

# DEVELOPMENT OF BLIND SPOT SYSTEM FOR PRIME MOVER TRUCK DRIVERS



# BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE) WITH HONOURS

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# Faculty of Mechanical and Manufacturing Engineering Technology



Bachelor of Mechanical Engineering Technology (Automotive) with Honours

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### DEVELOPMENT OF BLIND SPOT SYSTEM FOR PRIME MOVER TRUCK DRIVERS

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2022

#### **DECLARATION**

I declare that this thesis entitled "*Development of Blind Spot System for Prime Mover Truck Drivers*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.



#### APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive) with Honours.

Mohd Zakaria Signature : ALAN Ts MOHD ZAKARIA BIN MOHAMMAD NASIR Supervisor Name : Date 27/1/2022 ..... UNIVERSITI TEKNIKAL MALAYSIA MELAKA

#### DEDICATION

This thesis is devoted to the glory of Allah S.W.T, my Creator, my great teacher, and messenger, Mohammed (May Allah bless and grant him peace), who taught us the meaning of life and who is the source of all knowledge. I want to convey my gratitude to everyone who participated in many ways to the success of this study and helped make it an unforgettable experience for me.

My beloved parents, Daud bin Man and Syazana Abdullah supported me throughout my career. Their unconditional love, encouragement, support, and sacrifices have sustained us through the years for giving their moral, spiritual and financial support and prayers with served as my inspiration to finish this piece of work.

In addition, I would like to dedicate this thesis to my honorable teachers, who are highly well-informed, extremely diligent, and supportive. Their encouragement and guidance help me to complete my education and thesis.

I owe a special pledge to our project leader and supervisor, Ts Mohd Zakaria Bin Mohammad Nasir, who gave me the strength to do this research work and provided me with the necessary supervision and encouragement. Thank you for always giving me guidance and persistence help to complete this project thesis.

#### ABSTRACT

The number of heavy vehicle accidents in Malaysia due to this situation is troubling. This problem is due to Malaysia's growing population of road users. Furthermore, several sectors of the economy are expanding, resulting in increased demand for all industries in Malaysia. The only way to meet this high demand is to use a heavy vehicle. As a result, highways and narrow roads are often used by heavy vehicles. Due to the large size of heavy vehicles, it is also located in a large blind spot area where significant motor vehicle drivers cannot see other vehicles. However, as for larger vehicles such as lorries, trailers, and buses, the blind spot areas or zones are much larger. Accidents related to blind spot areas are based on the collision type angular/side, side swipe, and squeezed. This study was conducted to determine the prevalence of blind spot issues among Malaysia's rigid and small lorry drivers. Several types of data collection were conducted, which consisted of surveys, on-site measurements, and field experiments. This research aims to assist more experienced drivers in locating additional vehicles in their blind spots. This project also aims to create a framework that will attract users. The findings of this study can be a benchmark for future studies involving other classes of heavy vehicles. However, in terms of the location of blind spots, most drivers perceived that the rear is the blind spot area without knowing that the front and both sides of a truck are also blind spots. The Blind Spot System was developed to ensure driver safety and convenience. The Blind Spot System is comprised of a central hub and four sensor units. The ultrasonic sensor placed on the front and side body senses the obstacles and sends the Arduino MEGA to trigger the system and LED as an output blinks up. The device can identify other vehicles using ultrasound sensors and warn the driver with a buzzer and LED flickering. The sensor units will be placed strategically around the truck in areas known as blind spots or unvisible areas to the driver. While the system is operational, these sensors will continuously transmit sensor data to the hub unit, located in the driver's cabin in the most convenient location. Blind spots created by vehicles or other obstructions will illuminate red, alerting the driver to the presence of something in their path. The LED indicates clear areas will remain turned off. Then the hub unit displays the sensor data's result by LCD. This document will then detail the system's hardware and software design. This paper includes a variety of schematic diagrams, block diagrams, and data flow diagrams. More precisely, the hardware design section will cover power management and printed circuit board design. Following that, the software design section will discuss the logic of the code for the system's two distinct units and how they operate. Next, this document will illustrate and explain the system's housing design and analysis of aerodynamics. Following that, the paper will be detailing the system's testing procedures. This blind-spot warning system makes it easier for the driver to be more cautious in the lane. What distinguishes Blind Spot System is its portability. The trailers that the truck driver hauls are not uniform. Rather than that, they are constantly dropping off and picking up new ones. As a result, sensors cannot be integrated directly into trailers. Blind Spot System addresses this issue by providing portable sensors that can be installed or removed in a matter of minutes, allowing the driver to quickly transfer the sensors from the old trailer to the new trailer.

#### ABSTRAK

Jumlah kemalangan kenderaan berat yang telah berlaku di Malaysia akibat keadaan ini membimbangkan. Masalah ini berpunca daripada bilangan pengguna jalan raya Malaysia yang semakin meningkat. Tambahan pula, beberapa sektor ekonomi sedang berkembang, menyebabkan permintaan meningkat untuk semua industri di Malaysia. Satu-satunya cara untuk memenuhi permintaan yang tinggi ini adalah dengan menggunakan kenderaan berat. Akibatnya, lebuh raya dan jalan sempit sering digunakan oleh kenderaan berat. Bagaimanapun, bagi kenderaan yang lebih besar seperti lori, treler dan bas, kawasan atau zon titik buta adalah lebih besar. Kemalangan yang berkaitan dengan kawasan titik buta adalah berdasarkan jenis perlanggaran sudut/sisi, leret sisi dan terhimpit. Kajian ini dijalankan untuk menentukan kelaziman isu titik buta dalam kalangan pemandu lori tegar dan kecil di Malaysia. Beberapa jenis pengumpulan data telah dijalankan, yang terdiri daripada tinjauan, pengukuran di tapak, dan eksperimen lapangan. Penyelidikan ini bertujuan untuk membantu pemandu yang lebih berpengalaman dalam mencari kenderaan tambahan di tempat buta mereka. Projek ini juga bertujuan untuk mencipta rangka kerja yang akan menarik pengguna. Dapatan kajian ini boleh menjadi penanda aras untuk kajian masa hadapan yang melibatkan kelas kenderaan berat yang lain. Bagaimanapun, dari segi lokasi titik buta, kebanyakan pemandu menganggap bahagian belakang adalah kawasan titik buta tanpa mengetahui bahagian hadapan dan kedua-dua belah lori juga merupakan titik buta. Sistem Titik Buta dibangunkan untuk memastikan keselamatan dan keselesaan pemandu. Sistem Titik Buta terdiri daripada hab pusat dan empat unit penderia. Penderia ultrasonik yang diletakkan di bahagian hadapan dan sisi badan mengesan halangan dan menghantar mesej kepada Arduino MEGA untuk mencetuskan sistem dan LED sebagai output berkelip ke atas. Peranti boleh mengenal pasti kenderaan lain menggunakan penderia ultrasound dan memberi amaran kepada pemandu dengan buzzer dan LED berkelip. Unit penderia akan diletakkan secara strategik di sekeliling trak di kawasan yang dikenali sebagai titik buta atau kawasan yang tidak dapat dilihat oleh pemandu. Semasa sistem beroperasi, penderia ini akan menghantar data penderia secara berterusan ke unit hab, yang terletak di dalam kabin pemandu di lokasi yang paling mudah. Bintik buta yang dicipta oleh kenderaan atau halangan lain akan menyala merah, menyedarkan pemandu tentang kehadiran sesuatu di laluan mereka. LED menunjukkan kawasan yang jelas akan kekal dimatikan. Kemudian unit hab memaparkan hasil data sensor dengan LCD. Dokumen ini kemudiannya akan memperincikan reka bentuk perkakasan dan perisian sistem. Kertas ini merangkumi pelbagai rajah skematik, rajah blok dan rajah aliran data. Lebih tepat lagi, bahagian reka bentuk perkakasan akan merangkumi pengurusan kuasa dan reka bentuk papan litar bercetak. Selepas itu, bahagian reka bentuk perisian akan membincangkan logik kod untuk dua unit sistem yang berbeza dan cara ia beroperasi. Selepas itu, kertas ini akan memperincikan prosedur ujian sistem. Sistem amaran titik buta ini memudahkan pemandu untuk lebih berhati-hati di lorong. Apa yang membezakan Sistem Blind Spot ialah mudah alihnya. Treler yang dibawa oleh pemandu lori tidak akan kekal. Sebaliknya, mereka sentiasa menghantar dan mengambil yang baru. Akibatnya, penderia tidak boleh disepadukan terus ke dalam treler. Sistem Titik Buta menangani isu ini dengan menyediakan penderia mudah alih yang boleh dipasang atau dikeluarkan dalam masa beberapa minit, membolehkan pemandu memindahkan penderia dengan cepat daripada treler lama ke treler baharu.

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## LIST OF SYMBOLS AND ABBREVIATIONS

V	-	Voltage
Ι	-	Current
R	-	Resistance
Р	-	Power
Q	-	Charge
А	-	Ammeter
G	-	Gram
LED	-	Light-Emitting Diode
USB	- 10	Universal Serial Bus
IDE	S.	Integrated Development Enviroment
JKR	EK.	Jabatan Kerja Raya
MIROS	1	Malaysia Institute of Road Safety Research
PDS	Con and a second	Product Design Specifications
WHO	- 10	World Health Organization
SI	ملاك	و بنوم است (International System or Units
GND	_	Ground
RC	UNIVE	Remote Control IKAL MALAYSIA MELAKA
Ω	-	Ohms
TX	-	Transmit
RX	-	Receive
VSS	-	Voltage Source Supply
VDD	-	Voltage Drain Drain
NPN	-	Negative Positive Negative
LCD	-	Liquid Crystal Display
DC	-	Direct Current
US	-	Ultrasonic Sensor
mAh	-	milliampere/hour
G	-	vibration amplitude

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#### **CHAPTER 1**

#### **INTRODUCTION**

#### 1.1 Background

Driving has become an increasingly common activity in Malaysia. The high possibility could manifest if the motive force views the forthcoming road risks and appearance in reverse while riding on expressways. Therefore, it is essential to look both sideways and in the opposite direction before securely changing the demands. In addition, a common issue that drivers face is that the ranges are not apparent through the side and rearview mirrors, which is referred to as the truck's blind spot. Even if someone does not drive, the chances are that they are at the very least a frequent passenger in a vehicle. Therefore, despite how important travel is in Malaysian lives, it is still potentially risky. Then, I have firsthand knowledge of car accidents caused by a truck's blind spot. One of these mishaps directly involved one of the team members. As a result, I decided to use senior design to improve the roads for all users. With comfort and safety in mind, I designed the Blind Spot System for Prime Movers Truck Drivers. It consists of two parts: a hub and four sensor modules.

The sensor units will be positioned strategically around the truck in key blind spots or places not accessible to the truck driver. These sensors will continuously send sensor data to the hub unit seated in the cabin at the most suitable position for the driver while the device is turned on. The sensor data is shown on the hub unit. Blind spots with cars or other obstructions will turn red, alerting the driver to the presence of an obstacle. Clear areas will have their LEDs turned off. The system's portability is what sets Blind Spot System apart. The trailers that a truck driver transports are not all the same. They keep dropping off and picking up new ones. Figure 1.1 shows the blind spot area in a truck.



Figure 1.1: Truck Blind Spot Area

As a result, sensors cannot be directly integrated into trailers. Blind Spot System solves this problem by having portable sensors that can be mounted or removed in a matter of minutes, allowing the driver to quickly switch the sensors from the old trailer to the new trailer. All of the sensors are now totally wireless, making cable management a thing of the past. The Truck Smart design process is recorded in this article. It will begin by describing the project's inspiration and objectives. It will then go over specifications and criteria such as measurements and battery life in greater depth. The analysis chapter would detail the decisions taken for each device component and why they were made. Topics such as whether the ATmega258P, Arduino Uno, and ultrasonic technologies were selected are important decisions. The paper would then go through the different constraints (economic, sustainability, etc.) and principles (IEEE, DoT) that influenced the project's design decisions. This paper will then discuss, in detail, the hardware and software architecture of the device. Various schematics, block diagrams, and data flowcharts are used. The hardware design

section will cover power control and PCB design in particular. The software architecture section would illustrate how the wireless network was implemented and the rationale of the code for the two distinct units of the device. Next, this paper would demonstrate and describe the system's housing architecture and how it protects the environment. After that, the paper would go over the research techniques used on the device in detail. Finally, the managerial section reveals how the budget was broken up and a basic production process schedule in the milestone section.

#### **1.2 Problem Statement**

Automobile innovation has grown exponentially in recent years to reduce the chance of mishaps while driving a vehicle. As a result, numerous studies have been suggested regarding the user assistance system focusing on the blind spot district.

Blind spots are areas around a truck lorry that can't be seen, mostly by the driver. As a result, many street accidents occur due to the driver's inability to see other vehicles approaching the blind spot, significantly when changing lanes. To fix this problem, a device capable of detecting motors and cars inside blind spot stages must be developed to warn the driver about the situation in the blind spot ranges, ensuring the safety of road users.

In addition, motors in adjacent road lanes can also enter such blind spots, and a driver can no longer see abutting vehicles with only the vehicle's mirrors. Blind spots are specific zones that are too low to see behind regularly and ahead of cars. Besides, blind facets may appear on one side or the other in cases where side vision is impaired.

#### **1.3** Research Objective

This research aims to minimize road accidents caused by trucks and lorry with the Blind Spot System for the truck drivers. Specifically, the objectives are as follows:

- a) To Design a new Blindspot System for Truck Drivers using 3D CAD Software and Arduino MEGA 2560.
- b) Develop an electronic and control system for the entire system.
- c) Perform design analysis and optimization as well as an actual test prototype.

### 1.4 Scope of Research

The scope of this research are as follows:

- a. Create an electronic circuit that can be controlled by Arduino software.
- b. Create a model of the system's circuit and prototype.
- c. To test the efficiency of the blind spot system by using ultrasound sensors and programming applied in Arduino MEGA2560 Controller.
- d. When a vehicle enters the blind spot area, display a warning by calculating

the distance to the detected object and displaying data value and warning audio on the screen and speaker.

- e. To compare the result with actual test and simulation.
- f. The identified objectives are expected to appear and be presented by the project's completion result.

#### **CHAPTER 2**

#### LITERATURE REVIEW

#### 2.1 Introduction

This section includes a review of relevant evidence for the entire project. A writing audit has was used as a tool for those interested in learning more about the hypothesis. Furthermore, this section will cover the fundamentals of electrical design, the blind-spot method, and the Arduino program. Besides, the writing survey will help you learn more about the investigation and decide about the project. (Shabadin, n.d.).

#### 2.2 Road Conditions

The transport part entails transporting goods and personnel through the streets, beginning at one location and progressing to the next. The road is a path between two objectives cleared or attempted to allow transportation by mechanized and non-mechanized carriages. There are several points of interest in street transportation as compared to other modes of transportation. Compared to different modes of transportation, such as rail and air, the speculation needed for street transportation is minimal. Rail costs are less costly than growth, operating, and street support.

The transportation or delivery of goods and materials may be categorized as road transportation. Road transportation has a significant benefit because it can distribute goods and components door-to-door and cheaply. The main focus is on transporting goods to and from rural areas that are not fascinated by train, water, or air. Street transportation between urban areas, cities, and small towns will be provided at a reasonable cost. Despite its advantages, however, road transportation has some significant drawbacks. For example, in

the case of road transportation, the chances of mishaps and breakdowns are higher. Engine transportation is not as secure as other modes of transportation. Besides, street transportation is also less well-organized than different modes. It's inconsistent and inefficient. The rates of public transportation are disproportionately unsteady and crooked, and the pace of public transportation is moderate and restricted, which is a significant disadvantage. Long-distance transportation of bulky goods is also inefficient and expensive. Currently, street transportation has a significant negative impact on the environment. (Lum, 2019)

One of the essential factors in boosting a country's economy is its transportation infrastructure. Rapid monetary growth would result in a higher national wage. The rise in the standard of living affects the number of transportation requests needed to meet business and daily needs. The figure below depicts the number in 2014 and 2015, the Road Transport Department Malaysia enrolled vehicles (trucks) in Malaysia. Figure 2.1 shows the total number of trucks registered in Malaysia between 2014 and 2015.



Figure 2.1 Total Number of Truck Registered in Malaysia in 2014 and 2015

From 2014 to 2015, most Malaysian states experienced an increase in entirely lethal mishaps, including truck accidents. From 2014 to 2015, enlisted goods vehicles increased from 748,039 to 759,808. This situation would unquestionably cause traffic congestion, especially on the unwavering quality of transportation arrange frameworks, potentially lowering personal network satisfaction. In either case, the infrastructure for street transportation is improving every day. As the essence of the street can affect the current society's delight, it creates an adaptable creation to interface from one area to one territory.

These results indicate that identifying blind spots among lorry drivers is critical to preventing fatal accidents among Malaysia's vulnerable road users. In Malaysia, data provided by Road Transport Department shows that the total of goods vehicles increases every year (shown in Figure 2.2). However, the data given is dependent on the total capability of a goods vehicle, with no breakdowns required for each category of goods vehicle. (Shabadin, 2017)

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	100	10	$\sim$	1 <sup>1</sup>	- 10	U. 1	and the second second	

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2009	936,222
2010	966,177
2011	997,649
2012	1,032,004
2013	1,112,480

#### Figure 2.2 Number of Goods Vehicles Registered by Year

#### 2.3 Road Accidents

#### 2.3.1 Road Accidents happened in Malaysia

Accidents happen all the time and are very common in Malaysia, especially road accidents. Every day, road accidents occur, killing and injuring people. The number of fatalities rises every year, particularly during Malaysian holidays like Hari Raya Aidilfitri, Chinese New Year, and Christmas Day. The accident resulted in both deaths and injuries. A group interested in resolving the issue would find it difficult to resolve this tragedy. Road accidents occur due to causes, including several parties, and have various consequences, necessitating urgent solutions. Accidents frequently happen in Malaysia, and they can occur at any time and in any place. A variety of causes of accidents in Malaysia. Drivers who lose control of their vehicles, such as cars, buses, or motorcycles, are first. Drivers who want to get to their destination quickly can speed on the highway. Second, drivers should not adhere to traffic laws. They drive when the traffic light is red, for example. This mentality demonstrates that they are bold enough to break traffic laws while knowing the consequences and fines. Third, incidents often occur due to aggressive drivers, some of whom may be inebriated while on the road. One catastrophe will inevitably arise. Accidents may also happen due to irresponsible drivers who drive recklessly and have little regard for others. These drivers are egotistical and do not consider the safety of those on the lane. (Marks, 2017)



(Source: WHO, 2015)

#### Figure 2.3 Road Traffic Death By Type of Road User

In Malaysia, 6674 people were killed in traffic accidents in 2014 (shown in Figure 2.3). (RMP, 2014). In 2013, this country ranked third among all ASEAN countries regarding road traffic fatalities per 100,000 population (24.0 per 100,000). (WHO, 2015).

Prof Dr. Ahmad Farhan Sadullah, Director-General of the Malaysian Institute of Road Safety Research (MIROS), stated that "Our country's road death statistics are at an all-time high." In addition, the number of road fatalities in our country has reached "alarming" proportions. (SEAN, 2010)

In reality, large truck collisions are a significant traffic safety problem. For example, Figure 2.4 shows that in 2014, there were 1866 trucks involved in fatal collisions, 575 trucks involved in severe injuries, and 1047 trucks involved in minor injuries to drivers or passengers. (Haiqal, 2021)

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Figure 2.4: Road Traffic Death By Type of Road User in Malaysia for the Year 2014





The Malaysian government has introduced and implemented several policies, measures, and programs to minimize road traffic deaths in response to the rising number of road traffic deaths. One of these tactics is the Malaysian Road Safety Plan 2014-2020, created to achieve the goals (JKR & MIROS, 2014).

#### 2.3.2 Accidents because of blind-spot on the trucks or heavy vehicles.

Blind spots exist in any car, limiting the driver's ability to see around the vehicle when on the lane. Trucks are no exception, and their blind spots are much larger than those in cars, buses, or pickup trucks, which drivers can search simply by looking over their shoulders.

Most drivers on the road take their time passing trucks, unaware that they are putting themselves in danger by staying in the blind spot of a truck driver. Unfortunately, a trucker cannot be held liable if they cannot see another vehicle and switch lanes or make a switch that results in a truck accident. (Attorney, 2016)

On Malaysian highways, the number of trucks varies from state to state (shown in Figure 2.6). However, except for Sabah and Sarawak, the number of fatal truck accidents has increased from 2014 to 2015. The west coast states of Malaysia have the most significant number of fatal truck crashes. The east coast has a lower rate of truck-related fatalities.



Figure 2.6: Total Fatal Accidents Involving Trucks in Malaysia For the Year 2014 and 2015

From the graph shown below, the total fatal accidents involving trucks by time in Malaysia increased from the year 2014 to the year 2015. The most frequently occurring hours are between 4 pm to 6 pm for 2014 and 2015. Previous studies have shown that vehicle numbers would double the risk of accidents on roads during peak hours. (Masuri, Md Isa & Mohd Tahir, 2011).



Figure 2.7: Fatal Accidents Involving Trucks by Time in Malaysia For the Year 2014 UNIVERSITITEKN and 2015 LAYSIA MELAKA

According to the graph in Figure 2.7, the total number of fatal truck accidents in Malaysia increased from 2014 to 2015. For 2014 and 2015, the most common hours for accidents were between 4 and 6 p.m.

According to previous reports, the number of cars on the road would increase during peak hours, doubling the risk of road traffic accidents. (Attorney, 2016)

A commercial truck crash can be much more severe than a collision between two personal vehicles. This is because a fully-loaded commercial truck can weigh up to 25 times the weight of a typical vehicle. As a result of the loaded goods and weight, most big rig truck collisions involving other vehicles result in serious, if not fatal, injuries. (Masuri, Md Isa & Mohd Tahir, 2011)



Figure 2.8: Fatal Accidents Involving Trucks by Collision Type in Malaysia For the Year 2014 and 2015

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		Collision Types
UNIVERSITI 1	1EK	Head-on Collision LAYSIA MELAKA
	2	Rear Collision
	3	Right Angle Side
	4	Angular Collision
	5	Side Swipe
	6	Forced Collision
	8	Hitting Animal
	9	Hitting Object On Road
	10	Hitting Object Off Road
	11	Hitting Pedestrian
	12	Overturned
	14	Out of Control

From the bar chart given above, it can be concluded that there is a rapid increase in collision type 1 and collision type 2 from the year 2014 to 2015 (shown in Figure 2.8). (Haiqal, 2021)

#### 2.4 House of Quality

As seen in Figure 2.9, the house of quality is a design tool that enabled me to create and visualize the relationships between marketing requirements and engineering requirements.

Marketing requirements are needs and wants from the potential consumer's perspective. This includes costs, which consumers wish to as low as possible. The cost value under the marketing requirements means the product's price that the end-user will pay. Another marketing requirement is battery life, which consumers want as high as possible. The system's accuracy comes down to how often the Truck Smart system will accurately warn the user of blind-spot detection. This value needs to be as close to a hundred percent as possible. The portability of the design depicts the installation's ease. The system should be as easy to install as possible. The durability of the system is how long the product will last. The higher this is, the more likely the customer would buy it. Finally, the usability of the product should be as simple as possible.

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#### **Figure 2.9: House of Quality Specification**

The engineering requirements once again list the needs of the system. However, it is UNVERSITE TEKNIKAL MALAYSIA MELAKA done from the developers or engineer instead of the consumer's perspective this time. The smaller the dimensions of the system, the more appealing it will be, as it dramatically increases the portability and usability of the system. However, this will negatively affect battery life since there will be less space to house the battery. The same logic also applies to the weight of the system. However, less weight will negatively impact the system's durability as thinner construction material tends to be weaker.

The system's quality refers to the quality of the parts used in it. This is the difference between more expensive but longer-lasting and more trustworthy brands. The system's efficiency is based on how much power it uses to accomplish its task. Higher efficiency means much higher battery life, and therefore, better usability. The larger the power source it, the better the battery life but, the lower the portability. This will also directly affect install ease. (Santhoshkumar et al., 2016)

#### 2.5 Fundamental Principles of Electrical Engineering

#### 2.5.1 Basic Unit in Electrical Quantities

The International System of Units (SI units), frequently abbreviated as SI, is the unit system used in engineering and science. It is a metric. This system was implemented in 1960 and has been adopted as the official measurement method by most countries since then. The SI system's fundamental units are described in Table 2.1, along with their symbols. (John Bird, 2015)

¥. • • • • • • • • • • • • • • • • • • •		
Quantity	Unit	
length	meter, m	
mass	kilogram, kg	
Stime June	second, s	
electric current	ampere, A	
thermodynamic temperature	MALAYSIA Kelvin, K.A	
luminous intensity	mole, mol	

#### Table 2.1: Basic SI Units

Numerous derived SI units are formed by combining basic SI units. Two examples are as follows::

- Velocity—meters per second (m/s)
- Acceleration—meters per second squared (m/s<sup>2</sup>)
SI units can be multiplied or divided by a defining factor to change their size. The six most frequently occurring multiples are listed in Table 2.2, along with their definitions. (Dev Guis, 2021)

Prefix	Name	Meaning				
м	mega	multiply by 1,000,000	(i.e., ×10 <sup>6</sup> )			
k	kilo	multiply by 1,000	(i.e., ×10 <sup>3</sup> )			
m	milli	divide by 1,000	(i.e., ×10 <sup>-3</sup> )			
μ	micro	divide by 1,000,000	(i.e., ×10 <sup>-6</sup> )			
n	nano	divide by 1,000,000,000	(i.e., ×10 <sup>-9</sup> )			
Р	pico	divide by 1,000,000,000,000	(i.e., ×10 <sup>-12</sup> )			

## Table 2.2 Six Most Common Multiples

## 2.5.2 An Introduction to Electrical Circuit

The electrical circuit has been used as the primary material of the system in the majority of flow invention. This is also because an electrical circuit is made up of connected parts. It is undeniably increasing that photos are being used to promote circuit networks. Any use of electrical circuits in modern life is crucial because it reduces power transmission and force utilisation. Because of its versatility and adaptability, power has high expectations as compared to other sources. The electrical circuit's segments and components included resistors, capacitors, and inductors. The examination can be used to estimate the movement, voltage, and force in an electrical circuit. (Izzat Darwazeh, 2015)

As a solution, critical electrical circuit investigation and enactment are needed. In most cases, the picture is also used to build the segment's electrical circuit diagram. An image was used to replace an accurate representation of the component, which aided in developing

the electrical circuit graph. The standard symbol for the shape of an electrical circuit is depicted in Figure 2.10.



Figure 2.10: Standard Symbols for Electrical Component

Protons, neutrons, and electrons make up every atom. Protons, which have a positive charge, and neutrons, which have no charge, are contained within the nucleus. The electrons are even smaller negatively charged particles, with the centers having been evacuated. Variable materials have varying numbers of protons, neutrons, and electrons, resulting in different atoms. In neutral molecules, protons and electrons are quantized in terms of their numbers. A pinch is electrically balanced because the positive and negative charges cancel each other out. When an atom has more than two electrons, the electrons are distributed

among several shells with varying distances from the nucleus. This is because the nucleus and its electrons have strong forces of attraction that bind all particles together. Electrons in an atom's outer shell, on the other hand, are less strongly electrons whose shells are closer to the nucleus are more likely to be captured by the nucleus. Thus, as a result, an atom loses an electron, known as an ion. It is positively charged and is capable of attracting another electron from an atom. Free electrons flow from one atom to another, regardless of their source, and this flow is possible forever. (Mike Tooley, 2014)

On the other hand, electrons appear to travel in a specific direction when an electric pressure or voltage is applied to a particular object, and this causes electrons to flow from one place to another. Drift, or the movement of free electrons, is what makes an electric current run. As a result, the rate of charge movement is called a current.

Conductor materials are those in which electrons are loosely coupled to the nucleus and can easily pass from one atom to the next. The electrons in insulators are tightly bound to their nucleus. One coulomb equal to 6.24 1018 electrons is used to determine the amount of electrical charge Q, abbreviated as the Coulomb C. If electrons in a conductor move at a rate of one coulomb per second, the resulting current is one ampere. Because of this, a current of one ampere is equal to one coulomb per second or 1 A=1 C/s. As a result, one coulomb equals one ampere second, or 1 C equals 1. It denotes the number of coulombs of electrical charge., i.e., current I (in amperes) multiplied by time t (in seconds) equals charge Q (in coulombs). (John Bird, 2015)

$$Q = I \times i$$
 coulombs

## 2.5.3 Basic Circuit Laws



Figure 2.11: Open and Closed Circuit





While essential circuit elements (such as voltage, current, power, and resistance) are the subject of the fundamental laws of electrical circuits, the various parameters of those circuits (such as current and resistance) are what these laws define. Many circuits (shown in Table 2.3) with different battery voltages and resistances have been examined, resulting in a visual representation. All circuits must include three essential elements. The components include a voltage source, a conductive path, and a load in this scenario. To begin, you will need a voltage source, such as a battery, for the current to flow through the circuit.

Rows 1, 2, and 3 show the battery voltages double and triple, causing the current circuit to be double and triple. The total resistance is doubled and used to reduce the circuit's current in half by comparing lines 1 and 4 and lines 2 and 5.

Furthermore, a conductive path must be present to provide a path for the electricity to flow. Finally, it is crucial to have a load that uses power to have a proper circuit. For example, the light bulb is the load in the preceding circuit. Although a few of the more intricate electronic relationships and formulae are utilized regularly, if not daily, the fundamentals described in this section are widely used across all job functions related to electronics. For example, Georg Ohm and Gustav Kirchhoff discovered Ohm's and Kirchhoff's laws, also referred to as Ohm's and Kirchhoff's.

Ohms law, the most common (and most straightforward) formula in electronics, describes the relation of voltage, current, and circuit resistance. According to Ohms rule, the voltage's current flows are equal by resistance around the I = V/R, divided by the resistance. Different views of Ohm's law can be represented in numerous ways, all of which are widespread. For example, to represent the same voltage as the current flowing through a resistor, which flows through it as the resistance, we must multiply the current by the

resistance (V=IR). In comparison, resistance is equal to the difference between the voltage across a resistor and the current flowing through it (R=V/R).

When it comes to circuit power draw, we can say that the current flowing through it equals the voltage times the power (P=IV). Therefore, the law of Ohms can be used to measure the amount of power being used in a circuit. Ohm's law can be used to calculate circuit power draw if two of the circuit variables are known. The Ohms law formula is an essential circuit design tool for electronics, as it aids in creating large circuits. However, it is an absolute requirement at all circuit design and electronics levels. Determining how much power is dissipated in a component as heat is one of the most basic applications of Ohms law and the power relationship. Failure to understand this will prevent you from correctly choosing the right size component with the correct power rating for the application.

When selecting a 50 ohm surface mount resistor exposed to 5 volts during regular operation, consider the following factors, If we assume that the resistive voltage source will dissipate (P=IV), we have 5 volts2 (or V). Therefore, because a resistor with a higher power rating than 0.5 watts is required, we can conclude that the resistor will need to dissipate (P=IV=> P=(V/R)\*V=> P=(5volts2)/50ohms)=5 watts. In order to know if additional thermal issues or cooling are required, you must know the power usage of every component in a system. That information will enable you to determine whether an increase in the system's power supply size is required. Ohm's law has its own equation, which can be rearranged and expressed as:



To calculate the current from an equation based only on electric potential difference and resistance, you must know the electric potential difference and resistance. This equation is far more than just a powerful problem-solving formula. This equation depicts the two variables that influence the current flow. The current flow in a circuit concerns the ap plied voltage and the opposition to the external circuit's total resistance. The more significant the available voltage (i.e., the more influential the electric potential difference), the higher the current. And the lower the current, the more excellent the resistance. When the battery voltage increases while the resistance is reduced, the charge flows the most rapidly.

Because increasing battery voltage results in an increase in current, doubling the battery voltage results in doubling the current (if all other factors are kept equal). As a result, the load resistance must be doubled to double the current, resulting in a 50% reduction in current flow. Since resistance affects the current flowing through a circuit, resistors are frequently used in the circuits of electrical appliances to regulate the amount of current flowing through its various components. For example, a manufacturer can alter the current flowing through a particular circuit branch by increasing or decreasing the resistance in that branch. For another example, electric mixers and light dimmer switches vary the current flow at the load by increasing or decreasing the circuit's resistance. For example, by pressing the various buttons on an electric mixer, you can switch from mixing to beating mode by lowering the resistance and allowing more current to flow through the mixer. Similarly, turning the dial of a dimmer switch increases the resistance of the integrated resistor, thereby decreasing the current. (Burris, 2016)

#### 2.5.4 Series and Parallel Networks



Figure 2.12: Series Circuit

Figure 2.12 shows three resistors, named *R1*, *R2*, and *R3*, connected end-to-end, which is to say they are in series with a voltage source of *V* volts. As the circuit is closed, current I can flow, and voltmeter measurements *V1*, *V2*, and *V3* may be used to calculate the voltage around each resistor.

In a series circuit, (a) At the time of measurement, the current flow in the circuit is **UNIVERSITITEKNIKAL MALAY SIA MELAKA** the same for all sections; consequently, the same reading is acquired on both of the presented two ammeters., and (b) The total applied voltage, V, is equal to the sum of V1, V2, and V3.

$$V = V_1 + V_2 + V_3$$

3

As stated by Ohm's law:

V1 =IR1, V2 =IR2, V3 =IR3 and V =IR,0

where R is the total circuit resistance.

Since V = V1 + V2 + V3 then IR = IR1 + IR2 + IR3

then IR =IR1 +IR2 +IR3

Dividing throughout by I gives:

 $R = R_1 + R_2 + R_3_4$ 

Lastly, when a circuit has multiple resistors, the total resistance equals the sum of the individual resistances.

In a Parallel circuit, Figure 2.13 depicts three resistors, *R1*, *R2*, and *R3*, linked across each other, i.e., linked in parallel. For example, across a V volt battery source, they are three resistors connected in this manner.

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Figure 2.13 : Parallel Circuit

In a parallel circuit, the currents are identical (a) The current that flows through all three circuits is equal to the total circuit current known as *I*. Thus, I = II + I2 + I3. (b) Resistors are all electronically the same in their source voltage, V volts. Ohm's law states:

$$I_1 = \frac{V}{R_1}, \quad I_2 = \frac{V}{R_2}, \quad I_3 = \frac{V}{R_3} \text{ and } I = \frac{V}{R}$$

5

Where **R** represents the total circuit resistance. Since I = I1 + I2 + I3, then



When calculating the total resistance R of a parallel circuit, this equation must be used. For the particular case of two parallel resistors:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_2 + R_1}{R_1 R_2}$$

Hence, 
$$R = \frac{R_1 R_2}{R_1 + R_2} \quad \left(\text{i.e., } \frac{\text{product}}{\text{sum}}\right).(\text{Burris, 2016})$$

26

#### 2.5.5 Light-Emitting Diodes

On February 9, 1907, one of Marconi's engineers, Mr. H.J. Round of New York, NY, submitted an article to "Electrical World" magazine titled, "Marconi May Complete Transatlantic Communication in a Few Months." An explanation of carborundum. The carborundum and other substances contact led to a fascinating phenomenon during the investigation of the passage of current through the contact of carborundum and other substances. A yellowish light was produced when a potential of 10 volts was applied between two points on a carborundum crystal.

Mr. Round continued by observing that some crystals emitted green, orange, or blue light. It is possibly the first documented reference to the effect distinguishing light-emitting diodes (LEDs) from other electronic components. Unfortunately, no one seemed to care about Mr. Round's discovery, and nothing happened until 1922, when O.V. In Leningrad, Losov noticed the same thing. Los filed four patents between 1927 and 1942, but Losov was killed in action during WWII, and the details of his work were never revealed. Researchers didn't look into this effect seriously until 1951, after discovering the bipolar transistor. They found that light is emitted from the PN junction, the junction between the P-type and N-type doped materials. A semiconductor diode is made from a compound semiconductor made from two or more elements, such as gallium arsenide (GaAs).

Like a traditional diode, an LED conducts electricity only in one direction (and emits light only when conducting). Besides, the symbol for an LED is similar to that for a normal diode, but with two arrows to indicate light being emitted (Figure 2.14).



#### Figure 2.14 : Symbol of LED

Gallium arsenide, an LED made from pure gallium arsenide, emits infrared light, which is helpful for infrared sensors that the human eye cannot see. It was discovered that AlGaAs were created when aluminum was added to the semiconductor. By creating the resulting material, people were able to see red light. Besides, many attempts and enhancements were put into place to have the first red LEDs in the market by the 1960s. LEDs are appealing for various reasons, not the least of which is that they have a long lifespan and are incredibly dependable (typically 100,000 hours as compared to 1,000 hours for an incandescent light bulb). They also produce very pure, saturated colors and are extremely energy efficient (LEDs use up to 90 percent less energy than an equivalent incandescent bulb). More materials capable of generating different colors were discovered over time. Aluminum indium gallium phosphite emits green light, and gallium phosphide VERSITI TEKNIKAL MALAYSIA MELAKA produces green light. Even over several years, the only color missing was blue. It was significant because blue light has the shortest wavelength of visible light. Engineers discovered that they could quadruple the amount of data stored on and read from CD-ROM or DVD if they could develop a blue laser diode. Despite the hundreds of millions of dollars spent by semiconductor companies in their desperate search for a blue LED, the elusive element only remained elusive for decades. (Ron Schmitt, 2015)

#### 2.5.6 Battery Terminology

	No	Part of The Electrochemical							
	1	Copper							
	2	Aluminum							
	3	Iron							
	4	Silver							
	5	Lead							
- 51	6	Zinc							
y Wat	7	Sodium							
	8	Hydrogen							
	9	Carbon							
	_								

Table 2.4: List of Electromechanical

A battery is a closed vitality structure used to store electricity, often synthetic compounds. Table 2.4 above shows the list of electromechanical. However, because most types are battery-powered after use, they are only compatible with a limited set of hardware. The battery will be suited for storing direct current (DC) power produced by renewable energy sources, such as solar, wind, and hydro turbines. Batteries serve two purposes. First, they store energy for future use and second, they serve as a means of providing electrical power regardless of the time of day.(Andrew Leven, 2015)

Although it is possible to consider this well as a renewable energy source, it is better described as an energy wellspring than renewable energy. Lithium batteries are versatile and versatile, allowing them to be used for almost anything. It's no surprise that they're used in an almost infinite variety of applications and gadgets. They can be found in simple devices like wristwatches to high-end devices such as electric vehicles. NASA uses lithium batteries in their spacesuits as well. Lithi- um batteries are lightweight, which allows them to be used in various gadgets and devices. There are no restrictions on how lithium batteries can be used, and they can be used in multiple DIY ventures. The cathode varies depending on the type of cell. However, all of the cathodes contain some lithium compound. Graphite is almost always used for the anode. It may contain traces of other elements in a few unusual cases.

The electrolyte contains an organic compound containing lithium ions, usually in lithium salts. Finally, the porous separator acts as a separator, allowing lithium ions to pass through while separating the anode and cathode in the cell. Lithium ions flow through the electrolyte from the anode to the cathode when the cell discharges. The discharge causes the electrons on the anode side to burst, eventually driving the circuit. Consequently, any computer or gadget connected to the circuit is also conducted. The process is reversed when the cell is recharged, where the lithium ions pass to the anode from the cathode. The process by itself is pretty simple: what makes the cell complex is its shape and chemical differences. (Burris, 2016)

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#### 2.6 Study on Sensor Device

According to Dr Thomas Kenny (2005), Sensor technology differs, who states that a sensor is a device that converts an electrical signal from a physical phenomenon. Therefore, sensors can be considered a component of the interface between the physical and electrical worlds, such as computers. Jon Stenerson (1993) says sensors do simple tasks better and more accurately than people in his book. As a result, sensors are much faster and make far fewer mistakes. (Singh, 2016)

A Wireless Sensor Network (WSN) is a network of independent sensors that use these findings to detect physical or environmental conditions such as temperature, sound, vibration, pressure, motion, or contaminants. Surveillance applications, such as watching the battlefield, provided the impetus for the invention of wireless sensor networks, which are now used in a wide range of commercial and civilian applications. Sensors can be used for various applications such as industrial process monitoring and control, machine health monitoring, environment, and ecosystem monitoring, healthcare applications, home automation, and traffic control.(Bosch, 2019)

WSN does not depend on any pre-existing networking infrastructure in terms of connectivity. They can organize automatically in a mesh-type network they are resistant to partial failures. There is no expense to communicating internally since computer communication is independent of any external network. Furthermore, wireless sensor networks can also be used in delay-tolerant applications, practical in countries with limited infrastructure. Besides, data collected by sensors can be stored in a gateway's memory and then transmitted when an external network becomes available. In conclusion, no data will be lost, and installations can occur in rural areas that lack continuous or affordable network access. (Parallax, 2013)

#### 2.7 Blind Spot System for Truck

Blind-spot alert systems help alert users to cars that are either behind or to the side of the vehicle while changing lanes. It is one of the most common driver assistance systems in the modern automotive industry and can be found on mid-level and budget vehicle options. This technology detects other vehicles in the blind spots area using ultrasonic sensors mounted on this side of the vehicle. Additionally, blind-spot alert systems would warn by illuminating the light on or near the side mirror, primarily on the practical side of the vehicle. Users will usually get an audible beep or tone to let the driver know they need to look twice before changing the lanes when they activate one's signal lights while a blind-spot system is triggered. The installation of ultrasonic sensors along one side of the truck is depicted in Figure 2.15.



Figure 2.15: Installation Of Ultrasonic Sensors Along One Side Of The Truck



This article introduces a novel concept for a real-time driver assistance system that utilizes multiple sensors and actuators to monitor an area around the vehicle and communicate alerts to the driver (shown in Figure 2.16). The proposed method, dubbed the driving assistant, detects and alerts the driver to the presence of obstacles within the monitor via a combination of audio and visual signals. It utilizes simple ultrasonic sensors installed in the vehicle's two front corners and two blind spots. Due to the design's low cost and adaptability can be deployed as an add-on to existing vehicles. The modules are connected via a low-bandwidth, low-power cable link. It discusses the rationale for the driving assistant concept, how human reaction time affects vehicle operation safety, and suggests incorporating such a system into real-world automobiles. From conceptualization to design, construction, and presentation, we developed a driving assistant system that may be a potential solution for accident prevention. The three unique design features present in the prototype examined in this paper are highlighted here.:

- An ultrasonic sensor system is implemented to detect foreign objects in areas around the blind spots and the front corners of the vehicle.
- Their experiments show that the low-cost ultrasonic yields satisfying accuracy in distance measurement.
- An LED display, LCD, and a buzzer are introduced as the enhanced indicator design, providing hazard warnings alert to the truck driver.

From this previous study, we can infer that a substantial amount of image processing has been applied to many different systems. Image processing is a complex system in which the image must be taken multiple times to identify the objects in a detector on the system. Additionally, it connects between the sensor and the primary system. Because of the high cost and insignificant relevance, spending additional funds on this is unnecessary. Because of the many systems in the vehicle, waves generated by these systems can interfere with the system. Therefore, the ultrasonic method is more effective in detecting and measuring signals than systems less influenced by other components and architectures that are much simpler to comprehend. (Zhang et al., 2017)

## 2.7.1 Ultrasonic Sensor Principle

To detect unauthorized object access attempts, modern protection systems employ a variety of sensors. Sensors in the array include infrared, microwave, and ultrasound sensors

designed to track moving objects. Moreover, each sensor type has its own set of advantages and disadvantages. Microwave sensors, for example, work well in large apartments because microwaves move through dielectric materials. But, on the other hand, the sensors used highfrequency ultra-high frequency materials, and their radiation is harmful to living organisms.

Infrared sensors have a high sensitivity, are very inexpensive, and are widely used. However, even though an infrared sensor can use heating systems or the rate of temperature change exceeds a certain threshold, the sensors could generate false alarms if heating systems are enabled. In addition, however, infrared sensors lose a lot of their effectiveness when tiny insects touch the sensor lens. On the other hand, ultrasound motion detection sensors have several characteristics that set them apart. One of those characteristics is that they use little power, are cheap, and are highly sensitive.

Additionally, this sensor is used in various areas, such as the home, office, and cars. However, existing ultrasound sensors comprise several passive and active components and are relatively challenging to manufacture and analyze. Additionally, sensors frequently require a time-consuming tuning procedure.



Figure 2.17: Basic Sensor Operation Principle

The ultrasound transmitter TX continually transmits ultrasound waves into the sensor ambient space, as shown in Figure 2.17. These waves interact with various objects, bounce into the ultrasound receiver RX, and convert into sound waves. Therefore, it's essential to know the magnitude of the interference. If there are no moving objects in the scene, a constant interference number can be calculated. This scene is because any moving object alters the level and phase of the reflected signal, resulting in a change in the total received signal level.

For example, most low-cost sensors (car protection systems) detect moving objects using reflected signal amplitude analysis. Despite its ease of execution, this detection system's sensitivity to noise signals is high. Various airflows, sensor movement, deformations of room windows and doors, and gusts, for example, can all alter the interference figure and generate false alarm signals. A higher level of noise tolerance can be achieved if the received sensor analyses the frequency of the reflected signal rather than its amplitude.

The reflected signal spectrum simulates the Doppler Effect. The speed vector of a moving object contains a frequency component pointing in the direction of ultrasound radiation propagation. The sensor can detect object movement in any direction because ultrasound waves bounce off different surfaces, including windows, walls, furniture, and other objects. To implement this concept, the sensor must be able to identify and process the Doppler Effect frequency shift to pick up and identify moving objects.

The moving parts in air conditioning systems, heat generators, and refrigerators can lead to vibrations in the equipment, resulting in high-frequency Doppler components in the reflected ultrasound signal. Additionally, the reflected signal contains more low-frequency Doppler components because the heterogeneous variable temperature airflows have different ultrasound propagation speeds.

As a result, the noise-resistant motion detection sensor can constrain the Doppler signal's frequency range between lower and upper bounds, ensuring no false alarms occur. As a result, the ultrasound motion detection sensor was developed using the operating principles outlined above. (Kremin, 2015)

## 2.8 Arduino





An Arduino is a microcontroller development board that is open source (Figure 2.18). In plain English, you can use the Arduino to read sensors and power stuff like motors and lights. Arduino is an entirely open-source platform. Along with developing methods for receiving and transmitting electronic programs, it is critical to developing electronic developers. C++ was used to program the circuit board. In addition, you can upload programs to this board, which can then communicate with anything in the real world. You can use this to create devices that adapt and react to the outside world. For instance, you could read the humidity sensor attached to a potted plant and automatically water it if it becomes too dry.

The Arduino board will then be mounted on a dedicated machine or an electrical and electronic framework. This is expected to facilitate examining and investigating data obtained from the information gadget. For example, sensors, accelerometers, and receiving wires are equipped to transmit signals or yield to various devices, such as LEDs. The Arduino stage has been well-known to the general public, particularly in the hardware community, for quite some time. While the incorporation of Arduino is indeed making use of separate equipment to incorporate new code, it turns out to be simpler because there is no need for additional equipment to be used. It's just plugging a USB cable into it. Besides, C ++ is used as Arduino programming software, simplified. Also, as seen here, there are two subsections of the Arduino. One is for equipment, and the other is for programming. The example in Figure 2.19 demonstrates how to program the Arduino.



Figure 2.19: Programming of Arduino on Arduino IDE

You can also build a stand-alone chat server connected to your internet router. You can also set it to tweet every time your cat walks through a pet door. Additionally, you can

have it automatically brew a cup of coffee when your alarm goes off in the morning. Anything powered by electricity in some way will communicate with the Arduino in some way. Even if it is not powered by electricity, you can still communicate with it using things (such as motors and electromagnets). Thus, Arduino's capabilities are almost infinite. As a result, no single guide can cover anything you might ever need to know due to environmentally friendly components and ease of use. Arduino is incredibly well-liked for microcontroller applications. Arduino is a microcontroller that comes with a circuit board and a chip that allows for programming a variety of projects. Arduino microcontroller chips receive data from a computer, and programmable data is then sent to the board. (Dihayar, 2014)

# 2.9 Product Design Specification (PDS)

## 2.9.1 Introduction of Product Design Specification (PDS)

A specification document such as the Product Design Specification (PDS) is essential to fulfilling a particular client or client class requirements. Concerning both equipment components and plan programming. PDS must be both comprehensive and precise. Detailed specifications must be established for what to plan and build and how to carry them out. The PDS must be identified and defined in the most prominent terms. This is an official statement regarding creating this item and a critical reference point for the item's overall development. The PDS work records must be extraordinary to ensure that the arranging procedure works efficiently. I'm saying it could be irrelevant to the project, but even if it is, after finishing the structure of the PDS, a report comparing to the item is complete. This test must be confirmed by performing on a model or creation where the results are checked against PDS.

Another concept the author expounds on is the necessity of looking at three more areas when you consider product shape, material properties, and process capability. However, the spiral's increasing size reflects that the detailed information on the PDS increases with each iteration (shown in Figure 2.20). (Izhar,2016)



Inevitably, which sections of the PDS you consider critical will vary according to your perspective and objective. When one thinks of a business in which spare manufacturing capacity is being utilized profitably, one can appreciate a contrasting view held by an engineer who works for a foundry. On the other hand, an automotive engineer is developing a new type of lane-keeping that will improve road safety. As a result, product teams with expertise in engineering design, marketing, and production are required if a balance is to be maintained through the design activity. (Tadele, 2017)

# 2.9.2 A Project Design Specification (PDS) Checklist

	1					
	a) Human					
Safety	b) Environmental					
	c) Operational					
	a) Reliability					
Quality	b) Quality assurance and quality control					
	a) Assembly					
Manufacturing	b) Production of component					
	c) Transport					
	d) Purchase of component					
SAL MALAYSIA	a) Design cost					
Economic	b) Marketing analysis					
Level and a second	c) Distribution cost					
1000	d) Development and manufacturing cost a) Freenomic design					
Ergonomic L	b) User needs					
Ecological	a) Material selection					
	a) Future expectation					
Aesthetic	b) Fashion					
	c) Customer appeal					
	a) Disposal					
Life ovele	b) Maintenance					
Lite-cycle	c) Operation					
	d) Distribution					

 Table 2.5 : The plan detail checksheet

Because it can provide itemized data, PDS is commonly used in the planning and critical thinking processes. Furthermore, it should not guide the design by assuming the outcome, but it should include realistic constraints on the design. This list attempts to cover the essential questions that must be addressed when developing a PDS. It is, of course, not exhaustive; specific products will necessitate additional items. Furthermore, some products require the purchase of different things. Table 2.5 depicts the plan detail check sheet. Nonetheless, the following is the significance of PDS:

- I. The PDS is a control record that characterizes the differentiators required to reach the required objectives.
- II. The PDS is the accompanying archive that must be clearly reported and concisely written.
- III. Rather than an article, the PDS should use short, sharp, and final explanations.
- IV. PDS can recognize client requirements that must be met in all situations and client UNIVERSITI TEKNIKAL MALAYSIA MELAKA requests, regardless of the circumstances.
- V. The PDS will be estimated to keep a strategic distance from uncertainty appraisals and be approved later in the test.
- VI. PDS records, like any modification, must be legible and dated.

Test configuration will be used appropriately to relate exercises to reduce configuration costs and accelerate the structure procedure. Similarly, it aids in limiting structure changes in design and reducing the complexity of materials and labor. The designed test lowers manufacturing costs by reducing inspection, rework validation, and other costs.(Santhoshkumar et al., 2016)

Each identifying with the thing should be included in the specific structure item, or PDS. An appropriate structure should expect the outcome while considering a sensible limitation for the system. This rundown attempts to close any future discussions about when a PDS is developed. However, this is not an exhaustive list.(Mohan,2015)

#### 2.9.3 The System Boundary of PDS

PDS is critical for assisting with the project configuration planning process. It denotes a requirement that typically specifies the goal and plans estimations for analysis. Rules or details have been developed for specific projects based on a few restricted variables. So it generally is when a company makes explicit requests for item yield. Throughout the concept age process, the problem is bound to be separated. When the idea aging process is completed, each person's idea's assessment will be completed. The number of imprints received will be used to organize each concept. The use of pair-wise placement is another technique. Figure 2.21 depicts a spider chart that provides a valuable checklist of considerations based on an updated and revised list initially developed by Pugh (1990). These items can be considered sequentially or the most pertinent ones isolated and concentrated on. The mantra is a valuable specification rule that will be repeated frequently:



Figure 2.21: Information content of a typical product design specification. List originally developed by Pugh (1990).

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Designing a product that will sell is an integral part of the design process. Thus, design is deeply connected to selecting materials and implementing production processes. Still, since product design depends on what the consumer wants to buy and what the company can produce, decisions regarding which products to make and which production processes to use mustn't be based solely on customer desires. As previously stated, the starting point for manufacturing was a market need. Thus, before embarking on the design and manufacture of a product, a company must identify, anticipate, or create a market need. Furthermore, this is closely related to the notion that there is no point in creating something that no one wants to buy. Figure 2.22 depicts some of the information and research needed to create a PDS.



Formulation of specification

## Figure 2.22: Information Needed To Create The Product Design Specification

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Additionally, employing a morphological diagram is an excellent strategy for developing more defined and systematic concepts. Collecting theoretical thoughts would then aid in smoothing out the system of sub-work theory recognition and increasing idea generation. Engineering drawing includes so many different materials, and for reading the engineering drawing, we must have a diverse representation of these materials (shown in Figure 2.25). Steel, metals, wood, liquid, concrete, etc., have their special symbols of representations. Two examples are shown below in Figure 2.23 is a conventional representation of the drawing, and Figure 2.24 is a conventional representation of the material. (Robin Kent, 2015)

Title	Subject	Convention	Title	Subject		Convention		
Straight knurling			Splined shafts			$\bigcirc$		
Diamond knurling					}⊕		38	
Square on shaft	€>		Interrupted views	- <del></del> +				
Holes on circular pitch			Semi-elliptic leaf spring					
Bearings			Semi-elliptic leaf spring with eyes			*		
External		♦ Œ₽		Subject	Conv	ention	Diagrammatic Representation	
threads (Detail)			Cylindrical	M			W	
Internal screw threads			spring	M			- M	
(Detail)				æ	¢		<u></u>	
Screw threads (Assembly)			Cylindrical tension spring				<del>C</del> WK	

Figure 2.23 Conventional Representation of Machine Component



Figure 2.24 : Conventional Representation of Material



Figure 2.25: Drawing Utilizing Solidworks 2020 Software

The main issue is to ensure that the procedure is working properly throughout the development of one idea. The idea is to be great by selecting the best structure idea. It is expected that orderly arrangements will maintain a strategic distance from increasingly fundamental issues. Clarifications and models are critical for effectively communicating conceptual and product quality ideas and theoretical concepts of consistency. The level of data depicted must be equivalent for each purpose. Before making a judgment, each colleague should discuss the capability of each perfect. (Peter R.N. Childs, 2019)

# 2.9.4 Concept Selection Method

While the first stage may be sufficient for making fundamental design decisions, I will employ a two-stage concept selection methodology. The first stage is concept screening, while the second stage is referred to as concept scoring. Each comes with a decision matrix that the team uses to score, rank, and select the best idea. Regardless of the structure of the

method, the importance of group insight in improving and combining ideas is emphasized.(Peter J. Ogrodnik, 2018)

Both concept screening and scoring follow a six-step procedure that guides the team through the activity of concept selection:

- Prepare selection matrix
- Rate the concepts
- Rank the concepts
- Combine and improve the concepts
- Select one or more concepts
- Reflect on the results and the process

Design selection is often conducted in two phases to control the difficulty of reviewing hundreds of product ideas. Screening is a simple, rough assessment that yields a few viable alternatives. Scoring is a more in-depth examination of these relatively few principles to identify the single concept most likely contributing to the product's success. Rough initial ideas are evaluated using a screening matrix to use a general reference concept (see Table 2.6). Due to the difficulty of conducting detailed quantitative comparisons and the possibility of deception at this early stage. New alternatives can be discovered from the feature combinations found among different concepts during the screening and scoring process. (Yussoff et al., 2010)

	Concepts						
Selection Criteria	Α	В	С	D (REF)	E	F	G
Ease of handling	0	0	-	0	0	-	-
Ease of use	0	-	-	0	0	+	0
Readability of settings	0	0	+	0	+	+ 0	
Accuracy	0	0	0	0	-	0	0
Durability	0	0	0	0	0	+	0
Ease of manufacture	+	-	-	0	0	-	0
Portability	+	+	0	0	+	0	0
Sum of +'s	2	1	1	0	2	2	1
Sum of 0's	5	4	3	7	4	3	5
Sum of -'s	0	2	3	0	1	2	1
Net score	2 -1 -2 0 1 0		0	0			
Rank	1	6	7	3	2	3	3
Continue?	Yes	No	No	Combine with F	Yes	Combine with D	Revise

# Table 2.6: Example of a Concept Screening Matrix

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While the process is well-defined, the team is not the method that develops concepts and makes the decisions that ultimately determine the product's quality.

The matrices serve as visual guides for team members to reach consensus and focus on customer needs, other decision criteria, and product concepts for detailed evaluation and improvement. The Concept Scoring Matrix is depicted in Table 2.7. (Zhang et al., 2017)

UNIVERSITE TEKNIKAL MALAYSIA MELAKA									
ONVERO		Concept							
		A (Reference)		DF		E		G+	
		Weighted			Weighted		Weighted		Weighted
Selection Criteria	Weight	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Ease of handling	5%	3	0.15	3	0.15	4	0.2	4	0.2
Ease of use	15%	3	0.45	4	0.6	4	0.6	3	0.45
Readability of settings	10%	2	0.2	3	0.3	5	0.5	5	0.5
Accuracy	25%	3	0.75	3	0.75	2	0.5	3	0.75
Durability	15%	2	0.3	5	0.75	4	0.6	3	0.45
Ease of manufacture	20%	3	0.6	3	0.6	2	0.4	2	0.4
Portability	10%	3	0.3	3	0.3	3	0.3	3	0.3
	Total Score	2.75		3.45		3.1		3.05	
	Rank	4		1		2		3	
	Continue?		No		Yes		No		No

 Table 2.7: Example of a Concept Scoring Matrix

#### 2.9.5 Solidworks Software

SolidWorks is a computer-aided design (CAD) and computer-aided engineering (CAE) program developed by Dassault Systèmes, shown in Figure 2.26. It is primarily a Windows-based application. SolidWorks Corp. was founded in 1993 by Jon Hirschtick with its headquarters in Concord, Massachusetts, and launched its first product, SolidWorks 95, in 1995. In 1997 Dassault Systèmes, best known for its CATIA CAD software, acquired the company. It currently owns 100% of its shares and is led by Jeff Ray. It is a modeler of parametric solids. It was introduced to the market in 1995 to compete with other CAD programs such as Pro / ENGINEER, NX, Solid Edge, CATIA, and Autodesk Mechanical Desktop.

Furthermore, Solidworks enables you to model parts and assemblies and extract detailed drawings and other production-related information. It is a program that works based on new modeling techniques with CAD systems. The process consists of transferring the mental idea of the designer to the CAD system, "building virtually "the part or assembly. Subsequently, all the extractions (plans and swap files) are done in a reasonably automated way. The internship design has been carried out thinking of a new student or designer who wishes to get into a three-dimensional structure using the SolidWorks program to create machines, mechanisms, products, or models.



Figure 2.26: Example of 3d Design in Solidworks

#### **CHAPTER 3**

## METHODOLOGY

## 3.1 Introduction

The next part will help to define the exploration methodology employed by the project. The beginning includes a test in progress, an information gatherer, and an examination that can be measured. Additionally, it showcases the framework employed in the structure and development of the blind spot alert system. As well as analyzing the various technologies that will be used, the work also explores and demonstrates the different sensors, wireless networking, and software solutions. As a result, it demonstrates the development path for the project's revenue stream, from the project's earliest starting point to the end.

- 3.2 Microcontroller Selection
- 3.2.1 Arduino Mega 2560 Rev3



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Figure 3.1: Arduino Mega 2560 Rev3 Development Board Microcontroller

The Arduino platform is an open-source electronic prototyping platform built around simple-to-use hardware and software. According to my last comment, I'd say that to put it simply, Arduino is a microcontroller-based prototyping board that can be used to build digital devices that can detect inputs like a finger on a button, screen touch, and light sensors. Then, it transforms these inputs into outputs like LEDs turning on, motors rotating, and speakers playing songs.

As we talk about the Arduino MEGA in this project (shown in figure 3.1 above), we will be discussing it. As expected, Arduino MEGA is a simple and inexpensive Arduino board and, as a result, has a 50% share of the overall Arduino board market. Arduino MEGA is considered the best prototyping board for beginners in electronics and coding.

The ATmega2560 is the basis for the Arduino Mega 2560 microcontroller board. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Most shields designed for the Uno and previous boards, Duemilanove or Diecimila, are compatible with the Mega 2560 board. This kit contains everything needed to support the microcontroller. But, first, connect it to a computer via a USB cable or power it via an AC-to-DC adapter or battery. (Mighai, 2015)

#### 3.2.2 Atmega 2560



Figure 3.2: Arduino Mega with 2560 Microcontroller



Arduino MEGA is based on Microchip's high-performance, low-power AVR® RISC microcontroller features 256 KB ISP flash memory, 8 KB SRAM, 4 KB EEPROM, 86 general-purpose I/O lines, 32 general-purpose working registers, real-time counter, six flexible timer/counters with compare modes, PWM, four USARTs, byte-oriented Two-Wire serial interface, 16-channel 10-bit A/D converter, and a JTAG interface The device operates between 4.5 and 5.5 volts and achieves a throughput of 16 MIPS at 16 MHz. I have decided to use the Atmega 2560 (shown in Figure 3.3) in the Truck Blind Spot System for the formerly examined reasons. Atmega 2560provides the best balance of power, efficiency, price, and performance among all researched microcontroller units.
# 3.3 Solidworks Arduino Software Application

Solidworks is a software application that automates the design process. Additionally, a 3D solid modeling package enables users to create complete solid models in a simulated environment for design and analysis purposes. SolidWorks allows you to sketch ideas and experiment with various designs to create 3D models. Using a modeling package such as Solidworks to create the design saves time, effort, and money spent prototyping the design otherwise.

Other applications used in this venture include Arduino, which means to improve the process of building and programming an electronic system. In addition, a blinking, detection, and buzzer warning system cautioning framework will be implemented in this project because squinting is an important standard in developing a blind-spot alert system.

3.4 The component in Arduino System 3.4.1 **Ultrasonic Sensor** animals and low bass medical and diagnostic ( A notes chemistry destructive and NDE 200MHz 20Hz 20kHz 2MHz Infrasound Acoustic Ultrasound

Figure 3.4: Sound Spectrum of Ultrasonic Sensor

The term "ultrasonic" refers to sound, and the term "sonic" refers to sound that humans cannot hear (but bats and dogs can). Ultrasonic sensors operate by determining the properties of sound waves with a frequency greater than that of the human ear. They are founded on three fundamental physical principles: time of flight, the Doppler effect, and sound wave attenuation. In addition, ultrasonic sensors are non-intrusive in their operation because they do not require physical contact with their target. As a result, they can measure distances ranging from 0 to 2.5 meters with a precision of 3 centimeters.

The Ultrasonic Sensor emits a high-frequency sound pulse and then counts the time it takes to return the sound's echo. The sensor's front panel features two openings (shown in Figure 3.4). One opening transmits ultrasonic waves (in the manner of a miniature speaker), while the other receives them (like a tiny microphone). The speed of sound in air is approximately 341 meters per second; an ultrasonic sensor uses this information and the time difference between sending and receiving the sound pulse to determine the distance to an



Figure 3.5: HC-SR04 Ultrasonic Sensor

An ultrasonic sensor is a device that uses sound waves to determine the distance to an object. Ultrasonic sensors continuously emit short, high-frequency sound pulses (shown in Figure 3.5). These travel at the speed of sound through the air. If they collide with an object, they are reflected the sensor as echo signals. One opening (similar to a tiny speaker) generates ultrasonic waves from the second opening (like a remote microphone). Sound travels at approximately 340 meters (1100 feet) per second in the air. The ultrasonic sensor calculates the distance to an object by combining this information with the time interval between sending and receiving the sound pulse (shown in Figure 3.6). Thus, calculating the distance between an object and its prototype will be Distance = Time x Sound Speed / 2. Divide by two here because the sound wavemust travel to and from the object. The operating voltage is 5 volts of direct current. This sensor has a detection angle of 15 degrees.



Figure 3.6: Working of HC-SR04 Ultrasonic Sensor

Due to the reduced angle of detection, it is assumed that the objects being detected have a curved surface, allowing for continuous tracking of objects as they move. In addition, sound pulses can be reflected on the sensor by maintaining a curved surface on the object, which is impossible with cornered objects.

# 3.4.3 Buzzerniversiti teknikal malaysia melaka



Figure 3.7: Piezoelectric Buzzer

It is a simple device that can generate beeps and tones. The working principle of the device is the piezoelectric effect. The main component of this device is a piezo crystal, A unique material that changes shape when a voltage is applied to it. Encapsulated in a

cylindrical plastic coating, it has a hole on the top face for sound to propagate. A yellow metallic disc that plays an essential role in producing sound can be seen through the hole. The active buzzer has an oscillation source built-in, making it easy to incorporate, but it oscillates at a specific frequency. Figure 3.7 shows an active buzzer used in Arduino.

# 3.4.4 Light Emitting Diode (LED)

# Figure 3.8: LED used in the system

LEDs must be connected in series (in-line) with a resistor. Otherwise, the LED will quickly burn out due to the unrestricted current. The resistor value can range from 100 Ohms to approximately 10K Ohms. Reduced resistor values allow for more current flow, which increases the LED's brightness. Conversely, increased resistor values restrict current flow, dimming the LED. Figure 3.8 shows LED components used in the system.

# 3.4.5 Dupont Connector Wires



Figure 3.9: Jumper Wire Used in System

Jumper Wire cables are also referred to as Dupont. They are low-cost and are commonly used to connect hardware such as sensors, Arduino boards, and breadboards. There are two available types of connectors, one of which has a pitch of 2.54mm (100mm). It is used to connect and transfer data between other components. Figure 3.9 shows a male wire connector.

### 3.4.6 Switch



I/O port refers to an interface for INPUT and OUTPUT. For example, button switches, which are almost certainly familiar to most, are a switch value (digital value) component. It is in the conducting (closed) state when the circuit is pressed. The wires enable power to spill out of one circuit and flow into the next in an arrangement circuit. The wire is used to carry out the advancement of electrons. Figure 3.10 shows a push-button switch used in the system.

# 3.4.7 Breadboard



**Figure 3.11: Breadboard** 

A breadboard is a rectangular piece of circuit board with numerous mounting holes commonly used for testing electronic circuits and devices. Breadboards help us connect components to complete your basic circuit. For example, we use electronic connectors to connect electronic components and single-board computers or microcontrollers to our Arduino system. When connections are established, they can be removed and re-connected. Figure 3.11 shows a solderless breadboard used in the Arduino system.

3.4.8 Resistors VERSITI TEKNIKAL MALAYSIA MELAKA



Figure 3.12 : Resistors

Resistors are electrical components that obstruct the flow of direct or alternating currents. They can be used to safeguard, power, or control circuits. Resistors can also shape electrical waves to meet our needs in conjunction with other components. Resistors can have a fixed resistance value or be variable or adjustable within a specific range. Resistors, as passive components, can only reduce voltage or current signals and cannot increase them. I used multiple resistors in this system with specifications such as 1, 10, 100, 1k, 10k, 100k ohm values, respectively. Figure 3.12 shows the resistors used in the circuit.



### **3.4.9** Transistors

The NPN transistor is a type of transistor that one p-type material is sandwiched between two n-type materials. The NPN transistor amplifies the weak signal that enters the base and generates on the collector end, and there are strong signals. In this project, NPN Transistors pass the flicker signal into an Arduino. Figure 3.13 shows the NPN Transistors used in the circuit.

# 3.4.10 USB Cable



# Figure 3.14: USB Cable

The USB cable above is the most common A to B Male-Male peripheral cable. This USB cable is compatible with most SFE-designed USB boards, such as the USB Arduino UNO boards. Figure 3.14 shows the typical USB cable for the Arduino system to connect AC/DC.

3.4.11 LCD Display



Figure 3.15: 1602 LCD

In this blind spot project, i used an Arduino to drive the 1602 LCD. IIC / I2C module

soldered on LCD. Figure 3.15 shows the type of LCD used in the Arduino system.

# 3.4.12 Battery Pack



Figure 3.16 above shows a two-cell 18650 battery holder with a standard 2.1mm DC Barrel Jack connector. Connect two 18650 batteries in series to achieve a 7.4V output voltage (2 x 3.7V). This voltage is quite suitable for Arduino boards, including a 5V or 3.3V voltage regulator. The battery used in Figure 3.16 above is not an A, AA, or AAA battery; this is a rechargeable 18650 Li-ion battery with a 3.7V rated voltage. I use a Panasonic 18650 battery with a typical capacity of 3350 mAh. The battery is transformed into a power storage device. In addition, it is a cylindrical Lithium-Ion rechargeable battery (with the appropriate charger).

# 3.5 **Project Flow Chart**



Figure 3.17: Project Flow Chart

# 3.6 Product Design Specification (PDS)

The Product Design Specification document is created early in the planning phase. The project met numerous criteria for this project to be completed. It is critical to keep track of design documents and develop a solution if there is an issue with the project's design. It maintains the data necessary to define the architecture and system design as precisely as possible effectively.

NO	CATEGORIES	REQUIREMENT
1	PERFORMANCE	Maximum operating temperature up to 70 C
2	at a fut	High Sounding on the buzzer
3	XKA	Not harmful to use
4	SAFETY	High operating standard
5		No sharp edges on the design
6		Waterproof
7	كنيصل مليسيا ملاط	Aerodynamics surface
8 U	ERGONOMICS	Can use on a different type of trucks
9		Easy to use
10		Achieve high durability
11	DURABILITY	Lifespan up to 5 years
12		High working time
13		High working temperature
14		Affordable
15		Attractive look design
16	ECONOMICS	Maintenance cost
17		Warranty

# 3.6.1 Customer Requirements



# 3.6.2 PDS Criteria Table

NO	CATEGORIES	CRITERIA/DETAILS	NEW CRITERIA	
1	POWER SUPPLY	10000 mah Powerbank	Up to 5V DC	
2		Direct Current (DC)	10 to 32V DC	
		Weight	220 Crome (Sancar)	
3		weight	250 Grams (Control Box)	
4	DIMENSIONS	Color	Brown	
5		Sizing and dimensions	Sensor: 104.3(Width) ×80.5(Height) ×25.4(D) mm	
			Control Box: 152.6(W) ×89.2(H) ×53.8(D) mm	
7		Detection range	0.5~2.5m	
8	PERFORMANCE	Location	Rear bumper and side cargo	
9	ANA 13	Vibration Rating	5.9G	
Table 3.2 : PDS Criteria Table				
اونيۇم سىتى تىكنىكل مليسيا ملاك				

3.7 List of Raw Sketching and 3D Modelling LAYSIA MELAKA

The use of informal sketching and formal drafting and drawing is essential, and it has long served as a tool for visual thinking. Aside from that, the design in 3D modeling in Solidworks can be carried out based on the ideas sketched out. The Sketching and 3D design are shown in Figures 3.18, 3.19, and 3.20 below.

# 3.7.1 Sketching and Design 1



Figure 3.19 : Sketching And Design Sensor Case Using Solidworks

# 3.7.3 Sketching and Design 3



Figure 3.20 : Sketching And Design Arduino Case Using Solidworks



### **CHAPTER 4**

# **RESULTS AND DISCUSSION**

# 4.1 Fabrication Process

Fabrication is the process of creating anything from scratch according to a predetermined design. The design of the system is divided into four key sections. Software implementation, power distribution, sensor application, and printed circuit board design are all included in these areas. Depending on the product to be produced, it is typically accomplished according to a predetermined time frame or frequency. First and foremost, it is necessary to understand the significance of generating electrical items in the manufacturing system. There are also distinctions between individuals who work in fabrication and those who work in regular large-scale production. It is critical to determine how the digital nature of design files affects the manufacturing stability of goods, such as circuit boards, before proceeding with production. This strategy has less impact on the supply of items, the construction of circuits, and the writing of computer programs.

This project aims to design a printed circuit board that can accommodate the embedded CPU in the Arduino MEGA while also providing power to its sensor circuitry in a single package. One of the benefits of using the chip contained in the Arduino MEGA instead of the chip housed in the PCB is that it allows you to load any Arduino code into the device and have it comprehend and perform the functionality contained within the algorithm. We have performed extensive research on sensors and have decided that the HC - SR04 waterproof ultrasonic sensor will be used for the time being. Although this choice is based on the sensor's easy compatibility with the Arduino devices, its long range of up to 13 feet is a lot

more than the required distance for the system. Also, the many available libraries and functions will help the programmers reduce the code complexity and increase flexibility at the same time.



Figure 4.1 The Components Used to Setup a Test Bed

The following Figures 4.1 show the Printed Circuit Board (PCB), microcontroller, LCD, LED, Buzzer, and Ultrasonic Sensor, all attached as a breadboard component. These components represent the single system required to collect the sensor's data and send the data using a ribbon cable alongside the truck. Next, the main components, Arduino board, wire, and resistor, need to be soldered to the printed circuit board (PCB). This process connects electrically with electronic components using conductive tracks, pads. Finally, Figure 4.2 below shows the connection is soldered on the PCB board.



Figure 4.2 All components connection soldered in the PCB board



Figure 4.3 The main components install at board

Figure 4.3 represents the installation of the PCB board to the Arduino board, wire, and resistor. Then, the fabrication is continued by connecting the ultrasonic sensor to the Arduino board. Using the ribbon type cable, we need to crimp the ribbon cable using crimping tools and connect it to the connector to make it male and female jumper wire. The length of the ribbon cable used for the ultrasonic sensor is 3 meters in length. Figure 4.4 shows that the ribbon cable with male and female connectors can be used as a jumper wire.

Finally, the digital pin (5V, Trig, Echo, and GND) Arduino boards were coupled to each pair of ultrasonic sensors and parallel to that same ultrasonic sensor operation.



Figure 4.4 Connection between the ultrasonic sensor and the main board

Next, the production process fabricates a connection between LED and Arduino boards. Each LED connection has been soldered to a wire. It is parallel at the mainboard, and the connection will be soldered to the resistor of 14k ohm digital pin (A0 and GND), (A1 and GND), (A2 and GND), and (A3 and GND) on the Printed Circuit Board (PCB) to attached to the Arduino board. To connect to the digital pin in Figure 4.5, the coding of the Arduino set is necessary. As in Figure 4.6 below, the LED positive and negative terminal leads will be soldered to its jumper wire.



Figure 4.5 Connection between LED to the mainboard



Figure 4.6 LED soldered on jumper wire

Next, by fabrication, a connection between an LCD and the Printed Circuit Board (PCB) to attached with the Arduino board. The connection is parallel to the digital pin (VCC to 5V), (SDA, SCL, and GND) on the Printed Circuit Board (PCB). The display will show the value on four different sensors, as shown in Figure 4.7. The indicator on display is indicated by (S1 for sensor 1), (S2 for sensor 2), (S3 for sensor 3), and (S4 for sensor 4). The value on the display will show up if the detection of obstacles is below 0.5 meters long. Finally, the jumper wire is necessary to make the LED light display appear. The jumper wire is connected as per Figure 4.8. Finally, the coding set is required to connect the digital pin on the Arduino board.



Figure 4.7 Lcd shows display the indication of each sensor



Figure 4.8 LED light jumper wire on LCD mainboard

The last component in this circuit is the buzzer. The positive and negative terminal on the buzzer will be soldered on the Printed Circuit Board (PCB). The connection also will be parallel to the digital pin (D10 and GND) on the mainboard. Figure 4.9 below shows the connection of the buzzer.



Figure 4.9 Buzzer connection on the Printed Circuit Board (PCB)



Figure 4.10 Fabrication process flow chart

# 4.2 Block Of Diagram

The hardware block diagram (shown in Figure 4.11) describes the relationship between the battery-powered microcontroller and the sensor. The use of batteries allows the system to be portable from one trailer to another. The sensor's reading is sent from a sensor outside the truck across the ribbon cable to the truck's cabin's hub device. Ultrasonic sensors placed outside of the truck will transmit the frequency and waves to the binary data. To receive the output data, the coding is set up using a microcontroller to acquire the output data. This device is affordable, reliable, and efficient. The receiving device's bottom section of the hardware block diagram consists of a microcontroller in a truck cabin hub. The data coming in from multiple sensors is decoded and displayed to the driver. The LED display is the



Figure 4.11 Hardware Block Diagram



Figure 4.12 Software Block Diagram

After the hardware component has been set up, the sending and receiving algorithms are applied to the corresponding devices. Figure 4.12 shows the software block diagram for this project. First, a software component needs to be assigned from the Arduino library. Then, after the coding has been set up, upload it into the microcontroller. Each of the algorithms uses a different structure and set of libraries. The algorithm begins by taking the sensor's reading for the sending software configuration. For example, if the reading states that a vehicle is in the blind spot, the sensor's reading is sent across the data cable to the LCD on the truck. Next, the receiving algorithm implements a function from the coding implemented on the microcontroller.

# 4.3 Sensor Implementation and Schematic Profile

This system makes use of an HC-SR04 sensor and an Arduino Uno. The code returns the distance between the closest object in range and the threshold distance; if the distance is less than the threshold, a vehicle is in the blind spot. To begin reading, the microcontroller sends a pulse to the sensor and then waits for a response. The object's distance from the sensor is proportional to the length of the returning pulse. The Peripheral Sensor and Blind Spot System Cabin Hub (Table 4.1 & Table 4.2) Atmega2560 Pinout is shown below.

Truck Smart Peripheral Sensor ATmega328 Outputs				
ATmega2560Pin				
MALAYSIA 4	<b>Connection Description</b>			
5V	5V Vcc			
2	HC-SR04 Sensor echo line (Digital in)			
3	HC-SR04 Sensor trigger line (Digital out)			
anna-	HC-SR04 Sensor echo line (Digital in)			
ملىسىة ملاك	HC-SR04 Sensor trigger line (Digital out)			
	HC-SR04 Sensor echo line (Digital in)			
	HC-SR04 Sensor trigger line (Digital out)			
8	HC-SR04 Sensor echo line (Digital in)			
9	HC-SR04 Sensor trigger line (Digital out)			
Gnd	Ground			

 Table 4.1 Peripheral Sensor Atmega2560 Pinout



Figure 4.13 Peripheral Sensor Schematic Diagram

Truck Smart Hub ATmega328 Outputs				
ATmega328 Pin		<b>Connection Description</b>		
#				
5V	5V Vcc			
D10	Piezo Buzzer Positive Terminal			
SDA	Lcd SDA to Digital Pin SDA Arduino			
SCL	Lcd SCL to Digital Pin SCL Arduino			
A0	Sensor 1 LED output			
A1	Sensor 2 LED output			
A2	Sensor 3 LED output			
A3	Sensor 4 LED output			
GND	A AREA	Ground		

Table 4.2 Blind Spot System Cabin Hub Pinout

Blind Spot System Cabin Hub Schematic Diagram schematic (shown in Figure 4.14) has a similar layout to the Peripheral Sensor Schematic Diagram (Figure 4.13) using the same ATmega2560. However, the difference is the LED, LCD, and Buzzer scheme. There are 4 LEDs designed into the Hub to provide obstacle warnings and notifications. The design of the LED layout had to account for the output pin limitations of the ATmega2560 and provide a logical manner to report errors and faults (using four red LEDs). The LCD display will show four sensors' values from the ultrasonic sensor input. In addition, the buzzer will sound when the sensor detects obstacles ( in this system, the distance to ring the buzzer is below 25cm) distance is achieved. Both sets of LEDs (notification) were given direct lines to the chip's digital output pins to manage this. Table 4.30 and Table 4.31 provide the full scope

of the ATmega2560 outputs for the Peripheral Sensor and Blind Spot System Cabin Hub Schematic Diagram.



Figure 4.14 Blind Spot System Cabin Hub Schematic Diagram

### 4.4 Collecting the sensor's data

The device used to detect a vehicle in the blind spot will be the HC – SR04 ultrasonic sensor. This module offers excellent non – contact range detection with high accuracy and stable readings. The device can detect objects at distances from 1 to 6 meters long. In addition, its operation is not affected by sunlight, wind, snow, or rain (unless it is extreme to the point where you should not be driving), making it an excellent device to be used in the Truck Smart application. Since truck drivers work all over the country where the weather will vary depending on location, picking the waterproof SR04 makes it a great choice. The device comes complete with an ultrasonic receiver and transmitter module. It contains four pins and operates with a voltage of 5 Volts (DC) and a working current of 15 milliamps (mA). The four pins are labeled as VCC (supply voltage), GND (ground), TRIGGER (input), and ECHO (output). In addition, the "New Ping" library will be used to help handle the sensor's functionality.

The sensor will be connected to the microcontroller for power supply and input and output handling. Its VCC pin will be connected to the 5V output pin from the microcontroller, while its GND (ground) pin will also be connected to the ground pin from the MCU. The ECHO (output) pin can be connected to one of the digital input/output pins, but output pin two will be used for the initial design. The TRIGGER (input) pin will be connected to output pin 9. Therefore, these two cannot implement the sensor's functionality. The following Figure 4.15 represents the previously described sensor layout with the microcontroller.



Figure 4.15 Sensor's Layout and Integration with the System

The breadboard connection in the picture will be replaced with a connection on a printed circuit board (PCB). In addition, a new power supply will be integrated, and more components will be added to increase the functionality of the system in the PCB.

# 4.4.1 Peripheral Sensor Unit

The sensor units will be installed all over the truck and use the node bouncing mechanism to send data to the hub unit. The following are the functions of the sensor units that must be **UNIVERSITITEKNIKAL MALAYSIA MELAKA** programmed into the microcontroller:

- Operate the ultrasonic sensor and receive the corresponding output.
- Send the sensor's output data to the hub unit.
- Pass along any data received from the sensor towards the hub unit.
- Detect any errors or hardware malfunctions and relay to the hub unit.

The software flowchart in Figure 4.16 shows the sensor unit's software, focusing on the rest

of this section. The sensor assessment consists of a simple connection test between the

microcontroller, Ultrasonic Sensor, LCD, LED, and Buzzer module.



Figure 4.16 Software Flowchart: Peripheral Sensor Unit

The microcontroller will operate the sensor, receive its output, and transmit it to the LCD hub unit. This evaluation only checks if the sensor communicates appropriately with the other devices. Next, it is up to the user to ensure the sensor is detecting correctly and not showing any errors such as false positives. There is no way for the system to check if the sensor data is accurate. If the system cannot correctly communicate with the sensor, it will log an error, alert the hub unit, and notify the user of its false reading. From here, it will enter a loop of testing the connection and then testing the sensor until both assessments are positive. Once the sensor test is passed, the system will enter its main phase. Finally, the sensor will be rechecked once this is done, and the whole process is repeated.

# 4.4.2 Blind Spot System Cabin Hub Unit

The hub unit will be conveniently shown in the vehicle's cabin for the driver. In addition, it serves as a point of contact between the sensors and the user. The following are the functions of the hub unit that the microcontroller must perform that coding must be programmed into it:

- Detecting sensor units
- Keeping track of the status of each sensor unit
- Try to fix malfunctioning sensor units through software resets
- Display results of sensor data to the user through LCD with each sensor.
- Warn user through LEDs and Buzzer of the following:



Figure 4.17 Software Flowchart: Blind Spot System Cabin Hub Unit

As with the sensor unit, the logic flow of the hub unit is also split into two main stages and can be seen in Figure 4.17. When the device is turned on, it will begin in the setup stage. The first step is to test the hardware connection of the sensors to the hub in this phase. Once the sensors are configured, the hub unit will display the data value from the sensor. Once it is established that there are no connection errors, the hub will repeat the same test, but this time with the sensor output data. The hub unit will enter the main phase from this point forward. This phase essentially consists of an infinite loop in which the sensor output data is continually checked and displayed to the user. Figure 4.42 data analysis and troubleshooting stages are separated in Figures 4.18(Data Analysis) and 4.19(Troubleshooting) for readability and simplification (Hub Troubleshooting).



Figure 4.18 Software Flowchart: Data Analysis System

The data analysis flowchart in Figure 4.4.4 above shows a logic cycle that will be completed by the hub unit every single time that sensor data is received from the sensors. It will first use the information obtained by the sensors to determine what the distance is from the sensor to the closest object. It will then run a simple Boolean check to see whether or not the distance is more or less than the threshold value. Finally, the threshold value will be chosen based on road width standards and potential trailer widths. If the calculated value is less than the threshold, it means there is an object (car, truck, motorcycle, etc.) in the sensor's area and should be marked accordingly. So the hub unit will then turn the LED corresponding with the sensor that sent the data on to show the driver that there is an object in the area. For the opposite case where the calculated value is more than the threshold value, the hub unit will ensure the corresponding LED is off to show the driver the area is clear of any obstacles.



Figure 4.19 Software Flowchart: Troubleshooting the System

The Truck Smart system's automatic software troubleshooting steps can be seen above in Figure 4.4.5. These steps are in place as a precaution if a sensor unit develops a glitch while the system is in action. When entering the troubleshooting stage, it is essential to let the user know about an issue. The system displays the threshold value on the LCD hub cabin to

accomplish this. If the value is zero on the particular sensor, the user will know which sensor is malfunctioning. This will give the user knowledge that there is a problem with that sensor and not fully trust its output.

# 4.5 Housing Fabrication

# 4.5.1 Material Types and Properties

PLA (polylactic acid) is a thermoplastic monomer made from renewable, organic corn starch or sugar cane sources. Despite the differences in raw materials, PLA can be made with the same equipment as petrochemical plastics, making PLA production relatively cost-effective. It's also a popular 3D printing material for desktop fused filament fabrication 3D printers. PLA is widely used in 3D printing because it is easy to sand, paint, or post-process. This plastic is easy because it works with low extrusion temperatures and requires a heated bed, printer chamber, or reinforced nozzle. PLA also has the advantage of behaving better than many more rigid plastics and emitting no fumes or odors. Heat-resistant PLA can withstand temperatures of 110°C. However, by physically blending the polymer with PDLA, the melting temperature can be increased by 40–50°C. As a result, the heat deflection temperature can be grown from around 60°C to as high as 190°C (poly-D-lactide). The standard heat in Malaysia on a sunny day is only 33°C-36°C, which does not affect the melting point of this material. Therefore, if the test on the component has been used on a typical sunny day, it doesn't affect the melting point of PLA material.

# 4.5.2 Ultrasonic sensor housing

To house and protect the blind spot system, housing must be designed to withstand the conditions that the system is expected to encounter. Several environmental factors contribute to this, including wind gusts exceeding 100 km/h, rain, heat, freezing conditions, and

condensation. The encasement must have close tolerances and possibly rubber seals around all system-critical areas to deal with water-related situations. Heat provisions should be designed using materials research and ventilation ports in areas prone to overheating. Freezing conditions can result in case cracking if the design is too thin and brittle due to the case material expanding and contracting. Condensation will be managed by diverting excess water away from mission-critical areas. Figures 4.20 depict the Truck Blind Spot system's peripheral sensor housing concept. This design satisfies aerodynamic requirements and provides a practical space for the Truck Blind Spot system's components to be contained. An area has been extruded on the cabin hub system. To allow for heat dissipation, vents should be added.



Figure 4.20 Truck Blind Spot System's Peripheral Sensor Housing Concept

# 4.5.3 Aerodynamics of the Housing

The Truck Blind Spot system housing will be exposed to various environmental elements throughout its life. Wind will be the most powerful of these elements. The assumption is that this system will be exposed to winds of 70+ mph for extended periods while traveling on major interstates.

To ensure the Blind Spot system's operation and durability, some fundamental aerodynamic principles must be applied to the housing design. A low-pressure system creates drag, referred to as a "turbulent wake," in the airstream's tail end. This force tends to "drag" the object in the direction of travel. As a result, larger turbulent wakes have a higher drag coefficient. When it comes to housing shapes, the one that creates the minor turbulent wake is a design with a fillet. Figure 4.21 below shows the surface plot on the CFD Analysis on Solidworks. In this analysis, three types of analysis have been done: surface plot, cut plot, and flow trajectories in the top, side, and front plane. The display selection is the contour, isolines, vector, and streamlines on the surface plot in pressure parameter. And all the surface of the peripheral sensor was selected. The airflow is done to the X-Axis direction. On the tail of the sensor, there was slight turbulence that didn't affect the overall performance.



**Figure 4.21 CFD Analysis on the Surface Plot with Pressure of the Peripheral Sensor** This analysis ensures the effectiveness of the aerodynamics flow with minimal turbulence. Figure 4.22 below shows the CFD Analysis on the Cut Plot in a front plane of the peripheral sensor. Again, the contours and isolines are selected for this session. As the cut plot analysis, the turbulence wake occurs on the slopes section of the peripheral sensor.


**Figure 4.22 CFD Analysis on the Cut Plot in a Front Plane of the Peripheral Sensor** Lastly, Figure 4.23 below shows the CFD Analysis on the Flow Trajectories in the peripheral sensor's front, top and side plane. Again, turbulence wake is slightly occurring on the slope section, which is doesn't affect the airflow through it. The conclusion of this design is safe





Figure 4.23 The CFD Analysis on the Flow Trajectories

#### 4.5.4 Weatherproofing housing

The Truck Blind Spot system design is intended to be long-lasting and weather-resistant. Rain poses a threat to the system and, if not prepared for, can result in system failure. Near the sensor ports and on the bottom flat surface cover plate are the primary focus areas for preventing housing leakage. Rubber or silicone seals can be used to avoid moisture from seeping into the enclosure. The sensor portholes will be millimeter-perfect. A set of Orings will be included to keep water out of the system—design drainage holes on the underside of system-critical areas as a backup option. Including vents in the design could put the system at risk during inclement weather.

#### 4.6 Arduino Programming

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Arduino IDE 1.8.15.0 is the software for the Truck Blind Spot system. This software is easy to use, environmentally friendly and has a lot of valuable toolbars. Figure 4.24 depicts the identified Arduino board coding pins for ultrasonic sensors, buzzer, LCD, and LED components. The ultrasonic sensor input system used pins D2, D3, D4, D5, D6, D7, D8, and D9. The buzzer unit's output pin is 10. LED is another production component that uses an output pin of A0, A1, A2, and A3 pins. Buzzer positive terminal will use D10 digital pin and ground. Finally, the output pin of LCD is SDA and SCL on the Printed Circuit Board (PCB).

On the other hand, it is defined as the change in output voltage due to changes in input parameters. As a result, the distance value must be set correctly based on the system's suitability. Set the distance in centimeters using the SI unit (cm). As a standard project, the system uses a maximum distance of 400 cm.

MEGA	2560-HC-SR04-BU	ZZER-LED-NEWPING-SINGLE   #	rduino 1.8.15 Hourly Build 2021/05/3	_	$\times$
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00					<b>1</b> 90-1
MEGA2	560-HC-SR04-BUZ	ZER-LED-NEWPING-SINGLE			
#include	e "src/NewPing	.h"			
#include	s "src/LiquidC:	rystal_I2C.h"			- 1
					- 1
#define	ECHO_1	2			
#define	TRIG_1	3			
#define	ECHO_2	4			
#define	TRIG_2	5			
#define	ECHO_3	6			
#define	TRIG_3	7			
#define	ECHO_4	8			
#define	TRIG_4	9			
#define	LED_1	A0			
#define	LED_2	A1			
#define	LED_3	A2			
#define	LED_4	A3			
#define	buzzer	10			
#define	MAX_DISTANCE	400			
#define	PING_INTERVAL	100			

Figure 4.24 The define of coding pins of components in Arduino IDE

#### 4.6.1 Programming Setup

Figure 4.25 shows the void setup of pair ultrasonic sensor, LCD, LED, and buzzer output that connects Arduino pins 1, 2, 3, and 4, respectively. At the beginning of the coding, the setup function should match the declaration of some attribute. For example, the first operation to run the coding would be only once, and pinMode will also set serial contact.

NewFing sonar1 (TRIG 1. ECHO 1. MAX DISTANCE); // NewFing setup of pins and maximum distance.
NewFing sonar2(TRIG_2, ECHO_2, MAX_DISTANCE); // NewFing setup of pins and maximum distance.
NewPing sonar3(TRIG_3, ECHO_3, MAX_DISTANCE); // NewPing setup of pins and maximum distance.
NewPing sonar4(TRIG_4, ECHO_4, MAX_DISTANCE); // NewPing setup of pins and maximum distance.
BUZZ buzzi; LED ledl = (false, false, 0, 0, LED_1); KAL MALAYSIA MELAKA LED led2 = (false, false, 0, 0, LED_2);
LED led3 = {false, false, 0, 0, LED_3};
LED led4 = {false, false, 0, 0, LED_4};
LiquidCrystal_I2C lcd(0x27, 16, 2); // I2C address 0x27, 16 column and 2 rows void setup() (
Serial.begin (115200);
<pre>Serial.println("Blind Spot System init");</pre>
<pre>lcd.init();</pre>
<pre>lcd.backlight();</pre>
<pre>lcd.setCursor(0, 0);</pre>
<pre>icd.print("Blind Spot System init"); // print a simple message</pre>
delay(1000);
<pre>// lcd.clear();</pre>
pinMode(LED_1, OUTPUT);
pinMode(LED_2, OUTPUT);
pinMode (LED_3, OUTPUT);
pinMode(LED_4, OUTPUT);
pinMode(buzzer, OUTPUT);
<pre>digitalWrite(LED_1, HIGH);</pre>
<pre>digitalWrite(LED_2, HIGH);</pre>
<pre>digitalWrite(LED_3, HIGH);</pre>
<pre>digitalWrite(LED_4, HIGH);</pre>
4-1
lcd clear():

Figure 4.25 The coding void setup of the ultrasonic sensor, buzzer, LCD, and LED

#### 4.6.1.1 Ultrasonic sensor (HC SR-04)

According to Figures 4.26 and 4.27, the coding shows the ultrasonic loop sensor's void loop coding. The ultrasonic sensor will detect the objects and alert the buzzer with three different alert distances—the coding pin of D1, D2, D3, and D4. The alert distance is 50, 80, and 100 cm.

This system used four ultrasonic sensors for the front left and right side and rear left and right side. The loop usability should follow next and contain the code to be continuously executed. This coding uses the float function within D1, D2, D3, and D4. Floating-point numbers are often used to approximate analog and continuous values because they are more accurate than integers. This function is the core of all Arduino programs and does most of the work.

MEGA2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE | Arduino 1.8.15 Hourly Build 2021/05/31 10:33 File Edit Sketch Tools Help 🗈 🔷 🔛 Upload MEGA2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE } float d1, d2, d3, d4; // distance in cm int alertDistance1 = 50 10 tone interval // tone interval in milisec
int alertInterval 1 = 100; EKNIKAL MALAYSIA MELAKA int LEDState 1 = 0; int LEDState\_2 = 0; int LEDState\_3 = 0; int LEDState\_4 = 0; void loop() { id loop() {
 d1 = sonar1.ping\_cm(); delay(PING\_INTERVAL);
 d2 = sonar2.ping\_cm(); delay(PING\_INTERVAL);
 d3 = sonar3.ping\_cm(); delay(PING\_INTERVAL);
 d4 = sonar4.ping\_cm(); if (d1 == 0)d1 = 1000;if (d2 == 0)d2 = 1000;(d3 == 0) d3 = 1000;(d4 == 0) d4 = 1000;if if Serial.print(dl); Serial.print("|"); Serial.print(d2); Serial.print("|"); Serial.print(d3); Serial.print("|"); Serial.print(d4); Serial.print(" "); alertDistance1 int alertDistance2 = 80; int alertDistance3 = 100; int alertInterval\_1 = 500; int alertInterval 2 = 300

Figure 4.26 The void loop of ultrasonic sensor

Since Action Mega2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE | Arduino 1.8.15 Hourly Build 2021/05/31 10:33



Figure 4.27 The alert distance interval of ultrasonic sensor

## 4.6.1.2 LCD

Figure 4.28 is a String function to get or set the value of a character at a given position in a String. For example, the display character on the LCD is the S1, S2, S3, and S4. Since Blind Spot System used four sensors, "S equal to Sensor." It will display the reading from the ultrasonic sensor and appear on the LCD screen. The maximum reading of 500 cm is set on the coding. So the reading will display below 500 cm only. On the startup display on the LCD, using the void setup in coding, the "Blind Spot System Init.." will appear. Therefore, the distance between the sensor and the object will be measured with this coding in the system.

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MEGA2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE
String str_d1 = "S1:" + String(d1, 0);
String $\operatorname{str}_{d2} = "S2:" + \operatorname{String}(d2, 0);$
String str_d3 = "S3:" + String(d3, 0);
String str_d4 = "S4:" + String(d4, 0);
if (d1 == 1000) str_d1 = "s1: - ";
if (d2 == 1000)str_d2 = "32: - ";
if (d3 == 1000)str_d3 = "33: - ";
lf (d4 == 1000)str_d4 = "34: - ";
//dl
Icd.setCursor(0, 0); // move cursor to (0, 0)
Ica.print(""); //clear screen
Ica.setCursor(0, 0); // move cursor to (0, 0)
<pre>ica.print(str_al); // print message at (0, 0)</pre>
Ica.setCursor(0, 1); // move cursor to (0, 0)
lea.print(""); //clear screen
led setterisor(0, 1); // move cursor to (0, 0)
(//a)
lad print (", ), // move cursor (0, 0)
$\int dt = \frac{1}{2} \int dt$
led print (str d2).
//aa
//dt
led print (", "), // Move carsor en
$\int dt = \int dt = $
lcd-print(str d4): // print message at (0, 0)
// lcd.setCursor(0, 1); // move cursor to (2, 1)
// lcd.print(millis() / 1000); // print message at (2, 1)
Serial.print(",");
Serial.println(millis() / 1000);

Figure 4.28 String function on the LCD system

#### 4.6.1.3 Buzzer

Figure 4.29 depicts the void loop of the buzzer. Buzzer produces an alert sound with the distance interval when the ultrasonic sensor detects objects at a 50 cm distance connected with pin D2 and ground at the Arduino board. The pins must be contiguously to allow the bell to ring appropriately.

MEGA2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE | Arduino 1.8.15 Hourly Build 2021/05/31 10:33 File Edit Sketch Tools Help



### 4.6.1.4 LED

LED function in the system is to alert the driver blind spot area that found object or another vehicle trespassing. LED will blink when the ultrasonic sensor detects an object. This project used four LEDs for the front right and left and rear right and left side. Pin for LED is A0 and A1 for the front right and left side, and pin A2 and A3 for the rear right and left side. In order to function correctly, the positive and negative terminal of LED need to be adequately connected on the Arduino board. In Figure 4.30, the coding of the void loop of LED was shown.

MEGA2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE | Arduino 1.8.15 Hourly Build 2021/05/31 10:33 File Edit Sketch Tools Help

```
Unload
 MEGA2560-HC-SR04-BUZZER-LED-NEWPING-SINGLE
 id checkLED1()
            alertDistance1 ) {
      (d1
    led1.onoff = true;
    led1.interval = alertInterval_1;
    else
    led1.onoff = false;
  3
  if (led1.onoff) {
    if (millis() - led1.btime > led1.interval) {
       if (!led1.state)
         digitalWrite(led1.cpin, HIGH);
led1.btime = millis();
led1.state = true;
         Serial.print(" LED 1 On");
         else (
          digitalWrite(led1.cpin, LOW);
         led1.btime = millis();
led1.state = false;
Serial.print(" LED 1 Off");
       }
    }
   .
else {
    digitalWrite(led1.cpin, LOW);
    Serial.print (" LED 1 OFF State");
  }
void checkLED2() {
    (d2 < alertDistance1 ) {
led2.onoff = true;
led2.interval = alertInterval_1;</pre>
  if
      else
             ÷
    led2.onoff = false;
```

Figure 4.30 The coding of the void loop of four LEDs

#### 4.7 Measuring Voltage and Current Of The System

The Arduino Mega 2560 is an ATmega2560-based microcontroller board. The Arduino Mega can be powered by USB or an external power source. External power sources for Arduino are, in general, linear and switching power supplies, or having a specialized USB output (that is most often of the switching kind), and batteries of various sorts, in addition to the computer's USB connection. An AC-to-DC adapter (wall-wart) or a battery can provide external (non-USB) power. A 2.1mm center-positive plug can be plugged into the board's power jack to connect the adapter. Battery leads can be inserted into the POWER connector's Gnd and Vin pin headers. The board can be powered from a 6 to 20 volt external supply. If less than 7V is supplied, the 5V pin may supply less than five volts, making the board unstable. The voltage regulator may overheat and damage the board if more than 12V is used. There is a recommended voltage range of 7 to 12 volts.



Figure 4.31 Measuring The Voltage Flow in the circuit using a Multimeter

The connection in the system component to measure the voltage flow in the circuit using a multimeter is shown in Figure 4.31. The multimeter is once again used as a measuring tool to determine the voltage value in the system. Then the multimeter is then calibrated at 20 volts of DC. Next, a positive probe multimeter will be connected to the terminal VCC ultrasonic sensor. Finally, the negative probe multimeter is connected to the ground pin at the microcontroller.



Figure 4.32 Measuring the Current Flow in the circuit using a Multimeter

The connection in the system to measure the current flow is a little different from the voltage. Therefore, we can take the readings directly on the voltage flow but not the current flow. When dealing with current, certain precautions need to be taken or might damage the circuit and the multimeter fuse. First, the connection is set up in series (Figure 4.32). The red probe from the multimeter is then connected to the plus (+) terminal of the power supply using the adapter. Next, connect the black probe to the Arduino Mega 2560's 5V supply. Finally, connect the Arduino Mega 2560's GND to the power supply's minus (-) terminal. Putting the multimeter in series or in line with the power supply is referred to as this.

## 4.7.1 System Components Overview and Output Selection

The Blind Spot System project uses the battery's DC output or 5V USB car adapter. When deciding to use batteries, the ratios between their capacity (usually expressed in mAh) and the power required by the Arduino board and peripheral circuitry connected to it are frequently overlooked. Therefore, the Blind Spot system's preferred design should allow a fully active system to operate for at least 21 hours. In addition, each active component's consumption characteristics should be known to calculate the available online duration before a complete battery discharge.

Blind Spot System for Truck Drivers	Operating Voltage (V)	Operating (Idle) Current (mA)	Active Current (mA)	Current Draw (mA) @ 0% Idle	Power (mW)		
HC-SR04							
Range Sensor	5	15	15	Power (mW) 75*4 = 300 607.5 250 388.5			
LCD							
5		121.5 120		121.5	607.5		
LED							
	5	50	35	50	250		
ATmega2560 Chip @ 16MHz*	5	77.7	77.7	77.7	388.5		

Total Load Draw	5	264.2	247.7	264.2	1546				
Regulator Efficie	ency (est.)*	75%		*Estimations based on					
Battery Capacity	r (mAh)	550		ATmega2560 chip test data. The chip can be powered at 3.3 V and 8MHz, with an active current of 12.3 mA.					
Lifetime est. (ho	urs)	14.402							

 Table 4.3 Blind Spot System for Truck Drivers Power Consumption

A single battery-powered Blind Spot Sensor System includes the HC-SR04 Ultrasonic ranging module, LCD, LED, and Atmega2560 Chip. Table 4.3 above shows the estimated calculation for a 550 mAh battery (equivalent to the capacity of 9V batteries). Using these available estimates, the independent variable of the equation is the battery capacity. To achieve the preferred system operational period of 24 hours, the required battery capacity is estimated to be 5000 mAh. Therefore, battery time = 5000 mAh/208.3 mA = 24 hrs = at least 1 1days (worst case: Buzz with every measurement).



Figure 4.33 Battery holder with DC Plug

For practicality and a temporary power consumption buffer, the sensor battery to be integrated will be a 9V 550mAh Alkaline battery pack (shown in Figure 4.33). This battery is estimated to provide a 3-hour operational lifespan before recharging.

#### 4.7.2 Power Management and Distribution

A stable circuit design to manage and distribute power to the Blind Spot System's critical components is undeniably a critical infrastructure. Because a single battery can't always meet all of a circuit's needs due to its low voltage or capacity, it's vital to grasp the series and parallel mechanisms or how batteries can be connected to increase the said values. As a starting point, all batteries that make up a "pack" must be completely identical, perhaps from the same batch. In the case of alkaline batteries, they must all be brand new, and in the case of rechargeable batteries, they must all be fully charged or discharged. Identical batteries connected in series (the negative pole of the first goes to the positive pole of the second, etc.) maintain the capacity of a single battery and add the voltages. For example, 9V 550 mAH Alkaline batteries are connected for the Blind Spot System. Figure 4.34 below shows the sensor power schematic.



**Figure 4.34 Peripheral Sensor Power Schematic** 

When the voltage of a single battery is insufficient to power the circuit, the connection in series is employed. Figure 4.35 Cabin Hub Power Schematic will act as a "sync and receive" device. The power line to the hub is provided by the cigarette lighter port, which will provide a 12V output.



Figure 4.35 Cabin Hub Power Schematic

# 4.8 System Testing and Demonstration

After the prototypes are completed, we plan to run multiple test runs to evaluate the system's performance and tweak the design until accurate results are obtained. Phase 1 will test the individual circuits on a PCB before they are sent out for printing, and phase 2 will test the system as a whole using an actual truck in real-world driving conditions. We reached out to a truck driver, who agreed to use his truck for phase 2 testing. Figures 4.36 and 4.37 below show the truck's plotted area blind spot.



Figure 4.36 Blindspot area on the left side of the truck



Figure 4.37 Blindspot area on the front of the truck

Four sensors will be installed on the truck for this testing: one on the right door side, one on the left door side, and two on the front right and left. Each sensor will be identified by a part number, with numbers one and two in the front, three on the right door side, and four on the left. Figures 4.38 and 4.39 will show the placement of the sensors.



Figure 4.38 Placement of the sensor on the front and left door side

These sensors will be placed in various locations around the truck during the testing phase to determine which area is the most effective for detection. The driver's input and perspective also determine the final sensor placement.



Figure 4.39 Placement of the sensor on the front and right door side

## 4.8.1 Functionality test

These sensors will correspond to a single LED on the cabin's hub unit. The corresponding LED on the hub unit will light up whenever the sensor detects a vehicle in its vicinity. Before plugging into the trucks, we have done the testing as per Figure 4.40.



Figure 4.40 Blind Spot System Cabin Hub component testing

The code may need to be tweaked to increase or decrease the sensing range. After troubleshooting, we contacted the truck driver Mr. Azman, who will drive us around his truck for dynamic effects once acceptable results are seen while the truck is stationary. Next, the Blind Spot System Cabin Hub placement on the actual truck (shown in Figure 4.43).



Figure 4.41 The placement of Blind Spot System Cabin Hub on the actual truck

The LEDs will turn on and off depending on whether or not there is another vehicle on that side of the truck . The ultrasonic sensors in the system work by sending a signal into the environment, which bounces off the closest object and returns to the sensor's receiver. It calculates the object's distance based on its time for the signal to return. Next, the cabin hub system will warn the lorry driver about the potential collisions with others vehicles moving in the same direction on the side and in front of the truck during lane change maneuvers. When other vehicles entered the blind spot area, the truck driver couldn't see the view on the side mirror.



Figure 4.42 A motorcyclist in a blind spot area will trigger the buzzer to alert the driver

Figure 4.42 above shows a motorcyclist in a blind spot area to trigger the buzzer to alert the driver. Our initial concern was that the signal would not have enough time to return to the peripheral if the truck moved too quickly. A video of the system in action will be taken at this time for project demonstration. According to current calculations, the sensors will work at speeds up to 180 km/h faster than a truck's legal speed limit. In addition, the sensor will be tested at speeds up to 110 km/h, the highest permitted speed in Malaysia, for the purposed of this project.

## 4.9 Result of Voltage and Current Flow in the system



4.9.1 Voltage

Figure 4.43 The Graph for Voltage Flow in the System

Figure 4.43 shows the plot data in the test graph conducted for 15 seconds on the system. The voltage of reference is 5V, and the voltage value is low for the first 6 seconds, with a range of 3.5V to 5V. It is because the other component is still in sync with the microcontroller. The voltage is stable when the system is ready, almost near 5V. This is because the voltage from the output will go through the 5V voltage regulator on the microcontroller that will control the voltage on the system circuit. However, the voltage value to detecting an object in a blind spot is slightly increased by 4.8V in 7 seconds. The device's output voltage is stable after becoming undetected by the ultrasonic sensor.



## 4.9.2 Current



The test current flow on the system was performed out in 15 seconds (shown in Figures 4.44). In this project, the system used a 9V battery power source, I = W/(Vin-Vout). 9V Power Supply: I = 2/(9-5) = 2/4 = 500mA. The maximum power to be dissipated of about 2W. Therefore, the current value of its system's supply peak current value is 0.4 A. The highest current flow value in the operating system current is 0.4 A. This means that the system functions well within the safety range of current flow in a circuit. The highest current value is less significant than the battery's standard current value. When the sensors detect obstacles and send the data, it will not affect the system's current value during the test. The current and voltage value for the random distance collected by the sensor would be the same. It would be attributable to the electronic components if the voltage and current maintain the same when it performs but has the power supply.

#### **CHAPTER 5**

## CONCLUSION AND RECOMMENDATION

### 5.1 Conclusion

Many engineering challenges were overcome during the research and development phase of the Blind Spot System for Truck Drivers. As a result, for each component and line of code that has been integrated into the Blind Spot System, the system requirements shaped during the project's conceptual design stage have been taken into account. This project develops a blind spot system for prime mover truck drivers to reduce and prevent accidents on heavy trucks with other vehicles, especially motorcycles.

The blind spot alert system has been developed based on the literature review definition and information form. The circuit coding and prototype have both been completed. To develop the system, the system learns about its components and coding. Coding and 3D CAD software are very helpful in developing this system. The computer engineering and electrical engineering disciplines have shared the design workload equally. A current and voltage analysis was carried out to determine the device's functionality to perform and work properly. The system performed admirably to enhance existing technologies and ensure public safety. As a result, the Blind Spot System's core infrastructure comprises a few simple components that, when combined properly, deliver a marketable function to an industry in desperate need of a safety technology upgrade. This system also can operate blind spots.

Furthermore, this system can operate blind spots within a reasonable distance. Finally, the system can entice the driver with the buzzer's generated sound and LED blinking light. This blind-spot warning system makes it easier for the driver to be more cautious in the lane.

## 5.2 Recommendation

Very important to enhance current technology and safety for blind-spot alert systems for truck drivers. In the future, it can be modified from the prototype device to test the real truck that can be used for a blind-spot kit that can be a portable system for the next project. This system can also be upgraded to include the distance sensor and LCD monitor. Moreover, this system can be improved by displaying up to HD resolution. It is to ensure better views in the blind spot. This process can help drivers be more prepared and careful before changing lanes. Besides, the material can be enhanced to ABS(acrylonitrile-butadlene-styrene) instead of PLA (polylactic acid) in this project. Since the system is outside the truck, better housing material properties need to be done. PLA melts more quickly because it has a lower melting point than many fossil-based plastics. ABS offers a good balance of heat. The ultrasonic sensor can be added more in this project since the microcontroller has an extra empty slot for digital pins. The location on the different sensor placements will give a different result.

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#### APPENDICES

## APPENDIX A Technical Data Of Pic16f877a



#### TABLE 1-1: PIC16F87XA DEVICE FEATURES

Key Features	PIC16F873A	PIC16F874A	PIC16F876A	PIC16F877A
Operating Frequency	DC - 20 MHz			
Resets (and Delays)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)	POR, BOR (PWRT, OST)
Flash Program Memory ERSIT (14-bit words)		L MAKLAYS	SIA MELAP	(Д 8К
Data Memory (bytes)	192	192	368	368
EEPROM Data Memory (bytes)	128	128	256	256
Interrupts	14	15	14	15
I/O Ports	Ports A, B, C	Ports A, B, C, D, E	Ports A, B, C	Ports A, B, C, D, E
Timers	3	3	3	3
Capture/Compare/PWM modules	2	2	2	2
Serial Communications	MSSP, USART	MSSP, USART	MSSP, USART	MSSP, USART
Parallel Communications	10 <u></u> 21	PSP	9 <u>1 - 1</u> 71	PSP
10-bit Analog-to-Digital Module	5 input channels	8 input channels	5 input channels	8 input channels
Analog Comparators	2	2	2	2
Instruction Set	35 Instructions	35 Instructions	35 Instructions	35 Instructions
Packages	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN	28-pin PDIP 28-pin SOIC 28-pin SSOP 28-pin QFN	40-pin PDIP 44-pin PLCC 44-pin TQFP 44-pin QFN

## **APPENDIX B** Arduino Coding

/\* start read sensor 1,2,3,4 report

\*/ #include "src/NewPing.h" #include "src/LiquidCrystal\_I2C.h"



NewPing sonar1(TRIG\_1, ECHO\_1, MAX\_DISTANCE); // NewPing setup of pins and maximum distance. NewPing sonar2(TRIG\_2, ECHO\_2, MAX\_DISTANCE); // NewPing setup of pins and maximum distance. NewPing sonar3(TRIG\_3, ECHO\_3, MAX\_DISTANCE); // NewPing setup of pins and maximum distance. NewPing sonar4(TRIG\_4, ECHO\_4, MAX\_DISTANCE); // NewPing setup of pins and maximum distance. BUZZ buzz1; LED led1 = {false, false, 0, 0, LED\_1}; LED led2 = {false, false, 0, 0, LED\_2}; LED led3 = {false, false, 0, 0, LED\_3}; LED led4 = {false, false, 0, 0, LED\_4}; LiquidCrystal I2C lcd(0x27, 16, 2); // I2C address 0x27, 16 column and 2 rows

void setup() {
 Serial.begin(115200);
 Serial.println("Blind Spot System init..");
 lcd.init();
 lcd.backlight();
 lcd.setCursor(0, 0);
 lcd.print("Blind Spot System init.."); // print a simple message



UNIVERSITI TEKNIKA delay(1000);

lcd.clear();

float d1, d2, d3, d4; // distance in cm int alertDistance1 = 50;

// tone interval in miliseconds
 int alertInterval\_1 = 100;

int LEDState\_1 = 0; int LEDState\_2 = 0; int LEDState\_3 = 0; int LEDState\_4 = 0;

void loop() {
d1 = sonar1.ping\_cm(); delay(PING\_INTERVAL);
d2 = sonar2.ping\_cm(); delay(PING\_INTERVAL);
d3 = sonar3.ping\_cm(); delay(PING\_INTERVAL);

 $d4 = sonar4.ping_cm();$ if (d1 == 0)d1 = 1000; if (d2 == 0)d2 = 1000; if (d3 == 0)d3 = 1000; if (d4 == 0)d4 = 1000;Serial.print(d1); Serial.print("|"); Serial.print(d2); Serial.print("|"); Serial.print(d3); Serial.print("|"); Serial.print(d4); Serial.print(" "); /\* int alertDistance1 = 50; int alertDistance2 = 80; int alertDistance3 = 100: int alertInterval 1 = 500; int alertInterval 2 = 300; int alertInterval 3 = 100; \*/ // if (d1 < 50) { // buzz1.onoff = true; buzz1.interval = alertInterval 3; // // Serial.println("alertDistance3"); // } else if (d1 < 80) { // buzz1.onoff = true; 11 buzz1.interval = alertInterval 2; Serial.println("alertDistance2"); 11 // } else if (d1 < 120) { // buzz1.onoff = true; 11 buzz1.interval = alertInterval 1; Serial.println("alertDistance1"); // } else { // buzz1.onoff = false; // buzz1.interval = 2000; // Serial.println("No Alert"); // } if  $(d1 < alertDistance1 \parallel d2 < alertDistance1 \parallel d3 < alertDistance1 \parallel d4 < alertDistance1)$ buzz1.onoff = true:buzz1.interval = alertInterval\_1; buzz1.pwm = 255;Serial.print(" alertDistance1"); } else { buzz1.onoff = false; buzz1.interval = 2000;Serial.print(" No Alert"); } checkBuzzer(); checkLED1(); 115

checkLED2(); checkLED3(); checkLED4(); String str\_d1 = "S1:" + String(d1, 0);String str\_d2 = "S2:" + String(d2, 0); String str\_d3 = "S3:" + String(d3, 0);String str\_d4 = "S4:" + String(d4, 0);if (d1 == 1000)str\_d1 = "S1: - "; if (d2 == 1000)str\_d2 = "S2: - "; if (d3 == 1000)str d3 = "S3: - ";if (d4 == 1000)str d4 = "S4: - "; //d1 // move cursor to (0,0)lcd.setCursor(0, 0); "): lcd.print(" //clear screen lcd.setCursor(0, 0); // move cursor to (0,0)lcd.print(str\_d1); // print message at (0, 0)//d2 lcd.setCursor(0, 1); // move cursor to (0,0)lcd.print(" "): //clear screen lcd.setCursor(0, 1); // move cursor to (0,0)lcd.print(str\_d2); // print message at (0, 0)//d3 lcd.setCursor(9, 0); // move cursor to (0, 0)"); lcd.print(" //clear screen lcd.setCursor(9, 0); // move cursor to (0,0)lcd.print(str d3); // print message at (0, 0)//d4 lcd.setCursor(9, 1); // move cursor to (0,0)lcd.print(" "); //clear screen lcd.setCursor(9, 1); // move cursor to (0,0)// print message at (0, 0)lcd.print(str\_d4); // lcd.setCursor(0, 1); // move cursor to (2, 1)// lcd.print(millis() / 1000); // print message at (2, 1) Serial.print(" "); Serial.println(millis() / 1000); void checkLED1() { if (d1 < alertDistance1) { led1.onoff = true;led1.interval = alertInterval 1; } else { led1.onoff = false; } if (led1.onoff) { if (millis() - led1.btime > led1.interval) { if (!led1.state) { 116





if (led4.onoff) {

if (millis() - led4.btime > led4.interval) {

if (!led4.state) {
digitalWrite(led4.cpin, HIGH);
led4.btime = millis();
led4.state = true;
Serial.print(" LED 4 On");
} else {
digitalWrite(led4.cpin, LOW);
led4.btime = millis();
led4.state = false;
Serial.print(" LED 4 Off");
}
} else {
digitalWrite(led4.cpin, LOW);
118

Serial.print(" LED 4 OFF State"); } void checkBuzzer() { if (buzz1.onoff) { if (millis() - buzz1.btime > buzz1.interval) { if (!buzz1.state) { //digitalWrite(buzzer, HIGH); analogWrite(buzzer, buzz1.pwm); buzz1.btime = millis(); buzz1.state = true; Serial.print(" Buzzer On"); } else { //digitalWrite(buzzer, LOW); analogWrite(buzzer, 0); buzz1.btime = millis() + buzz1.interval - 100; buzz1.state = false; Serial.print(" Buzzer Off"); } else { digitalWrite(buzzer, LOW); Serial.print(" Buzzer OFF State"); UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Pin Category	Pin Name	Details							
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external							
		power source.							
		5V: Regulated power supply used to power							
		microcontroller and other components on the board.							
		3.3V: 3.3V supply generated by on-board voltage							
		regulator. Maximum current draw is 50mA.							
		GND: ground pins.							
Reset	Reset	Resets the microcontroller.							
Analog Pins	A0-A5	Used to provide analog input in the range of 0-5V							
Input/Output	Digital Pins 0 - 13	Can be used as input or output pins.							
Pins	N.Y.								
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.							
External	2,3	To trigger an interrupt.							
Interrupts	the last								
PWM	کل 3, 5, 6, 9, 11 ک	Provides 8-bit PWM output.							
SPI	10 (SS), 11 (MOSI), 12	Used for SPI communication.							
	(MISO) and 13 (SCK)								
Inbuilt LED	13	To turn on the inbuilt LED.							
TWI	A4 (SDA), A5 (SCA)	Used for TWI communication.							
AREF	AREF	To provide reference voltage for input voltage.							

# APPENDIX C Arduino Uno Pin Descriptions

# APPENDIX D Gantt Chart

	Month		/larc	h		Apr	il		May			June				
	Week (W)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Activity			BACHELOR DEGREE PROJECT 1												
	Title Selection.															
	Introduction															
pt	Background.															
nce	Problem Statement,															
ပိ	Objectives, and															
	Scope of Research															
	Literature Review															
	Method Selection															
gy	Project Flow Chart															
lolc	Product Design	Ye.														
ethod	Specification	E S				Т						1				
W	Sketching Ideas							7			Ν	1				
	Material Selection									7						
	Report Preparation								-							
	Submission Full					/						+	1			
eport	Report PSM 1	٥ ر		-	e.i.		2	3	5:	~	1	يبو	91			
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<sup>1</sup> In general, if I is the current in amperes and t is the time in seconds that the current flows, then I t represents the amount of electrical charge in coulombs, i.e., the amount of electrical charge transferred.

<sup>2</sup> Ohm's Law Formula RSITI TEKNIKAL MALAYSIA MELAKA

<sup>3</sup> As a result, 1 ampere equals 1 coulomb per second, or 1 A equals 1 C/s. As a result, one coulomb equals one ampere second, or one C equals one .In general, if I the current in amperes and t is the time in seconds that the current flows, then I t represents the amount of electrical charge in coulombs, i.e., the amount of electrical charge transferred.

<sup>4</sup> In a series circuit, the total resistance is calculated by adding the values of the individual resistances.

<sup>5</sup> The source voltage, V volts, is constant across all resistors.

<sup>6</sup> Where R represents the total circuit resistance. Because I = I1 + I2 + I3

<sup>7</sup> By dividing everything by V, you get 1/R

<sup>8</sup> When calculating the total resistance R of a parallel circuit, this equation must be used. For the special case of two parallel resistors:



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## TAJUK: DEVELOPMENT OF BLIND SPOT SYSTEM FOR PRIME MOVER TRUCK DRIVERS

SESI PENGAJIAN: 2020/21 Semester 1

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