UNIVERSITI TEKNIKAL MALAYSIA MELAKA

AUTO HIGH BEAM HEADLIGHT SYSTEM FOR MOTORCYCLES USING 12-V BATTERY SUPPLIER (AHBM)

ADAM ZAIM ARIFFUDIN BIN NASARUDIN

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY
(AUTOMOTIVE TECHNOLOGY) WITH HONOURS

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Faculty of Mechanical Technology and Engineering

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**A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours**

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BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **AUTO HIGH BEAM HEADLIGHT SYSTEM FOR MOTORCYCLES USING 12-V BATTERY SUPPLIER (AHBM)**

SESI PENGAJIAN: **2024-2025 Semester 1**

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I declare that this Choose an item. entitled "Auto High Beam Headlight System for Motorcycle Using 12-V Battery Supplier" is the result of my own research except as cited in the references. The choice of an item has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Name : Adam Zaim Ariffudin Bin Nasarudin

Date : 9 January 2025

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 Technology) with Honours.

Signature	:	
Supervisor Name	:	Profesor Madya Ts. Dr Muhammad Zahir Bin Hassan
Date	:	9 January 2025

DEDICATION

This project is dedicated to all the people who have helped me along the way with their constant support, encouragement, and direction. My success has been built on the unwavering love and support from my dear family. I express my gratitude to my parents for their unwavering patience, selflessness, and unwavering belief in me. My biggest source of motivation has been your advice and assistance. Thank you to my siblings for their support and encouragement; it has given me the will and fortitude to keep going. To my close friends, it has been a doable and genuinely pleasurable journey because of your friendship and support. My recollections of the late-night study sessions, our shared experiences, and your unflinching support will last a lifetime. I owe a great deal of thanks to my great supervisor, Prof. Ts. Dr. Muhammad Zahir Bin Hassan, for your valuable counsel and assistance. Your knowledge, perceptions, and support have been essential to this project's successful conclusion. Your confidence in my skills and dedication to my academic development have been incredibly motivating. I want to thank each one of you for being a vital part of my journey and for assisting me in reaching this important goal

ABSTRACT

The need for improved visibility and safety elements in motorcycle lighting systems has been highlighted by the rise in nighttime driving accidents. The goal of this project is to create an automatic high beam lighting system that runs on a 12-volt battery pack for motorcycles. The suggested method makes use of sensors and advanced algorithms to automatically modify the headlight settings in response to the ambient light, maximizing lighting and reducing glare for other drivers. A light sensor and a camera are integrated into the system architecture to monitor ambient light levels and identify impediments and oncoming vehicles, respectively. This provides the best visibility possible, a sophisticated control unit interprets the sensor data and dynamically shifts between high and low beam settings. The system can be integrated into most motorcycles' current electrical systems because it uses a 12-volt battery supply. A comprehensive testing programme was implemented in urban, suburban, and rural driving scenarios to verify the efficacy of the auto high beam system. The planned results showed notable increases in driver visibility and a decrease in glare that interfered with other road users' visibility. Furthermore, the system demonstrated strong performance in ensuring sufficient lighting even in inclement weather. A notable accomplishment in motorcycle safety technology is the creation of this auto high beam lighting system. The technology makes riding safer by improving sight at night and reducing driver attention. This project not only aligns with current automotive safety standards but also offers a practical solution for widespread implementation in the motorcycle industry

ABSTRAK

Keperluan untuk meningkatkan elemen keselamatan dan keterlihatan dalam sistem pencahayaan motosikal telah diketengahkan oleh peningkatan dalam kemalangan semasa memandu pada waktu malam. Tujuan projek ini adalah untuk mencipta sistem pencahayaan lampu tinggi automatik yang beroperasi menggunakan pek bateri 12-volt untuk motosikal. Kaedah yang dicadangkan menggunakan sensor dan algoritma canggih untuk menyesuaikan tetapan lampu kepala secara automatik mengikut cahaya persekitaran, memaksimumkan pencahayaan dan mengurangkan silau untuk pemandu lain. Sensor cahaya dan kamera diintegrasikan ke dalam seni bina sistem untuk memantau tahap cahaya persekitaran dan mengenal pasti halangan serta kenderaan yang datang dari arah bertentangan. Untuk memberikan keterlihatan terbaik, unit kawalan canggih menafsirkan data sensor dan secara dinamik beralih antara tetapan lampu tinggi dan rendah. Sistem ini boleh diintegrasikan ke dalam sistem elektrik motosikal sedia ada kerana ia menggunakan bekalan bateri 12-volt. Program ujian yang menyeluruh telah dilaksanakan dalam senario pemanduan bandar, pinggir bandar, dan luar bandar untuk mengesahkan keberkesanan sistem lampu tinggi automatik ini. Hasil yang dirancang menunjukkan peningkatan yang ketara dalam keterlihatan pemandu dan pengurangan silau yang mengganggu keterlihatan pengguna jalan raya lain. Tambahan pula, sistem ini menunjukkan prestasi yang kukuh dalam memastikan pencahayaan mencukupi walaupun dalam cuaca buruk. Penciptaan sistem pencahayaan lampu tinggi automatik ini merupakan pencapaian penting dalam teknologi keselamatan motosikal. Teknologi ini menjadikan pemanduan lebih selamat dengan meningkatkan penglihatan pada waktu malam dan mengurangkan keletihan pemandu. Projek ini bukan sahaja selari dengan piawaian keselamatan automotif semasa tetapi juga menawarkan penyelesaian praktikal untuk pelaksanaan yang meluas dalam industri motosikal.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC	-	Alternating Current
ADDR	-	Address Pin
ADB	-	Adaptive Driving Beam
AHB	-	Auto High Beam
AHBM	-	Auto High Beam Headlight System
ATmega328P	-	A microcontroller chip used in Arduino boards
BMS	-	Battery Management System
CNC	-	Convolutional Neural Network
CPU	-	Central Processing Unit
DC	-	Direct Current
D0 - D7	-	Data Bit 0 to Data Bit 7
FMVSS	-	Federal Motor Vehicle Safety Standard
GND	-	Ground
HREF	-	Horizontal Reference
Hz	-	Hertz
I2C	-	Inter-Integrated Circuit
ISO	-	International Organization for Standardization
LED	-	Light Emitting Diode

Lux	-	SI unit of illuminance
mA	-	Milliampere
PCLK	-	Pixel Clock
PWM	-	Pulse Width Modulation
RESET	-	Reset
SAE	-	Society of Automotive Engineers
SCCB	-	Serial Camera Control Bus
SCL	-	Serial Clock (I2C)
SDA	-	Serial Data (I2C)
SI	-	International System of Units
SIOD	-	Serial Input/Output Data **(**SCCB**)**
SIOC	-	Serial Input/Output Clock **(**SCCB**)**
UNO	-	Reference to Arduino UNO, a microcontroller board
USB	-	Universal Serial Bus
V	-	Voltage
VCC	-	Voltage Common Collector (Power Supply)
VGA	-	Video Graphics Array
VSYNC	-	Vertical Synchronization
XCLK	-	External Clock

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CHAPTER 1

INTRODUCTION

1.1 Overview

High beam headlights play a crucial role in enhancing visibility and safety for motorcyclists, especially during low-light conditions or on poorly illuminated roads. Motorcycle high beam headlights provide a significant improvement in visibility and safety for riders. Motorcycle headlights have historically had limited illumination capabilities. They frequently produced a narrow beam that made vision difficult, especially in low light. But high beam headlights transformed this scene by casting a brighter, wider beam of light that greatly increased the rider's field of vision. The rider's visibility to other road users is improved as well as their ability to detect obstructions and hazards thanks to the increased illumination. Furthermore, by increasing their visibility in traffic, high beam headlights greatly decrease the inherent risk of motorcycle riders and reduce the risk of accidents based on poor visibility (Hu et al., 2022). Here's **Figure 1.1** below shows the difference between high beam and low beam (kumore.en, 2023).

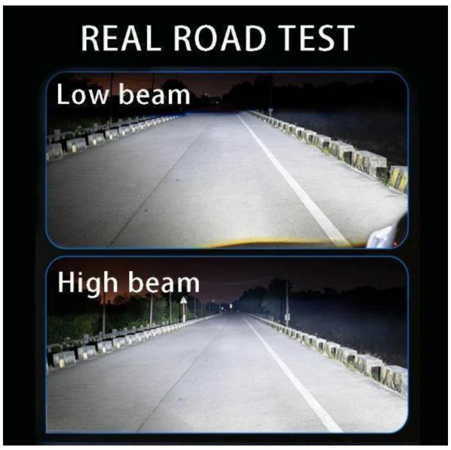

Figure 1.1: The difference between high beam and low beam

(Source: kumore.en, 2023)

However, there are a few disadvantages or impacts to applying high beam lights. Even though they improve visibility, high beam lights should only be used carefully to prevent disturbing or distracting other drivers. High beam glare can cause dangerous situations by restricting other drivers' vision, particularly on twisting or tight roadways (Tank et al., 2024). As a result, it's critical that motorcycle riders understand when and when to utilise high lights safely. When greater lighting is required to detect potential hazards, such as on dark, open roads with little traffic, using high beams is most appropriate. To prevent blinding other cars and pedestrians, it's crucial to switch to a low beam when driving through cities or when you're getting close to one. Manually switching between low and high beams can be cumbersome for riders, especially in dynamic riding situations. Thus, there is a growing need for automated solutions that can intelligently control the activation of high beam headlights, optimizing visibility while minimizing glare for oncoming traffic (Hu et al., 2022). **Figure 1.2** below shows the driver feeling distracted by the glare from the car behind (Drivesafely, 2022) and **Figure 1.3** below the low and high beam switch manual operation is depicted in the diagram below (BikeWale, 2023).

Figure 1.2: High beam glare.
(Source: Drivesafely, 2022)

Figure 1.3: Manually switch high and low beam.
(Source: BikeWale, 2023)

Auto high beam technology, prevalent in modern automotive systems, represents a paradigm shift in headlight functionality, offering enhanced visibility and convenience for drivers. Utilizing sensors, cameras, or intelligent algorithms, these systems automatically adjust headlight settings based on surrounding conditions, optimizing illumination while minimizing glare for other road users. For example, in many cars today, when the system detects oncoming vehicles or streetlights, it seamlessly switches from high to low beams to prevent dazzling other drivers, then reverts to high beams once the road ahead is clear. This seamless transition not only improves visibility for the driver but also enhances safety for all road users by reducing the risk of glare-related accidents, making auto high beam technology an indispensable feature in modern vehicle lighting systems. Auto high beam technology, found in numerous contemporary automotive systems, is utilized by brands like Toyota, Honda, BMW, Mercedes-Benz, and Audi. For instance, Toyota integrates automatic high beams into models like the Camry, Corolla, and RAV4 through its Toyota Safety Sense suite, offering advanced driver assistance features. Similarly, Honda incorporates auto high beams into vehicles such as the Accord and CR-V as part of its Honda Sensing safety technology package. **Figure 1.4** below shows a car using auto high beam and detecting the car in front (Toyota Europe, 2021).

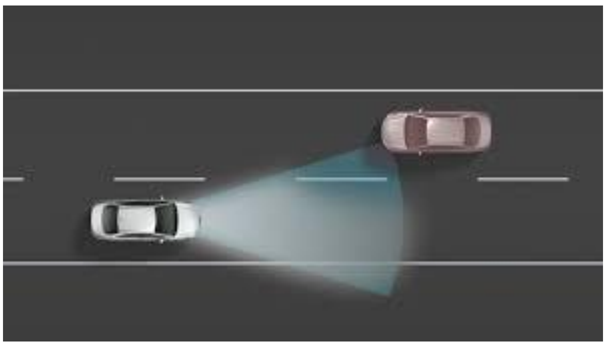

Figure 1.4 Shown that car using Auto High Beam

(Source: Youtube Toyota Europe, 2021)

1.2 Research Background

The Auto High Beam Headlight System (AHBM) represents a significant advancement in motorcycle safety and technology. While auto high beam systems are prevalent in cars, their adaptation for motorcycles presents unique challenges and opportunities. Existing literature on auto high beam technology primarily focuses on automotive applications, highlighting the benefits of improved visibility, reduced glare, and enhanced safety for drivers (Gowri Shankar et al., 2023). However, there is a notable gap in research specifically addressing the integration of auto high beam systems into motorcycles, which operate under distinct environmental and regulatory conditions. As such, this project aims to fill this gap by exploring the feasibility and effectiveness of implementing auto high beam technology in motorcycles, leveraging a 12-volt battery supply for power.

The integration of AHBM, along with the inclusion of a duo switch for auto and manual control, offers numerous potential advantages. By automatically adjusting headlight settings based on surrounding conditions, the system enhances rider visibility and safety, particularly in low-light conditions or on poorly illuminated roads. The duo switch provides riders with the flexibility to seamlessly transition between automatic and manual control modes, catering to individual preferences and riding scenarios. In automatic mode, the system intelligently adjusts headlight settings based on sensor data, optimizing illumination while minimizing glare for other road users. Conversely, manual mode allows riders to directly control headlight activation, providing on-demand adjustment of beam intensity to suit specific riding environments or preferences. Through a comprehensive review of existing literature and empirical research, this project aims to elucidate the benefits and challenges of auto high beam technology for motorcycles and pave the way for its widespread adoption in the motorcycle industry (Gowri Shankar et al., 2023).

1.3 Objectives

The objectives of this research are as follows:

i. To design an Auto High Beam Headlight System (AHBM) for motorcycles with 12 Volt battery supply.
ii. To develop a prototype of the Auto High Beam Headlight System design.
iii. To conduct comprehensive testing and validation procedures that evaluate the performance and reliability of the Auto High Beam Headlight System.

1.4 Scope of Research

The scope of the project to develop an Auto High Beam Headlight System (AHBM) for motorcycles using a 12-V battery supplier encompasses several key study areas. It involves the design and integration of an automated system that can intelligently switch between high and low beam headlights based on real-time road conditions, enhancing safety and visibility for motorcyclists. The project will explore the use of advanced sensors and control algorithms to detect oncoming traffic and ambient light levels, thereby adjusting the headlight intensity accordingly. Additionally, the study will consider the energy efficiency and environmental impact of the system, particularly focusing on the selection of a suitable 12-V battery that balances performance with sustainability. The research will also delve into the current limitations of motorcycle headlight intensity and the potential safety benefits of improved lighting systems, aiming to reduce the frequency of accidents related to poor visibility and headlight glare.

1.5 Organization Thesis

The remainder of this thesis is comprised of four further chapters as summarised below.

Chapter 2: A review of literature review relevant to the present study about (AHBM) conducting the development system for motorcycles.

Chapter 3: The proposed of present methodology involved in this project will be explained.

Chapter 4: The chapter highlighted the present finding, results, and discussion.

Chapter 5: Conclusion is drawn from the overall findings of the research along with recommendations for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the present era, motorcycles are a means of transportation in almost every society. Every aspect of human society is impacted by transportation, which is a necessary component of daily living. It emphasises the interconnectedness between human existence and the environment to meet demands of the present and the future (Lee et al., 2018). As seen in **Figure 2.1**, there are 12,933,042 private motorbikes and 13,288,797 cars registered in Malaysia. Then came 1,205,744 number cargo trucks, 568,585 other vehicles, and 185,035 public service vehicles, including buses, taxis, and private rental automobiles (Paultan, 2022).

State	Private Vehicles		Public Service Vehicles (PSV)	Goods Vehicles	Others	Total
	Motorcycles	Cars				
Perlis	84,500	26,510	385	2,007	1,365	114,767
Kedah	954,751	341,197	7,273	40,710	20,104	1,364,035
Penang	1,408,528	1,130,601	9,586	80,254	26,710	2,655,679
Perak	1,359,771	772,591	9,534	75,638	42,708	2,260,242
Selangor	1,423,821	1,157,268	24,273	194,390	104,724	2,904,476
Federal Territories	1,863,260	3,987,468	78,752	268,340	122,509	6,320,329
Negeri Sembilan	557,482	343,007	4,635	50,160	7,845	963,129
Melaka	472,701	344,459	3,425	28,486	8,830	857,901
Johor	1,873,005	1,498,587	20,365	153,471	66,183	3,611,611
Pahang	600,470	392,200	4,310	45,640	14,663	1,057,283
Terengganu	393,228	211,124	2,159	22,172	6,015	634,698
Kelantan	549,363	309,663	3,928	29,689	7,264	899,907
Sabah	402,237	697,541	9,574	116,292	65,807	1,291,451
Sarawak	798,227	813,569	5,834	95,373	71,782	1,784,785
Business Partner Portals	191,698	1,263,012	1,002	3,122	2,076	1,460,910
Total	**12,933,042**	**13,288,797**	**185,035**	**1,205,744**	**568,585**	**28,181,203**

Figure 2.1: Number of Registered Vehicle in Malaysia

(Source: Paultan, 2022)

The rider manually flips a switch located at the head of the motorcycle to switch between the high beam and low beam settings for their headlights. Nighttime motorbike accidents are the most common type of accidents on the road (Fakir et al., 2023). When driving at night, most motorcyclists use their high beams, which makes it difficult for onlookers to see well. Furthermore, most cyclists fail to convert from high beam to low beam, which interferes with other riders' or drivers' beams coming from the other direction. The driver loses vision and his ability to see things or movements that are out of alignment with his eyes when this powerful light beam strikes his eyes. Then, the overview flow for this chapter is shown in **Figure 2.2**.

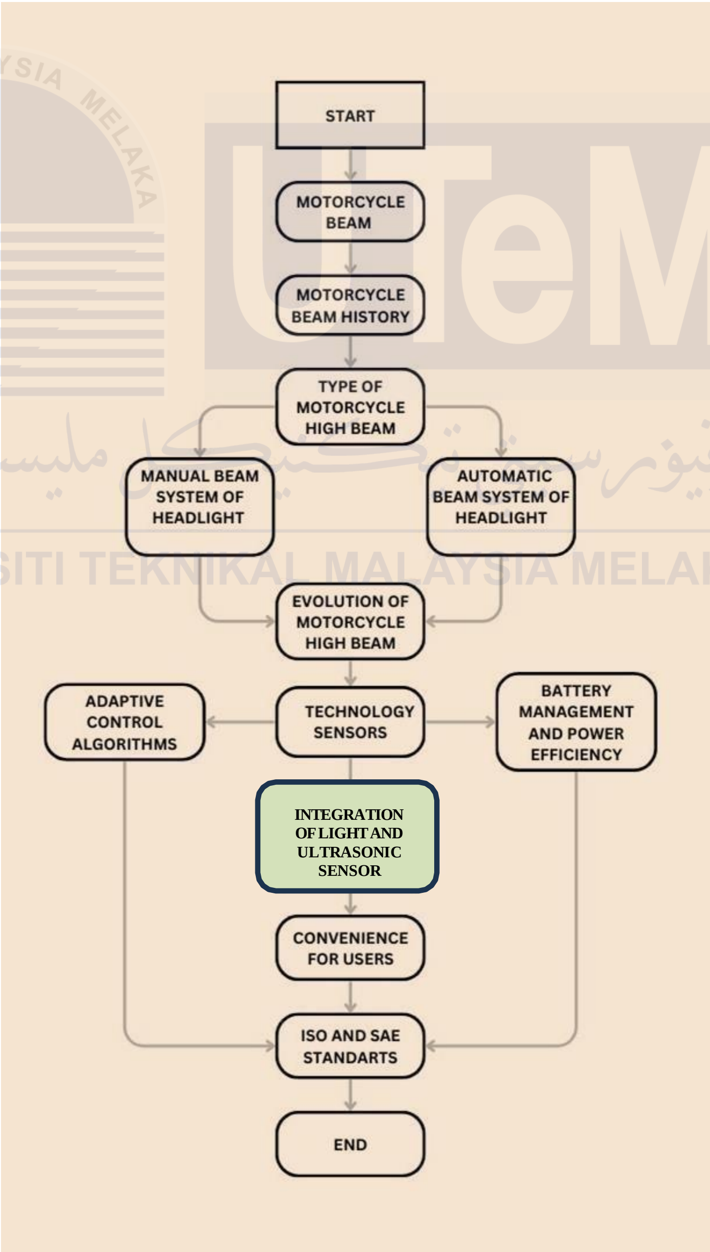

Figure 2.2: Overview of Literature Review Section

2.2 Motorcycle Beam and High Beam History

The development of technology for transport and the pursuit of rider safety are both reflected in the rich tapestry of motorbike beam history. Lighting on motorbikes was basic at best, frequently consisting of basic lights or halogen lamps, going back to the original models, which were basically bicycles with engines. Motorcycle lighting systems developed along with the vehicles themselves. The evolution of motorcycle headlights—from gas or oil lamps to modern illumination systems—reflects wider advancements in the field of automotive technology. Examples of bicycle or motorcycle lights are shown in **Figure 2.3** just before the development of more modern lighting (Presscall, 2020) and the **Figure 2.4** shows the system used for Carbide lamps (Thorpe, 2005). Motorcycles started using electric lighting early in the 20th century instead of acetylene lamps or other obsolete lighting sources, which provided more consistent illumination (Guo et al., 2023).

Figure 2.3: Carbide lighting for 1920's motorcycle

(Source: Presscall, 2020)

Figure 2.4: Figure show the system flame from rock and water (Carbide Lamps)

(Source: Thorpe, 2005)

As motorcycle beam technology advanced, sealed beam headlights—which offered a more dependable and consistent light source—arrived in the middle of the 20th century. This invention made the dual-beam system possible, which enables motorcyclists to alternate between low and high beams to accommodate varying riding conditions and improve safety for both them and other vehicles (Guo et al., 2023).

Figure 2.5: LED Motorcycle Headlight Bulb
(Source: ubuy.com, 2023)

These days, motorcycle beams are about more than simply visibility; they're also about cutting-edge technology, energy economy, and stylish design. With the development of LED and laser technology, motorbike illumination has never been possible before. Motorcycle beams are travelling the world, lighting the way for riders ahead of them. Examples of are LED motorcycle headlight bulbs shown in **Figure 2.5** (ubuy.com, 2023)**.**

2.3 Low Beam and High Beam of Motorcycle Headlight

The story of innovation in motorbike headlight beams' past is one of improving road safety. In this sense, the differentiation between high and low beams in motorbike headlights has been a crucial advancement. Low beams offer a broad distribution of light for visibility without blinding oncoming vehicles, while high beams, intended for long-distance illumination, enable riders to see farther ahead on dark, unlit roads (Amar Punekar, 2023). In the United States, manual selection of low and high beam headlamps was required by the Federal Motor Vehicle Safety Standard (FMVSS) 108, which was created in 1969. According to Joewono Prasetijo (2020), this standard was essential in ensuring that high beams maximise forward visibility when other cars are not present, and low beams minimize glare for oncoming or leading vehicles. The evolution of these beams

reflects the continuous effort to ensure the safety of riders, striking a balance between the necessity of minimizing the danger of glare-related accidents and the need for visibility. Motorcycle beam development and regulation show a persistent attempt to enhance rider-road environment interaction and provide a safer travel experience for all (Prasetijo et al., 2020).

The development of high beam headlights, which provided riders with more brightness and range and decreased the likelihood of accidents caused by low visibility, was a noteworthy advancement (Aman Jha, 2021). This allowed riders to confidently handle difficult terrain. Motorcycle headlights have continued to be improved by additional advancements in lighting technology, including halogen, LED, and adaptive lighting systems, which have improved visibility, energy efficiency, and durability (Cavallo et al., 2015). For motorcycle riders, these innovations not only increase safety but also make riding more pleasurable.

The evolution of motorcycle headlights from basic beams to high beams reflects a continuous quest for safety, efficiency, and technological excellence in the automotive industry. From the early days of gas lamps to the cutting-edge lighting systems of today, motorcycle headlights have undergone significant transformations, driven by the needs and expectations of riders for enhanced visibility and safety on the road. As motorcycle technology continues to advance, it is likely that we will see further innovations in lighting systems, further improving rider safety, and enhancing the overall riding experience.

2.4 Type Beam System of Headlight Motorcycle

The advancement of motorcycle headlight lighting technology has kept pace with the development of vehicle lights. In the past, motorcycle riders had to physically switch between low and high lights when operating a motorcycle. While the manual method is straightforward, it necessitates rider intervention to modify the light according to visibility requirements and prevent blinding oncoming traffic. As a result, an automatic high beam system was developed to facilitate use, improve visibility, and boost safety even more. The detail for the tyre changer is explained after this.

2.4.1 Manual Beam System Headlight

Motorcycles' manual beam systems are evidence of its straightforward control and simplicity, which have been trademarks of motorcycle design for many years. With this arrangement, the rider must manually flip between the low and high beams as shown in **Figure 2.6**, usually using a switch that is mounted on the handlebar (Amar Punekar, 2023). Riders can react to changing lighting conditions and approaching traffic thanks to the manual operation, which guarantees they can maintain optimal visibility without blinding other road users.

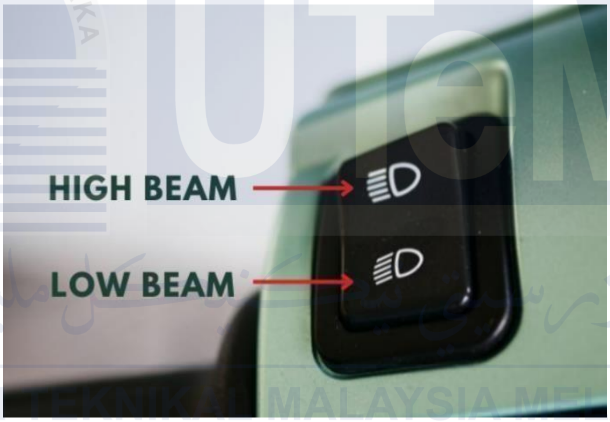

Figure 2.6: Switch for high beam and low beam
(Source: Amar Punekar, 2023)

Ensuring that the headlight beams are correctly aligned is crucial for this system to function effectively without causing glare to other road users. A practical guide on aligning motorcycle headlights for the MOT (Ministry of Transport test) provides detailed instructions on how to ensure that the headlight beams are set correctly, which is essential for the safety of both the rider and others on the road.

2.4.2 Automatic Beam System Headlight

Motorcycle headlights with automated beams are a major improvement in terms of rider convenience and safety. These systems automatically alter the headlight beams based on ambient light levels and the presence of other vehicles, thanks to sensors. The high lights automatically engage when the motorcycle enters a darker area, like a tunnel, or when the sensors detect that the ambient light level is low. On the other hand, the system will save energy and lessen glare for other drivers by turning off the headlights or switching to low beams in well-lit areas or during the day.

Additionally, certain automatic beam systems come with Adaptive Driving Beam (ADB) technology, which modifies the headlight's pattern and direction in addition to its intensity depending on the speed and lean angle of the motorcycle. This guarantees improved visibility in a variety of riding situations, including around curves. Furthermore, automated high beams can change from high to low lights in response to the detection of approaching cars, lowering the possibility of blinding other motorists, and improving general road safety (Akshay Ganesh et al., 2015).

2.5 Evolution of Auto High beam Technology

2.5.1 Technology Sensors

Auto high-beam systems utilize sensors to improve safety and convenience for motorcycle riders by performing two essential functions: light detection and vehicle detection. Light detection involves continuously monitoring ambient light levels, including natural and artificial sources, to determine whether to activate low or high beam headlights based on light intensity. Vehicle detection involves identifying nearby vehicles and switching from high beam to low beam when an oncoming vehicle approaches to prevent glare. When the road is clear, the system reactivates the high beam for enhanced visibility. **Table 2.1** shows the type of sensor that can be used for this project.

Table 2.1: Type of sensor

Sensor Type	Example	Function	Use in Auto High Beam
Light Sensor	BH1750FVI Digital Light Intensity Sensor	Measures ambient light levels	Adjusts headlight intensity based on surrounding light conditions
Ultrasonic Sensor	HC-SR04 Ultrasonic Distance Sensor	Measures distance using ultrasonic waves	Detects the proximity of objects or other vehicles to adjust beam intensity

2.1.1 Integration of Light Sensor and Ultrasonic Sensor

Motorcycle-specific car lighting systems that incorporate both light and ultrasonic sensors are a major development in the field of vehicular safety technology. This integration's main objective is to reduce glare for oncoming cars while improving motorcyclists' sight at night. The digital ambient light sensor BH1750 detects the amount of light in the environment and notifies the system when it gets dark enough to need high beams. In addition, the HC-SR04 ultrasonic sensor, which can identify objects as far away as six meters, evaluates the closeness of cars up ahead and lowers the high beams when one is detected. This dual-sensor system ensures that high beams are only activated when conditions are optimal, thereby reducing the risk of accidents due to improper lighting.

Research has indicated the positive impact of these integrated systems in enhancing traffic safety. Zeng et al. (2018) found that automatic high beam systems considerably lower the risk of nighttime crashes by illuminating the road optimally without glaring at other motorists. Motorcycles are especially susceptible on the road because of their smaller size and increased chance of being missed by other vehicles, therefore this is very crucial. To maintain safety and visibility, the system can respond to changing traffic circumstances quickly and accurately by switching between high and low lights as needed. Ultrasonic sensors are used to detect the presence of other vehicles.

The implementation of these sensor systems in motorcycles also takes care of several functional issues. For example, a study by Huang et al. (2019) highlights how crucial it is for sensors to function reliably in a variety of weather situations, like rain and fog, which can have an impact on both light and ultrasonic sensors. The HC-SR04 and the BH1750's exceptional low-light precision make them appropriate for the demanding and frequently hostile environments that motorcycle riders encounter. By integrating these technologies, the auto high beam system can function consistently and dependably, improving motorcycle riders' safety and comfort under a variety of driving scenarios.

Figure 2.7 shows Adaptive Driving Beam that used for car (autosys, 2023). Motorcycles benefit greatly from this adaptive lighting feature since it makes sure the headlights are used as efficiently as possible to provide vision in low light without requiring user intervention. The intensity and direction of the beam can also be changed via sophisticated technologies, which enhances the riding experience even more. This field's research, like Hind's study, looks at the "sensor work" done in the creation of autonomous cars, which has a lot in common with the integration of sensors in motorbike headlights (Hind, 2023).

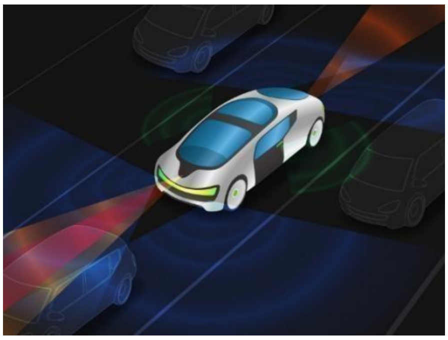

Figure 2.7: Adaptive Driving Beam (ADB) assesses the driving environment.

(Source: autosys, 2023)

These intelligent lighting systems significantly improve the riding experience by providing better visibility and reducing the distraction caused by constantly adjusting the beams manually. By integrating these sensors, automatic motorcycle headlights represent a significant step forward in vehicular lighting technology, offering a safer and more comfortable ride.

2.1.2 Battery Management and Power Efficiency

Battery management and power efficiency are critical components in the design of an Auto High Beam Headlight System for motorcycles. Effective battery management ensures the longevity and reliability of the battery, which is especially important for the consistent operation of high-demand systems like headlights.

2.1.2.1 Battery Management System (BMS)

An electronic device that monitors the performance of a rechargeable battery, be it a single cell or a battery pack, is called a battery management system (BMS). The **Figure 2.8** is an example of a BMS device (Amazon.com, 2017). The BMS is responsible for several tasks, such as preventing the battery from being used beyond its acceptable operating range, keeping an eye on its condition, producing more data, reporting that data, managing the battery's surroundings, authenticating it, and guaranteeing its balance.

Figure 2.8: Electronic Device BMS

Source: (Amazon.com, 2017)

The Battery Management System (BMS) is essential to the development of an Auto High Beam Headlight System for motorcycles. The BMS maintains an effective and secure power supply for the motorcycle's headlights by functioning as the battery's central nervous system. It closely monitors and controls the temperature, current, and voltage of the battery cells—all of which are essential for maintaining the strength of the 12-volt battery that runs the headlights. The BMS protects the battery from damage that can impair the high beam system's operation or possibly result in dangerous scenarios like heat runaway or explosions by avoiding overcharging and over discharging (Okhio et al., 2023).

Furthermore, the BMS contributes to the longevity and consistent performance of the battery, which is essential for the reliability of the AHBM System. It ensures that all cells within the battery pack operate within their optimal range, performing cell balancing to equalize the voltage levels across all cells. This not only maintains a consistent voltage level, crucial for the steady operation of the headlight system but also maximizes the efficiency of the battery, thereby enhancing the overall power efficiency of the motorcycle. In essence, the BMS is integral to the project, ensuring that the high beam headlights are powered by a battery that is managed effectively for peak performance and safety (Okhio et al., 2023).

2.1.2.2 Power Efficiency

The efficiency with which a motorcycle headlight transforms electrical energy from the battery into visible light is known as power efficiency. Due to its greater luminous efficacy—that is, its ability to produce more light per unit of power consumed—LED technology has completely changed motorbike headlights as compared to halogen bulbs (Amar Punekar, 2022). as shown in **Figure 2.9**, the LED shines more than the Halogen bulb (vividlumen Industries, 2021). In addition to being brighter, LED consumes less electricity, which lessens the load on the motorcycle's electrical system and prolongs battery life. Motorcycles are vehicles with limited space and power, therefore it's critical to use energy as efficiently as possible to guarantee that all systems, such as the Auto High Beam Headlight System, operate as best they can without depleting the battery (Keith Remy, 2023).

Figure 2.9: Different ability that produce more light between LED and Halogen

Source: (vividlumen Industries, 2021)

2.1.3 Adaptive Control Algorithms

Adaptive control algorithms are a class of control technique utilised in many systems where conditions might change suddenly, such as industrial processes and automobiles. The algorithms enable the system to automatically modify its behaviour in reaction to these changes. The basic concept is that by monitoring the outputs and adjusting to any fluctuations or uncertainties, the controller—which is frequently a tiny computer inside the system—can learn and become more efficient over time (Cao et al., 2012).

The introduction of Auto High Beam Headlight Systems for motorcycles has made adaptive control algorithms a crucial technological accomplishment in automobile lighting systems. These algorithms are made to automatically modify the headlights' beam pattern to optimise rider visibility and minimise glare for approaching vehicles. These systems can identify the presence of other vehicles on the road and modify the headlight beams accordingly by combining cameras, sensors, and machine learning techniques such convolutional neural networks (Somasiri et al., 2023). This dynamic adjustment improves safety and comfort when riding at night by enabling the rider to maintain maximum visibility without endangering other drivers.

Adaptive control algorithms, for instance, would evaluate information from the motorcycle's surroundings, such as the amount of light in the area or the presence of other vehicles, and then modify the headlight beams appropriately in the context of an Auto High Beam Headlight System. By doing this, the rider may see as well as possible and without blinding other motorists. Because the algorithms are adaptable and self-correcting, they work well in systems where accurate control is required despite continually changing conditions (Annaswamy & Fradkov, 2021).

2.1.4 Convenience for Users

Convenience for users refers to features, systems, or designs that make tasks easier, more efficient, and more user-friendly. It aims to enhance the overall user experience by minimizing effort, reducing cognitive load, and providing seamless interactions. Whether in technology, products, or services, convenience prioritizes user needs and simplifies processes. For example, automatic coffee makers, voice-controlled assistants, and contactless payment methods all contribute to user convenience.

Motorcycles with auto-high beam headlight systems include a dual-purpose switch that combines manual and automatic functionality for high beam activation. In manual mode, the rider flips the switch on and off as needed, switching between the high and low beams. During intricate traffic circumstances, quick adjustments are possible thanks to this shared interface. When the system is in auto mode, it makes adaptive light adjustments based on traffic, road conditions, and ambient light. At night or when facing the car from the front, it seamlessly transitions to a low beam, which lessens the rider's cognitive strain. The simplicity and safety of this switch are further enhanced by its combination with keyless start technology.

2.2 ISO and SAE

Among the most well-known groups involved in the creation of international standards are SAE (Society of Automotive Engineers) and ISO (International Organisation for Standardisation). An international federation of national standards bodies, ISO develops standards that guarantee the effectiveness, safety, quality, and compatibility of goods and services in a range of sectors. The aerospace, automotive, and commercial vehicle industries are the main areas of interest for SAE, a global association of engineers and technical specialists. It creates and upholds standards that promote mobility engineering and enhances the automotive industry's sustainability, safety, and growth.

Standards from SAE and ISO are quite important. They offer a technological foundation and a common language for product creation, which is critical for innovation and international trade. Standards guarantee quality, safety, and compatibility—all essential for retaining customer confidence and adhering to legal requirements. For example, the growing requirement for safe automobile systems in a more connected world is reflected in the ISO/SAE 21434 standard, which addresses cybersecurity in road vehicles. Though optional, these standards are widely used since they reflect the industry's consensus on best practices and were created through a cooperative process including experts from all over the world. **Figure 2.10** shows the safety requirements of the ISO and SAE standards (Mahmoud Ammar, 2020).

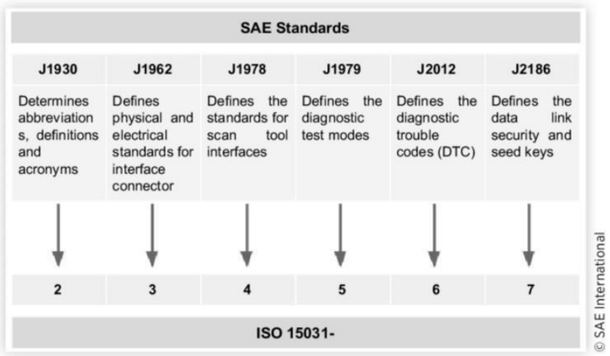

Figure 2.10: Multiple OBD-II-related SAE standards are incorporated into a single ISO standard.

(Source: Mahmoud Ammar, 2020)

2.2.1 ISO and SAE Standarts for Motorcycle Beam

Motorcycle headlight regulations are essential for maintaining road safety and reducing glare, especially for high beams. An essential reference for adaptive driving beam (ADB) systems that maximise visibility without glaring at other cars is the SAE J3069 standard (Hu et al., 2022). With the use of this technology, high beams can illuminate areas as efficiently as possible while rerouting or dimming portions of the beam in response to approaching vehicles.

The ISO standard established recommendations for headlight intensity, pattern, and alignment to minimise glare, however it did not specifically address motorbike high beams. The impact of opposing glare from car high beams is examined in research published in the International Journal of Environmental Research and Public Health, which emphasises the significance of anti-glare amenities and appropriate headlamp alignment to minimise glare (Hu et al., 2022).

2.3 Summary

Motorcycles with auto high beam headlights have increased rider safety and convenience. These headlights automatically change how bright they are depending on the surrounding traffic and the state of the road. The device automatically transitions to a low beam to reduce glare when riding at night or when it encounters approaching cars. On the other hand, it turns on the high beam for improved visibility in clear weather. Auto high beams increase overall riding happiness through lowering cognitive burden and guaranteeing smooth transitions. Adding keyless start technology to them improves user safety and convenience even more.

CHAPTER 3

METHODOLOGY

3.1 Overview

Auto High Beam (AHB) and Adaptive Driving Beam (ADB) are two modern technical innovations on cars that make driving easier. By automatically turning on the high beam or low beam, this technology seeks to make driving at night easier for drivers. Furthermore, it can recognise the car ahead of it and switch the lights from high beam to low beam. Motorcycles also use the beam method, but there are several advantages and disadvantages.

The aim of this study is to investigate the Auto High Beam technology; however, it varies in that it operates on bikes. **Figure 3.1** shows the Flow chart of the project development AHBM. To achieve the goals of this work, each step is covered in further detail in this chapter.

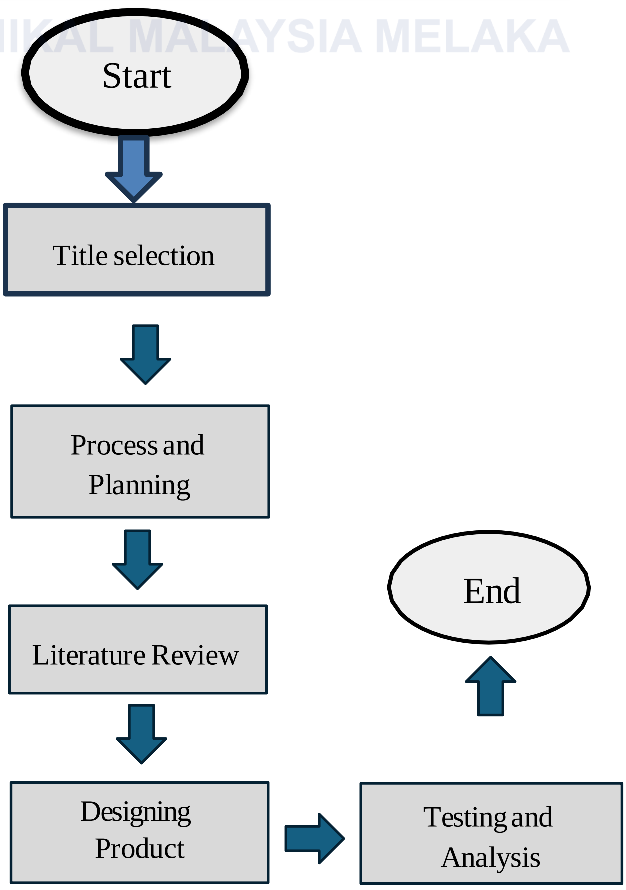

Figure 3.1: Flow chart of the project development AHBM

3.1.1 Title Selection

The title is chosen either by the lecturer or own topic proposed by FYP students. The final topic for the author is '**AUTO HIGH BEAM HEADLIGHT SYSTEM FOR MOTORCYCLES USING 12-V BATTERY SUPPLIER (AHBM)**' and being supervised under Prof. Ts. Dr. Muhammad Zahir Bin Hassan.

3.1.2 Process and Planning

The author has completed identifying all procedures that need to be taken to achieve the objective of this project. The procedures can be referred to in **Figure 3.1** which is summarized by the author. All the procedures are well planned in detail and systematically to prevent problems during the completion of the project.

3.1.3 Literature Review

The development of motorcycle auto high beam systems that incorporate the HC-SR04 ultrasonic sensor with the BH1750 light sensor represents a significant leap in rider convenience and safety. Research shows how important it is for these systems to automatically adjust high beam headlights based on current environmental conditions to improve visibility and reduce accidents. The HC-SR04 ultrasonic sensor improves depth perception for better obstacle identification, which is essential for safe nighttime riding, while the BH1750 sensor provides accurate ambient light measurements to enable correct estimation of lighting requirements. To ensure smooth functioning within the 12-volt electrical framework, careful consideration of power management and sensor calibration is necessary when integrating these sensors into motorcycle systems. Challenges including sensor accuracy, environmental robustness, and user acceptance prompt ongoing research and iterative refinement, ultimately aimed at developing reliable and effective auto high beam systems that advance rider safety and comfort on the road.

3.1.4 Designing Product

Designing an auto high beam system for motorcycles involves selecting and integrating components to ensure safety, functionality, and rider convenience. Key components include light detection modules like the BH1750 for accurate ambient light measurement and camera sensors like the HC-SR04 ultrasonic sensor for visual input. These sensors are interfaced with a microcontroller (e.g., Arduino or ESP32) that processes data and controls the high beam relay. Power management using DC-DC converters ensures compatibility with the motorcycle's 12-volt system. Weatherproof housing protects electronics from environmental elements, ensuring reliability. Continuous calibration and iterative design improvements are essential for optimizing performance and enhancing the rider's experience.

3.1.5 Testing and Analysis

Testing and analysis are critical phases in the development of an auto high beam system for motorcycles. These phases ensure the reliability, accuracy, and safety of the system. Initial testing involves bench testing of individual components like the BH1750 light sensor and HC-SR04 ultrasonic sensor to verify their functionality and calibration. Subsequent field testing under various lighting conditions assesses real-world performance, focusing on responsiveness and accuracy in detecting ambient light and oncoming traffic. Data collected during testing is analyzed to identify and address any discrepancies or malfunctions. Iterative testing and refinement are necessary to optimize the system's performance, ensuring it reliably switches between high and low beams, enhancing rider safety and convenience.

3.2 Background Research

In the development of any innovative product, it is crucial for researchers to conduct a detailed study on the structure of the market and the available Auto High Beam systems, particularly for motorcycles, before developing new technology. Furthermore, it's essential to explore how these systems work and their effectiveness in enhancing visibility and safety. By analyzing the strengths and weaknesses of each product, researchers can identify areas for potential improvement and innovation.

The selection of the best Auto High Beam system is not solely based on its effectiveness in optimizing beam control but also on how well it aligns with the primary objectives of this project. The ideal technology for development is chosen by considering numerous factors, ensuring a comprehensive evaluation of the field. This extensive research provides a broader perspective, facilitating the identification of the best options for creating a new smart Auto High Beam system for motorcycles.

To validate the developed system, it will be subjected to various testing conditions. These tests aim to demonstrate the system's ability to achieve satisfying results in line with the project's objectives. This rigorous testing process is essential to ensure the reliability and performance of the newly developed Auto High Beam technology for motorcycles.

3.3 Product Design Development

The development of the Auto High Beam technological system on motorcycles employing a 12-volt battery source is the main topic of this section. As a result, the design development process must be divided into multiple primary sections. Currently, the industry overview, component design, and idea design comprise the core portion. Every component included works well with the others. The workflow of (AHBM) system in this chapter is shown in **Figure 3.2**.

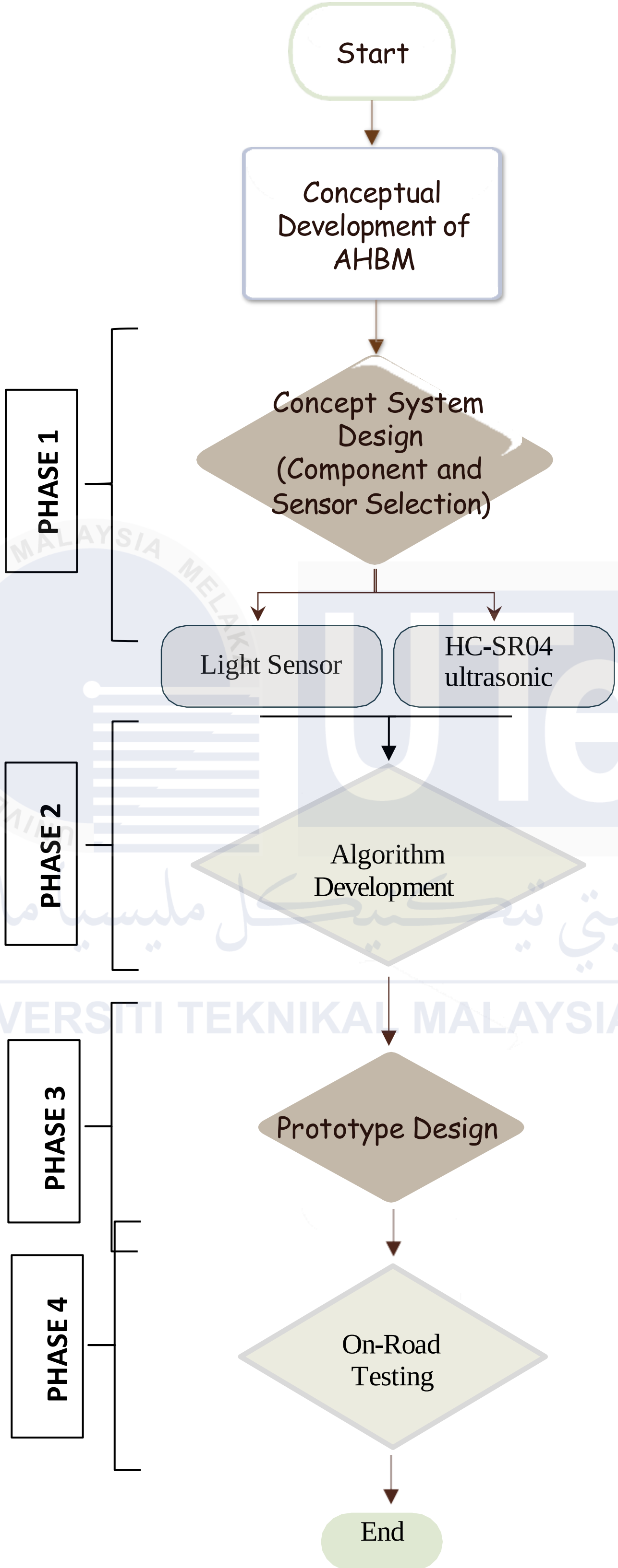

Figure 3.2: Product Development Process

3.3.1 Concept System Design

When paired with a vehicle, the new product design concept is a crucial component of the overall system architecture. The goal of this product's design concept is simplicity and flexibility, with modern, straightforward technologies making installation, disassembly, and maintenance easier. Meanwhile, a new method that works extremely well with any motorcycle is referred to as adaptable design.

In the beginning the system's flow needs to be understood to determine which components are required for the AHBM system. The operation of the AHBM system is shown in **Figure 3.3**.

Figure 3.3: Workflow of Auto High Beam system for motorcycle

3.3.2 Process Flow of AHBM

The flow process of the Automatic High Beam Motorcycle (AHBM) system is designed to automatically control the high and low beam modes based on environmental conditions and the presence of objects in front of the vehicle. This system utilizes two primary sensors, an ultrasonic sensor and a light-dependent resistor (LDR) sensor, to ensure accurate and efficient decision-making. By integrating data from both sensors, the system determines when to activate the high beam for maximum visibility or switch to the low beam to prevent glare for other road users. The process begins with the low beam set as the default mode, and the system continuously monitors changes in sensor data to make real-time adjustments as needed.

The **Figure 3.4** illustrates the flowchart operational process of the Automatic High Beam Motorcycle (AHBM) system, which intelligently switches between high and low beams based on inputs from an ultrasonic sensor and a light-dependent resistor (LDR) sensor. The system is initiated with the low beam mode activated by turning on Relay 1, while Relay 2 for the high beam remains off. This default state ensures safety and prevents excessive glare until conditions necessitate a switch to the high beam.

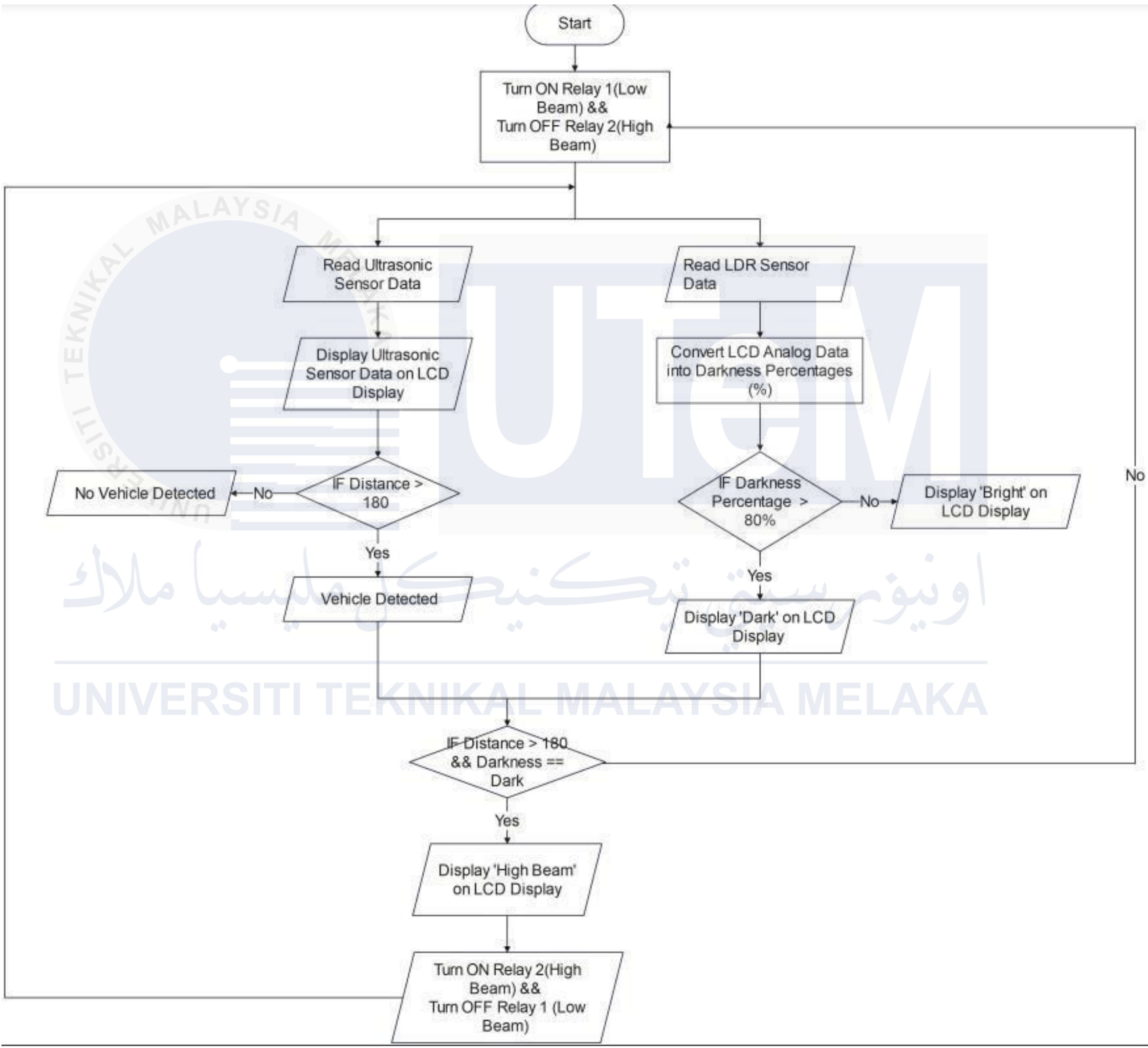

Figure 3.4: Flow process of AHBM

The system operates by continuously monitoring data from the ultrasonic sensor and the LDR sensor. The ultrasonic sensor detects objects in front of the vehicle by measuring distances and displaying the results on the LCD. If an object is detected at a distance greater than 180 units or centimetres, it is interpreted as a vehicle or obstacle within the sensor’s range. Simultaneously, the LDR sensor measures the ambient light intensity and converts the analogue readings into a percentage indicating the darkness level. If the darkness percentage exceeds 80%, the system classifies the environment as “dark” and displays this status on the LCD. Conversely, if the percentage is below 80%, the system displays “bright,” indicating sufficient ambient light.

The AHBM system integrates the data from both sensors to determine the appropriate headlight mode. If the ultrasonic sensor detects a vehicle at a distance greater than 180 units and the LDR sensor confirms the environment is dark, the system activates the high beam by switching on Relay 2 and turning off Relay 1. This configuration ensures optimal visibility for the rider. However, if no vehicle is detected or the ambient light is bright, the system maintains the low beam to avoid causing glare to oncoming traffic or pedestrians.

This dynamic decision-making process highlights the AHBM system’s ability to enhance nighttime driving safety. By combining ultrasonic distance measurement with ambient light detection, the system provides a reliable and automated solution to adjust headlight intensity based on real-time conditions. This not only improves visibility for the rider but also ensures the comfort and safety of other road users.

3.3.3 Component Selection and Programming of System

3.3.3.1 BH1750 Ambient Light Sensor

The BH1750 Ambient Light Sensor is an essential part of motorbikes' automatic high beam systems. The I2C communication protocol is used by this 16-bit sensor to provide accurate measurements of ambient light in lux, the SI-derived unit of illuminance. It can detect the light conditions properly since it can measure light intensity from 1 lux to a maximum of 65535 lux. When used with an auto high beam system, the BH1750 sensor may identify when ambient light levels drop below a certain point—for example, at night or when entering a tunnel—and alert the system to turn on the motorcycle's high beams for improved visibility.

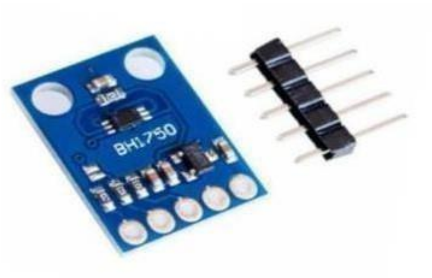

Figure 3.5: BH1750 Light Sensor

Figure 3.5 shows the light sensor used in the AHBM system. Light sensor, BH1750 is essential to the automation of the high beam control. To meet the demands of the system, it offers two measurement modes: continuous and one-time, with varying resolutions. The sensor continuously measures the ambient light levels when it is connected into the electrical system of the motorcycle. It interacts with the microprocessor upon sensing low light levels, and the microcontroller processes the data and initiates the high beam circuit. This automated response improves rider convenience by automatically adjusting the high beams, while simultaneously increasing safety by guaranteeing ideal lighting. The sensor is an effective and dependable option for this application due to its low power consumption and capacity to reject light noise from 50Hz/60Hz sources.

3.3.3.2 HC-SR04 ultrasonic sensor

The ultrasonic sensor is a crucial component in the development of a motorcycle auto high beam system that improves road visibility and rider safety. Ultrasonic sensor is a reliable way to identify obstructions and make sure the high beam headlights are adjusted on time. It does this by measuring distance using ultrasonic waves. This sensor is strategically mounted on the motorcycle and gives real-time data on the closeness of objects in the path of the vehicle. This information allows the system to modify the headlight beam dynamically to prevent collisions. The HC-SR04 ultrasonic sensor, while an excellent tool for prototyping and testing, is not ideally suited for real-world applications in automotive systems, particularly for motorcycles. Its primary limitation lies in its ability to detect objects only at relatively short ranges (typically up to 4 meters). This restricts its effectiveness in real-world scenarios where longer detection distances are crucial for high-speed vehicles to respond adequately to approaching objects or changes in lighting conditions.

The HC-SR04 is utilized solely for the purpose of testing and validating the feasibility of the Auto High Beam Motorcycle (AHBM) system. Its simplicity, low cost, and ease of integration make it an ideal choice for fabricating and evaluating the initial system prototype. By using the HC-SR04, we can efficiently test the logic and operation of the beam-switching system, ensuring its functionality under controlled conditions.

Integration efficiency and stability, a few issues with the HC-SR04 ultrasonic sensor integration with the auto high beam system must be resolved. One such difficulty is the requirement for exact sensor calibration, particularly in situations involving dynamic riding, to guarantee correct distance measurements and reduce false detections. Furthermore, the reliability of the sensor's obstacle detection may be impacted by external elements such road vibrations and wind noise. To improve this, reliable filtering methods and signal processing techniques are needed. To ensure smooth functioning and prevent needless glare to other road users, the system's response time and integration with other sensors, including the BH1750 light sensor, must also be properly synchronized. Despite these challenges, the incorporation of the HC-SR04 ultrasonic sensor represents a significant step forward in the development of auto high beam systems for motorcycles, offering potential improvements in rider safety and overall riding experience. **Figure 3.6** shows the HC-SR04 ultrasonic sensor that can be used in the Auto High Beam system.

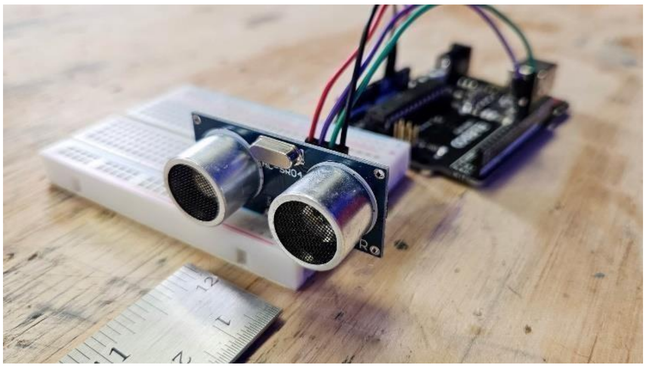

Figure 3.6: HC-SR04 ultrasonic sensor

3.3.3.3 Arduino UNO

The second component is Arduino-UNO as shown in **Figure 3.7**, which is an open-source microcontroller board that is equipped with sets of 14 Digital pins and 6 Analog pins that can interface with other circuits. It is a programmable device that can be simply 31 connected to a computer with a universal serial bus (USB) cable alternative current (AC) to direct current (DC) adapter or battery. This component acts as a brain of the system as this is where the data being processed then the decision is made based on the program uploaded in the memory.

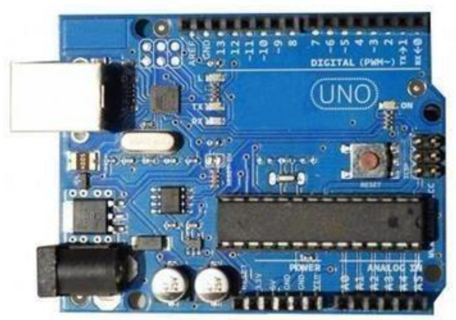

Figure 3.7: Arduino-UNO Model-R3

The auto high beam motorcycle project's Arduino UNO is its central processing unit (CPU), which regulates how the system reacts to sensory inputs. This microcontroller board, which is based on the ATmega328P, has six analogue inputs and fourteen digital input/output pins, six of which can be used as PWM outputs.

3.3.3.4 LCD Display

The LCD display as shown in **Figure 3.8**, plays a critical role in the Auto High Beam Motorcycle (AHBM) system by providing real-time feedback on the system's status, ensuring user awareness and enhancing safety. Utilizing a 16x2 I2C LCD, it effectively communicates essential information such as the distance to detected objects, the current beam status (high or low beam), and the ambient brightness condition (bright or dark). This real-time display allows riders to monitor the system's functionality immediately, ensuring confidence in its operation. Furthermore, the use of an I2C interface minimizes wiring complexity, making it ideal for compact motorcycle systems. By offering a clear and concise interface, the LCD display bridges the interaction between the rider and the automated lighting system, contributing to a safer and more efficient riding experience.

Figure 3.8: LCD Display

3.3.3.5 LED Light Bulb

The central controller in this system is the Arduino UNO, which processes data from the HC-SR04 ultrasonic sensor and the BH1750 light sensor to control the brightness of the LED bulbs. The HC-SR04 ultrasonic sensor provides real-time distance measurements, enabling the Arduino to detect nearby vehicles or obstacles and adjust the high beams accordingly. Through precise distance calculations, the Arduino dynamically modulates the LED brightness to avoid blinding other drivers while maintaining optimal visibility for the rider. Additionally, the BH1750 sensor informs the Arduino of ambient light conditions, prompting it to activate the high beams in low-light situations for enhanced visibility. By seamlessly integrating the HC-SR04 ultrasonic sensor and the BH1750 sensor with the Arduino UNO, this system creates an energy-efficient and responsive auto high beam solution tailored for motorcycles, ensuring safety and adaptability to changing traffic conditions and ambient light levels. **Figure 3.9** shows the LED bulb.

Figure 3.9: LED Bulb Motorcycles

3.3.3.6 Relay Module

A relay module is an electronic component that acts as an electrically controlled switch, enabling a system to control high-power devices using low-power control signals. In the Auto High Beam (AHBM) system for motorcycles, the relay is used to control the switching between high and low beams. When the microcontroller receives input from light and distance sensors, the relay activates or deactivates the power to the motorcycle's lights based on traffic and environmental conditions. This allows the system to automatically adjust the headlights without driver intervention, ensuring safety and convenience when riding at night. Additionally, the relay serves as an isolator between the low-voltage control circuit (microcontroller) and the high-power headlight circuit, protecting sensitive electronic components from potential damage. **Figure 3.10** shows the relay module.

Figure 3.10: Relay Module

3.3.3.7 Type of Battery

The importance of a 12-volt battery as the main power provider is essential for motorcycling auto high beam systems. The electrical system's mainstay is the battery, which supplies the voltage required to run parts like the relay module, Arduino UNO, LED lights, and sensors like the BH1750 and HC-SR04. The system’s capacity to improve rider safety and convenience would be compromised in the absence of a dependable power source. Because it automatically adjusts headlight brightness based on current environmental circumstances, the auto high beam system is essential to motorcycle safety because it maximizes visibility while reducing glare for other road users. By seamlessly integrating advanced sensors and control algorithms, this system helps mitigate accidents, particularly in low-light conditions, ultimately contributing to a safer riding experience for motorcyclists.

3.3.3.8 Program Code

The HC-SR04 ultrasonic sensor and the BH1750 light sensor are integrated by the Arduino program of the motorcycle’s auto high beam system to control headlight brightness according to ambient light levels and the vicinity of obstacles. The setup function sets up the pins for the BH1750 sensor and the ultrasonic sensor (trigger and echo) as well as serial connectivity for debugging. The software uses the BH1750 sensor to continuously measure the ambient light level and the ultrasonic sensor to determine the distance to the closest obstacle within the loop function.

The program controls when the high beam headlights activate or deactivate based on predetermined threshold levels. The high beam headlights are turned on to improve the rider's visibility when the ambient light level drops below a certain threshold and there are no obstructions in the rider's safe visible distance. On the other hand, the high beam headlights are turned off to avoid glare and to protect other drivers if an obstruction is seen within the designated range or if the ambient light level exceeds the threshold.

This Arduino code creates an adaptive auto high beam system specifically designed for motorcyclists by utilizing the capabilities of the HC-SR04T ultrasonic sensor and the BH1750 light sensor. The technology enhances rider safety and comfort by optimizing headlight brightness in real-time, especially in low-light settings and when travelling over hard terrain, by merging these sensors with precise control algorithms. Furthermore, the program's modular design and adjustable threshold values provide simple customization and adaption to changing environmental circumstances, guaranteeing dependable performance in a variety of riding scenarios. Program code to the control unit system is summarized in **Table 3.1.**

Table 3.1: Program Coding

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>


// I2C LCD Address (commonly 0x27 or 0x3F). Adjust if necessary.

LiquidCrystal_I2C lcd(0x27, 16, 2);


const int trigPin = 12;

const int echoPin = 10;

const int ldrPin = A3;

const int relayPinLowBeam = 6;

const int relayPinHighBeam = 5;

float duration, distance;

int ldrValue;

int darknessThreshold = 800;

int objectThreshold = 180;

const int maxLdrValue = 1023; // Maximum ADC value for LDR


void setup() {

  pinMode(trigPin, OUTPUT);

  pinMode(echoPin, INPUT);

  pinMode(relayPinLowBeam, OUTPUT);

  pinMode(relayPinHighBeam, OUTPUT);


  Serial.begin(9600);

  lcd.init();
```

```
  lcd.backlight(); // Turn on the LCD backlight
}


void loop() {
  // Measure distance
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);
  distance = (duration * 0.0343) / 2;

  // Read LDR value and calculate darkness percentage
  ldrValue = analogRead(ldrPin);
  int darknessPercentage = map(ldrValue, 0, maxLdrValue, 0, 100);


  // Determine statuses
  String brightnessStatus = (ldrValue > darknessThreshold) ? "Dark" : "Bright";
  String vehicleStatus = (distance >= objectThreshold) ? "Vehicle Not Detected" : "Vehicle
Detected";
  String beamStatus = "Low Beam"; // Default beam status


  // Control Relays
  if (ldrValue > darknessThreshold) {
    if (distance <= objectThreshold) {
      digitalWrite(relayPinLowBeam, LOW);
      digitalWrite(relayPinHighBeam, HIGH);
      beamStatus = "Low Beam";
```

```
  } else {
    digitalWrite(relayPinLowBeam, HIGH);
    digitalWrite(relayPinHighBeam, LOW);
    beamStatus = "High Beam";
  }
} else {
  digitalWrite(relayPinLowBeam, LOW);
  digitalWrite(relayPinHighBeam, HIGH);
  beamStatus = "Low Beam";
}

// Display on Serial Monitor
Serial.println("=========================================");
Serial.print("Vehicle Status: ");
Serial.println(vehicleStatus);

Serial.print("Brightness Status: ");
Serial.println(brightnessStatus);

Serial.print("Beam Status: ");
Serial.println(beamStatus);

Serial.println();
Serial.print("Distance Measured: ");
Serial.print(distance, 2); // Two decimal places
Serial.println(" cm");

Serial.print("Darkness Level: ");
Serial.print(ldrValue);
Serial.print(" (");
```

```
  Serial.print(darknessPercentage);
  Serial.println("%)");

  Serial.println("=====================================");

  // Display on LCD
  lcd.clear();
  lcd.setCursor(0, 0); // Line 1
  lcd.print("Dist: ");
  lcd.print(distance, 1); // One decimal place
  lcd.print(" cm");

  lcd.setCursor(0, 1); // Line 2
  lcd.print(beamStatus.substring(0, 9)); // Display "High Beam" or "Low Beam"
  lcd.print(", ");
  lcd.print(brightnessStatus.substring(0, 6)); // Display "Bright" or "Dark"

  delay(1000);
}
```

3.3.3.9 Explanation

Table 3.2: Program Coding 1

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

 LiquidCrystal_I2C lcd(0x27, 16, 2);

const int trigPin = 12;
const int echoPin = 10;
const int ldrPin = A3;
const int relayPinLowBeam = 6;
const int relayPinHighBeam = 5;

float duration, distance;
int ldrValue;
int darknessThreshold = 800;
int objectThreshold = 180;
const int maxLdrValue = 1023;
```

- Wire.h: Enables I2C communication between the microcontroller and peripherals.
- LiquidCrystal_I2C.h: Provides functions for controlling an LCD with an I2C interface.
- **Explanation:** Initializes the LCD at the I2C address 0x27 with a 16x2 character configuration. Adjust the address (0x27 or 0x3F) based on your hardware.
- trigPin and echoPin: Ultrasonic sensor (distance measurement).
- ldrPin: LDR (light-dependent resistor) input to measure ambient light intensity.
- relayPinLowBeam and relayPinHighBeam: Outputs controlling the relays for low and high beams.
- duration: Stores the pulse duration from the ultrasonic sensor.
- distance: Calculates the object distance based on duration.
- ldrValue: Stores the light intensity from the LDR.
- darknessThreshold: LDR value above which the environment is considered dark.
- objectThreshold: Distance threshold for detecting vehicles (in cm).
- maxLdrValue: ADC maximum value for a 10-bit resolution.

Table 3.3: Program Coding 2

```
void setup() {
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(relayPinLowBeam, OUTPUT);
  pinMode(relayPinHighBeam,  OUTPUT);

  Serial.begin(9600);
  lcd.init();
  lcd.backlight();
}
```

- Configures pin modes for inputs and outputs.
- Initializes serial communication for debugging.
- Sets up the LCD display with the backlight on.

Table 3.4: Program Coding 3

```
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);


  duration = pulseIn(echoPin, HIGH);
  distance = (duration * 0.0343) / 2;
```

- Generates a 10-microsecond pulse on the trigger pin to initiate ultrasonic measurement.
- Measures the time (duration) it takes for the echo to return.
- Calculates the distance using the speed of sound (0.0343 cm/µs).

Table 3.5: Program Coding 4

```
ldrValue = analogRead(ldrPin);

int darknessPercentage = map(ldrValue, 0, maxLdrValue, 0, 100);
```

- Reads the analog input from the LDR to determine light intensity.
- Maps the raw LDR value (0-1023) to a percentage (0-100).

Table 3.6: Program Coding 5

```
String brightnessStatus = (ldrValue > darknessThreshold) ? “Dark” : “Bright”;
String vehicleStatus = (distance >= objectThreshold) ? “Vehicle Not Detected” :
“Vehicle Detected”;
String beamStatus = “Low Beam”;

if (ldrValue > darknessThreshold) {
  if (distance <= objectThreshold) {
    digitalWrite(relayPinLowBeam, LOW);
    digitalWrite(relayPinHighBeam, HIGH);
    beamStatus = “Low Beam”;
  } else {
    digitalWrite(relayPinLowBeam, HIGH);
    digitalWrite(relayPinHighBeam, LOW);
    beamStatus = “High Beam”;
  }
} else {
  digitalWrite(relayPinLowBeam, LOW);
  digitalWrite(relayPinHighBeam, HIGH);
  beamStatus = “Low Beam”;
}
```


- Determines if the environment is bright or dark (brightnessStatus).
- Checks if a vehicle is detected based on the distance (vehicleStatus).
- Controls the relays to switch between low and high beams:
- High beam for dark conditions and no vehicle detected.
- Low beam for dark conditions with a vehicle detected or for bright conditions.

Table 3.7: Program Coding 6

```
Serial.println("========================================");
Serial.print("Vehicle Status: ");
Serial.println(vehicleStatus);

Serial.print("Brightness Status: ");
Serial.println(brightnessStatus);

Serial.print("Beam Status: ");
Serial.println(beamStatus);

Serial.print("Distance Measured: ");
Serial.print(distance, 2);
Serial.println(" cm");

Serial.print("Darkness Level: ");
Serial.print(ldrValue);
Serial.print(" (");
Serial.print(darknessPercentage);
Serial.println("%)");
Serial.println("========================================");
```

- **Purpose:** Displays key values and statuses on the serial monitor for debugging.

Table 3.8: Program Coding 7

```
lcd.clear();
lcd.setCursor(0, 0);
lcd.print(“Dist: “);
lcd.print(distance, 1);
lcd.print(“ cm”);


lcd.setCursor(0, 1);
lcd.print(beamStatus.substring(0, 9));
lcd.print(“, “);
lcd.print(brightnessStatus.substring(0, 6));
```

Explanation: Updates the LCD with:

- Distance (line 1).
- Beam status and brightness status (line 2).

Table 3.9: Program Coding 8

```
delay(1000);
```

Purpose: Pauses execution for 1 second to allow readable updates on the LCD and serial monitor.

The provided Arduino code outlines the implementation of an auto high-beam system for motorcycles, integrating the BH1750 ambient light sensor and simulating the functionality of the HC-SR04 ultrasonic sensor for object detection. The setup initializes the BH1750 sensor for ambient light measurement and configures a digital pin to control a relay module, which regulates the high beam. In the loop, the ambient light level is continuously monitored, and a placeholder function simulates distance measurement from the ultrasonic sensor. Based on these inputs, the system dynamically toggles the high beam, ensuring it is activated in low-light conditions when no obstacles are detected. The code structure demonstrates a straightforward approach to auto high-beam control, leveraging ambient light sensing and simulated distance data. However, it’s important to note that while the HC-SR04 ultrasonic sensor provides distance measurements, it may not offer the same level of accuracy and reliability as a camera-based system for object detection. Future iterations of the system may explore integrating additional sensors or refining algorithms to enhance obstacle detection capabilities. Overall, the code serves as a foundational framework for building an auto high-beam system, highlighting the importance of integrating multiple sensors for reliable operation in varying environmental conditions. Further development would be required to improve the accuracy and responsiveness of the system, ultimately contributing to improved safety and visibility for motorcycle riders during nighttime travel.

3.3.3.10 Wiring

The key for all components in AHBM system to work correctly is wiring, which must be done precisely relating to program code to be uploaded in the Arduino UNO. Furthermore, the wiring arrangement needs to be neat and tidy, to allow further maintenance to be done more easily. **Figure 3.8** and **Figure 3.9** illustrate a wiring diagram for Light sensor and Ultrasonic sensor. The pin connection of sensor Arduino is summarized in **Table 3.10** and **Table 3.11.**

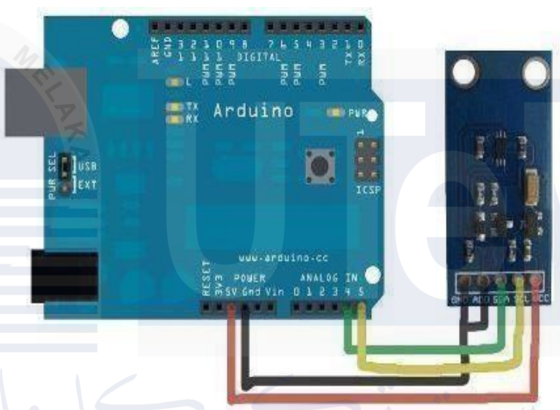

Figure 3.8: Wiring of system (Light Sensor)

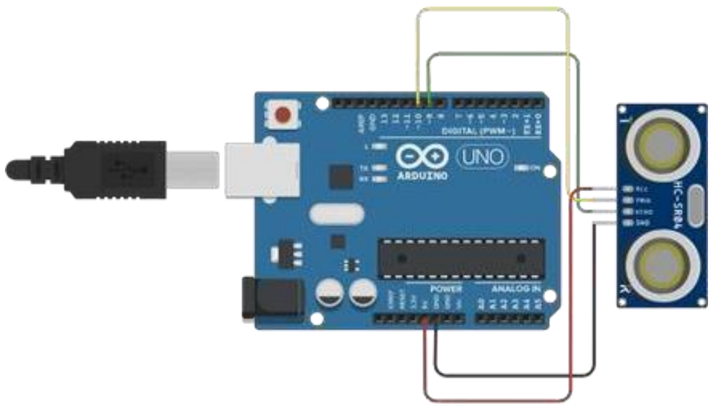

Figure 3.9: Wiring of system (ultrasonic sensor)

Table 3.10: Pin connection for BH1750

BH1750 Pin	Function	Arduino UNO Pin
VCC	Power Supply	5V
GND	Ground	GND
SDA	I2C Data	A4 (SDA)
SCL	I2C Clock	A5 (SCL)
ADDR	Address Pin	GND

Table 3.11: Pin connection for HC-SR04

Pin	JSN-SR04T	Arduino UNO	Function
VCC	VCC	5V	Powers the sensor with a 5V supply
GND	GND	GND	Ground connection
TRIG	TRIG (Rx)	Digital Pin (e.g., D2)	Sends the pulse to initiate the measurement
ECHO	ECHO (Tx)	Digital Pin (e.g., D3)	Receives the pulse proportional to the distance

The system combines an ultrasonic sensor (HC-SR04), an LDR light sensor, a relay module, an LCD display, and a high/low beam LED light. The ultrasonic sensor detects obstacles in the vehicle's path, while the LDR sensor detects the intensity of ambient light. Both sensors provide critical input signals to the Arduino Uno, which processes the data and controls the headlight beam mode accordingly. The relay module is used to switch between the high beam and low beam, based on signals from the Arduino, ensuring the appropriate headlight mode is activated in real-time. Additionally, the LCD display outputs system status information, allowing users to monitor system functionality. **Figure 3.10** illustrates the integration of an (AHBM) system using Arduino Uno as the primary microcontroller.

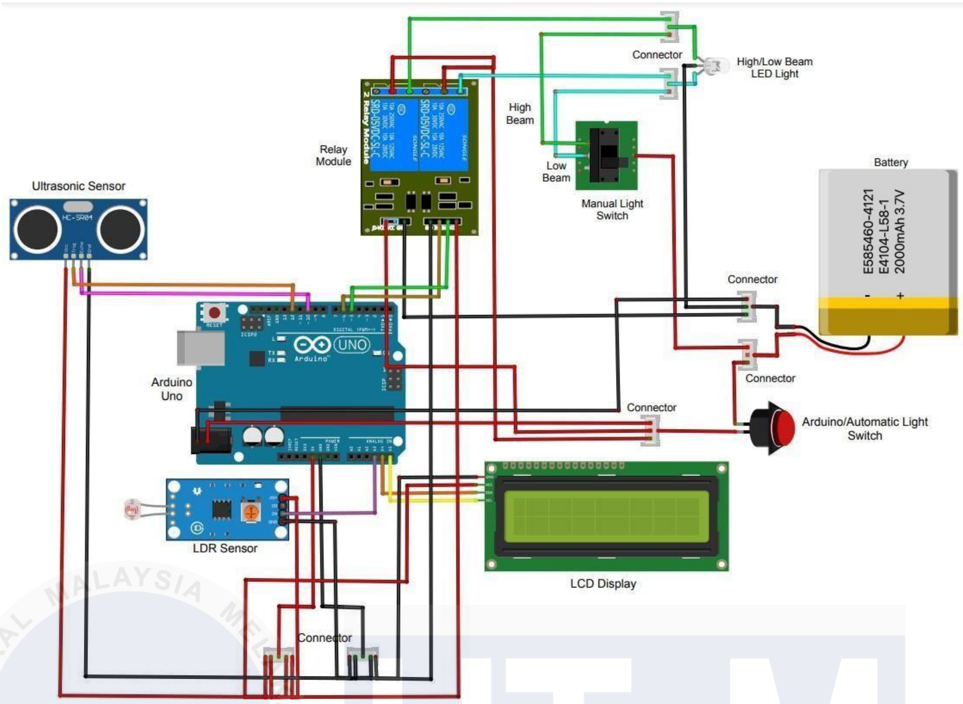

Figure 3.10: Integration of AHBM

A batterypowers the system, providing energy for all components, including the Arduino, sensors, relay, and LED light. The manual light switch is also included to allow the rider to override the system and manually control the high or low beam settings if necessary. The wiring ensures proper connectivity between components, with clearly defined power, ground, and signal connections for efficient communication. This modular design supports testing and debugging while maintaining functionality, demonstrating the system's capability to improve road safety and enhance user convenience during nighttime driving.

3.3.3.11 Prototype Design

Throughout all the methods involved, a complete and working prototype of the AHBM system was produced at the end of this project. The AHBM device is made in a compact rectangular shape that is very suitable for mounting on the body or other parts of the motorcycle. Meanwhile, both sensors are installed on the front of the body or under the headlights. The battery can be placed on the lower part of the motorcycle body. With this design concept, the AHBM device is easy to install and maintain on all vehicles. This achieves one of the objectives of this project.

3.4 On-Road Testing

The final testing phase of the AHBM system prototype involves evaluating its performance under various conditions using two key sensors: the BH1750 Ambient Light Sensor and the HC-SR04 ultrasonic sensor.

An effective auto high beam motorcycle system must adeptly identify potential in diverse road and weather conditions. To assess the system's performance comprehensively, three distinct test conditions were established to evaluate its real-world efficacy.

3.4.1 Dry or Transitioning Conditions (transition from day to night)

During testing under dry or transitioning conditions, particularly during the transition from day to night, the AHBM system showcased its capability to seamlessly adjust to changing light conditions. The BH1750 Ambient Light Sensor accurately detected the diminishing daylight, prompting the system to smoothly transition from low to high beam mode as the ambient light levels decreased. This smooth transition ensures that riders maintain optimal visibility and safety as daylight fades, enhancing overall riding experience and safety during dusk and nighttime travel.

3.4.2 Detection of Moving or Static Objects

On-road testing for the auto high beam system for motorcycles, incorporating the HC-SR04 ultrasonic sensor for object detection, entails assessing its efficacy in accurately identifying both moving and static objects. Mounted on the motorcycle, the sensor undergoes real-world evaluation across diverse road environments, such as urban streets, highways, and rural areas. It must reliably detect moving elements like vehicles, pedestrians, and cyclists, as well as static obstacles such as parked cars or road signs. The sensor's performance is crucial in providing timely feedback to the auto high beam system, enabling it to adjust headlight brightness dynamically while ensuring optimal visibility and safety for the rider and other road users. Through iterative testing and refinement, this development fine-tune the sensor's settings and placement to enhance its sensitivity and reliability, ultimately contributing to the effectiveness of the auto high beam system in improving nighttime visibility and minimizing glare for oncoming traffic.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

A significant milestone in the evolution of motorcycle safety technology has been achieved with the results of the Auto High Beam for Motorcycles (AHBM) system. This innovative technology, designed to enhance rider safety and visibility, automatically adjusts the motorcycle's headlight beams in real time based on environmental conditions and object detection. The results provide a comprehensive assessment of the system's functionality, reliability, and overall performance, offering valuable insights into its readiness for real-world application. By addressing critical aspects such as the integration of the HC-SR04 Ultrasonic Sensor for object detection and the BH1750 Ambient Light Sensor for light intensity measurements, the findings highlight the strengths and limitations of the AHBM system while paving the way for further advancements in the field.

The results reveal the AHBM system's ability to dynamically switch between high and low beams with precision, demonstrating its effectiveness in improving nighttime visibility and reducing the risk of glare for other road users. The system has undergone rigorous testing to ensure its functionality under various conditions, including different light intensities and object distances. This chapter delves into the performance evaluation of the key sensors, the reliability of the decision-making algorithm, and the overall impact of the system on motorcycle safety. Additionally, the results provide insights into potential areas for optimization, ensuring the technology can be refined to meet the highest safety standards.

By presenting a thorough analysis of the system's final performance, this chapter offers a detailed exploration of the AHBM system's contributions to advancing motorcycle safety technology. These findings mark a significant step forward in the development of intelligent headlight systems, demonstrating the potential of AHBM to revolutionize safety for motorcyclists and other road users alike.

4.2 Prototype Design and location for AHBM System

The prototype for this system's design can be seen in **Figure 4.1**. The AHBM device is designed to be small and rectangular, making it ideal for placement on the motorcycle's body or other components. The location of AHBM system on the motor side can be seen in **Figure 4.1** and **Figure 4.2**.

Figure 4.1: Prototype Casing AHBM System after connecting on motorcycle

Figure 4.2: Location AHBM system on the motor side

Figure 4.3 shows the AHBM system placed in the basket or carrier of a motorcycle. This placement is chosen specifically for testing purposes, as the basket provides a convenient and secure location for the system components. In this position, the system operates effectively while allowing for easy monitoring and adjustments during the testing phase. Although the AHBM system is shown in the motorcycle basket in this example, it is designed to be flexible and can be installed in various locations on the motorcycle. The final placement of the system depends on design requirements, aesthetics, or user preferences. The placement in the basket is a temporary measure to ensure the system functions properly before being permanently installed in a more suitable location.

Figure 4.3: Location AHBM system on the motor side

Figure 4.4: Location AHBM system on the motor side

The ultrasonic sensor is strategically positioned at the top of the system, facing forward. This placement ensures that the sensor has a clear and unobstructed field of view to detect objects or obstacles effectively within its sensing range. Care is taken to avoid any interference from surrounding structures or components, which could disrupt its performance. By maintaining this optimal positioning, the sensor can accurately measure distances and respond to objects ahead, enhancing the overall functionality of the system.

Similarly, the light sensor is installed at the front of the motor, in a location that allows it to receive light from the environment directly in front of the vehicle. This placement is chosen carefully to avoid interference from the motorbike’s own headlight, which could skew the sensor’s readings. By ensuring the sensor only detects external light sources, its functionality remains precise, contributing to the accurate operation of the system. **Figure 4.4** shows the location where the sensor is placed or installed.

4.3 Schematic Diagram of AHBM System

Figure 4.5 shows a schematic diagram of the AHBM system. The circuit schematic seen in **Figure 4.5** is primarily powered by a 12-volt battery. This circuit combines an ultrasonic sensor with a light sensor to provide data to an Arduino Uno. The light sensor, a BH1750 in particular, measures the amount of light in the surrounding environment and may use this information to decide whether it is dark enough to activate the headlights. In the meantime, the ultrasonic sensor gauges an object's proximity. This information can be utilized to identify adjacent cars and adjust the high beam intensity to avoid blinding other drivers. After processing the data from various sensors, the Arduino Uno sets off a relay in response to predetermined conditions, such as low light levels and the absence of any cars within a specific range. The headlight bulb is switched on and off by this relay, which functions as a switch. Additionally, there's a manual switch that allows the rider to manually override the automatic system, offering direct control over the high beam headlights. This system is an example of a motorbike smart auto high beam lighting system, which automatically adjusts the headlights based on traffic and environmental circumstances to improve safety and convenience. **Figure 4.6** shows the wiring and connection of all components.

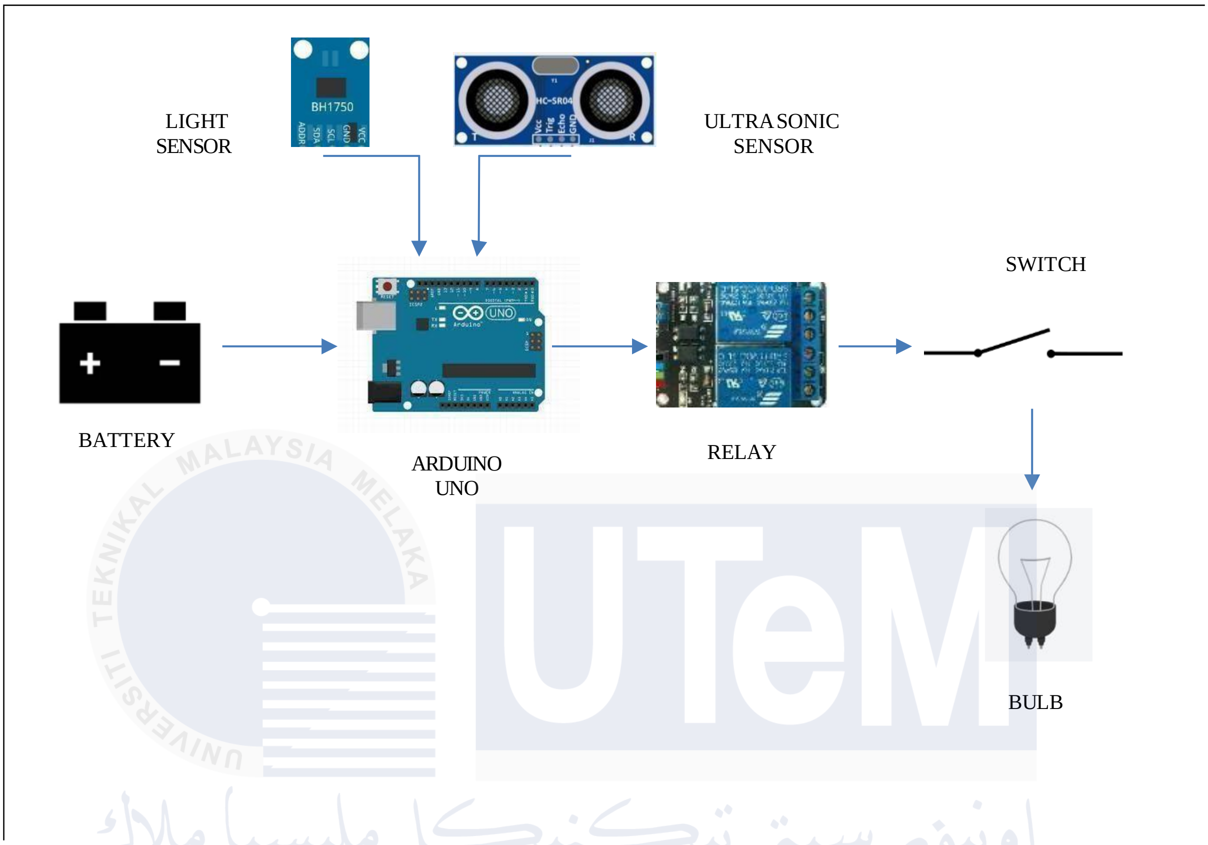

Figure 4.5: Schematic Diagram

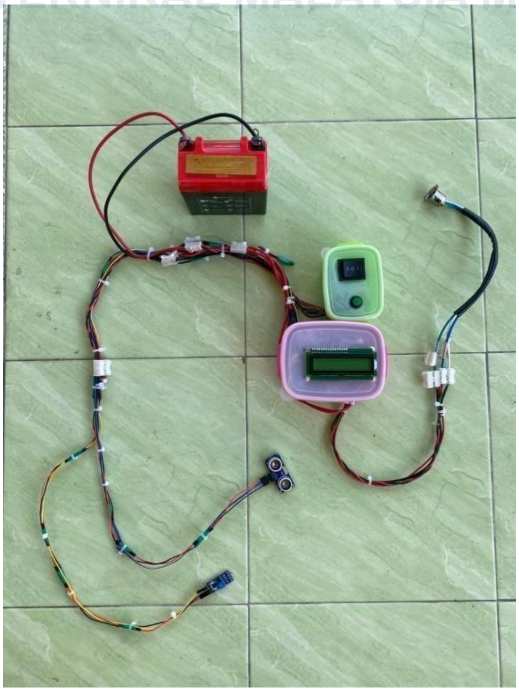

Figure 4.6: Wiring and connection of all components

4.4 Simulation Testing for AHBM System

Testing for the Auto High Beam Motorcycle (AHBM) system was conducted through a series of controlled simulations to evaluate the individual performance of the sensors under various conditions. The testing process focused on two primary scenarios: varying ambient light conditions (dark and bright environments) and the presence or absence of an object in front of the sensor. These simulations were performed on the Tinker Cad platform, which facilitated a virtual environment for testing without the need for physical hardware. Each sensor—ultrasonic for obstacle detection and LDR (Light Dependent Resistor) for ambient light sensing—was tested separately to assess their individual responses to environmental changes. The key objective was to observe how effectively each sensor could detect objects and measure ambient brightness, ensuring that the system could accurately switch between high and low beams based on these inputs. By validating sensor functionality in these simulated conditions, the tests provided valuable insights into their reliability, performance, and integration within the AHBM system, contributing to a more robust design for real-world deployment

4.4.1 Dry or Transitioning Conditions

During testing in dry or transitional settings, especially when day turned to night, the (AHBM) system demonstrated its capacity to adapt to changing light conditions with ease. As the ambient light levels dropped, the BH1750 Ambient Light Sensor precisely sensed the waning daylight, causing the system to switch seamlessly from low to high beam mode. As shown in **Figure 4.7**, the ambient light sensor senses that there is not enough light outside, which is why the light bulb is on while **Figure 4.8** shows the ambient light sensor sensing that there is enough light outside and causing the bulb to not light up or dim.

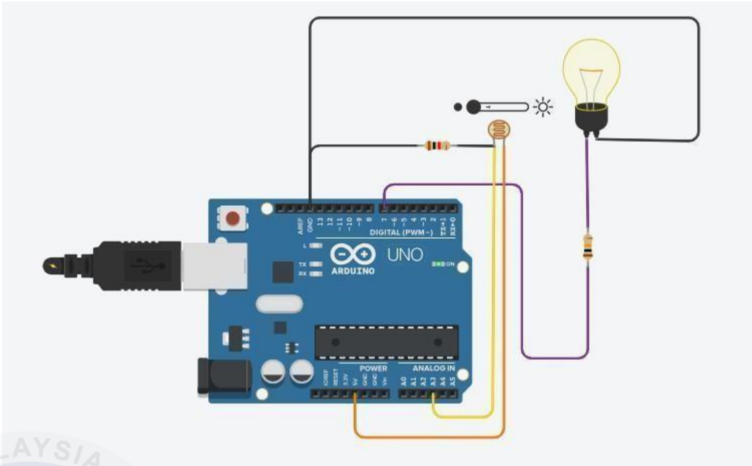

Figure 4.7: The light of bulb is on (Light Sensor)

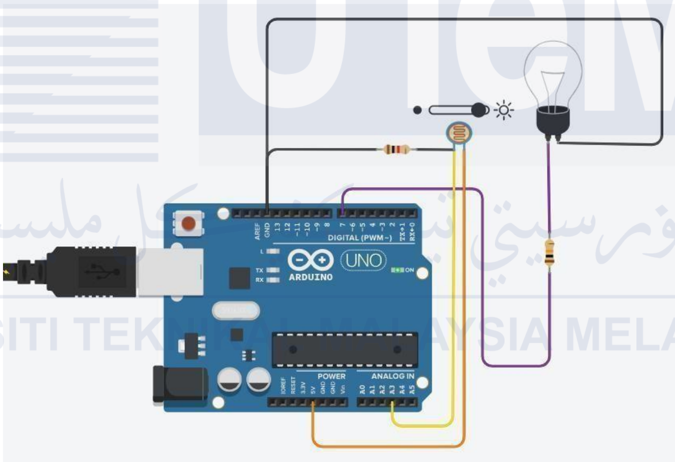

Figure 4.8: The light of bulb is off (Light Sensor)

4.4.2 Detection of Moving or Static Objects

On-road testing of the auto high beam system for motorcycles, which incorporates the HC-SR04 ultrasonic sensor for object detection, requires an evaluation of its effectiveness in accurately identifying moving and static objects. Because of that, simulations are done to find out the effectiveness and testing. When the ultrasonic sensor is facing nothing, **Figure 4.9** indicates that the lamp will light up; however, when an object is in front of the ultrasonic sensor, **Figure 4.10** indicates that the bulb will not light up or will dim.

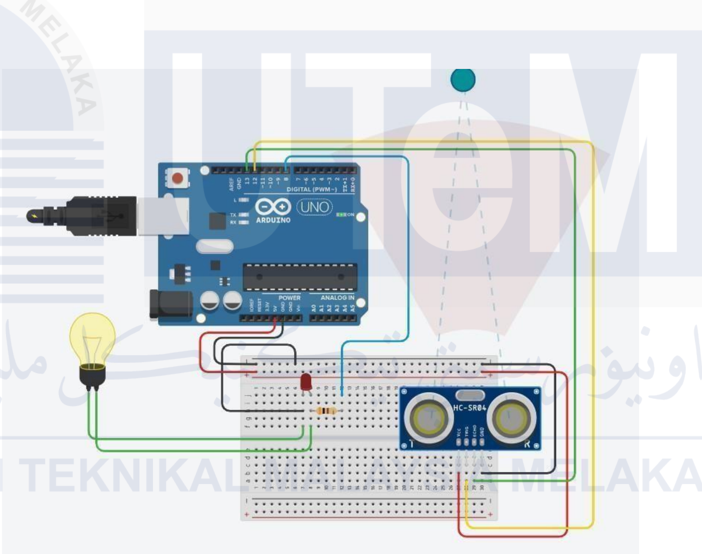

Figure 4.9: The light of bulb is on (Light Sensor)

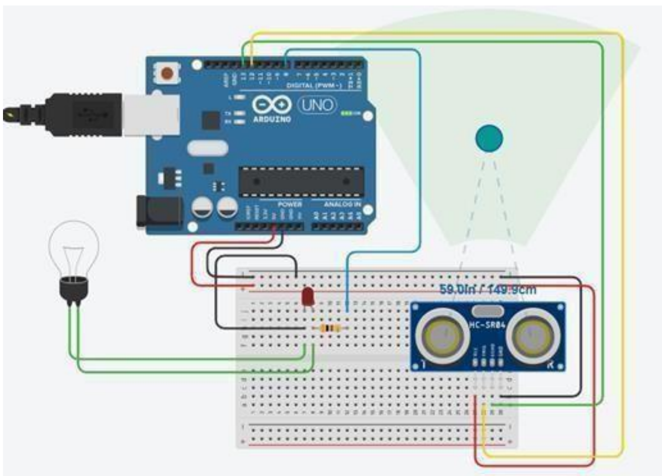

Figure 4.10: The light of bulb is off (Light Sensor)

4.5 Result Simulations AHBM System

Simulations were conducted to obtain preliminary results, using both sensors separately to determine the effectiveness of each sensor. The simulations were carried out online using Tinker Cad, allowing for the testing of only two scenarios: weather conditions being either dark or bright, and the presence of an object in front. This approach provided insights into how each sensor responds individually to changes in ambient light and obstacle detection, validating the sensors' performance and their integration into the Auto High Beam Motorcycle System. **Table 4.1** shows the result of simulations using TinkerCad.

Table 4.1: Result Simulations

Condition	Mode (Bright/Dark/Object)	Beam Mode on system (Low/High)	Result
Dry or Transitioning Conditions	Dark	Low/High	Pass
	Bright	Low/High	Pass
Detection of Moving or Static Objects	No objects	Low/High	Pass
	Have object	Low/High	Pass

4.6 Test results in Real-World Simulations

The Auto High Beam for Motorcycle System is designed to automatically adjust the motorcycle's headlight beam in response to varying environmental conditions, ensuring optimal visibility and safety under all circumstances. The system uses a combination of an ultrasonic sensor and a Light Dependent Resistor (LDR) to detect potential obstacles and surrounding light levels. The LDR sensor plays a crucial role in determining whether the environment is bright or dark, with a threshold set at a value of 800. If the LDR value exceeds this threshold, indicating bright conditions such as daylight or street lighting, the system automatically switches to low beam. Conversely, when the LDR value is less than or equal to 800, indicating darker conditions like night or low visibility, the system activates the high beam. The ultrasonic sensor is used to detect objects in front of the motorcycle, with a threshold of 180 cm. If an object is detected within this range, regardless of the ambient light levels, the system defaults to low beam to prevent blinding the driver of the approaching vehicle. This ensures that the headlights adjust dynamically based on both light intensity and the proximity of nearby objects.

To assess the real-world performance of the system, various test conditions were simulated, including daylight, nighttime, and partially illuminated environments, as well as scenarios with both clear visibility and objects detected at varying distances. The transitions between high and low beam are monitored and adjusted every second based on the readings from the sensors. Results from the tests were displayed on both a serial monitor and an LCD screen, showing real-time data on the vehicle's status, beam status (high or low), distance to detected objects, and the signal for brightness level. The system was evaluated in terms of its ability to respond to changes in light levels, such as transitioning between high and low beam as the ambient light fluctuated, and its ability to detect nearby obstacles and switch to the appropriate beam mode. These tests were crucial in determining how well the system adapts to real-world scenarios, ensuring its reliability and functionality in various driving conditions. The collected data provides a comprehensive view of the system's performance, confirming its capability to enhance safety and visibility by intelligently adjusting the headlights in response to environmental cues.

4.6.1 Static test

The static test for the Auto High Beam for Motorcycle project is crucial to distinguish between static objects such as buildings or parked vehicles and moving objects like pedestrians or other vehicles. The primary purpose of this test is to prevent false alarms that could distract the rider, improve system accuracy, and ensure better performance in real-world scenarios. Additionally, the static test helps identify and resolve initial issues before conducting on-road testing, thereby ensuring the safety of the rider and other road users. This test is also essential to evaluate the effectiveness of each component, particularly the ultrasonic and light sensors, under specific conditions. The results of this test are vital for fine-tuning the system to meet established quality and safety standards, providing a more comfortable and safer riding experience.

4.6.1.1 LDR Light Sensor Testing

The light sensor (LDR) plays a crucial role in the Auto High Beam system by detecting variations in light intensity and determining the appropriate headlight mode. The testing is conducted under two specific conditions to evaluate the sensor's functionality.

The first condition is bright light detected. In this condition, a source of bright light, such as a flashlight, is directed toward the light sensor to simulate oncoming vehicle headlights. When The sensor detects a high intensity of light, it sends a signal to the system to switch the headlights to a low beam. This response is designed to prevent glare from high beams, ensuring safety for other road users, such as oncoming vehicles or pedestrians. The system's ability to consistently switch to low beam upon detecting bright light confirms the accuracy and reliability of the sensor. **Figure 4.11** and **Figure 4.12** illustrate that when bright light is detected by the sensor, the system automatically changes to a low beam mode.

Figure 4.11: A flashlight phone is directed toward the light

Figure 4.12: The LCD indicates that the area is bright, and the system switches to low beam.

The second condition is low, or no light detected. For this condition, the light sensor is exposed to low ambient light or complete darkness, simulating clear road conditions without any oncoming vehicles. The sensor recognizes the absence of bright light and signals the system to activate the high beam. This mode ensures maximum visibility for the rider in situations where the road is clear, enhancing safety during nighttime driving or in low-light environments. **Figure 4.13** and **Figure 4.14** demonstrate that when low or no light is detected, the system changes to high beam mode.

Figure 4.13: There is not any light toward light sensor.

Figure 4.14: The LCD indicates that the area is dark, and the system switches to a high beam.

4.6.1.2 Ultrasonic Sensor Testing

The ultrasonic sensor plays a crucial role in the Auto High Beam system by detecting objects within its sensing range and determining the appropriate headlight mode. The testing is conducted under two specific conditions to evaluate the sensor's functionality.

The first condition is an object detected within sensing range. In this condition, an object is placed in front of the ultrasonic sensor within the specified detection range. When the sensor detects the object, it sends a signal to the system to switch the headlights to a low beam. This response is designed to prevent glare from high beams, ensuring safety for other road users, such as oncoming vehicles or pedestrians. The system's ability to consistently switch to low beam upon detecting an object confirms the accuracy and reliability of the sensor. **Figure 4.15** and **Figure 4.16** show that when the object is detected within sensing range, the system will change into a low beam.

Figure 4.15: The diagram shows the system switching to low beam due to the presence of an object within the ultrasonic sensor's sensing range.

Figure 4.16: The LED indicates the distance level of an object within the ultrasonic sensor's sensing range.

The second condition is no object detected within sensing range. For this condition, no object is present within the detection range of the ultrasonic sensor. The sensor recognizes the absence of obstacles and signals the system to activate the high beam. This mode ensures maximum visibility for the rider in situations where the road is clear, enhancing safety during nighttime driving or in low-light environments. **Figure 4.17** and **Figure 4.18** show that when no object is detected within sensing range, the system will change into a high beam.

Figure 4.17: The diagram shows the system switching to high beam due to no object within the ultrasonic sensor's sensing range.

Figure 4.18: The LED indicates the distance level of an object within the ultrasonic sensor's sensing range.

4.6.2 On-road Testing

The on-road test for the **Auto High Beam for Motorcycles (AHBM)** system is a critical phase to evaluate the system's performance in real-world driving conditions. This test focuses on assessing the AHBM's ability to dynamically adapt to varying environmental conditions, such as changes in ambient light intensity, the presence of moving vehicles, and road obstacles. Unlike the static test, the on-road test provides a realistic simulation of the challenges faced by riders during nighttime or low-light driving, ensuring that the system functions effectively and reliably in diverse scenarios.

The primary objective of the on-road test is to validate the system’s real-time decision-making capabilities. This includes determining the accuracy of the ultrasonic sensor in detecting moving objects like vehicles and pedestrians, as well as the LDR sensor's ability to measure ambient light and adjust the headlight beams accordingly. The test also examines the system’s response time, consistency in switching between high and low beams, and its ability to minimize glare for oncoming traffic. The results of the on-road test are essential to ensure the AHBM system meets safety and usability requirements, providing riders with enhanced visibility, improved safety, and a seamless riding experience under real-world conditions.

4.6.2.1 Range Detection Test (Ultrasonic Sensor)

The ultrasonic sensor plays a vital role in the Auto High Beam system during on-road testing bydetecting objects within its sensing range and dynamically determining the appropriate headlight mode in real-time driving scenarios. The on-road test is conducted under two specific conditions to evaluate the sensor's performance in realistic environments.

The first condition occurs when an object is detected within the sensing range during the ride. In this scenario, moving objects such as vehicles or pedestrians are detected bythe ultrasonic sensor. Upon detection, the sensor signals the system to switch the headlights to a low beam. This ensures the rider avoids causing glare to oncoming traffic or nearby road users, thereby enhancing overall safety. The system's ability to consistently and promptly switch to a low beam upon detecting an object demonstrates its reliability and adaptability in real-world conditions. **Figures 4.19** and **Figure 4.20** illustrate how the system effectively transitions to a low beam mode when objects are detected during on-road testing.

Figure 4.19: Object are detected during on-road testing.

Figure 4.20: The LED indicates the distance level of an object within the ultrasonic sensor's sensing range.

The second condition involves no object being detected within the sensing range. In this case, the absence of obstacles on the road allows the sensor to signal the system to activate the high beam. This mode provides maximum visibility for the rider, especially in poorly lit or open-road environments, ensuring a safer and more confident riding experience. **Figures 4.21** and **Figure 4.22** show the system's transition to a high beam when no objects are present within the sensor's range during on-road tests. This real-world evaluation confirms the system's ability to make accurate, timely decisions under varying conditions, proving its effectiveness in improving rider visibility and safety. **Table 4.2** shows the result of range detection of object test.

Figure 4.21: No objects are detected during on-road testing.

Figure 4.22: The LED indicates the distance level of an object is out of ultrasonic sensor's sensing range.

Table 4.2: Result of Range Detection of object Test

Test Case	Criteria	Expected Outcome	Condition Environment	Beam Mode on System outcome due to condition environment (Low/High)	Result
Detection of Moving or Static Objects	Distance greater than 180 cm	System should switch to high beam	No objects	Low/High	Pass/fail
	Distance less than or equal to 180 cm	System should switchto low beam	Have object	Low/High	Pass/fail

4.6.2.2 Transitioning light Test (Light Sensor)

The light-dependent resistor (LDR) or light sensor plays a critical role in the Auto High Beam system during on-road testing by detecting ambient light intensity and dynamically determining the appropriate headlight mode in real-time driving scenarios. The on-road test is conducted under two specific conditions to evaluate the sensor's performance in realistic environments.

The first condition occurs when the ambient light intensity is low, indicating a dark environment. In this scenario, the LDR sensor detects a decrease in light levels and signals the system to activate the high beam. This ensures maximum visibility for the rider in poorly lit areas, enhancing safety during nighttime driving or on roads with minimal lighting. The system's ability to promptly switch to high beam under these conditions demonstrates its reliability and responsiveness in real-world situations. **Figure 4.23** and **Figure 4.24** illustrate how the system effectively transitions to high beam mode when low light levels are detected during on-road testing.

Figure 4.23: The image illustrates the system switching to high beam mode due to the absence of light detected by the LDR sensor.

Figure 4.24: The LED indicates no ambient light detected by the LDR sensor, reflecting the surrounding brightness conditions.

The second condition involves high ambient light intensity, indicating a well-lit environment, such as urban areas or the presence of light and oncoming vehicles with headlights. In this case, the LDR sensor detects the brighter light and signals the system to switch to a low beam, preventing glare and ensuring the safety of other road users. This transition allows for a smoother and safer riding experience, reducing the likelihood of accidents caused by excessive glare. **Figure 4.25** and **Figure 4.26** demonstrate the system's ability to switch to a low beam when high light levels are detected during on-road testing. This evaluation confirms the LDR sensor's accuracy and responsiveness, proving its effectiveness in dynamically adapting the headlight mode based on real-time ambient lighting conditions. **Table 4.3** shows the result of transitioning of light test.

Figure 4.25: The image depicts the system switching to low beam mode due to the presence of light detected by the LDR sensor.

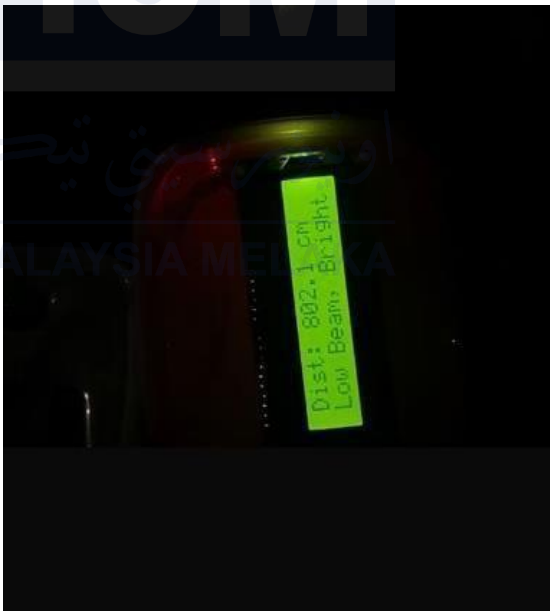

Figure 4.26: The LED indicates that have ambient light detected by the LDR sensor, reflecting the surrounding brightness conditions.

Table 4.3: Result of Transitioning light Test

Test Case	Criteria	Expected Outcome	Condition Environment	Beam Mode on System due to condition environment (Low/High)	Result
Dry or Transitioning Conditions	LDR value less than or equal to threshold (≤ 800) indicating dark environment	System should switch to high beam	Dark	Low/High	Pass/fail
	LDR value exceeds threshold (> 800) indicating bright environment	Systemshould switch to low beam	Bright	Low/High	Pass/fail

4.6.3 Overall System Performance

Following the completion of all tests, the data was collated to analyze the new prototype's overall performance in the actual world. Gathering the data allows the experiment to be examined to see what needs to be done. This is because a variety of factors, such as parallax and random error, can lead to experiment errors. Consequently, these mistakes will be reduced in the following session till a noteworthy outcome is achieved. Additionally, it lessens deficiencies and strengthens the system. The results for every test and the time the trials were carried out are displayed in **Table 4.4**.

Table 4.4: Overall Results

Test Case	Criteria	Expected Outcome	Result	Description
Light Detection in Bright Environment	LDR value exceeds threshold (> 800) indicating bright environment	Systemshould switch to low beam	Pass	The system correctly detected bright light and switched to low beam.
Light Detection in Dark Environment	LDR value less than or equal to threshold (≤ 800) indicating dark environment	Systemshould switch to high beam	Pass	The system detected a dark environment and activated the high beam.
Object Detection at Close Range	Distance less than or equal to 180 cm	System should switch to low beam, regardless of light conditions	Pass	The system detected objects within the 180 cm range and switched to low beam.
Object Detection at Long Range	Distance greater than 180 cm	System should adjust beam based on light conditions (low or high beam)	Pass	The system detected no close objects and adjusted the beam based on ambient light.
High Beam Activation	LDR value ≤ 800, no object detected within 180 cm	Systemshould remain in high beam	Pass	The system remained in high beam mode when no object was detected in dark conditions.

Low Beam Activation	LDR value > 800 or <800, object detected within 180 cm	Systemshould switch to low beam	Pass	The system switched to low beam when an object was detected, even in bright conditionsor dark environment.

4.1 Summary

The Auto High Beam System for motorcycles was evaluated through three distinct tests: Tinker Cad simulation, static testing, and on-road testing. These tests aimed to validate the system's performance in terms of transitioning between light and dark environments and detecting objects within a predefined range. In the Tinker Cad simulation, the logical flow of the system was analyzed, ensuring that it responded appropriately to varying inputs from the Light Dependent Resistor (LDR) and ultrasonic sensors. The static test involved testing the physical components in a controlled environment to verify the system's ability to detect light intensity and objects accurately. Finally, the on-road test assessed the system's functionality in real-world conditions, including dynamic changes in ambient lighting and varying object distances. The system successfully passed all tests, confirming its reliability and compliance with design expectations.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Project Highlight

This thesis outlines the common issues that motorcycle riders encounter in the first chapter. It was reported that users must manually operate the motorcycle light system, and some of them neglect to switch from high beam to low beam. They feel challenged because of this manual labor. The thesis goes on to say that its goal is to offer the greatest capabilities for automatically switching the headlights between high and low beam. This chapter also includes a summary of the research's objectives, scope, and overview.

A review of the literature opens the second chapter, which contains the thesis. It describes the development of new motorcycle technology known as Auto High Beam for Motorcycles as well as the history of beam motorcycles. Motorcycle light conversions can be divided into two categories: automatic headlight beam systems and manual beam systems. This chapter then goes on to discuss Auto High Beam Technology’s evolution.

For chapter three, the thesis discusses the methodology used in this research. this This chapter begins with an introduction and continues with the proposed methodology. In this sub section, it describes the planning for this project. It is mentioned that this project is divided into two parts namely FYP 1 and FYP 2. After that, the concept design is being approached for better assessment. The selection of components was checked in the creation of this project. In addition, there is also information in chapter three about the explanation of the aduino algorithm on the Auto High Beam motorcycle system. Then, this chapter explains about the test according to the situation in question to find out the effectiveness of the Auto High Beam motorcycle system.

In chapter four, the thesis shows the results of the tests that have been obtained from the previous chapter. The finished product is then discussed in this chapter in relation to performance at each condition.

5.2 Conclusion

The development of the Auto High Beam motorcycle system represents a significant advancement in motorcycle safety technology. Through meticulous research, design, and testing, the project has successfully addressed the challenge of improving rider visibility and safety during nighttime travel. By integrating sensors such as the BH1750 Ambient Light Sensor and the HC-SR04 Ultrasonic Sensor, the system demonstrates its ability to adapt to changing environmental conditions and detect potential hazards on the road. The careful selection of sensors and adherence to procedural sequences ensured the development of a robust and reliable prototype that meets the project's objectives.

Furthermore, the completion of the Auto High Beam motorcycle system holds promise for enhancing rider safety and reducing accident rates on the roads. With its capability to effectively adjust high beam intensity in response to ambient light levels and detected obstacles, the system offers a practical solution to mitigate the risk of accidents, particularly in low-visibility conditions. Moreover, the project's success underscores the importance of innovation and collaboration in advancing motorcycle safety technology, highlighting the potential for future developments and improvements in rider safety systems.

In conclusion, the Auto High Beam motorcycle system represents a significant step forward in enhancing rider safety and visibility during nighttime travel. Its successful development and testing demonstrate its potential to contribute to reducing accident rates and improving overall road safety for motorcycle riders. Moving forward, continued research and innovation in motorcycle safety technology hold the key to further advancements and improvements in rider safety systems, ensuring a safer and more secure riding experience for all.

5.3 Recommendations

Consider adding temperature and humidity sensors for ambient adaptation and combining cutting-edge sensors like Lidar for accurate detection to improve the Auto High Beam Motorcycle System. If using a camera, use a more potent microcontroller for better picture processing. To guarantee dependability, use advanced redundancy, power management, and fail-safes. Provide simple calibration procedures and a user interface for tracking and adjusting. To get user input, make sure all regulations are followed and carried out through field test. Provide thorough training materials and documentation, cut expenses, and build the system to be both scalable and upgradeable to accommodate new features and enhancements in the future.

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APPENDICES

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

// I2C LCD Address (commonly 0x27 or 0x3F). Adjust if necessary.
LiquidCrystal_I2C lcd(0x27, 16, 2);

const int trigPin = 12;
const int echoPin = 10;
const int ldrPin = A3;
const int relayPinLowBeam = 6;
const int relayPinHighBeam = 5;
float duration, distance;
int ldrValue;
int darknessThreshold = 800;
int objectThreshold = 180;
const int maxLdrValue = 1023; // Maximum ADC value for LDR

void setup() {
 pinMode(trigPin, OUTPUT);
 pinMode(echoPin, INPUT);
 pinMode(relayPinLowBeam, OUTPUT);
 pinMode(relayPinHighBeam, OUTPUT);

 Serial.begin(9600);
 lcd.init();
```


APPENDIX 1 PROGRAM CODE

```
  lcd.backlight(); // Turn on the LCD backlight
}

void loop() {
  // Measure distance
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  duration = pulseIn(echoPin, HIGH);
  distance = (duration * 0.0343) / 2;

  // Read LDR value and calculate darkness percentage
  ldrValue = analogRead(ldrPin);
  int darknessPercentage = map(ldrValue, 0, maxLdrValue, 0, 100);

  // Determine statuses
  String brightnessStatus = (ldrValue > darknessThreshold) ? "Dark" : "Bright";
  String vehicleStatus = (distance >= objectThreshold) ? "Vehicle Not Detected" : "Vehicle Detected";
  String beamStatus = "Low Beam"; // Default beam status

  // Control Relays
  if (ldrValue > darknessThreshold) {
    if (distance <= objectThreshold) {
      digitalWrite(relayPinLowBeam, LOW);
```

```
    digitalWrite(relayPinHighBeam, HIGH);
    beamStatus = "Low Beam";
  } else {
    digitalWrite(relayPinLowBeam, HIGH);
    digitalWrite(relayPinHighBeam, LOW);
    beamStatus = "High Beam";
  }
} else {
  digitalWrite(relayPinLowBeam, LOW);
  digitalWrite(relayPinHighBeam, HIGH);
  beamStatus = "Low Beam";
}

// Display on Serial Monitor
Serial.println("====================================");
Serial.print("Vehicle Status: ");
Serial.println(vehicleStatus);

Serial.print("Brightness Status: ");
Serial.println(brightnessStatus);

Serial.print("Beam Status: ");
Serial.println(beamStatus);

Serial.println();
Serial.print("Distance Measured: ");
Serial.print(distance, 2); // Two decimal places
```

APPENDIX 1 PROGRAM CODE

```
  Serial.println(" cm");

  Serial.print("Darkness Level: ");
  Serial.print(ldrValue);
  Serial.print(" (");
  Serial.print(darknessPercentage);
  Serial.println("%)");

  Serial.println("======================================");

  // Display on LCD
  lcd.clear();
  lcd.setCursor(0, 0); // Line 1
  lcd.print("Dist: ");
  lcd.print(distance, 1); // One decimal place
  lcd.print(" cm");

  lcd.setCursor(0, 1); // Line 2
  lcd.print(beamStatus.substring(0, 9)); // Display "High Beam" or "Low Beam"
  lcd.print(", ");
  lcd.print(brightnessStatus.substring(0, 6)); // Display "Bright" or "Dark"

  delay(1000);
}
```


APPENDIX 1 PROGRAM CODE

Gantt Chart for PSM 1																
No	Task Project	Plan / Actual	Week													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	PSM title registration	Plan														
		Actual														
2	Project briefing with supervisor	Plan														
		Actual														
3	Research about this PSM title	Plan														
		Actual														
4	Introduction Chapter 1	Plan														
		Actual														
5	Literature review Chapter 2	Plan														
		Actual														
6	Design idea for AHBM system	Plan														
		Actual														
7	Feature and function specification	Plan														
		Actual														
8	Methodology chapter 3	Plan														
		Actual														
9	Design workflow of AHBM	Plan														
		Actual														
10	Design prototype for AHBM system	Plan														
		Actual														
11	Preliminary result and discussion chapter 4	Plan														
		Actual														
12	Writing PSM report	Plan														
		Actual														
13	Sent full report to supervisor for checking															
14	Presentation PSM															

APPENDIX 2 GANT CHART

Gantt Chart for PSM 2																
No	Task Project	Plan / Actual	Week													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Designing coding and programming	Plan														
		Actual														
2	Selection material for AHBM system	Plan														
		Actual														
3	Prototype design generation	Plan														
		Actual														
4	Prototypes assemble	Plan														
		Actual														
5	Report writing chapter 4	Plan														
		Actual														
6	Testing system for final result	Plan														
		Actual														
7	Report writing chapter 4	Plan														
		Actual														
8	Report writing chapter 5	Plan														
		Actual														
9	Finalize report and send to SV for checking	Plan														
		Actual														
10	Submission of PSM 2 report	Plan														
		Actual														
11	Presentation preparation	Plan														
		Actual														
12	Presentation PSM 2	Plan														
		Actual														

APPENDIX 2 GANT CHART