over the previous year [3]. By comparison of road user category between 2019 and 2020 cars users contribute around 29.1 % reduction on deaths. From here, the projected view shows that even though number of registered vehicles in Malaysia keep on increase in but there was reduction on deaths. This due to current new modern car have enhance on safety features by having advance detection and monitoring. Knowing that top cause for any car accident is through human error, many automotive manufacturers are working hard to equip their new developing cars with different features and technologies that will aid drivers in minimizing the likelihood of making mistakes that may lead to an accident. With help of various sensors, new module cars come out with high tech features such as blind-spot warning, forward collision warning (FCW), electronic stability control and many more. For

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an example, all the new module cars applied with an application for lane management focuses on keeping the vehicle safe while driving [4]. By installing cameras behind the rear - view mirror, the application can monitor road lane markings and detect any drifts outside of a lane [5].

The automotive industry's innovative technology have helped to reduce the number of car accidents and deaths all around the world. With all of the innovation and future technology accessible to drivers, car accidents expected to drop dramatically. However, based on the data published still having high number of car road accidents. Because there is no data logger system to pre-alert drivers to avoid accidents. Moreover, in Malaysia there is old cars users on the road without equipped with any advance detection and monitoring. In order to react to this situation, the Preventive Maintenance Data Logger (PMDL) Monitoring System is the first step to solve this problem that crosses national boundaries and threatens the safety and health of people worldwide [6]. This is proven efficient by United Sates market in 1999 when black box system is introduced. It is important to improving the treatment of crash victims and the road status in order to decrease the accidents rate. PMDL Monitoring System is also constructing safer vehicle and helping insurance companies with their vehicle accident investigations. Therefore, all the cars nevertheless new module cars nor old cars must be install with PMDL Monitoring System.

PROJECT OVERVIEW

For these project, a PMDL Monitoring System are designed and fabricated which is that can be installed for any vehicular. This device will be designed for vehicles which will help to keep data to measure the vehicle speed, location, date and time using GPS module sensor, measure the distance of vehicle while driving using distance sensor and also using accelerometer to detect impact of accidents that hit the chassis of the vehicle. Data from various sensors on the vehicle is collected, digitized, compressed and then stored in an externally mounted protective storage unit. The protective storage unit is a tamper-proof unit designed to with stand the extreme shock impact, pressure and heat [7]. All the data will be stored at SD Card and also transferred to Cloud using Android System [8]. This device also can detect any wrong handling of vehicles and send the notification to the user or owner by smart-phone using Blynk application. PMDL Monitoring System is a Internet of Things (IoT) based intelligent system device. The purposed system is experimented with real time data sets and simulated using Blynk application [9]. PMDL Monitoring System is an independent device which works all the time with its own power supply. The device can give the vehicle data even the vehicle system is corrupted or damage [10]. This is one of the advantages of the system.

METHODOLOGY

This sub chapter is explained about how the PMDL Monitoring System was developed and fabricated. PMDL Monitoring System is committed mainly into two approaches. The first one is how to detect and record data from the vehicle. The second is how to present the data recorded to the user in a simplified way. To implement the first approach, some major components and different type of sensors were used. While the second approach was implemented using a BLYNK application. This program receives the data serially from the PMDL Monitoring System memory, presents it in real-time graphics and finally saves it to a SD Card.

In order to know what type of sensors should be installed into the vehicle, research was carried out to identify the main information needed for better accident analysis and prevention information vehicle to user. After filtering the information and taking into consideration what could be done and what could help the most, the following data were found to be the most important ones needed after an accident: Speed Measurement, Position of the crash, Date and Time of the incident, Location of the accident and Distance between other vehicles on the road.

Based on the flow chart shown in Figure 3, project started with the background of study to understand better and get the some idea about the project. Then, identify the problem statement and create the objectives of the project. Next, come out with a design of the PMDL Monitoring System. The electronic schematic are developed and followed with software programming. After that, notification application are created in the mobile phone and matched with the programming. All the circuit and programming part are tested to make sure it works properly. If the device works as needed, then fabrication processes are continued and ended with the achieved the objectives of this project.

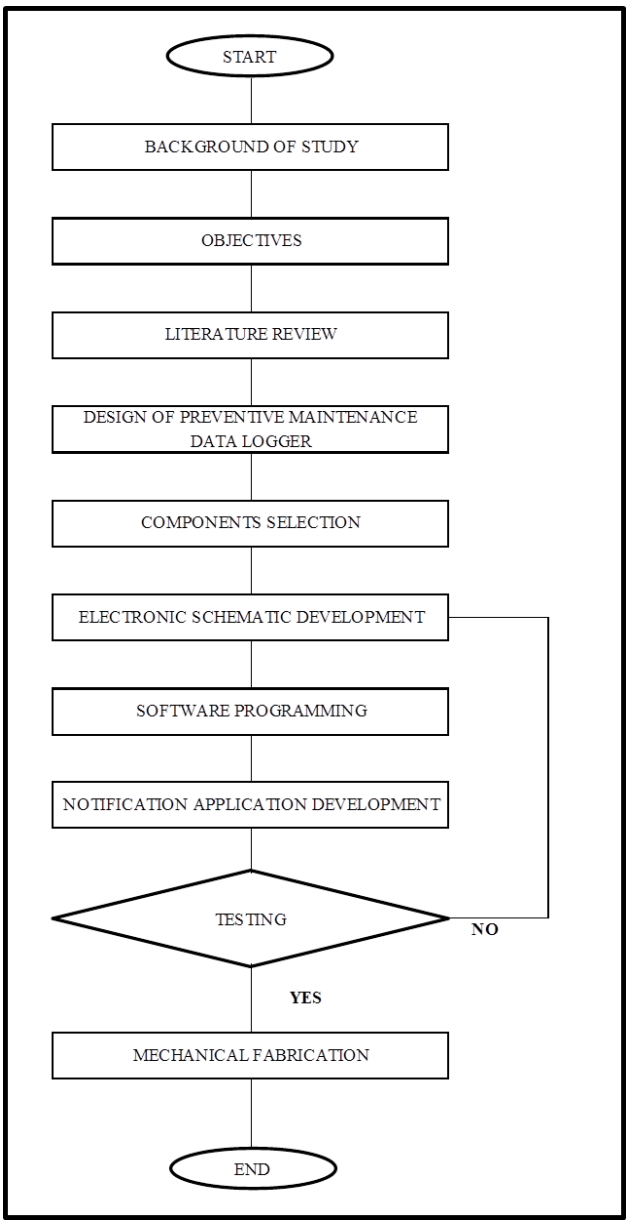

Figure 3. Flow Chart of Preventive Maintenance Data Logger Development

Physical Properties of Preventive Maintenance Data Logger

Prior to constructing the drawing of PMDL Monitoring System design, the physical and dynamic properties of this project should be measured. The dimensions of PMDL Monitoring System are designed based on electronic components size selection. All the size of the components must be small and compact. Furthermore, the design of PMDL Monitoring System should have some physical properties such as hard, anti-crashed, water proof and have high melting point. Besides, the location of PMDL Monitoring System in the vehicle also takes part in designing this project. The size of end product of the project must be in small scale and compact. The Table 1 shows the properties that PMDL Monitoring System design should have.

Table 1. Properties of Preventive Maintenance Data Logger

CRITERIA	PROPERTIES
Tensile Strength	High (540 to 750 Mpa)
Hardness	Hard (70 – Rockwell B)
Modulus of Elasticity	193 GPa
Corrosion Resistance	Excellent
Melting Point	High (More Than 1400 Celsius)
Location	Middle Of Vehicle (Under The Hand Brake Compartment)

Design of Preventive Maintenance Data Logger

PMDL Monitoring System design is drawn using SolidWorks software based on all the criteria and physical properties needed. SolidWorks formerly known as “unigraphics” is a high end CAD/CAM/CAE. It is used for design parametric and direct solid or surface modelling. By using this SolidWorks software, analysis of engineering can be produces using finite element method. This drawing software is very suitable for our project designing.

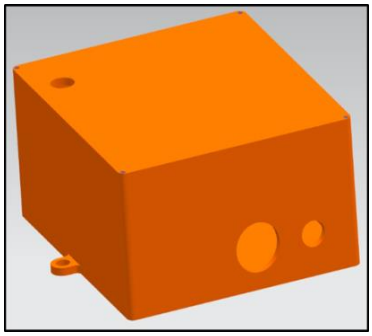

Figure 4. 3D Design of Preventive Maintenance Data Logger

Circuit Development

The circuit for PMDL Monitoring System are developed based on flow chart in the figure 5. This flow chart explained how the processes of circuit development have been done. The components that selected for this project are Arduino microcontroller, distance sensor module, accelerometer and GPS module. Then, electronic block diagram are created for understand the flow of this project. Prior to the circuit development, the schematic diagram for electronic are designed using the Circuit IO software. Once the design is finalised, the circuit are fabricated and tested.

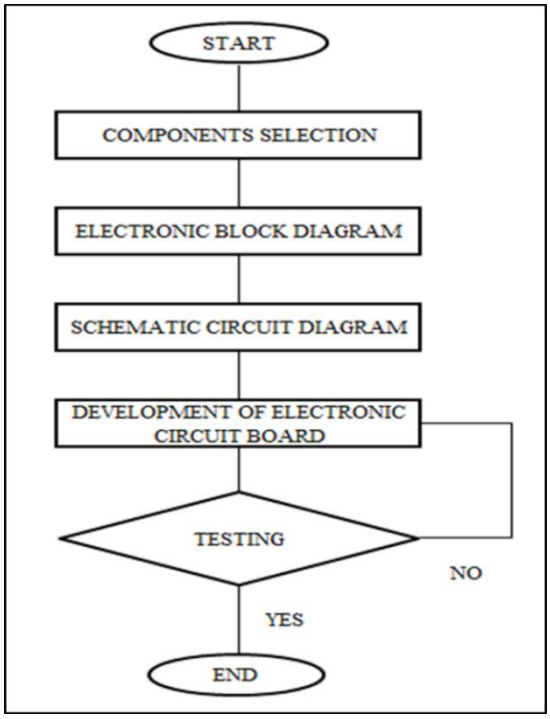

Figure 5. Circuit Development Flows Chart

Software Development

Figure 6 explained about the flow chart processes that to develop the software for PMDL Monitoring System. When dealing with software, the first step is downloading and install the Arduino 1.8.2 IDE software to your computer. Here is the procedure on how to install Arduino software;

i. Search the software at Arduino official website.
ii. Clicks download Arduino software for windows installer.
iii. After finish downloading, click run administration to run the software.
iv. Accept all the terms and conditions.
v. Finally, click install for Arduino software installation on your computer.

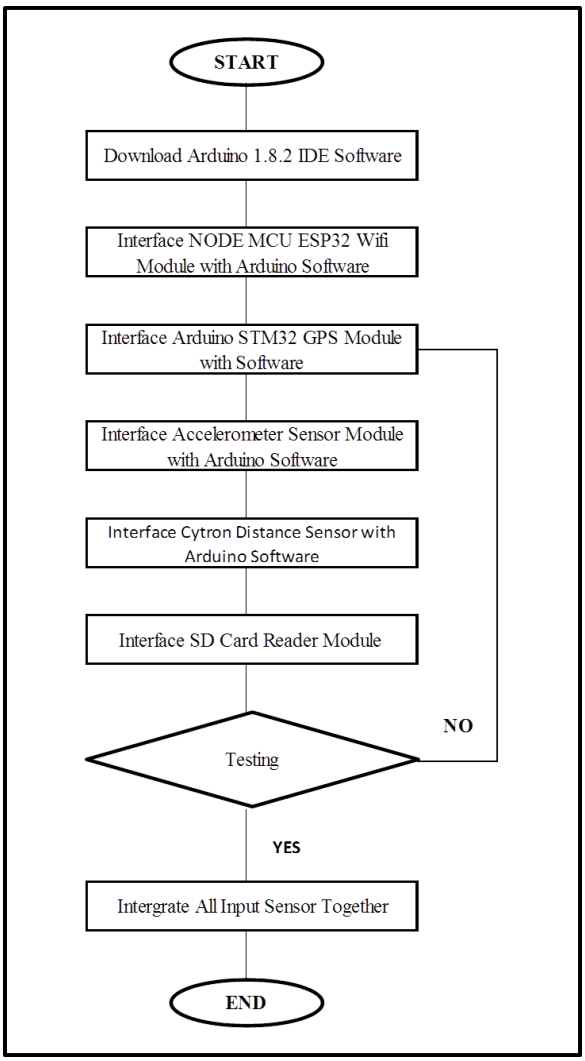

Figure 6. Software Development Flows Chart

Then, connect the Arduino NODE MCU ESP32 Wi-Fi microcontroller to the computer using USB cable and click computer management to make sure the device is detected. After that, click tools icon on the top of Arduino software and select the board type and download it. The microcontroller are interfaced and the details are flashed in the Arduino 1.8.2 IDE software. Figure 7 shows the step on how to interface Arduino NODE MCU ESP32 Wi-Fi microcontroller.

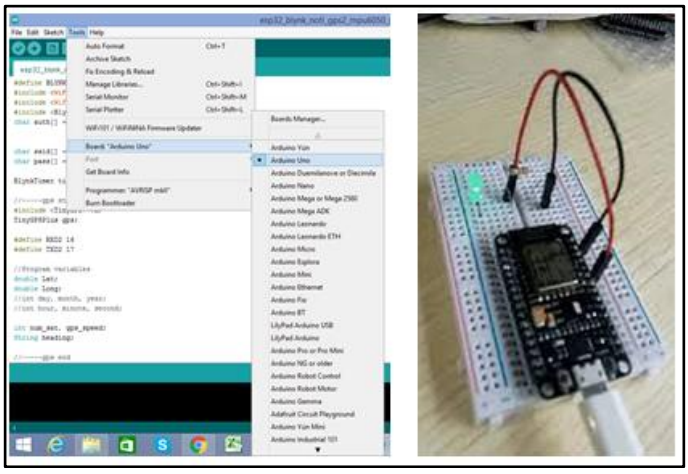

Figure 7. Interface of Arduino NODE MCU ESP32 Wi-Fi Board

After that, GPS STM32 module are connected to the Arduino NODE MCU ESP32 Wi-Fi microcontroller using wire and dotted board. GPS STM32 module is interfaced to the Arduino software by downloading the hardware in the library. The output of this step will take several minutes to be complete.

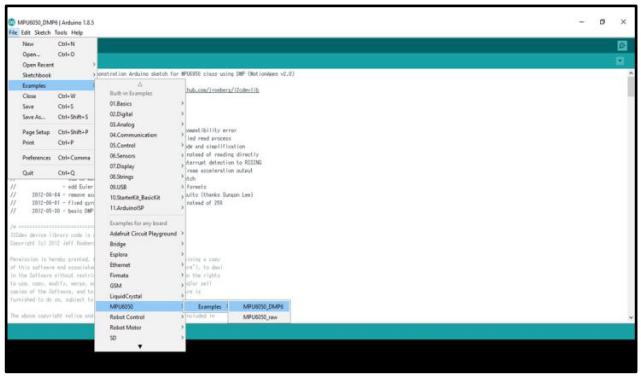

Figure 8. Interface of GPS STM32 module to Arduino Software

This step followed by other input devices such as MPU 6050 GY-521 3 Axis Gyro Accelerometer sensor module, Ultrasonic Range Finder and Micro SD Card Reader Interface Module (Cytron). When complete interface all the devices with the Arduino software, test the entire devices whether they work according to the coding instructions properly or not. If all the devices work correctly, integrate all of them together in Arduino NODE MCU ESP32 Wi-Fi module. Finally, write the purpose instructions and coding completely in the Arduino 1.8.2 IDE software to achieve the project objectives.

Application Development

Blynk application is used in this project which is to send notification from PMDL Monitoring System to the user's smartphone. Blynk is a platform with iOS and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things. There are three major components in Blynk platform; Blynk Application, Blynk Server and Blynk Libraries. Blynk Server is also an Open-Source Netty based Java server, responsible for forwarding messages between Blynk mobile application and various microcontroller boards. From the figure 9, it can be seen that data from the microcontroller are transferred to Blynk libraries using Wi-Fi or Ethernet. The stored data in Blynk library are sent to Blynk application for user's notification using Blynk server.

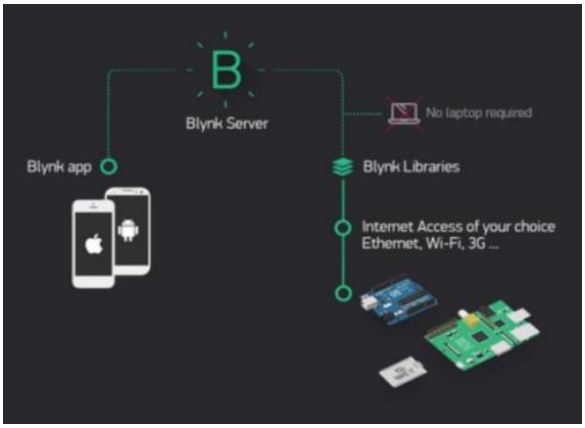

Figure 9. Blynk Application Process Flow

The development of Blynk application for these projects is explained with step by step in figure 11. First, create a Blynk account after download the Blynk Application. Then, user need to create a New Blynk account. After user have successfully logged into account, start by creating a new project. Next, select the Arduino hardware model that will be used in this project. Auth Token is a unique identifier which is needed to connect hardware to smartphone via arduino software. Every new project created will have its own Auth Token. User will get Auth Token automatically on email after project creation. Then, download Blynk library using computer. Figure 10 shows that how the Blynk application are interfaced with Arduino 1.8.2 IDE software. After that, copy the auth token that had received and paste it in the arduino software.

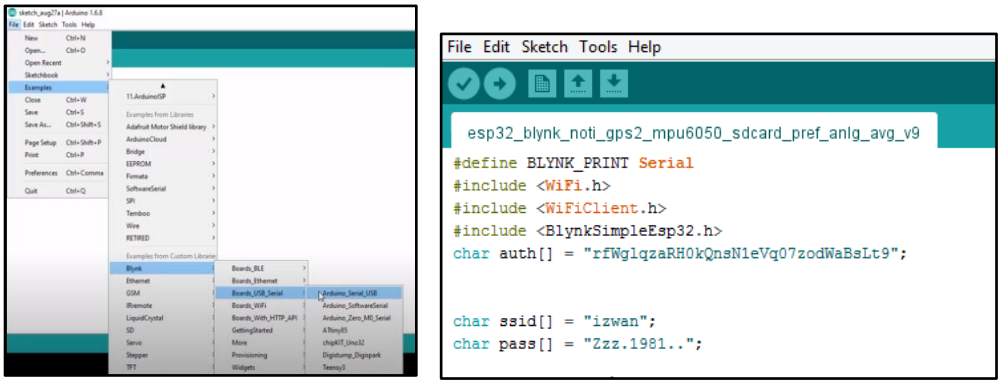

Figure 10. Blynk Application Interfaced with Arduino Software.

Once complete the application interface, tap anywhere on the canvas to open the widget box. All the available widgets are located here. The most important parameter to set is PIN. The list of pins reflects physical pins defined by your hardware. If your LED is connected to Digital Pin 8 - then select D8 (D – stands for Digital).

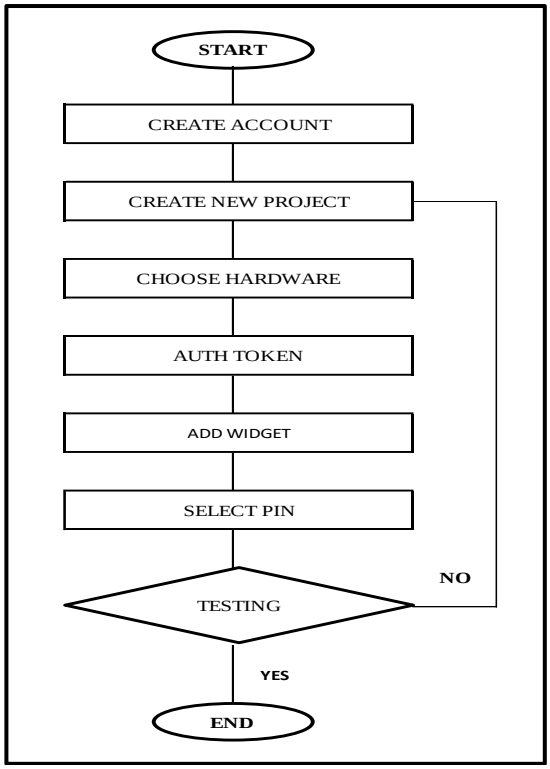

Figure 11. Blynk Application Flows Chart

Fabrication Developent

Figure 12 shows process of PMDL Monitoring System fabricated. The flow start from choosing Stainless Steel 304 AISI material which has fulfilled the entire characteristic needed for this project. The finite element analysis that is attached at Appendix D show the proof that these design are strong and hard enough. Then, go through with cutting process, bending process, welding process and grinding process to make the housing of PMDL Monitoring System. After that, drilling process is conducted to drill screw hole on the top of project design. Finally, deep orange colour powder coating is used to make a great finishing for this product.

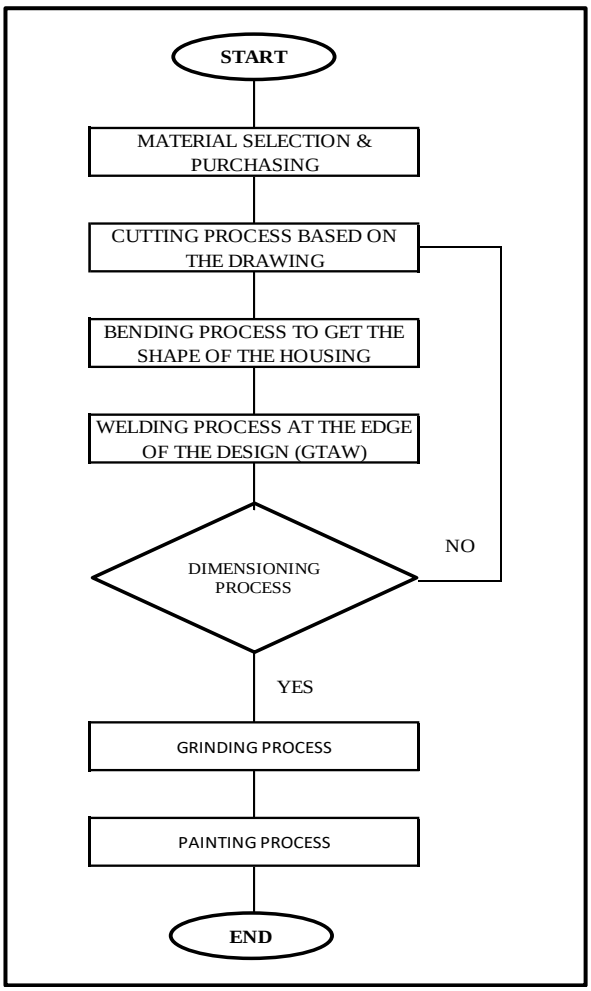

Figure 12. Fabrication Flows Chart

RESULTS AND DISCUSSION

The results and discussions of the PMDL Monitoring System are divided into hardware and software. In hardware results, it consists of mechanical part and electrical part.

Mechanical

Figure 13 shows the final design of PMDL Monitoring System after fabrication process. The finite element analysis is done by using SolidWorks software for the whole proposed design. Stainless Steel 304 material are used for develop the steel housing of this project. This was because it has 1400 Celsius melting point. When vehicle involved in an incident such accident and fire, PMDL Monitoring System will not destroy or damage because of it has high melting point characteristics. Other than that, Stainless Steel 304 is selected as material for this project because it is a hard material and anti-crashed. The crash force that had chosen for this analysis is 2500 Newton for every 1 tonne vehicles that involved in the incident and the results of finite element analysis for this project are made to proof the strength of the design.

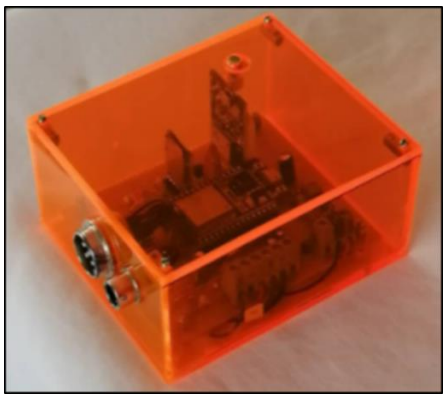

Figure 13. Preventive Maintenance Data Logger Design

Electrical

In electrical hardware design, all the devices are connected on the dotted board and spotted with soldering process based on schematic diagram developed. All the electronic components are located compactly on the 85mm x 100 mm size dotted board. Figure 8 shows the final electrical board that had been made for PMDL Monitoring System.

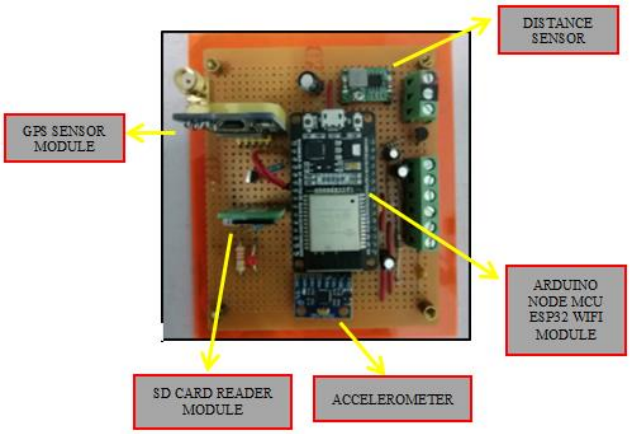

Figure 14. Preventive Maintenance Data Logger Electrical Board

Software

This sub chapter are discussed about the results and data produced from the Arduino 1.8.2 IDE software. As we can see on the figure 15, it displayed the real time data produced when vehicle was on the road. The data has shown the results about reading ID, date, time, location's longitude and latitude, crash impact point (x, y, z) and distance between other vehicles (front and rear). By using this device, driver performance and location of the vehicle can be monitored. The input data from sensors are saved in SD card even though network coverage is weak. This is one of the advantages of this project where investigator still can get the original data even the internet coverage or Wi-Fi network are very low since it is stored locally in the internal storage.

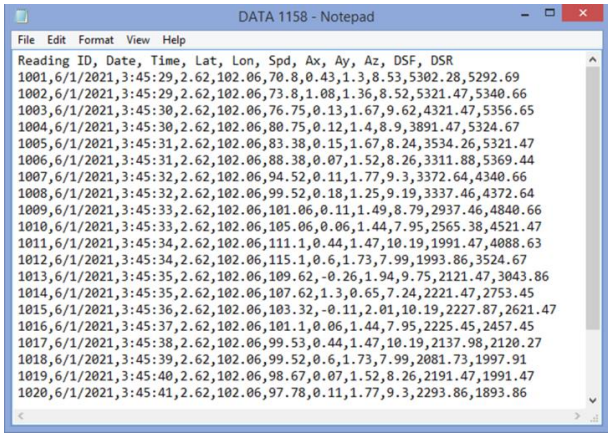

Figure 15. Real Time Data For Data Logging Process And Monitoring

Speed Analysis

The real time data in the Figure 15 was produced from PMDL Monitoring System which is tested in Perodua Bezza. From the data, speed analysis in kilometre per hour for every second are plotted in the graph in Figure 16 below.

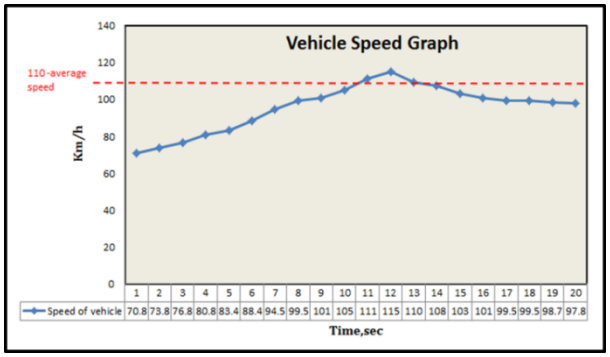

Figure 16. Vehicle Speed Analysis Graph

The graph describe the speed of the vehicle when the vehicle was manuvering at the speed of above 110 kmh. This analysis was made for 20 seconds where the average speed limit in Malaysia is 110 km/h. In this analysis, several conclusion can be made; the graph patterns are slightly rising up and then get down. Here we can see that the vehicle speed above 110 km/h reached at the 11th and 12th seconds. When the vehicle speed above than average speed, driver or users will get preventive notification from PMDL Monitoring System to their smart phone via Blynk application which remind them to slow down. After driver gets the notification, they will slow down due to prevent from accidents. These are shown in the graph pattern where it slowly rise down and maintain the speed of the vehicle.

Distance Analysis

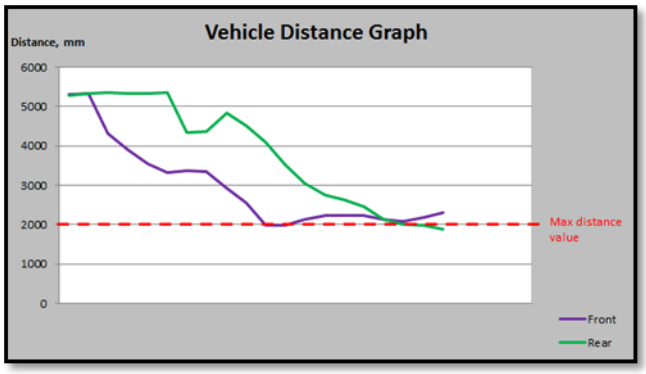

Figure 17. Vehicle Distance Analysis Graph

The graph on Figure 17 describe about the vehicle distance between other vehicles when it was on the road. The vertical axes on the graph describe the distance in millimetre and the horizontal axes are time in seconds. This data are produced from front and rear distance sensors and it was saved in the SD card. We can see that distance sensor can detect until 5000 millimetres and the maximum distance difference between two vehicles is 2000 millimetres. The purple colour line show the front distance sensor data and green colour line is the rear distance sensor data. Front distance of the vehicle is decrease from 5000 millimetres to below than 2000 millimetres. This means that driver is driving very fast or very near to the vehicle in front of him which can cause an accident. Here, Preventive Maintenance Data Logger Monitoring System will prevent from the crash or incident by sending notification to driver or user via Blynk application. The reminders are appearing on driver or user smartphone for every 5 seconds until they achieved the safe distance. This also same goes to rear distance sensor where the graph shows that distance difference are less than 2000 millimetres at the end of line graph (green line). This is happen because of other vehicle driver who is too near with this driver which can bring to an accident. By using this device, investigators can get the data from SD card to find out who is making the trouble.

CONCLUSION

PMDL Monitoring System was developed to prevent the user from accident by alerting the user in the first place to increase their alertness level. Furthermore, it also works as 'Black Box' for small vehicles. The real time data when vehicle was on the road are continuosly stored in the SD card. The data logging process will assist the investigator during the post accident analysis for insurance and research. Blynk application is used and the notification sends to smartphone using Wi-Fi system. It is used to provide the user with relevant notifications to increase their alertness level. For future works, the PMDL Monitoring System will be enhance in terms of its software reliability and the complete fabrication using the actual stainless steel materials.

ACKNOWLEDGEMENT

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