DEVELOPMENT OF A REVOLUTIONIZING PORTABLE TRAFFIC LIGHT CONTROL USING LORA WIRELESS TECHNOLOGY

ABDUL HAKIM BIN HAMZAH

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF A REVOLUTIONIZING PORTABLE TRAFFIC LIGHT CONTROL USING LORA WIRELESS TECHNOLOGY

ABDUL HAKIM BIN HAMZAH

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

Faculty Of Electronics and Computer Technology and Engineering
Universiti Teknikal Malaysia Melaka

2025

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI DAN KEJURUTERAAN ELEKTRONIK DAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DEVELOPMENT A REVOLUTINIONIZING PORTABLE TRAFFIC LIGHT CONTROL USING LORA WIRELESS TECHNOLOGY

Sesi Pengajian : 2024/2025

Saya ABDUL HAKIM BIN HAMZAH mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.
√	**TIDAK TERHAD**	

Disahkan oleh:

_______________________ ______________________________

Alamat Tetap:

VIGNESWARA RAO GANNAPATHY
Pensyarah Kanan
Jabatan Teknologi Kejuruteraan
Fakulti Teknologi Dan Kejuruteraan Elektronik Dan Komputer
Universiti Teknikal Malaysia Melaka

Tarikh : 12 JAN 2025 Tarikh : 07 FEBRUARI 2025

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this project report entitled Development of a Revolutionizing Portable Traffic Light Using LoRA Wireless Technology is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Student Name	:	ABDUL HAKIM BIN HAMZAH
Date	:	12th JAN 2025

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology with Honours.

Signature : ....

Supervisor Name : MR. VIGNESWARA RAO A/L GANNAPATHY

....

Date : 7th February 2025

....

Signature : ....

Co-Supervisor Name (if any) :

....

Date : ....

DEDICATION

To my beloved mother, Mardina Binti Mohamad,

And

To my precious father, Hamzah Bin Ahmad,

and

To my treasured siblings, Mohammad Haziq Bin Hamzah, Muhammad Hafiy Bin Hamzah and Amirul Hadif Bin Hamzah

ABSTRACT

The ‘Revolutionizing Portable Traffic Light (RPTL)’ is designed to replace flagmen working in construction zones by offering a safer and more efficient way to manage traffic. One of the main issues successfully addressed by this project is replacing flagmen who are often exposed to accidents and weather changes while controlling traffic. The goal of this project is to create a traffic light system with its own algorithm, integrated with LoRa technology, which allows it to communicate wirelessly even at long distances between the two traffic lights and ensures a stable connection. This system also uses ultrasonic sensors to detect vehicles on the road and helps identify more congested areas, allowing the traffic light to prioritize those areas. The project also includes an automated system that detects vehicles using ultrasonic sensors. When a vehicle is detected, the traffic light will turn green, and it will calculate how many vehicles have entered the road, ensuring that the number of vehicles entering and exiting is the same. If both roads have vehicles at the same time, the traffic light will prioritize the 'master' light to enter the construction zone first. Once completed, it will give way to the 'slave' light to enter the construction zone. In conclusion, this mobile traffic light system with ultrasonic detection and LoRa connectivity represents a significant advancement in traffic management improvements.

ABSTRAK

‘Revolutionizing Portable Traffic Light (RPTL)’ direka untuk menggantikan petugas bendera yang bekerja di zon pembinaan dengan menawarkan cara yang lebih selamat dan lebih cekap untuk mengurus trafik. Salah satu isu utama yang berjaya ditangani oleh projek ini adalah menggantikan petugas bendera yang sering terdedah kepada kemalangan dan perubahan cuaca ketika mereka mengawal lalu lintas. Matlamat projek ini adalah untuk mencipta sistem lampu isyarat yang mempunyai algoritma tersendiri dan digabungkan dengan teknologi LoRa iaitu membolehkan ia berkomunikasi secara tanpa wayar walaupun dalam keadaan jarak yang jauh antara kedua-dua lampu isyarat dan memastikan sambungan berada dalam keadaan stabil. Sistem ini juga menggunakan sensor ultrasonik untuk mengesan kenderaan di jalan raya dan membantu mengenal pasti kawasan mana yang lebih sibuk dan lampu isyarat tersebut perlu memberi keutamaan. Projek ini juga termasuk projek yang mempunyai sistem automatik dengan mengesan kenderaan menggunakan sensor ultrasonik. Apabila kenderaan dikesan, lampu isyarat akan bertukar kepada hijau dan ia akan mengira berapa banyak kenderaan yang telah memasuki jalan tersebut dan akan memastikan jumlah kenderaan masuk dan jumlah kenderaan keluar adalah sama. Sekiranya kedua-dua jalan raya mempunyai kenderaan pada waktu yang sama, lampu isyarat akan memilih lampu isyrat 'master' terlebih dahulu untuk masuk zon pembinaan. Apabila selesai, ia akan memberi laluan kepada lampu isyarat 'slave' untuk masuk zon pembinaan. Kesimpulannya, sistem lampu isyarat mudah alih ini yang mempunyai sistem pengesanan melalui penderia ultasonik dan sambungan melalui LoRa merupakan kemajuan penting dalam penambah baikkan dalam pengurusan trafik.

ACKNOWLEDGMENTS

First and foremost, I would like to praise Allah the Almighty, whose wisdom and strength I relied upon to complete this project. Without His guidance and blessings, this endeavor would not have been possible.

I am deeply grateful to my supervisor, Sir Vigneswara Rao A/L Gannaptahy, for her invaluable guidance, words of wisdom, and unwavering patience throughout this project. Her support and encouragement have been instrumental in my academic journey.

My heartfelt thanks extend to Universiti Teknikal Malaysia Melaka (UTeM) for providing the resources and environment conducive to my research. I am also profoundly thankful to my colleague for generously sharing his insights and ideas, which greatly contributed to the development of this project.

I wish to express my deepest appreciation to my parents and family members for their unconditional love, unwavering support, and constant prayers during my studies. Their faith in me has been my greatest source of motivation.

Lastly, I would like to extend my sincere thanks to my fellow colleagues and classmates, the faculty members, and all other individuals who have offered their cooperation and assistance. Your collective support and encouragement have been vital in the successful completion of this project.

Thank you all from the bottom of my heart.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

V	-	Voltage angle
Hz	-	Hertz
GHz	-	Giga Hertz
dB	-	decibels
RSSI	-	Received Signal Strength Indicator

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Revolutionizing Portable Traffic Light (RPTL) is designed to replace flagmen in construction zones and addresses several issues that call for better traffic management ideas. Traditionally, flagmen are used to direct traffic in construction areas, but this method puts their safety at risk because they are exposed to moving vehicles, heavy machinery, and bad weather. According to Statista in figure 1, there were 814 fatal construction accidents in Malaysia between 2014 and 2023, showing the dangers workers and drivers face. Flagmen also face challenges like communication problems and fatigue from long hours, which makes it harder for them to manage traffic well. These problems highlight the need for new solutions that can improve safety, control traffic better, and make construction zones more efficient.

The RTPL, with its wireless communication features, provides a practical solution to replace flagmen. This advanced system uses technologies like real-time vehicle tracking, smart traffic lights, and wireless connections to automatically control traffic without needing people to manage it. By using sensors, the traffic lights can detect cars, adjust the light timing based on traffic flow, and help reduce congestion and delays in construction zones. The portability of the RTPL means it can be easily moved as construction work progresses, making it flexible and adaptable to changes in traffic patterns and construction site needs. Also, the system is automated, which reduces human error and helps ensure traffic safety rules are followed, lowering the chances of accidents and improving traffic control. With this new technology, construction sites can be safer, run more smoothly, and improve public safety overall.

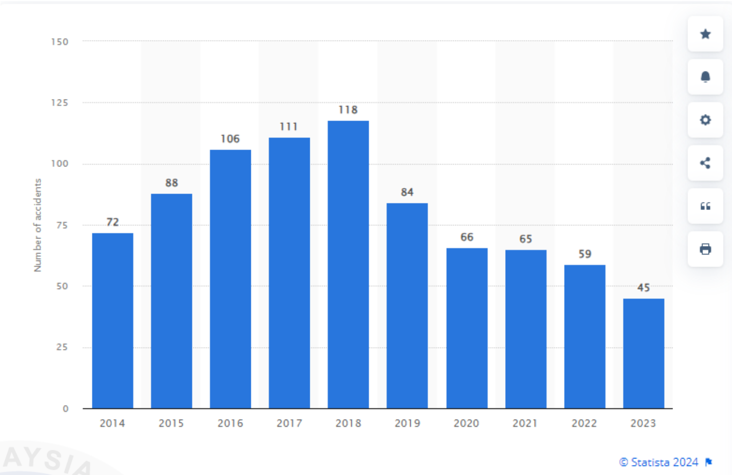

Figure 1- The data of fatal accidents at construction zones

1.2 Problem statement

The primary issue addressed by this project is the road traffic controller at construction zones, flagman is exposed to dangerous which is accidents and weather changes. The flagman also is lack of communicate due to noise interference making them difficult to communicate with each other. Furthermore, the flagman is working for 24 hours, and they need to deal with weather changes such as heat, rain, thunderstorm and so on. This will cause them to have headaches and be unwell to do work on the site. This project aims to control the traffic flows and reduce the accident rate at construction zones.

1.3 Objectives

i. To investigate current traffic light systems used in construction zones and evaluate their potential for implementation.

ii. To develop an algorithm for a smart traffic light that enhances traffic flow in construction areas.

iii. To integrate and test the developed algorithm in a portable construction traffic light system utilizing LoRA technology.

1.4 Scope

The project's scope entails several key components:

i. Investigate the system using LoRA connection: This entails examining the functionality and feasibility of utilizing LoRA (Long Range) connection technology in the context of the portable wireless traffic light system. LoRA enables long-distance communication between devices with low power consumption, making it potentially suitable for transmitting data between traffic lights and control systems in construction zones. Investigating this technology involves assessing its range, reliability, and compatibility with the traffic light system.

ii. Creating the system using Arduino IDE: This means creating a traffic light system using Arduino IDE and connecting to the components. Making the system with Arduino IDE involves writing code to detect vehicles and understand the traffic patterns. Additionally, it includes programming the system to manage traffic flow effectively and ensuring that lights change according to vehicle presence and movement.

iii. Explore using a sensor for the traffic light: This involves testing how a sensor can be added to the traffic light system. The sensor can detect when a vehicle is waiting or has passed through a construction area. Exploring this sensor means checking how accurate, reliable, and helpful it is for managing traffic in construction zones.

1.5 Sustainable Development Goals (SDG)

The Portable Traffic Light also are following the Sustainable development Goals, such as:

i. Goal 3: Good Health and Well-being – promoting road safety and reducing the risk of accidents at intersections and construction zones.

ii. Goal 9: Industry, Innovation and Infrastructure - enhancing transportation infrastructure and promoting innovation in traffic management technologies.

iii. Goal 11: Sustainable Cities and Communities – Promoting a safe and sustainable for town traffic.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the crucial facts and details discovered by various studies and research. It provides an explanation of different ways to handle construction zones, particularly focusing on the use of portable traffic lights, which is important because it aligns with our main goal. Additionally, it discusses the application of Long Range (LORA) technology which is wireless technology compared to wired.

2.2 Construction Zone

A construction zone is an area where construction work is taking place. It is a place where workers are building, fixing or improving something. It might be road, bridge and buildings. These places are usually use a marks to prevent from accident such as signs, cones and barriers. Construction zones can be temporary or a long period of time depending on the project. It might be change for the traffic like closing the road or change the way of the road. Road constructions are involving the design such as stop mark, road work ahead, lane closure sign and speed limit. The aim of this sign marks is to warn the driver that have a construction area ahead and the speed limit that the driver needs to follow.

Traffic management is challenging during construction because of the effects of traffic congestion, travel time, delay, and queue length. Long-term work zones on urban roads lead to many problems such as speed, inconvenience, and economic losses to drivers [1]. It happens because when too many cars trying to pass through the narrow, blocked area lanes closed. This will make the traffic becomes slow and making the cars wait in long line. The driver also feel frustrated because they cannot go to the destination by the time they plan.

Other than that, Driving involves a variety of intricate activities and demands the driver's undivided attention [2]. Most of the driver through construction zone face the unclear signage. It makes the driver and user of road hard to understand because of the mistakes. This can confuse drivers and making it difficult for them to know what they need to do. Plus, sometimes the sign are not put at the right place and make the driver difficult to notice the sign.

Figure 2- Construction Zone

2.2.1 Type of Road

In Malaysia, roads come in various types to accommodate different traffic needs and configurations. These include two-way roads, which facilitate traffic flow in both directions. Then, T-junctions, where one road intersects another to form a T-shape. After that, four-junctions, also known as crossroads, where four roads intersect. Lastly, roundabouts which is circular intersections designed to manage traffic flow efficiently. Each type serves a specific purpose in the transportation network, ensuring smooth and safe travel for motorists across the country.

There are several types of roads, each serving different purposes. Highways are large roads that connect cities and allow fast travel over long distances. Main roads are important for local traffic and connect neighbourhoods or smaller towns. Side streets are smaller roads in cities or towns, usually for local traffic. Alleys are narrow roads or pathways between buildings, often for service vehicles or pedestrians. Lastly, Rural roads are found in the countryside, connecting farms and small communities.

Each type of road faces its own set of challenges. Many challenges have to be met in various environments. On the highways, they must be efficient when interring in the highway, when they have to approach any toll [3]. Highways often experience heavy traffic, accidents, and wear from constant use. Main roads can become congested, and frequent repairs are needed due to high local traffic. Side streets may be poorly maintained, with parking issues or narrow lanes that hinder emergency vehicle access. Alleys are sometimes blocked by trash or obstacles, making them difficult to navigate. Rural roads are often in bad condition due to limited resources for maintenance and can become hazardous in bad weather if not properly cleared. In urban areas, they have to deal with vulnerable users (pedestrians, bicycles, etc.) and they have top handle round-about crossing and intersections [3].

2.2.1.1 Two-Way Road

A two-way road is a type of road where vehicles can travel in both directions. This means that cars and other vehicles can go in opposite ways on the same road. It is designed so that each side of the road has space for vehicles going in one direction, and the other side is for vehicles going the opposite way. Drivers need to be careful and follow traffic rules to avoid accidents when using a two-way road.

Figure 3– Two-way road

2.2.1.2 T-Junction

A T-junction is a type of road intersection where one road ends and meets another road, forming the shape of the letter "T." At this junction, one road comes to a stop and either turns left or right to continue on the other road. Drivers need to be careful when approaching a T-junction because they have to decide which direction to go, either left or right, depending on the road signs and traffic rules.

Figure 4 – T-Junction Road

2.2.1.3 4 Junction Road

A 4-junction road, also known as a four-way intersection, is a place where four roads meet. It looks like a plus sign or a cross. Vehicles can come from all four directions and have to decide which way to go, whether turning left, right, or going straight ahead. Traffic signals, road signs, or roundabouts are often used to manage the flow of traffic and keep things organized. It's important to follow traffic rules carefully at a 4-junction road to avoid accidents.

Figure 5 – 4 Junction Road

2.2.1.4 Roundabouts

A roundabout is a circular intersection where traffic flows in one direction around a central island. Vehicles entering the roundabout must yield to those already inside, meaning they wait for an empty space before entering. Roundabouts help keep traffic moving smoothly and reduce the chances of accidents compared to traditional intersections. Drivers simply follow the curve of the circle to exit at their desired road, making it easier and safer to navigate compared to other types of intersections.

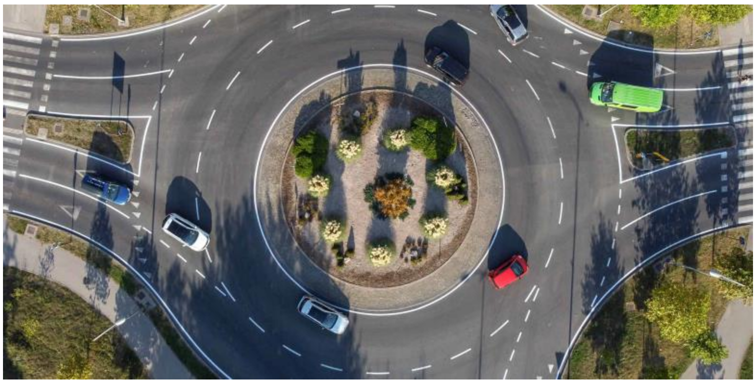

Figure 6 – Roundabouts Road

2.2 Flagman

Flagmen or traffic control workers are key to keep traffic safe and flowing smoothly around construction sites. They work for government agencies or construction companies and are responsible for directing vehicles through work areas to prevent delays and protect both workers and drivers. Using tools like traffic cones, warning signs, and barriers, they help guide vehicles safely around obstacles. Flagman are needed especially on two-lane highways for controlling traffic and make sure everything runs safely and efficiently. The main objective of the proposed training is to deliver a realistic experience to trainees in an immersive virtual environment using the current traffic control protocols and standards [4].

In addition, they communicate with drivers, pedestrians, and construction workers to coordinate movement and ensure safe passage through work zones. They also need to stay watchful for any signs of danger or obstacles, quickly notifying construction teams and emergency responders when needed to keep the work site safe. A flagman basically wear different uniforms according to the weather condition. So that the driver need to always alert and focus on their surrounding while driving. An autonomous vehicle needs to make safe decisions and facilitate forward progress in the presence of road construction workers and flagmen [5] . The figure 3 shows the photo of the human flagman at construction zone.

Figure 7 - Flagman

2.3.1 Automatic Flagman

Flagman was once upgraded to automatic flagman at some point in the past. Automated flagman can replace workers in construction zones by using advanced technology such as sensors, cameras and automated control systems to control traffic flow and ensure safety. The system can detect approaching vehicles, analyze traffic conditions and implement pre-programmed or adaptive traffic control strategies, including directing vehicles to stop, yield or proceed through work zones as needed. The automatic flagman helps control traffic at the construction site. When cars approach, it raises its arm to stop them. The workers feel safer with the automatic flagman on duty because it can work all day without getting tired. People are amazed by how the automatic flagman looks and moves, making it a helpful addition to the team. The figure 4 shows the photo of automatic flagger for construction zone.

Figure 8 - automatic Flagman

Table 1- The differences of Human flagman and automatic flagman

Aspect	Automated Flagman	Human Flagman
Consistency	Provides uniform signaling and operation, reducing errors.	Performance can vary based on fatigue or distraction.
Safety	Reduces risk of accidents by eliminating human presence in hazardous areas.	Exposed to traffic, increasing accident risk.
Cost-Effectiveness	Lower long-term labor costs; no need for breaks or shifts.	Ongoing labor costs for shifts and breaks.
Operational Hours	Can operate 24/7 without rest, allowing for extended work hours.	Limited to shift hours and requires downtime.
Training Requirements	Minimal training needed and easy to set up and use.	Requires training and ongoing education.

Weather Resistance	Often designed to withstand harsh weather conditions.	Performance can be affected by weather.
Remote Operation	Can be monitored and controlled from a distance.	Requires physical presence for operation.
Traffic Flow	Maintains smoother traffic flow, reducing congestion.	Can cause delays due to communication with drivers.
Data Collection	Capable of collecting and analyzing traffic data for insights.	Limited data collection capabilities.
Adaptability	Can be programmed to adjust to changing conditions quickly.	Limited adaptability and may take time to react to changes.
Fatigue	No fatigue or distraction, ensuring continuous performance.	Can become fatigued, affecting performance.

2.2 Long Range (LoRa)

LoRa is a physical layer that provides a long-range communication link. This has been standardized and extended by adding a MAC layer LoRaWAN (Long Range Wide Area Network) to it. This defines the network architecture and communication protocol. LoRaWAN specification is standardized and open sourced by the LoRa alliance [6]. Operating in the sub-gigahertz frequency band, LoRa facilitates the creation of cost-effective and scalable networks, positioning it as a critical element in the field of smart technology.

Figure 9 – LoRA Logo

LoRa technology enables devices to communicate over several kilometers in rural areas and up to several kilometers in urban environments, making them ideal for applications such as smart cities, agriculture, environmental monitoring, asset tracking and industrial automation. A LoRa network usually consists of end devices equipped with LoRa transceivers, a gateway that forwards data between the end devices and a central network server, and a network server, which manages the network and data routing. The most recent communication technology in Low Power Wide Area Networks (LPWAN) is LoRa. It emphasizes long-distance transmission with excellent sensitivity for detection and can function effectively even in the presence of noise interference or noise floor. LoRa utilizes chirp spread spectrum modulation, incorporating six spreading factors. The frequency of these chirps' changes depending on the spreading factors. Elevating the spreading factor extends the reach of LoRa communications, albeit at the expense of reducing the data transmission rate [7].

LoRa technology operates in both unlicensed sub-gigahertz bands, such as 915 MHz, 868 MHz and 433 MHz, as well as the 2.4 GHz band. While the sub-gigahertz band offers longer range due to its lower frequency and better penetration through obstacles, the 2.4 GHz band allows higher data rates but at the expense of range. we have proposed a new method for maximizing the wireless sensing network's throughput communicating with Long Range (LoRa) modulation at a 2.4GHz frequency [25]. LoRa's capability to function over extensive distances while consuming minimal power in comparison to other technologies has garnered significant interest from the research community. Consequently, it has found extensive application in constructing sensor nodes, IoT gateways, and related systems. The LoRa gateway enables wireless communication utilizing an unlicensed frequency band of 925.2MHz, while it employs another unlicensed frequency band of 2.4GHz WiFi to communicate with a cloud storage server [8].

In practical terms, LoRa technology finds application in IoT scenarios, ranging from smart cities and agriculture to industrial automation and asset tracking. Whether it's monitoring soil moisture levels in agricultural fields or tracking assets in a logistics network, LoRa provides a cost-effective and scalable communication solution. The LoRa modulation was hailed as a breakthrough that could address the challenges of the IoT concept. Despite being adopted by numerous IoT devices, there remains a need for further examination of the scalability of this technology [9].

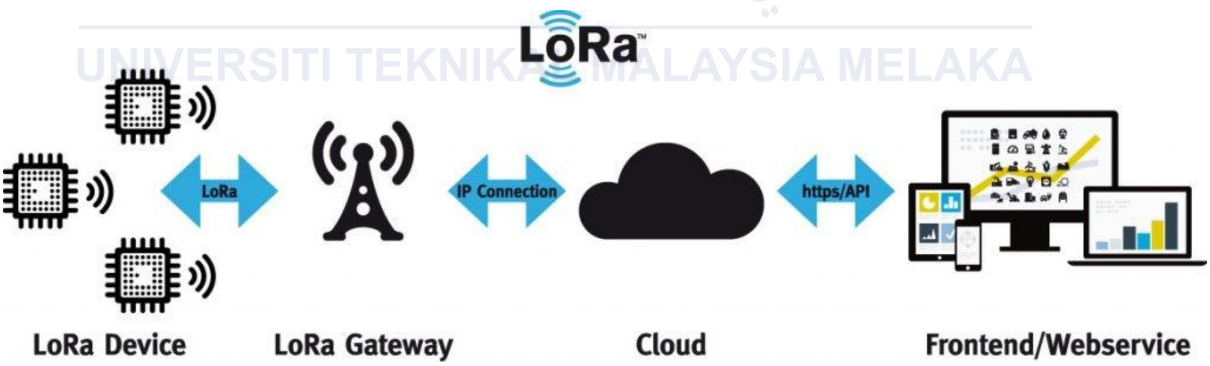

Figure 10 – LoRA Connect to IoT

LoRa employs chirp spread spectrum modulation for efficient and robust communication. Its most significant advantage lies in its long-range communication capability. With the support of base stations and gateways, LoRa can cover several kilometers within a smart city area. The link budget, measured in dB, is the key factor determining the range under specific environmental conditions. Compared to other technologies, LoRa boasts a superior link budget. However, the range of LoRa in a given environment is primarily influenced by obstacles and structures within that area [10]. LoRa technology represents a significant advancement in wireless communication for IoT applications. Its long-range capability, low power consumption, resilience to interference, and cost-effectiveness make it an attractive choice for organizations seeking to deploy IoT solutions that require reliable, long-term connectivity. As the IoT ecosystem continues to evolve, LoRa is poised to play a pivotal role in shaping the future of connected devices and smart technologies.

LoRa (Long Range) is better than traditional RF (radio frequency) for certain applications because it can send data over much longer distances. LoRa is designed for low-power, long-range communication, making it ideal for smart city applications, agriculture, and IoT devices. It can cover up to several kilometres, while RF is usually limited to shorter distances. LoRa also uses less power, allowing devices to run for years on a small battery. In addition, LoRa is more reliable in areas with obstacles, like buildings or trees, because it can penetrate through them better than regular RF signals. This makes LoRa a more efficient and cost-effective choice for long-distance, low-power communication. Long-range (LoRa) modulation offers significant advantages in wireless sensing networks, including extended range, low power consumption, robustness in challenging RF environments, scalability, adaptability, low infrastructure costs, and support for IoT applications [26].

LoRa uses different frequencies in different countries, depending on local regulations. In most countries, LoRa operates in the unlicensed Industrial, Scientific, and Medical (ISM) band, but the specific frequency ranges can vary. To deploy loRa devices in different countries accordingly have to select the specified spreading factors for each region of the country and Some of the specimens are for Europe 868 MHZ and 433 MHZ bands proposed by the European telecommunications standards institute (ETSI), for the United sates915 MHZ,433 MHZ bands proposed by federal communication commission (FCC) [27]. These frequency differences help avoid interference with other wireless devices and ensure that LoRa can work effectively in each region. The choice of frequency is based on local laws and the need to ensure long-range communication with minimal power usage.

2.2.1 LoRaWAN

LoRaWAN is a Media Access Control (MAC) layer protocol built on top of LoRa modulation. It acts as a software layer defining how a device utilizes LoRa hardware, such as during transmission, and dictates the format of messages. Built upon LoRa (Long Range) modulation technology, it offers a set of standardized protocols for managing communication between LoRa devices and network gateways.

As a critical component of LoRa-based IoT networks, LoRaWAN provides the infrastructure and protocols necessary to efficiently and securely orchestrate and manage large-scale IoT deployments. It enables a variety of applications, including smart cities, industrial automation, agriculture, environmental monitoring, and asset tracking, by offering long-range and low-power communication capabilities with robust security features.

LoRaWAN is also suitable for transmitting small-sized payloads, such as sensor data, over long distances. LoRa modulation provides significantly greater communication range with low bandwidths compared to other competing wireless data transmission technologies. The following figure illustrates various access technologies that can be used for wireless data transmission and their expected transmission ranges and bandwidth. The figure 5 shows the difference between bandwidth and range [11].

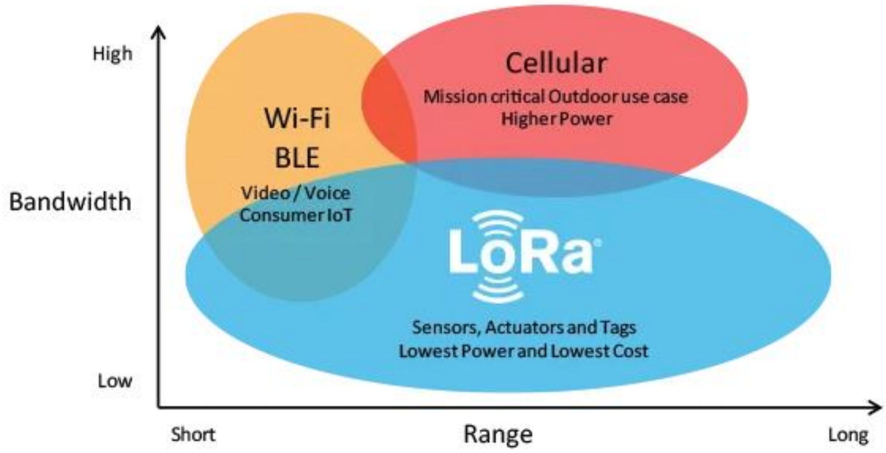

Figure 11 - LoRAWAN

2.3 Traffic Light

In the present, there are more cars used on the road due to the population in each country has increased. It causes traffic major congestion problem in almost country especially in large cities. Traffic congestion problem affect the economy and the environment both directly and indirectly, as part of the problem of air pollution. It also loses waiting time for transportation and fuel consumption [12]. Traffic lights are important devices used to manage the flow of cars and pedestrians at intersections, ensuring safe and organized movement of traffic in busy urban, suburban and rural areas. These systems help to reduce accidents, prevent congestion, and improve overall road safety by controlling the timing of vehicle and pedestrian movements. The traffic light intersection systems, in the cities of the Republic of Bulgaria, operate with a fixed cycle lengths and phase sequences regardless of the traffic flow parameters [28].

They have three main colors which are red, yellow, and green. When the light is red, cars must stop, allowing pedestrians to cross the street safely. The green light means that cars can go, while the yellow light warns drivers that the light is about to change to red, so they should prepare to stop. In transport hubs, a traffic light can be used as an element of intelligent traffic control system. Number of sections in traffic lights are produced depending on the necessary structure of the traffic light control cycle and the directions of traffic flows. Traffic lights are adapted to all types of controllers. The color of the traffic light body is gray, black or yellow. LED traffic lights are the most compact and consume less lectricity [13].

The placement and design of traffic lights are carefully planned to ensure they are visible and easy to understand for everyone on the road. They play a crucial role in keeping everyone safe, reducing accidents, and improving the overall flow of traffic. By using different colours to show who has the right of way and traffic lights also useful reduce accidents at intersections, protecting people's lives and preventing damage to property. It help vehicles and pedestrians move in an orderly way, which helps avoid traffic jams on busy streets.

Traffic lights help reduce traffic jams, especially as the number of cars on the road keeps growing. During busy times, like rush hour, there are often long delays, and cars can get stuck in traffic. Traffic lights help by controlling the flow of cars and pedestrians, making sure that each direction gets time to move. This helps prevent gridlock and keeps traffic moving more smoothly. Modern traffic light systems can even adjust the timing based on how much traffic is on the road, giving more green light time to busy lanes. This helps shorten waiting times and makes it easier to drive, even with more cars on the road. The number of cars has increased drastically so that it is very common to get stuck in traffic in rush hours. The road infrastructures in cities use multiple lanes and also traffic lights to direct traffic and to ensure and safety [29].

Figure 12 - Traffic Light

2.5.1 Technologies on Traffic Light

Traffic lights use a combination of timers, sensors, and sometimes cameras to control the flow of traffic. Timers make sure the lights change after a set period, while sensors detect vehicles waiting at the intersection and adjust the light accordingly. Cameras can track traffic and help adjust light timing. In smart cities, traffic lights are connected to a central system that can change light patterns based on real-time traffic flow.

In some locations, traffic lights have buttons for pedestrians to use when they want to cross the road. These pedestrian buttons inform the traffic light system that someone is waiting to cross. When the button is pressed, it signals the system to change the light, but it doesn't turn green immediately. Instead, it lets the system know that pedestrians are waiting. The button ensures that pedestrians can cross safely at the right time and prevents the light from changing too early when traffic is still heavy. Currently, in Sri Lanka different methods for control traffic lights in pedestrian crossings are available. Such as time base traffic lights and button push traffic lights [30].

Technologies on Traffic Lights replace traditional time-based traffic lights by being linked to a network of sensors monitoring intersections. These devices enable the traffic lights to gather real-time data about the vehicles at the intersection and adjust traffic flow accordingly to optimize efficiency [14]. Technologies on traffic light system is used to solve traffic problems such as regulating traffic. This helps traffic become smoother and avoid traffic congestion.

2.5.1.1 Technology on Traffic Light by using Timer

A timer traffic light uses a fixed schedule to control how long each light stays on. The green, yellow, and red lights change after a set amount of time, in a repeating cycle. The timing is pre-programmed and follow the timer that have been set up. These lights are simple to set up and are often used in areas with predictable traffic. Auxiliary countdown timers, providing the remaining time of the current traffic phase, improve the safety and smoothness of the entire traffic system [15].

Furthermore, timer traffic light also use a timer to decide how long each light stays on. The lights change in a fixed order, no matter how much traffic there is. This helps keep things organized at intersections and makes sure drivers and pedestrians know what to expect. Timer traffic lights are commonly used in places with steady or light traffic. The timers in the system have a predetermined amount of time to switch the direction of traffic flow. Because of this, even though there is little traffic density, vehicles must wait longer [16].

Figure 13 – Timer on Traffic Light

However, some traffic light using timer have been improved their system. An improved system that adjusts traffic light timers based on traffic conditions. The system looks at the number of cars waiting at the previous intersection and counts the vehicles arriving at the current one to adjust the light timers in real-time [17]. By adapting the length of green, yellow, and red lights depending on the number of cars waiting or approaching, it can reduce congestion and improve overall traffic efficiency. For example, if an intersection is congested, the system will extend the green light to clear the traffic, while during lighter traffic periods, it shortens the green light to keep traffic moving smoothly in other directions. This dynamic approach minimizes waiting times, lowers fuel consumption, and helps reduce emissions, while some systems even incorporate predictive algorithms to anticipate traffic patterns and optimize signal timing proactively.

2.5.1.2 Technology on Traffic Light by using IR Sensor

A traffic light using an IR (infrared) sensor is a smart way to control traffic. The IR sensor is placed on the road to detect vehicles. When a car passes by, the sensor picks up the infrared light reflected from the car. Based on this, the system knows there is a car at the signal and can change the light accordingly. If no car is detected, the traffic light stays green, saving time and reducing unnecessary waiting. This system helps improve traffic flow and makes traffic lights more efficient. It is also helpful for areas with low traffic, as the light can change without wasting time for waiting vehicles. The sensor also can store the record by counting the cars pass through the sensor. The microcontroller with the aid of IR sensors keep count of number of vehicles passing on the roads and store these records [18].

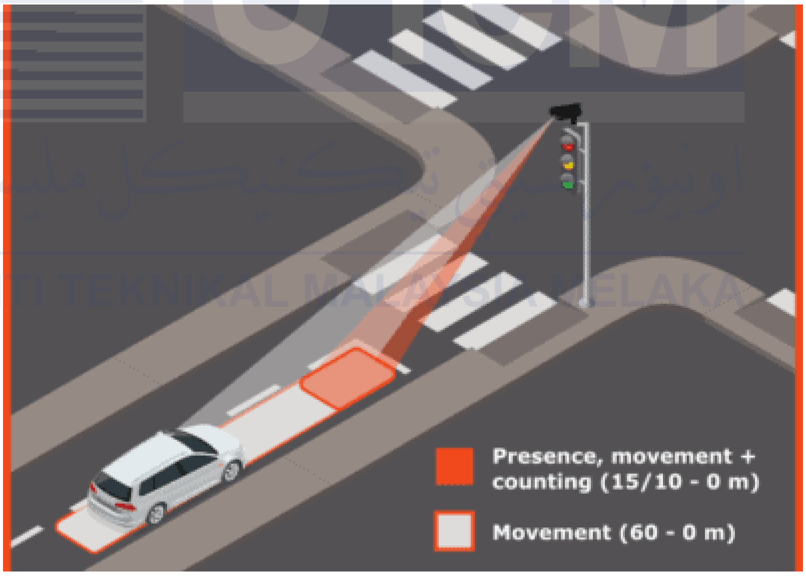

Figure 14 – Infrared Sensor on Traffic Light

The sensor works by emitting infrared light and measuring how it bounces back from nearby objects. If a car passes, it reflects the infrared light which the sensor detects. This tells the system that a vehicle is present. There are two types of infrared sensor which are Passive Infrared sensor and Active Infrared Sensor. A passive infrared (PIR) sensor detects heat emitted by objects, particularly warm bodies like humans and animals. It works by sensing the infrared radiation that these objects emit naturally. When a person or vehicle moves in front of the sensor, it picks up the changes in infrared energy. Traffic is sense using digital IR Sensors and IR Sensors detect vehicles further based on the signal reflected from them. Sensors placed adjacent to the road to control the traffic density by changing traffic signal appropriately [19]. Then, an active infrared (IR) sensor works by emitting infrared light and then detecting the light that bounces back from objects. It has two main parts: an infrared emitter that sends out infrared light and a detector that receives the reflected light. When an object, like a car or person, passes in front of the sensor, it blocks or reflects the infrared light, which the sensor picks up. This change signals the sensor that something is present.

IR sensors play an important role in smart cities by helping manage traffic and improve safety. In a smart city, IR sensors are used in traffic lights to detect vehicles, allowing the lights to change automatically based on real-time traffic conditions. For example, if an IR sensor detects that no cars are present, the traffic light can stay green for cross traffic, reducing unnecessary waiting times. This makes the city's traffic flow more efficient. IR sensors can also help in parking systems by detecting whether parking spaces are occupied, guiding drivers to available spots. Additionally, they can be used in smart street lighting systems, turning lights on only when movement is detected, saving energy. By connecting these sensors to a central system, data can be collected and used to improve traffic planning and overall city management, making the city smarter and more sustainable.

IR sensors are known for being low-cost, making them a popular choice in various applications, including traffic management and safety systems. They are inexpensive to manufacture and maintain compared to other sensors, like ultrasonic or radar sensors. IR sensors work by emitting infrared light and detecting how it reflects off objects, which doesn't require complex technology or high-priced components. This makes them affordable for widespread use, especially in applications where large numbers of sensors are needed, such as in traffic lights, parking systems, and smart city infrastructure. Their low cost, combined with their reliability and ease of installation, makes IR sensors a cost-effective solution for improving traffic flow and safety. The proposed system mainly uses Active IR Sensors for both receiving and emitting infrared radiation. IR sensors are mostly preferred because of its low cost and easy to use [23].

2.5.1.3 Technology on Traffic Light using Ultrasonic Sensor

Ultrasonic sensors in traffic lights help control traffic more efficiently by detecting vehicles and pedestrians. These sensors send out sound waves, which bounce off objects and return to the sensor, allowing it to measure the distance to things like cars or people. The system uses this information to adjust the timing of traffic lights, for example, making a green light longer when cars are waiting or changing lights when no one is around. This helps reduce traffic jams and keeps traffic moving smoothly. Ultrasonic sensors are cost effective, work well in all weather, and are easy to maintain, making them a good choice for modern traffic control systems. The ultrasonic sensors can work all day and their testing accuracy is high, these sensors are deployed around the entrances of intersections to obtain the quantity of the traffic flows [20].

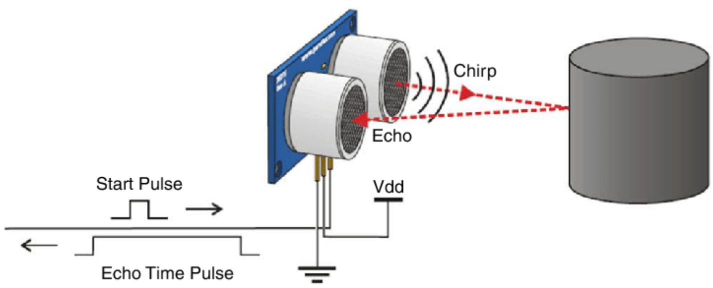

Figure 15 – How ultrasonic sensor works

Ultrasonic sensors are helpful in construction zones for safety and traffic control. They can detect vehicles or construction equipment, helping adjust traffic signals to keep the flow smooth and avoid accidents. These sensors can also monitor the speed of vehicles near the work zone and warn drivers if they're going too fast. They help protect workers by detecting when someone enters a dangerous area and triggering alerts. Additionally, ultrasonic sensors can collect data on traffic, helping manage road closures or lane changes more efficiently. Overall, they make construction zones safer and more organized. The ultrasonic sensor is useful for detecting many kinds of vehicles, such as automobiles, pedestrians, reduced effort, better security, greater security, and cheaper costs were addressed [21].

Ultrasonic sensors work like many others by using a single transducer to transmit and receive pulses [22]. These sensors can be easily integrated with other systems, such as traffic lights, to adjust light timing based on the presence of vehicles. For example, when connected to a traffic light system, the ultrasonic sensor can detect waiting cars and help change the light more efficiently. They can also work with cameras or radar to provide more detailed information, like vehicle speed, and be linked to central traffic management systems to share real-time data for better decision-making. This integration helps create smarter and more efficient systems in construction zones or smart cities.

An ultrasonic sensor is a directional sensor, which means it can focus on objects in front of it but cannot detect objects behind it. This allows the sensor to be focused on a specific angle, making it ideal for applications where precise detection in one direction is needed. In a construction zone, this directional capability is useful for detecting vehicles or equipment approaching a work area, helping to manage traffic flow and improve safety. Since it cannot detect objects behind it, the sensor can be positioned to monitor specific areas, ensuring accurate data collection and preventing interference from irrelevant sources. Traffic management is also done by the control unit in tandem with the ultrasonic sensors placed at the dividers of the road. It senses the density of the traffic and through the website gives the information about the level of traffic congestion [24].

2.5 Sensor Comparison from Previous Work Related to the Project

Table 2 - Comparison between Sensors used in Portable Traffic Light

No	Article / Author	Year	Title	Hardware	Summary
1	Deepika, J. Akilandeswari, J.	2024	Autonomous Vehicle Driver Assistance System for Road Signs and Lane Detection Based on Deep Neural Networks Framework	Camera (Lane Detection)	This journal explores using deep neural networks for traffic sign recognition, lane detection, and vehicle identification in autonomous driving. It improves traditional methods by using previous frames for better lane detection and aims for real-time performance with minimal hardware. The system's effectiveness is measured by accuracy, data collection, and efficiency.
2	Devika S Govind A Lekshmi D	2024	Next-Generation Traffic Control: Adaptive Timer and Emergency Vehicle Priority in Intelligent Traffic Management	Camera (Vehicle Detection)	This journal presents an adaptive traffic control system that adjusts signal timings based on vehicle counts and prioritizes emergency vehicles using YOLO v8 and siren recognition. The system improves traffic flow, reduces delays, and enhances public safety compared to traditional fixed systems.
3	Soom J Leier M Janson K Tuhtan J	2024	Open Urban mmWave Radar and Camera Vehicle Classification	Radar and Camera	This journal discusses the challenges of using cameras for traffic monitoring in adverse weather conditions like fog, rain, and snow, which can reduce the performance of vehicle detection systems. It evaluates open camera and mmWave radar

			Dataset for Traffic Monitoring		data for classifying vehicles on embedded hardware and introduces an open multi-sensor traffic monitoring dataset with over 8,000 annotated frames and radar point clouds collected in various weather conditions.
4	Ghodhbane, Raouia Masmoudi Hernandez, Aurelien	2024	A Pressure and Temperature Wireless Sensing Network Communicating with LoRa Modulation	LoRA (SX1280)	This paper explores using LoRa technology to collect pressure and temperature sensor data over a wide range. It evaluates the performance of a LoRa network with different settings and successfully transmits data despite interference in the 2.4 GHz band. The study also examines the communication range under various spreading factor settings.
5	Bhavanam, Bhanu Pratap Reddy	2024	Exploring LoRa Signal Propagation in Indoor and Outdoor Environments: A Comparative Study	LoRA (SX1276)	This study compares LoRa signal propagation in indoor and outdoor environments, focusing on signal attenuation. Conducted at VIT University, India, the research examines received signal strength (RSSI) and signal-to-noise ratio (SNR) over distances of 72.9 meters indoors (across 8 floors) and 1050 meters outdoors. The results show that LoRa experiences greater signal attenuation indoors than outdoors, highlighting its distinct characteristics and potential for various applications in both environments.

6	Ghodhbane, Raouia Masmoudi	2024	Maximization of Wireless Sensing Network's Throughput Communicating with Long Range (LoRa) Modulation	LoRA (SX1280)	This paper presents a method to maximize throughput in a wireless sensing network using LoRa modulation at 2.4GHz. The proposed network topology relies on adjusting the spreading factor (SF) in scenarios with dense traffic between a LoRa master board and multiple sensor nodes. The receiver dynamically adjusts the SF during the preamble period using channel activity detection, optimizing throughput without excessive packet exchanges. The paper examines the performance of the proposed dynamic SF adjustment algorithm across various scenarios and SF settings.
7	Vyas, Toral Varia, H. R.	2023	Impact of Construction Work Zone on Urban Traffic Environment		This research focuses on improving traffic management in construction work zones (CWZs), considering both traffic congestion and environmental factors like air pollution and noise. Using TransCAD to estimate air pollution and AI-based models (ANFIS, FFNN, SVR) to predict noise levels, the study analyzes the impact of traffic flow, speed, and heavy vehicle ratios. The proposed model suggests using traffic diversion signs to guide drivers and optimize traffic flow, offering an analytical solution for managing CWZs and minimizing their environmental impact.

8	Zelikov, Vladimir Denisov, Gennady	2023	The Use of Duplicate Transport Traffic Lights	Traffic Light	This paper proposes a new traffic light design to improve safety at the Sretensky Boulevard and Academician Sakharov Avenue intersection. The compact design enhances visibility, allows height adjustments, and reduces delays, improving road safety and traffic flow for cyclists and drivers.
9	Zhang, Shuyang Zhang, Qingwen	2023	A VT-HMM-Based Framework for Countdown Timer Traffic Light State Estimation	Countdown Timer Traffic Light	This paper presents a state estimation framework for countdown timer traffic lights, aiming to improve road safety and traffic flow. The system integrates time-domain information into a variable transition Hidden Markov Model (VT-HMM) to estimate traffic light colors and countdown numbers from noisy inputs. It uses a dynamic state transition matrix and a Viterbi-based recursive decoding method to select the optimal state chain. Experiments demonstrate the system's robustness and effectiveness, as well as its performance under varying noise levels.
10	Tomar, G. S.. Bansal, Jagdish Chand.	2023	Smart Traffic Light	Camera Detection	This paper proposes a traffic management system that adjusts signal timers based on real-time traffic density using machine learning and image processing. It optimizes traffic flow at four-way intersections by estimating traffic and adjusting signal

					timings, reducing congestion and mimicking a traffic officer's decision-making.
11	Thota, Mahesh Kumar Prathibhava	2023	Emergency Vehicle Detection Using IoT in Smart Cities	Ir Sensor Radio-Frequency	This paper explores the use of IoT and edge computing for real-time video analytics in emergency vehicle detection in smart cities. It examines the integration of sensor networks, computer vision algorithms, and edge computing, focusing on low latency, accuracy, and resource optimization. The goal is to improve emergency response systems, enhancing efficiency and safety in smart cities.
12	Jagadeesh, Vaddi Reddy, Thumkunta Lokeshwar	2023	Traffic Control System for Emergency Vehicles using RFID and Sensors	Ultrasonic Sensor	This paper presents a system for prioritizing emergency vehicles at traffic signals to improve response times during emergencies. The system uses Radio Frequency Identification (RFID) to identify emergency vehicles and ultrasonic sensors to detect traffic density. When an emergency vehicle approaches a traffic signal, the system automatically adjusts the signal to clear the path, allowing the vehicle to pass without delay. This process continues until the emergency vehicle reaches its destination, all without human intervention.
13	Lavric, Alexandru Petrariu, Adrian I.	2022	LoRa Modulation: A 2.4GHz Communication Strategy	LoRA (SX1280)	This paper examines LoRa modulation technology and its potential for solving key IoT challenges, such as power efficiency and long communication distances. It evaluates the

					performance of LoRa 2.4GHz modulation, highlighting its advantages for IoT applications. Additionally, the paper introduces a Software Defined Radio (SDR) traffic generator for LoRa, designed to assess the scalability of LoRa 2.4GHz technology. The traffic generator is implemented and tested using SDR hardware.
14	Kamoona, Zaid Jameel Radhi Ilyas, Muhammad	2022	Investigating the Performance of LoRa Communication for Nominal LoRa and Interleaved Chirp Spreading LoRa	LoRA	This paper introduces Interleaved Chirp Spreading LoRa (ICS-LoRa) to improve the data transmission rate of LoRa networks. It compares Nominal LoRa and ICS-LoRa using two transmitters and receivers. Simulations with different spreading factors show both systems detect the same symbols, with ICS-LoRa resulting in a 50% decrease in FFT amplitude, indicating a trade-off between range and transmission rate.
15	Maduka, N. C. Ajibade, I. I.	2022	Modelling and Optimization of Smart Traffic Light Control System	IR Sensor	This research proposes a smart traffic management system for a four-way junction, using a PIC microcontroller and IR sensors to dynamically adjust signal timings based on traffic density. The system includes a crossbar to reduce traffic violations and improve flow. It aims to ensure smooth traffic management by responding to various traffic conditions effectively.
16	Weijing Shi; Ragunathan	2021	Opportunities and Challenges for Flagman	Camera	This paper addresses the challenges of gesture recognition for autonomous vehicles interacting with flagmen during road

	Rajkumar; Eran Kishon		Recognition in Autonomous Vehicles		construction. It presents (i) a taxonomy for organizing traffic gestures, (ii) a large dataset of flagman gestures, and (iii) experiments on gesture recognition algorithms. The study categorizes gestures based on semantics, appearance, and context, collecting data on various gestures with and without props like signs and flags. A recognition algorithm is developed, using different human pose features, and extensive experiments are conducted to evaluate each component.
17	Basla Siripatana; Kittipong Nopchanasuphap; Somporn Chuai-Aree	2021	Intelligent Traffic Light System Using Image Processing	Camera	This paper presents an intelligent traffic light system that adjusts waiting times based on real-time traffic volume using image processing. The system calculates vehicle counts and waiting times from traffic video, optimizing green and red light durations to reduce delays by 45.35%. Developed with Lazarus and OpenGL, it contributes to smart city development and promotes STEM education through IoT and AI integration.
18	Chanwattanapong, Wanchalerm Hongdumnuen, Suthat	2021	LoRa Network Based Multi-Wireless Sensor Nodes and LoRa Gateway for Agriculture Application	LoRA (SX1276)	This research presents a LoRa network for agricultural applications, using sensor nodes to measure soil moisture, temperature, humidity, raindrops, and light intensity. The system transmits data over 925.2 MHz for node-to-gateway and 2.4 GHz for gateway-to-cloud communication. Experimental results show over 90% accuracy in soil moisture measurements

					at various depths, with a 600-meter LoRa range and cloud data transmission every 15 seconds.
19	Zhang, Xingyu Guo, Liping	2021	Research on Traffic Information Perception Technology Based on Radar and Video Fusion	Radar Sensor	This paper explores traffic information perception technology by integrating millimeter-wave radar and video sensors. It aims to enhance the accuracy and comprehensiveness of traffic data for applications like traffic prediction and signal control. By combining radar and visual sensor data, the system provides a more reliable and detailed traffic perception, laying the groundwork for the development of intelligent traffic systems.
20	Dzhibarov, Dian Grigorov, Ivan	2021	Road traffic modelling and development of a specific traffic light control system		This paper focuses on developing a traffic signal control system for a specific intersection. It examines vehicle, pedestrian, and other traffic movements at the intersection, aiming to reduce congestion. A traffic flow model is created to assess the intersection's performance, optimize signal phase lengths, and improve traffic signal cycles. The study proposes a concrete solution for effective traffic light control to enhance traffic management and reduce obstructions.

21	Gopinath, N. Ezhilarasi, D.	2021	Self-Activating Street Lights Using Sensors and Arduino	Ultrasonic Sensor	This paper presents an automated street lighting system to reduce energy waste by controlling light intensity based on environmental brightness and movement detection. The system uses an Arduino UNO board integrated with sensors to adjust the brightness of LED lights. The sensing unit detects surrounding light levels and human or vehicle movement, enabling efficient operation of street lights. This approach provides an energy-saving and environmentally friendly solution to street lighting management.
22	Chang, Daeyeol Hopfenblatt, James Edara, Praveen	2020	Immersive Virtual Reality Training for Inspecting Flagger Work zones		This study developed an immersive virtual reality training module for transportation agency staff who inspect flagger operations in road construction and maintenance work zones. The training aims to provide a realistic experience in an immersive environment, using current traffic control protocols and standards. The module was created by modeling roadway geometrics, work zone signage, and flagger movements through motion capture technology. Feedback from staff at a state department of transportation (DOT) showed strong support for the virtual reality approach, highlighting its advantages over traditional training methods.

23	Liya M L ; Aswathy M	2020	LoRa technology for Internet of Things(IoT):A brief Survey	LoRAWAN	This work focuses on the use of LoRaWAN technology for sensor systems in the Internet of Things (IoT). It reviews existing literature to explore the potential applications of LoRaWAN, providing valuable insights for researchers and designers on its feasibility for system integration and data transmission.
24	Wickramasinghe, K. S. Ganegoda, G. U.	2020	Pedestrian detection, tracking, counting, waiting time calculation and trajectory detection for pedestrian crossings traffic light systems	Camera (Image Processing)	This paper explores the use of image processing technologies to enhance pedestrian safety and traffic flow at crossings in Sri Lanka. By implementing pedestrian detection, tracking, counting, waiting time detection, and trajectory analysis, the paper aims to improve traditional traffic light systems. The Haar-cascade classifier for pedestrian detection achieved 50.47% precision and 85.5% recall. The pedestrian counting module had 72% accuracy, while the waiting time model showed an average error rate of 0.714. The trajectory detection module achieved a 78.23% correct prediction rate.
25	Firdous, Anam Niranjan, Vandana	2020	Smart Density Based Traffic Light System	IR Sensor	This paper proposes a smart traffic management system to address traffic congestion and reduce delays at traffic junctions. Unlike conventional systems that require manual intervention, the system uses Arduino Uno with IR sensors to automatically adjust traffic signal timing based on real-time traffic density. IR

					sensors detect vehicles by measuring the signal reflected from them, and the system processes this data to control the traffic signals, which are designed using LEDs. Additionally, the system is powered by solar energy, making it an energy-efficient solution for managing traffic more effectively.
26	Jihene REZGUI, Mamadou BARRI and Reiner GAYTA	2019	Smart Traffic Light Scheduling Algorithms	Traffic Light	This paper proposes three Smart Traffic Light Scheduling (STLS) algorithms designed to improve traffic flow at intersections. Unlike traditional systems, which use pre-determined cycles, the proposed algorithms incorporate real-time data, considering both vehicle density and waiting times. The algorithms also prioritize emergency vehicles. Simulations on the Isolated Intersection Simulator (IIS) platform show that the STLS algorithms significantly reduce traffic congestion, tripling the performance of traditional traffic lights. Additionally, they nearly double the average vehicle speed and cut the number of idle vehicles by half.
27	Shilpa Devala ; A. Karthikeyan	2019	LoRa technology-an overview	LoRA	This paper discusses the growing popularity of IoT and the need for low-power, long-range technologies for battery-operated systems. While existing technologies like Zigbee, Wi-Fi, and Bluetooth consume high power, LoRa (Long Range) is an emerging solution that addresses these challenges. LoRa

					provides low power consumption with long-range capabilities, making it ideal for embedded systems in IoT applications. The paper highlights the advantages of LoRa over other technologies and explains the features of LoRaWAN (Long Range Wide Area Network), an open, secure standard for IoT connectivity supported by the non-profit LoRa Alliance.
28	Jihene REZGUI, Mamadou BARRI and Reiner GAYTA	2019	Smart Traffic Light Scheduling Algorithms	Traffic Light	This paper proposes three Smart Traffic Light Scheduling (STLS) algorithms to improve traffic flow and reduce congestion. Tested on the Isolated Intersection Simulator (IIS), the algorithms consider both traffic density and vehicle waiting times, while prioritizing emergency vehicles. Simulations show a threefold reduction in delay times, nearly double the average vehicle speed, and a halving of static vehicles compared to traditional systems.

2.6 Summary

This section provides an overview of the research relevant to our project. Chapter 2 of the study reviews key concepts and technologies related to traffic management, focusing on construction zones and traffic lights.

Construction zones are areas where roadwork takes place, often causing traffic congestion, delays, and confusion due to unclear signage. Various road types in Malaysia, including highways and rural roads, face specific challenges related to congestion, maintenance, and safety.

Flagmen, responsible for directing traffic in construction zones, ensure safety, but automated flagmen using sensors and cameras are being introduced to reduce human error and increase consistency. Long Range (LoRa) technology, which offers long-distance communication with low power consumption, is being used in IoT applications for smart cities and other industries.

Traffic lights help manage vehicle and pedestrian flow, reducing accidents and improving safety. Smart traffic light systems, using timers, sensors, and cameras, adjust in real time to optimize traffic flow. Technologies such as IR and ultrasonic sensors detect vehicles and adjust light timing and reliable performance in all weather conditions.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter outlines the methods and strategies utilized development of revolutionizing portable traffic light control using LoRA wireless technology. It also offers an overview of the project's flowchart, block diagram, parameters, and testing techniques employed to visualize, process, and incorporate the portable traffic light into the LoRa system.

3.2 Project Flowchart

The system uses an ultrasonic sensor to accurately count how many vehicles are crossing the road. When a vehicle is detected, information about movement is collected and sent wirelessly through the LoRA module to a receiver unit. Once the receiver gets this important data, it triggers a quick response by turns the first traffic light green so the vehicle can go. At the same time, the other traffic lights turn red and the vehicles at there have to stop at the traffic light line and letting the vehicle move smoothly in the detected direction.

This smooth coordination helps traffic flow more efficiently and makes intersections safer. By quickly changing traffic lights based on real time sensor data, the system reduces traffic jams and lowers the risk of accidents. Additionally, the wireless transmission of vehicle information through the LoRa module ensures fast communication between the detection unit and the traffic system, allowing quick decisions and precise control of traffic. With this system, traffic is managed more effectively, vehicle movement is prioritized, and road safety is improved.

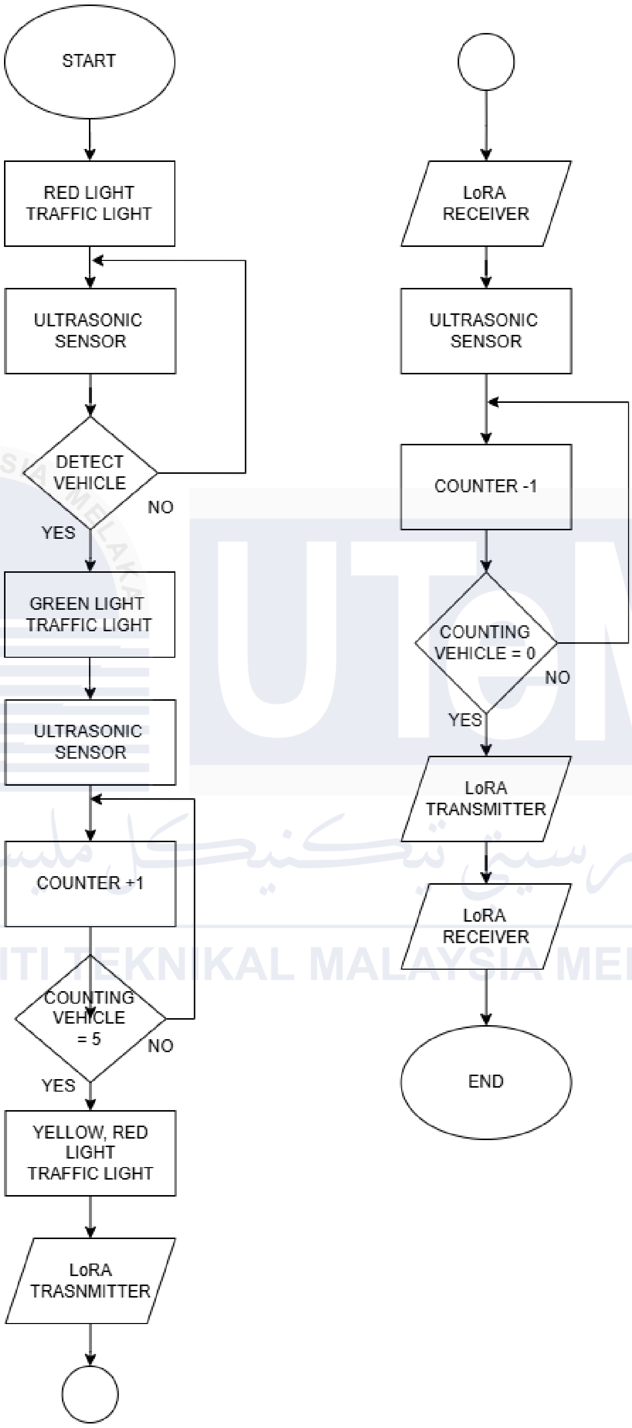

Figure 16 - Flowchart of The Project

3.3 Project Overview

The goal of this project is to create a portable traffic light control system using LoRA wireless technology. LoRa stands for Long Range, and it provides the wireless connection for traffic light systems. The core of the system is the Arduino MEGA which runs the control algorithm that manages the traffic lights. The LoRa module handles communication, ensuring reliable data transfer over long distances. By combining these components, the project aims to improve traffic management, making it more flexible and efficient for use in different places.

The project began by building the LoRa system, using the LoRa module to send and receive the control signals. The system also uses an ultrasonic sensor to detect traffic and identify busy roads where the traffic light needs to change. By using the sensor's ability to detect cars, the project aims to create a responsive traffic light system that improves road safety and helps traffic flow more smoothly.

Figure 17 - Project Overview

During the testing phase, the project carefully examined all the different parts such as the simulated traffic lights, the rules for controlling traffic flow, the vehicle detection systems, and the LoRa communication system. Each part was tested one by one to ensure it worked properly. This meant making sure that every component was able to do its job as it was supposed to and met the required standards. By testing each part comprehensively, any potential issues could be spotted early on, which allowed for adjustments or improvements to be made right away. This careful testing process helps ensure that when everything comes together, the entire system will run smoothly without any problems.

The testing also helped identify areas that might need improvement. If any part wasn't working perfectly or needed some changes, those changes were made to improve the performance of that specific component. This way, we ensured that each piece of the system was ready to work at its best. After everything was tested and fine-tuned, the next step was to put all the parts together to form a complete traffic light system. By doing this, we made sure that every part worked well with the others and that the whole system would function properly in any traffic situation. The goal was to ensure that the system would be able to handle different types of traffic flow smoothly, without causing any issues or delays.

3.4 Project Block Diagram

The main input for this product is ultrasonic sensors, which play a key role in detecting vehicles on the road in construction zones. These sensors detect vehicles in real-time and send the data for further use. To transmit this data wirelessly, the product uses the SX1278 LoRA module. This wireless connection allows smooth communication between the traffic light systems and the traffic flow algorithms, helping to make real-time changes based on the vehicle detection.

The brain of this product is the Arduino MEGA microcontroller. The Arduino runs the programmed instructions and controls all the connected parts. It acts as the main unit that brings together inputs from the ultrasonic sensors and the LoRA transmitters. The product also uses a special library for the ultrasonic sensors to help detect vehicles. The information gathered from the sensors is then used to adjust the traffic flow, ensuring safety in construction areas.

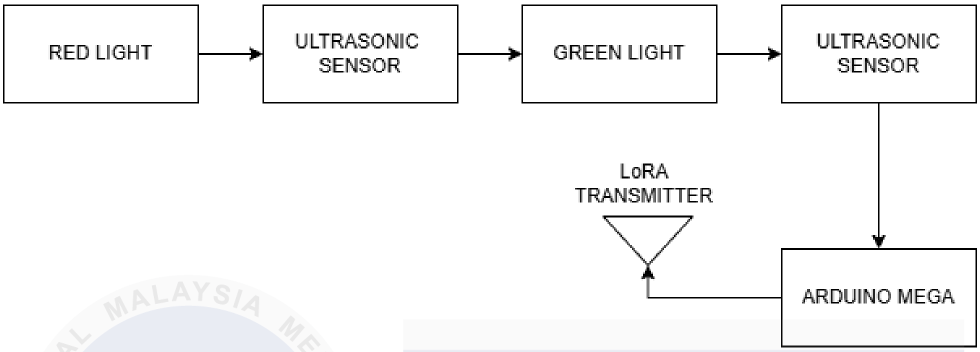

Figure 18 - Block Diagram of Transmitter

This product includes an LED on traffic light to show the current traffic conditions. These lights work like the other traffic light by changing from red to green to yellow based on the traffic status. The system is powered by a 5V source which helps save energy and making it perfect for long-term use at construction sites. The LED is controlled by an Arduino MEGA which helps ensuring smooth traffic flow and improving safety on the road. By bringing all these parts together, the product makes traffic management more efficient and also helping track vehicles and communicate effectively.

The Arduino ensures that the LED displays the traffic conditions accurately, providing precise control over the light's changes. This control method not only makes the system more reliable but also allows it to adjust smoothly to different traffic situations. By combining these components, the product provides a complete solution for managing traffic flow, improving safety, and enabling real-time communication and vehicle tracking and helps improve the overall efficiency of transportation management.

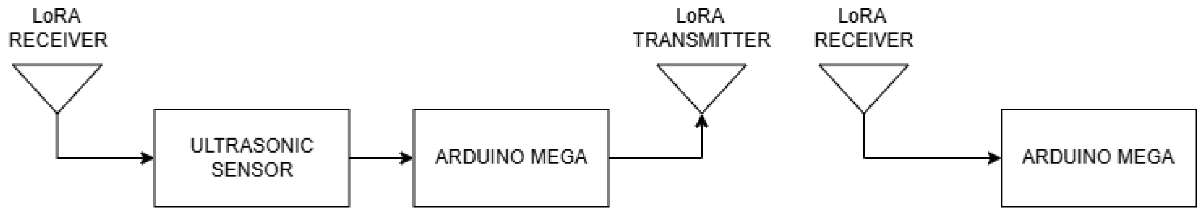

Figure 19 - Block Diagram of Receiver

3.5 Project Hardware

The hardware of this project includes several important parts, such as the ultrasonic sensor, LoRA module, LEDs, LCD 16x2 and Arduino MEGA.

3.5.1 Arduino MEGA

The Arduino Mega is a powerful microcontroller board with more pins and memory than other Arduino boards, making it ideal for larger projects. It has 54 digital I/O pins, 16 analog inputs, and can control a variety of sensors, motors, and lights. Programmable through the free Arduino software which is Arduino IDE, it is commonly used for robotics, home automation, and other projects that require multiple connections and complex control.

The function of the Arduino Mega is to act as the brain of an electronic project, controlling and managing various components like sensors, motors, lights, and displays. It takes input from sensors (such as ultrasonic or motion sensors), processes that data, and then makes decisions or actions based on the code have been written. It can control outputs like turning on a light, moving a motor, or sending data to a computer. With its many input/output pins, the microcontroller is especially useful in complex projects that require a lot of connections or need to handle multiple tasks at once.

In this project, the Arduino Mega is the microcontroller, and it executes the program to carry out all the tasks that have been written. Once the program is uploaded to the Arduino Mega, it begins running automatically. The code instructs the Mega on what actions to take, such as reading inputs from sensors, processing that information, and controlling outputs like lights and displays. The Mega continuously performs these tasks in a loop, following the instructions from the program, until it is turned off or the code is changed. This makes the Arduino Mega the central control unit, handling all the operations in the project based on the programmed logic.

Figure 20 – Arduino Mega

3.5.2 Ultrasonic Sensor

An ultrasonic sensor uses sound waves to measure distance or detect objects. It emits high-frequency sound waves that bounce off objects and return as an echo. By measuring the time it takes for the sound to return, the sensor calculates the distance to the object. Ultrasonic sensors are widely used in applications like distance measurement. It also offering reliable performance in various environments, even in the dark, making them ideal for object detection and proximity sensing.

An ultrasonic sensor is generally considered a **digital sensor** because it works by sending a pulse and measuring the time it takes for the echo to return, which is processed as a digital signal. The sensor typically outputs a digital pulse (high or low) to indicate whether an object is detected or not, and the microcontroller uses the time duration of this pulse to calculate distance. Although the measurement involves time (which can be seen as an analog concept), the sensor's output is usually treated as a digital signal for easy processing by devices like Arduino or other microcontrollers.

In this project, ultrasonic sensors have been used to detect vehicles such as lorries, buses, cars, and motorcycles. The first sensor is used to detect whether there are any vehicles present. The second sensor is used to count how many vehicles enter the construction zone. The third sensor is used to count how many vehicles exit the zone.

Figure 21 – Ultrasonic Sensor

3.5.3 SX1278 LoRA Module

LoRa technology was created in **2009** by **Semtech Corporation**, a company that specializes in analog and mixed-signal semiconductors. The technology was developed to provide long-range, low-power communication for Internet of Things (IoT) applications, addressing the need for wireless networks that could cover large areas while consuming very little energy. LoRa's capabilities have since made it widely adopted in various industries, from smart cities to agriculture and asset tracking.

The LoRa SX1278 module is a wireless communication device that uses LoRa (Long Range) technology to transmit data over long distances with low power consumption. Operating in the 433 MHz frequency band, it is ideal for IoT projects, remote sensing, and applications like smart agriculture or asset tracking. The module can send data over several kilometers while using minimal energy, making it perfect for battery-powered devices.

The range of the LoRa SX1278 module can vary depending on factors like the environment, antenna, and power settings. In ideal conditions, such as an open field with no obstacles, the SX1278 can transmit data up to **15 kilometers** or more. In urban environments or areas with obstacles like buildings and trees, the range may be reduced, typically ranging between **2 to 5 kilometers**. Using high-gain antennas or increasing transmission power can also help extend the range further.

Its energy efficiency allows devices to run on battery power for years, unlike Wi-Fi or Bluetooth, which consume more energy and have shorter ranges. This makes LoRa a popular choice for IoT, smart agriculture, and long-distance wireless communication projects.

In this project, LoRa is used to transmit and receive data between two traffic lights. The LoRa modules enable the traffic lights to communicate wirelessly over a long distance, allowing them to share information such as signal status or traffic flow. This communication could be used to synchronize the lights, improve traffic management, or even allow remote monitoring. The long-range and low-power nature of LoRa make it ideal for this application, especially in areas where traditional wired connections may be difficult or costly to implement.

Figure 22 – LoRA SX1278 Module

3.5.4 16x2 LCD

A 16x2 LCD is a display screen that can show up to 32 characters, arranged in 2 rows of 16 characters each. It is commonly used in electronics projects, especially with Arduino, to display simple text or data like sensor readings or status messages. These LCDs are popular due to their affordability, ease of use, and low power consumption. They can be connected by a parallel interface or an I2C module, which simplifies wiring and communication with microcontrollers.

The screen is compact, energy-efficient, and does ntt require a complex graphical interface, making it perfect for applications like counter, reader sensors, or control panels. Additionally, its low cost and wide availability make it a popular choice.

Figure 23 – 16x2 LCD

The 16x2 CD is used to show important information about how the traffic light system is working in real-time. It can display details about the number of vehicles detected by the system. The LCD also shows when data is being sent or received by the system, so you can see if everything is working correctly. For example, if the system detects a vehicle, the LCD will display the count of cars, and if data is being transferred with receiver, the screen will show that the system is sending or receiving information.

3.5.5 LED Traffic Light

LED traffic light uses light-emitting diodes to display red, yellow, and green signals, offering advantages like energy efficiency, durability, and brighter visibility in various weather conditions. Compared to traditional lights, LEDs consume less power, last longer, and require less maintenance, making them more cost-effective over time. They are commonly used in modern traffic systems for better performance and reliability and can be integrated with smart traffic management systems for more advanced features like adaptive signal control.

LED traffic lights are more better because they are more energy-efficient, lasting longer and using less power than traditional incandescent or halogen lights. This reduces both energy costs and the frequency of maintenance or bulb replacements. LEDs are also brighter and more visible, making them safer for drivers in various weather conditions, such as fog or direct sunlight. Additionally, LED lights can be easily adapted for smart traffic systems and have a longer lifespan, making them a cost-effective and environmentally friendly choice for modern traffic control.

In this project, LEDs are used to show visual signals and indicate the status of the system. They light up in different colours (like red, yellow, and green) to let people know what is happening with the traffic lights. The Arduino MEGA acts as the brain of the system. It is a small computer that controls how everything works. It connects and manages all the different parts of the system, like the sensors and the LEDs, making sure they all work together correctly. The Arduino MEGA sends instructions to the LEDs, telling them when to light up, and it also collects data from the sensors to make decisions, such as changing the traffic lights when cars are detected. By organizing all these components, the Arduino helps the system run smoothly and efficiently.

Figure 24 – LED Traffic Light

Additionally, the project integrates a real traffic light, which serves as an output device, demonstrating the practical application of the system. This setup not only showcases the project's technical capabilities but also illustrates its potential for real-world implementation in traffic management and control systems.

Table 3 - List of Components

NO	NAME OF COMPONENT	QUANTITY
1	ARDUINO MEGA	2
2	SX1278 LoRA Module	2
3	ULTRASONIC SENSOR	2
4	TRAFFIC LIGHT LED (RED, YELLOW, GREEN)	2
5	LCD 16x2	2

3.5.1 Schematic Circuit

The traffic management system shown in the diagram is like a roadmap detailing how different parts work together. In this project, the circuit are starts with the ultrasonic sensor, gathering info about vehicles detect or not and passing through the traffic light stop line. Then comes the Arduino MEGA, which is the microcontroller of this project, process the data and sending instructions. The LoRA modules are used for wireless connection to transmit and receive data. Finally, there are the LED traffic lights, controlled by the microcontroller, showing drivers when to stop or go based on the situation. This system is using modern tech to make intersections safer and traffic smoother.

The circuits used to transmit and receive signals are designed with the same components and connections. This means that the components and wiring used for transmission are the same as those used for reception.

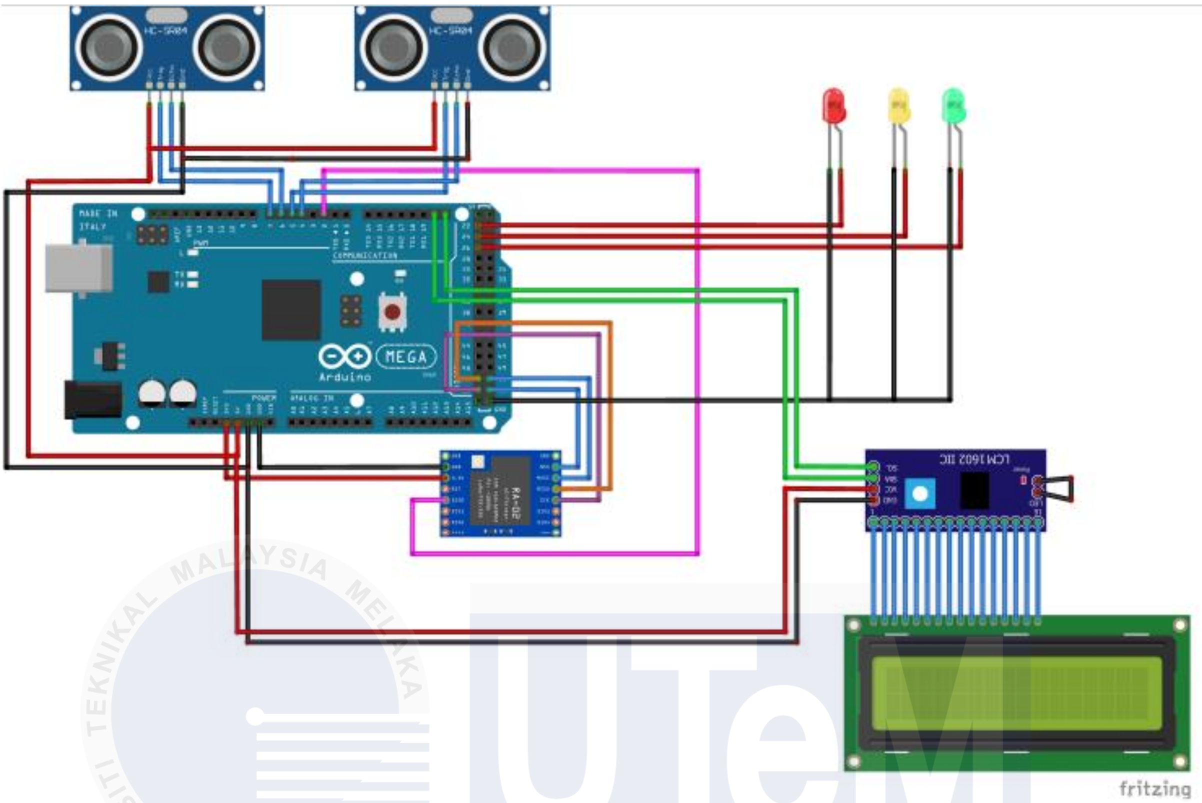

Figure 25 - Schematic Circuit

3.6 Project Software

The software for this project is created using the Arduino IDE, which is a program used to write and upload code to the Arduino MEGA as the main controller of the system. The Arduino IDE uses the C++ programming language to create the main functions and control how the hardware parts work. This platform makes it easy for developers to write the code, check it for errors, and send it to the Arduino MEGA. Using the Arduino IDE helps make sure the system works smoothly by allowing the code to work well with the other parts of the project.

Figure 26 - Arduino IDE

3.6.1 LCD Library

The 16x2 LCD screen needs a special library, to show information correctly. A library is like a helpful tool that makes it easier to control the LCD. For this project, we are using a library called **LiquidCrystal_I2C**, which was created by Frank de Brander. This library allows the Arduino to easily communicate with the LCD and control what is shown on the screen. It handles tasks like displaying text, making sure the letters appear in the right place, and updating the display when needed. Without this library, it would be much harder to get the LCD to work properly. By using this library, we can display real-time information, like traffic light status and vehicle counts, on the screen without any complicated setup.

3.6.2 LoRA Library

The LoRA module also needs its own library to help it communicate between the Arduino and the LoRA device. A library makes it easier to send and receive data wirelessly. For this project, we are using a library called **LoRA**, which was created by Sandeep Mistry.

This library allows the Arduino to easily send information to the LoRA module, and vice versa, without needing to manually handle all the complicated details of wireless communication.

By using the LoRA library, the system can send and receive data over long distances without wires. This is important for tasks like sharing traffic information between sensors and traffic lights. The library makes sure that the data is transmitted correctly, ensuring the system works smoothly. Thanks to this library, we can set up a reliable and efficient wireless connection between the different parts of the system, helping them work together in real time.

3.7 Printed Circuit Board (PCB)

A Printed Circuit Board (PCB) is a flat board used in electronics to connect and hold different components like chips, resistors, and capacitors. It has thin copper paths that carry electrical signals between parts. PCBs are found in almost all electronic devices, helping them work properly by providing a way for the parts to communicate and be connected.

In this project, the PCB is used as the main board to connect all the parts, like the ultrasonic sensor, LCD, LoRa, LED traffic light and Arduino Mega. It acts as a platform to link everything together so they can work as one system. The design of the PCB was made using Proteus software, which helped to draw and test the circuit before building it. This software made sure that all the parts are connected correctly and will work properly in the project. The figure below shows the circuit connection in Proteus before creating the PCB schematic. The circuit are same for both transmitter and receiver module.

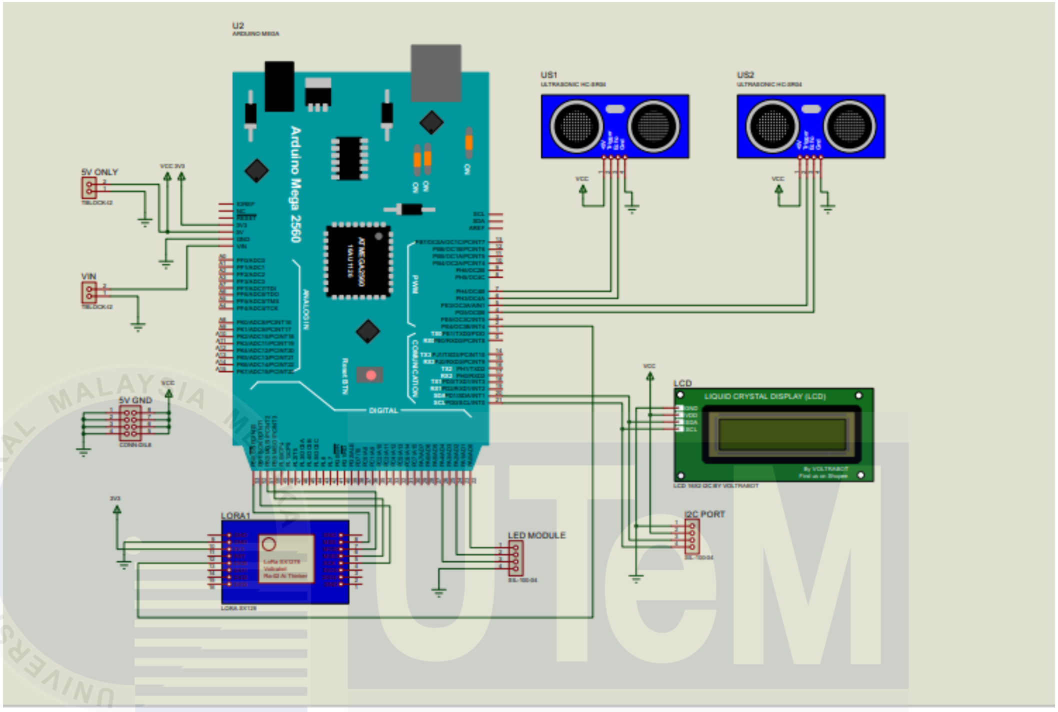

Figure 27 – Schematic Circuit for PCB Board

Once the circuit is created, it needs to be converted into a PCB schematic diagram. This diagram helps show how the components will be placed on the board. After that, the PCB can be designed based on the user's preferences, including the layout and how the parts are arranged on the board. The design process allows for the proper placement of components, ensuring the board will function correctly and fit the desired size and shape for the project. The figure below shows the result of the board after convert to PCB schematic diagram.

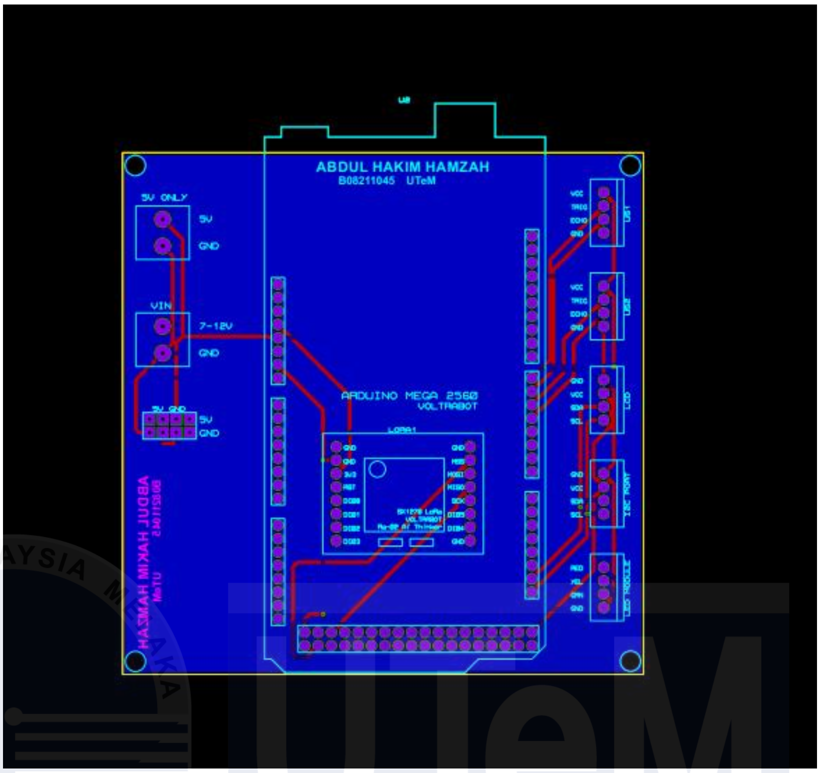

Figure 28 – PCB Schematic Diagram

Once the PCB schematic has been created, the design can be viewed in 3D using the software. In the 3D view, the user can see how the board will look in real life, giving a clear idea of the layout, component placement, and overall appearance before it is actually built. This helps in making sure everything fits correctly and looks as expected.

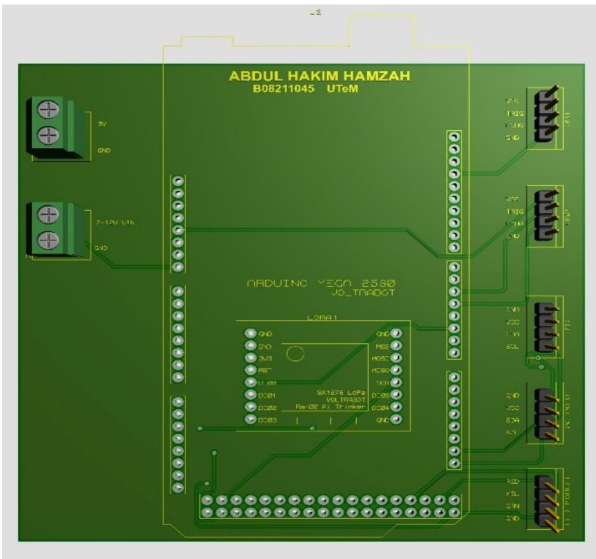

Figure 29 – PCB Board in 3D view

Lastly, the design can be printed and transferred onto the board. Before adding the components, the user can place male or female pins to make it easier to insert and remove the components later. These pins must be soldered onto the board and will stay permanently in place. This step helps ensure that the components can be easily connected and disconnected during the assembly process.

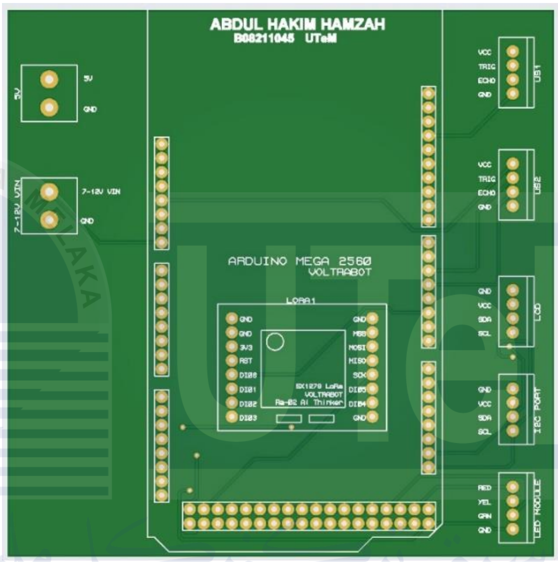

Figure 30 – PCB Board

3.8 Summary

This chapter explains the methods used in this project. It starts with an overview of the project, describing its size and scope. The project block diagram provides a simple visual showing how all the parts of the project are connected and organized. Next, the hardware and software used in the project are discussed, explaining the specific components, the microcontroller, and the software programs that were used to build and run the project. This section covers both the hardware and software parts. Then, the project flowchart shows the steps or actions followed in the project, making it easier to understand how everything works. Lastly, the schematic circuit diagram shows all the electrical connections and parts used in the project, which helps in setting it up and using it correctly.

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Introduction

This chapter looks at the creation of a new portable traffic light system. It uses LoRA technology for easy communication and ultrasonic sensor real-time detection. The chapter explains the whole process of building the system from the first idea to the finished product, including steps like development, testing, simulations, and solving problems. This chapter is important because it shows if the project's original goals were achieved. It also checks how well the system works and looks at how useful tools like the Arduino IDE software were in building it.

4.2 Result

The traffic light system was tested using an Arduino MEGA and other component such as ultrasonic sensor, LCD and LoRA module. This setup included connecting an ultrasonic sensor to the Arduino MEGA to detect vehicles and control the algorithm of the traffic.

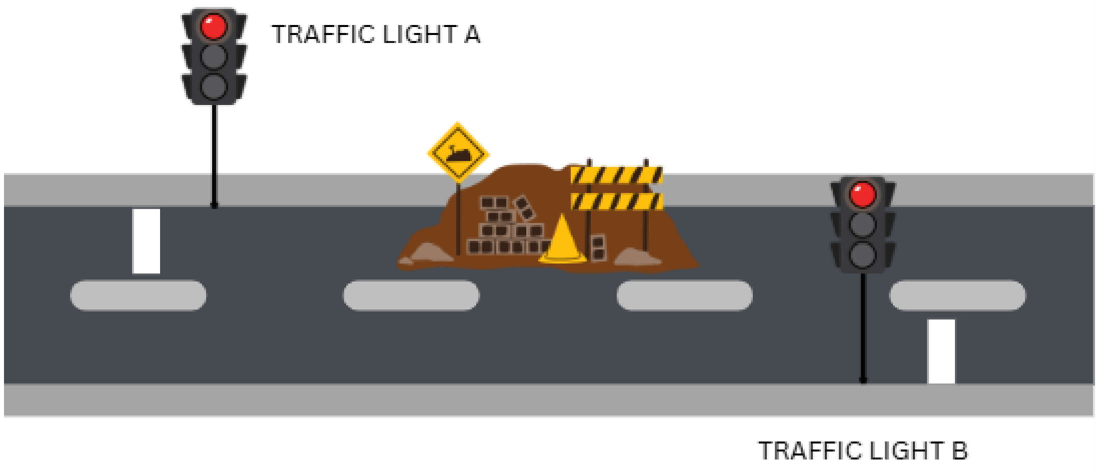

Figure 31 – The Place Position of Traffic Light

At the start, both boards will show their roles, either as the master or the slave. One board must be the master, and the other will be the slave. The master board will control the system, while the slave board will follow the instructions from the master, making sure everything works together smoothly.

The LED traffic light will start with a red LED as a default condition to make sure vehicles stop at the construction zone. When the first sensor on Traffic Light A detects a vehicle, the LCD will display "Car Waiting" and the green LED will turn on, allowing the vehicle to enter the construction zone. The second sensor will count the vehicles, from 1 to 5 and the LCD will show how many vehicles have entered the construction zone. After that, LoRa on Traffic Light A will send the data each time a vehicle is detected.

Figure 32 – Red, Yellow and Green LED Traffic Light

Figure 33 – The display of 'Car Waiting'

Pseudocode for code Car waiting Part

IF distance from second sensor is less than or equal to waiting distance AND both counters are 0:

    IF car is not already waiting:

        Set carwaiting to true // Car is now waiting

        Print "Car Waiting..." to serial monitor

        Display "Car Waiting..." on LCD

        Wait for 2 seconds // Delay to display the message

        Turn off red LED

        Turn on green LED

```
        Wait for 100 milliseconds  // Short delay


        Start LoRa transmission:
            Send -1 to indicate a car is waiting
        End LoRa transmission


        Wait for 500 milliseconds  // Short delay
    END IF
ELSE:
    Set carwaiting to false  // Car is no longer waiting
END IF
```

Figure 34 – The display of counting vehicle

Pseudocode for code Count Increase

```
IF object is detected (distance1 < thresholdDistance):
    IF object has not been counted yet:
        IF counter1 is less than 5:
            Reset the timer (previousMillis = current time)
            Increase counter1 by 1  // Increment vehicle count
            Print "Vehicle IN B: " and the current value of counter1 to serial monitor
            Display "Vehicle IN B:" and the current value of counter1 on LCD
            Wait for 2 seconds  // Debounce delay to avoid multiple detections
            Turn on the green LED to indicate vehicle is in
```

```
Turn off the red LED

Wait for 300 milliseconds  // Short delay to avoid repeated detections

Start LoRa transmission:
   Send the current value of counter1
End LoRa transmission

IF counter1 reaches 5:
   Turn off the red LED
   Turn on the yellow LED
   Turn off the green LED
   Wait for 2 seconds  // Wait for 2 seconds

   Turn on the red LED
   Turn off the yellow LED
   Turn off the green LED

   Wait for 1 second  // Short delay before sending the count

   Print "Sending Total vehicle B: " and the current value of counter1 to serial
monitor
   Display "Sending Total" and the current value of counter1 on LCD
   Wait for 2 seconds  // Wait for 2 seconds

   Start LoRa transmission:
      Send the current value of counter1
   End LoRa transmission

   Reset counter1 to 0  // Reset the counter after sending

Set objectDetected to true  // Mark that an object has been detected
Wait for 500 milliseconds  // Debounce delay to avoid multiple detections
```

```
        END IF
    END IF
ELSE:
    Reset objectDetected to false  // Reset the object detection state if no object is detected
END IF
```

After 5 vehicles are detected, the LED will turn yellow and then red. The yellow LED is meant to slow down vehicles, and the red LED signals them to stop. Then, LoRa Traffic Light A will send the total number of vehicles that have entered to the receiver so that LoRA receiver knows how much the vehicles have entered the construction zones.

Figure 35 – The display of Sending Data

When the vehicles exit the zones, the second sensor on Traffic Light B will detect and count how many vehicles have passed through. The count will decrease from 5 to 0. When the counter reaches 0, it will send the data to the LoRa Traffic Light A, allowing the traffic light to activate its sensor again if a vehicle is detected. The LCD will show “All Vehicle OUT. Sending 0”.

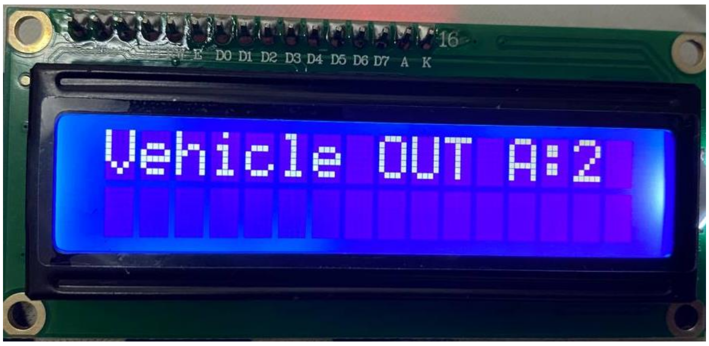

Figure 36 – The Display of Count Decrease

Figure 37 – The display of ‘All Vehicle Out, Sending 0’

Pseudocode for Code Count Decrease

```
IF distance1 is greater than or equal to lowerThresholdDistance AND distance1 is less than
or equal to upperThresholdDistance:
    // If an object is detected in range and has not already been counted
    IF objectInRangeDetected is false:
        IF counter is greater than 0:
            DECREMENT counter by 1  // Decrease the counter
            SET carwaiting to false
            SET objectInRangeDetected to true  // Indicate that an object in range is detected

            PRINT "Vehicle OUT A: " followed by counter to Serial Monitor
            DISPLAY "Vehicle OUT A:" and the counter on the LCD
            WAIT for 2 seconds  // Debounce delay

        IF counter equals 0:
```

```
        PRINT "All the Vehicle is OUT. Sending 0" to Serial Monitor
        DISPLAY "All Vehicle OUT" and "Sending 0" on the LCD
        WAIT for 2 seconds

        // Send counter value via LoRa
        BEGIN LoRa packet
        SEND counter value
        END LoRa packet

        SET objectDetected to true
        WAIT for 100 milliseconds

    END IF
ELSE:
    // No object detected in range, reset the detection state
    SET objectInRangeDetected to false
END IF
```


The counting system will work the same on Traffic Light A and Traffic Light B. The LED traffic lights will start with a red light by default to make sure vehicles stop at the construction zone. When the first sensor on Traffic Light A detects a vehicle, the LCD will display "Sensor detected, wait 5 seconds." This 5-second wait is to decide which traffic light will control the signal. If both lights detect a vehicle at the same time, Traffic Light A will be the master and Traffic Light B will follow. After the 5-second wait, the LCD will show “Car Waiting” and the green light will turn on, allowing the vehicle to enter the construction zone. The second sensor will count the vehicles, from 1 to 5, and the LCD will show how many vehicles have entered. Then, LoRa on Traffic Light B will send this data to LoRa on Traffic Light A each time a vehicle is detected.

Figure 38 – The Display of ‘Sensor Detected, Waiing 5 seconds’

In some situations, the number of vehicles entering the construction zone is less than 5. In this case, the Traffic Light will wait for 10 seconds for the next vehicle to enter. If no vehicle enters, the LED will turn yellow and red, and the LCD will display “No Car Detected” This aims to reduce the waiting time for vehicles on the other side.

Figure 39 – The Display of No Car detected

Pseudocode for code ‘Detection not reach until 5’

```
IF counter1 is greater than 0 AND counter1 is less than 5:
    IF current time (millis()) minus previousMillis is greater than or equal to interval:
        IF noCarDetected is false:
            TURN on yellow LED
            TURN off green LED
            WAIT for 2 seconds
            TURN off yellow LED
            TURN on red LED

            PRINT "No Car Detected anymore" to the Serial Monitor
```

```
        DISPLAY "No Car Detected anymore" on the LCD

        WAIT for 2 seconds

        SET noCarDetected to true  // Prevent spam of the message

        SEND counter1 value by LoRa

        RESET counter1 to 0 after timeout
      END IF
    ELSE:
      SET noCarDetected to false  // Reset flag if car is detected
    END IF
END IF
```

Lastly, if the connection is lost due to a hardware issue, the LCD will display "Starting LoRa Failed" when the project begins. This message indicates that the system could not establish a successful connection between the devices. In this case, the user may need to check the hardware connections or troubleshoot the network setup to resolve the issue and ensure proper communication between the devices.

Figure 40 – The display of 'Starting LoRA Failed'

Pseudocode for code Receiving and LoRA Failed

```
START
```

```
INITIALIZE LoRa with appropriate pins and frequency

IF LoRa initialization fails:
    PRINT "LoRa Start Failed" to the Serial Monitor
    DISPLAY "LoRa Start Failed" on the LCD
    STOP execution

DISPLAY "LoRa Receiver" on the LCD for 2 seconds

LOOP:
    IF packet is available (LoRa.parsePacket() returns a packet size):
        PRINT "Received: " to the Serial Monitor

        INITIALIZE an empty string (receivedData)

        WHILE data is available in the LoRa packet:
            READ data from the packet and append it to the receivedData string

        PRINT receivedData to the Serial Monitor

        CLEAR the LCD display
        DISPLAY "Received Data:" on the LCD (row 1)
        DISPLAY the receivedData on the LCD (row 2)

    WAIT for 100 milliseconds (short delay)

END LOOP
END
```

4.3 Analysis

This chapter gives an overview of the analysis done for this project. Several types of analysis have been carried out, such as cost analysis, weather changes and traffic flow control. These analyses help us understand how the project works and how it can be improved. By looking at these factors, we can see how well the system performs and where changes may be needed.

4.3.1 Analysis by Signal Strength

Signal strength is how well a device can pick up a signal, such as from Wi-Fi or a phone network. A strong signal means things are working smoothly like fast internet or clear calls. A weak signal can cause things to be slow, blurry or not work at all. Factors such as distance from the signal source or obstacles, such as walls, can affect strength. The closer to the source, the better the signal.

RSSI (Received Signal Strength Indicator) is a measurement used to show how strong the signal is. It is given in dBm (decibel milliwatts), which is a unit that helps measure signal power levels. When looking at RSSI values, a higher number means a stronger signal, and a lower number means a weaker one.

For example, an RSSI value closer to 0 (like -30 dBm) indicates a very strong signal, where things like internet speed or call quality are usually great. Conversely, a more negative value (such as -90 dBm) means a weak signal, which can lead to slow speeds or poor connections.

The figure below shows the result of testing and measuring the signal strength inside the building by using LoRA module from 1 meter to 10 meter.

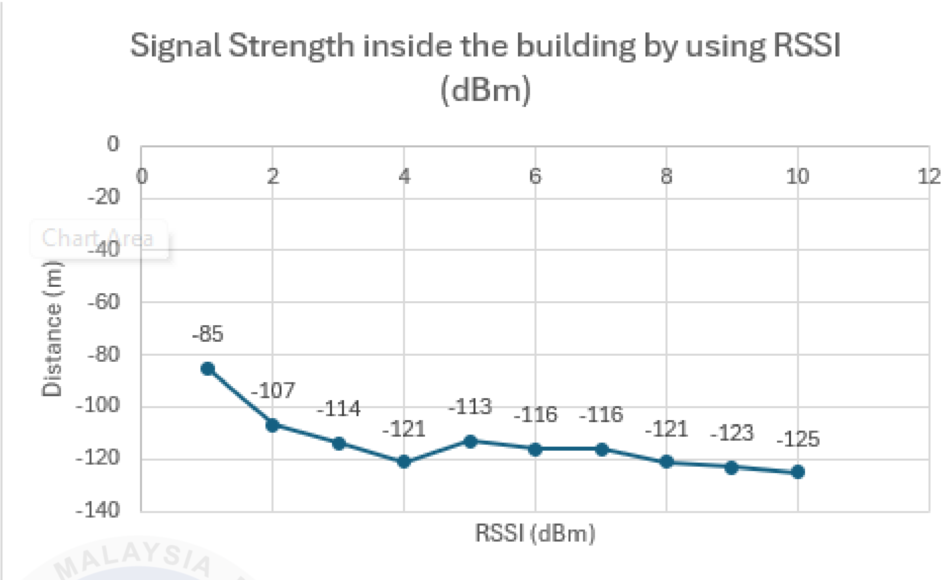

Figure 41 – Chart of signal strength for LoRA
inside the building using RSSI (dBm)

In suburban areas, signal strength can be affected by various factors. While it is not as clear and open as the countryside, it is usually better than in a more congested urban environment. There may be some buildings, trees or other obstructions that can weaken the signal a bit, but in general, the signal is still quite strong. In terms of RSSI, you may see values between -50 dBm and below in that area, which still indicates a good signal.

The figure below shows the result of testing the signal strength in suburban area by using LoRA module.

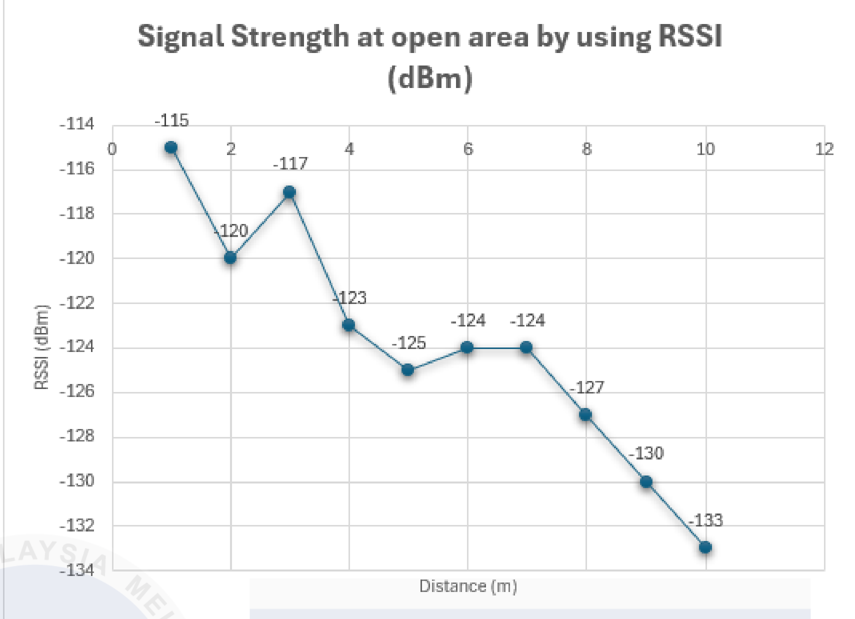

Figure 42 – Chart of Signal Strength at open area by using RSSi (dBm)

Signals in open areas usually suffer more losses than those inside buildings. In open spaces, the signal can travel further, but things like distance, weather and interference from other devices can weaken it. Inside a building, the signal may be blocked or attenuated by walls, floors and materials, but it is often more stable because there is less open space for the signal to scatter. Building structures can help focus signals, making them more consistent, while in open areas, signals can spread out and lose strength more easily.

4.3.2 Analysis by Cost

The following tables compare the costs of two common ways to control traffic which are using a flagman or a traffic light system. The tables look at different factors like setup costs, maintenance, daily running costs, training, and long-term expenses to help understand the financial impact of each choice. By looking at these factors, decision-makers can choose the option that works best for their budget, efficiency, and long-term needs.

Table 4 - Analysis for Cost

Factor	Flagman	Traffic Light
Initial Setup Cost	Low, as it requires minimal equipment.	Moderate, due to the installation of traffic lights and sensors.
Maintenance Cost	Moderate, mainly for flagman wages.	Low, as traffic lights require minimal maintenance and infrequent repairs.
Operational Cost	Ongoing, as flagman wages are paid daily.	Low, with costs mainly for electricity and occasional monitoring.
Training Cost	Low, as flagmen only need basic training.	Low, since traffic lights need minimal training once installed.
Long-Term Cost	High, due to flagman wages over extended periods.	Low, with a one-time setup cost and minimal ongoing expenses.

4.3.3 Analysis by Weather Impact

This table compares the impact of weather on flagmen and traffic lights, highlighting the differences in their performance under various conditions. It looks at factors such as visibility, safety risks, operational continuity, and maintenance needs during bad weather. This comparison helps in understanding how each method performs in adverse conditions, aiding in the decision-making process based on reliability and safety concerns.

Table 5 – Analysis by Weather Impact

Factor	Flagman	Traffic Light
Impact of Weather	High, as flagmen are affected by weather conditions such as rain, heat, and storms.	Low, as traffic lights are not directly impacted by weather, though extreme conditions may require maintenance.
Visibility	Low in bad weather, as rain, fog, or snow can make flagmen harder to see.	High, as traffic lights remain visible even in poor weather, ensuring consistent control.
Safety Risks	Higher, as flagmen are at risk in extreme weather, which can lead to accidents.	Lower, as traffic lights do not move and do not pose a direct safety risk during bad weather.
Operational Continuity	Interrupted, as flagmen may not be able to work during severe weather conditions.	Consistent, as traffic lights continue to operate even in bad weather.
Maintenance Needs	Moderate to High, as flagmen require special clothing and equipment for weather conditions, which may need replacement.	Low, as traffic lights only need occasional maintenance but generally perform well in any weather.

4.3.4 Analysis by Working Impact

This table compares how flagmen and traffic lights control traffic flow, focusing on factors like traffic management, response time, communication, and coordination. It highlights the limitations of using a flagman, such as slower response and limited coordination, compared to the efficiency and clarity of traffic lights, which can adjust quickly and manage multiple lanes at once. This comparison helps in evaluating which system is better for maintaining smooth traffic flow in various situations.

Table 6 – Analysis by Controlling Traffic Flow

Factor	Flagman	Traffic Light
Traffic Flow Control	Limited, as it depends on the flagman's ability to manage traffic manually, which can cause delays.	Efficient, as traffic lights can handle high traffic volumes and optimize flow by automatically adjusting signals.
Response Time	Slow, as flagmen must visually assess and react to traffic, leading to slower adjustments.	Fast, as traffic lights can adjust signals in real-time based on sensor inputs, allowing for quick responses.
Communication	Direct, as flagmen communicate with drivers through signals and gestures, which can sometimes be unclear.	Clear, as traffic lights provide standardized signals that are easily understood by all drivers.

Coordination	Limited, as flagmen can only control one direction at a time, making it harder to manage multiple lanes or directions.	Excellent, as traffic lights are designed to coordinate multiple directions and lanes simultaneously.

4.4 Summary

Traffic lights are generally more effective than flagman for managing construction zones. Although they require higher initial setup costs, they are more cost-effective in the long-term because they do not require a fixed salary like a flagman. Traffic lights also perform better in all weather conditions, providing consistent visibility and control, while flagman can be affected by bad weather. In terms of traffic flow, traffic lights manage high volumes of vehicles more efficiently, reducing delays, while flag markers are less effective in handling busy traffic. Overall, traffic lights offer a more reliable, safe and cost-effective solution for construction zones.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the development of a portable traffic light system using real-time detection with LoRA technology successfully meets the goals set for this project. The first objective was to study the current traffic light systems used in construction zones. By reviewing these existing systems and found areas that could be improved and recognized the need for a more flexible and efficient solution. This research helped guide the design of the new portable traffic light system, which was created to better handle the specific challenges of construction zones.

One of the key benefits of this system is the development of an algorithm to improve traffic flow in construction areas. The smart traffic light system uses LoRA technology to allow smooth communication between both traffic lights. This lets the system adjust traffic signals in real-time based on current traffic conditions and help to reduce congestion and ensure better traffic flow, especially in the busy environment of construction zones. The algorithm plays a big role in improving traffic management and meeting the needs of construction sites.

The final goal was to integrate and test the algorithm in a portable traffic light system using LoRA technology. The project successfully integrated and tested the developed algorithm and making the system portable. This project shows the potential of LoRA-based systems to improve traffic management, offer more sustainable and efficient solutions for managing traffic in construction areas and other changing environments.

5.2 Future Improvement

The development of a portable traffic light system using LoRA technology can be improved by adding a few additional features, such as an alert system that detects when the number of vehicles entering a construction zone does not match the number of vehicles exiting. In other words, the system would alert if any vehicles are stuck in the middle of the construction zone. Another improvement would be to install a camera to prioritize emergency vehicles, such as ambulances, police cars, and fire trucks, when they need to pass through the construction zones for emergency purposes. This would make the portable traffic light system smarter and more efficient.

5.3 Commercialization Potential

This portable traffic light project has many possible uses in different areas. In the construction sector, it can help modernize the current system by detecting and counting vehicles and displaying the total number of vehicles to workers. This can improve safety and make traffic flow smoother within construction zones. The project is also flexible enough to be used at events like school events, company events and sports events. It can help manage traffic during these events and ensuring that everything runs smoothly without causing traffic jams.

Additionally, the system can be set up quickly in emergencies such as major accidents, road closures or natural disasters where good traffic management is important to keep people safe and avoid more accidents. In these situations, the portable traffic light system can help manage traffic around the affected areas and allow emergency vehicles to pass through quickly. It also helps reduce traffic jams or delays. Overall, this portable traffic light system can be used in many different situations, making traffic management more efficient, organized, and able to respond quickly to changing needs.

REFERENCES

[1] Alexandru Lavric, Petrariu, A. I., & Popa, V. (2022). *LoRa Modulation: A 2.4GHz Communication Strategy*. https://doi.org/10.1109/iccakm54721.2022.9990110

[2] Basla Siripatana, Kittipong Nopchanasuphap, & Somporn Chuai-Aree. (2021). *Intelligent Traffic Light System Using Image Processing*. https://doi.org/10.1109/sea-stem53614.2021.9668057

[3] Bhavanam, B. P. R., & Ragam, P. (2024). Exploring LoRa Signal Propagation in Indoor and Outdoor Environments: A Comparative Study. *2024 IEEE International Conference on Smart Power Control and Renewable Energy (ICSPCRE)*, 1–6. https://doi.org/10.1109/icspcre62303.2024.10675046

[4] Chang, D., Hopfenblatt, J., Praveen Edara, & Balakrishnan, B. (2020). *Immersive Virtual Reality Training for Inspecting Flagger Work zones*. https://doi.org/10.1109/aivr50618.2020.00066

[5] Chanwattanapong, W., Hongdumnuen, S., Kumkhet, B., Junon, S., & Sangmahamad, P. (2021, September 1). *LoRa Network Based Multi-Wireless Sensor Nodes and LoRa Gateway for Agriculture Application*. IEEE Xplore. https://doi.org/10.1109/RI2C51727.2021.9559804

[6] Cosovanu, L.-M., & Done, A. (2020). Development of Visible Light Communication System for Automotive Applications Based on Organic Light Emitting Diode Panels. *2020 International Conference on Development and Application Systems (DAS)*, 84–89. https://doi.org/10.1109/das49615.2020.9108953

[7] Deepika, J., & Akilandeswari, J. (2024). Autonomous Vehicle Driver Assistance System for Road Signs and Lane Detection Based on Deep Neural Networks Framework. *2024 Third International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)*, 1–6. https://doi.org/10.1109/icdcece60827.2024.10549252

[8] Devalal, S., & Karthikeyan, A. (2018, March 1). *LoRa Technology - An Overview*. IEEE Xplore. https://doi.org/10.1109/ICECA.2018.8474715

[9] Dzhibarov, D., & Grigorov, I. (2021). Road traffic modelling and development of a specific traffic light control system. *2021 International Conference Automatics and Informatics (ICAI)*, 382–384. https://doi.org/10.1109/icai52893.2021.9639850

[10] Firdous, A., Indu, & Niranjan, V. (2020). Smart Density Based Traffic Light System. *2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*. https://doi.org/10.1109/icrito48877.2020.9197940

[11] G, D. S., Govind A, & Lekshmi D. (2024). *Next-Generation Traffic Control: Adaptive Timer and Emergency Vehicle Priority in Intelligent Traffic Management*. https://doi.org/10.1109/icemps60684.2024.10559373

[12] Gopinath, N., D Ezhilarasi, SB Kiruthika, & S. Hemavathi. (2021). Self-Activating Street Lights Using Sensors and Arduino. *2021 4th International Conference on Computing and Communications Technologies (ICCCT)*, 469–472. https://doi.org/10.1109/iccct53315.2021.9711871

[13] Hacène Fouchal, Kruk, T., & Rabat, C. (2023). *A Distributed Scheme for Optimal Road Intersection Management*. https://doi.org/10.1109/wincom59760.2023.10322975

[14] Joshi, N., Shah, K., Heniya, N., Zaveri, J., Nikam, R., & Deherkar, K. (2023). Smart Traffic Lights. *2023 IEEE World Conference on Applied Intelligence and Computing (AIC)*, 76–80. https://doi.org/10.1109/aic57670.2023.10263856

[15] Kithmin Wickramasinghe, & Gamage Upeksha Ganegoda. (2020). Pedestrian Detection, Tracking, Counting, Waiting Time Calculation and Trajectory Detection for Pedestrian Crossings Traffic light systems. *Pedestrian Detection, Tracking, Counting, Waiting Time Calculation and Trajectory Detection for Pedestrian Crossings Traffic Light Systems*. https://doi.org/10.1109/icter51097.2020.9325479

[16] Li, Z., Li, C., Zhang, Y., & Hu, X. (2017). *Intelligent traffic light control system based on real time traffic flows*. https://doi.org/10.1109/ccnc.2017.7983196

[17] M L, L., & M, A. (2020). LoRa technology for Internet of Things(IoT):A brief Survey. *2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)*. https://doi.org/10.1109/i-smac49090.2020.9243449

[18] Maduka, N. C., Ajibade, I. I., & Bello, M. (2022). Modelling and Optimization of Smart Traffic Light Control System. *2022 IEEE Nigeria 4th International Conference on Disruptive Technologies for Sustainable Development (NIGERCON)*.

https://doi.org/10.1109/nigercon54645.2022.9803073

[19] Mahesh Kumar Thota, Prathibhavani P.M, Shruthi Gujja, Deeksha Ravula, & R, V. K. (2023). *Emergency Vehicle Detection Using IoT in Smart Cities*. https://doi.org/10.1109/icseiet58677.2023.10303407

[20] Naik, D. R., Das, L. B., & Bindiya, T. S. (2018, October 1). *Wireless Sensor networks with Zigbee and WiFi for Environment Monitoring, Traffic Management and Vehicle Monitoring in Smart Cities*. IEEE Xplore. https://doi.org/10.1109/CCCS.2018.8586819

[21] Raouia Masmoudi Ghodhbane. (2024). *Maximization of Wireless Sensing Network's Throughput Communicating with Long Range (LoRa) Modulation*. 594–599. https://doi.org/10.1109/atsip62566.2024.10638955

[22] Raouia Masmoudi Ghodhbane, Hernandez, A., & Sabri Janfaoui. (2024). A Pressure and Temperature Wireless Sensing Network Communicating with LoRa Modulation. *2022 IEEE Symposium on Computers and Communications (ISCC)*, 1–3. https://doi.org/10.1109/iscc61673.2024.10733589

[23] Rezgui, J., Barri, M., & Gayta, R. (2019). *Smart Traffic Light Scheduling Algorithms*. IEEE Xplore. https://doi.org/10.1109/SmartNets48225.2019.9069760

[24] *Semtech LoRa Technology Overview | Semtech*. (n.d.). Www.semtech.com. https://www.semtech.com/lora

[25] Shi, W., Rajkumar, R., & Eran Kishon. (2021). *Opportunities and Challenges for Flagman Recognition in Autonomous Vehicles*. https://doi.org/10.1109/iv48863.2021.9575209

[26] Vaddi Jagadeesh, Thumkunta Lokeshwar Reddy, & G. Sundari. (2023). *Traffic Control System for Emergency Vehicles using RFID and Sensors*. https://doi.org/10.1109/iciccs56967.2023.10142622

[27] Vladimir Zelikov, Gennady Denisov, Vladimir Kliavin, Zlobina, N., Strukov, Y., & Zelikova, N. (2023). *The Use of Duplicate Transport Traffic Lights*. https://doi.org/10.1109/summa60232.2023.10349371

[28] Vyas, T., & Varia, H. R. (2023). Impact of Construction Work Zone on Urban Traffic Environment. *Impact of Construction Work Zone on Urban Traffic Environment*, *16*(1).

https://doi.org/10.2478/ijssis-2023-0005

[29] Zaid, & Ilyas, M. (2022). *Investigating the Performance of LoRa Communication for Nominal LoRa and Interleaved Chirp Spreading LoRa*. https://doi.org/10.1109/icaiot57170.2022.10121818

[30] Zhang, S., Zhang, Q., Chen, F., Wu, J., Jiao, J., & Wang, L. (2023). A VT-HMM-Based Framework for Countdown Timer Traffic Light State Estimation. *IEEE Transactions on Intelligent Transportation Systems*, *24*(9), 9449–9461. https://doi.org/10.1109/tits.2023.3265985

APPENDICES

Appendix A

DEVELOPMENT OF A REVOLUTIONIZING PORTABLE TRAFFIC LIGHT CONTROL USING LORA WIRELESS TECHNOLOGY														
Project Activity	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
CHAPTER 1														
CHAPTER 2														
CHAPTER 3														
CHAPTER 4														
CHAPTER 5														
DRAF SUBMISSION														
REPORT SUBMISSION														
PRESENTATION														