

GPS BASED E-TOLL GATE COLLECTION SYSTEM

A Project Report Phase - II

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

By

GOUTHAM K (39130147)

GOWTHAM M (39130148)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION
ENGINEERING**

SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA

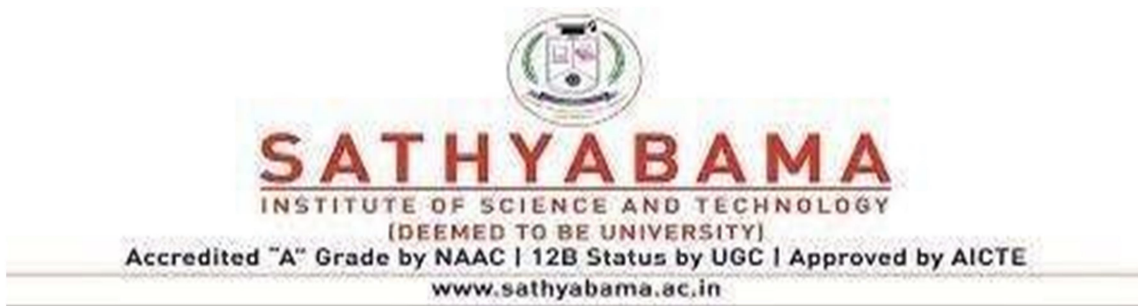
**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI -

600 119

APRIL - 2023



DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **GOUTHAM K (39130147)** and **GOWTHAM M (39130148)** who carried out the project entitled "**GPS BASED E-TOLL GATE COLLECTION SYSTEM**" under our supervision from November 2022 to April 2023.

Internal Guide
Dr. L. Megalan Leo, M.E., Ph.D.

Head of the Department
Dr. T. Ravi, M.E., Ph.D.

Submitted for Viva Voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We, **GOUTHAM K (39130147)** and **GOWTHAM M (39130148)** hereby declare that the project report entitled “**GPS BASED E-TOLL GATE COLLECTION SYSTEM**” done by us under the guidance of **Dr. L. Megalan Leo, M.E., Ph.D.** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

DATE:

PLACE:

SIGNATURE OF CANDIDATES

1. 
2. 

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to the Board of Management of **SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. N. M. Nandhitha, M.E., Ph.D.**, Dean, School of Electrical and Electronics and **Dr. T. Ravi, M.E., Ph.D.**, Head of the Department, Department of **Electronics and Communication Engineering** for providing me necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our project guide **Dr. L. Megalan Leo, M.E., Ph.D.** for his valuable guidance, suggestions, and constant encouragement paved way for the successful completion of our project work.

We wish to express our thanks to all teaching and non-teaching staff members of the Department of Electronics and Communication Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

Transportation has emerged as a dominant part of India. Toll plazas play a crucial role in maintaining the road transportation. At present, manual toll collection is most widely used collection method in India. It significantly requires a toll collector or attendant. Due to manual intervention, the processing time at toll plazas is highest. The project has been designed for the automation in toll tax payment using GPS and GSM Technology. Automation of toll plaza has been experimented using combination of Microcontroller, RFID, Global positioning system, Global system for Mobile. Implementation of automation in toll plaza enhances the monitoring of vehicles that are travelling in predestined routes. This project aims in designing a system, which automatically identifies the vehicle that advance towards the toll plazas and observes the vehicle number and the time of arrival. If matches exist between vehicle data and GPS data, then predetermined amount is automatically taken from the user account. It passes this information to avoid the Traffic congestion at toll plazas and helps in consuming less amount of fuel. And we can also collect amount by distance travelled on highway road. A GPS-based E-toll gate system is a modern and innovative approach to collecting tolls on highways and other major roads. It utilizes the Global Positioning System (GPS) technology to accurately calculate the distance travelled by a vehicle on a particular road, and then charges the corresponding toll amount to the driver's account. The system works by equipping toll gates with GPS receivers and transceivers. When a vehicle enters the toll gate, its location is captured by the GPS receiver and transmitted to the central server. The server calculates the distance travelled by the vehicle on the road and automatically deducts the toll amount from the driver's account. The driver is then notified of the toll deduction and the remaining balance on their account. One of the key benefits of the GPS-based E-toll gate system is its accuracy. Unlike traditional toll gates where tolls are calculated based on the number of axles or weight of the vehicle, the GPS system calculates tolls based on the exact distance travelled by the vehicle. This ensures that drivers only pay for the distance they have travelled, and not more.

TABLE OF CONTENTS

CHAPTER No.	CHAPTER NAME	PAGE No.
	Abstract	iv
	List of Figures	vii
	List of Tables	viii
	List of Abbreviations	ix
1	Introduction	1
	1.1 Objective	4
2	Literature Review	8
	2.1 Literature Survey	8
	2.2 Summary of Literature Survey	11
3	Methodology	13
	3.1 Existing System	13
	3.2 Open problems in existing System	14
	3.3 Problem Management strategy	15
	3.4 Our proposal based on discussed Problems	16
	3.4.1 Flowchart of the proposed model	18
	3.5 Working of the Proposed Model	19
	3.6 Financial Reporting on the Cost	20
	3.7 Project Setup and Block Diagram	21
	3.8 Source Code and its Explanation	23
	3.8.1 The Actual Code	23
	3.8.2 Explanation of the Code	26
	3.8.3 Code's Time and Space Complexity	31
	3.9 The Formula Used-Haversine Formula	32
	3.9.1 General Facts about Haversine Formula	32

	3.9.2 A Model Calculation for Haversian Formula	32
4	Hardware Description	34
4.1	Components Required	34
4.1.1	Software Components Description	34
4.1.1.1	Arduino IDE	34
4.1.2	Hardware Components Description	37
4.1.2.1	Arduino Board	37
4.1.2.2	GPS Module (GPS Geo M8M)	40
4.1.2.3	LED display	53
5	Results and Discussions	56
6	Conclusion	59
7	Future Scope and Development	61
	References	62

LIST OF FIGURES

FIGURE NO	TITLE	PAGE NUMBER
3.1	Flowchart of the proposed System	18
3.2	Overall Hardware setup	21
3.3	Block diagram of the proposed system	22
3.4	Code-part-1	27
3.5	Code-part-2	27
3.6	Code-part-3	28
3.7	Code-part-4	28
3.8	Code-part-5	29
3.9	Code-part-6	29
3.10	Code-part-7	30
4.1	Arduino UNO WIFI R3	38
4.2	Latitude	44
4.3	Longitude	46
4.4	Depiction of how each point in Earth's surface have different points	48
4.5	Image describing how satellites locate a co ordinate	50
4.6	GPS Neo M8N module	51
4.7	Pin Layout of GPS	52
4.8	LED Display	53
5.1	Initial screen before travelling	57
5.2	Final screen displaying the output. Output consists of distance, and the price	58

LIST OF TABLES

TABLE NO	TITLE	PAGE NO
4.1	Features of GPS Neo M8M	51
4.2	LCD display Description	54

LIST OF ABBREVIATIONS

ETC – Electronic Toll Collection

GPS – Global Positioning System

DSRC - Dedicated Short-Range Communication

RFID- Radio Frequency Identification

IR – Infrared Ray

ANPR- Automatic Number Plate Recognition

OBU- On board Unit

LCD- Liquid Crystal Display

IDE- Integrated Development Environment

CHAPTER 1

INTRODUCTION

Paying toll is something that every vehicle owner would have done at some point in their lives. One of the most well-known and widely used methods is the one using the toll booth. Though this method is extremely simple, it is very inefficient as it requires the owner to keep ready an exact amount or wait for the official at the booth to give them change. The other method which is popular is tolling using RFID scanner and tag. Even though this is an improvement over the toll booth system, it is not very cost effective. Recent studies have shown that in India, delays at toll booths can cost the country up to Rs.60000 crore per annum. With the increased development in highways and the number of vehicles on the road, the number of toll booths required is increasing every year. Though the number of vehicles on road have increased each year, the number of vehicles paying toll has either remained same or increased only by a little which proves to be a loss to the government. The government is, therefore, willing to pay Rs.14000 crore every year to stop this tolling system. In this paper, we propose a new type of tolling that minimizes the need for toll booths and also helps to reduce slow traffic by a little. The proposed system contains Arduino which takes the signal coming from GPS module and checks if the user has entered a specified range. This range is marked in the system using its latitude and longitude coordinates. If so, credits are deducted from the user's account and a message is sent to the user notifying them of the deduction. Toll collection has been an important aspect of human history for thousands of years. From ancient times to the modern era, tolls have been levied on goods and people traveling along trade routes, through mountain passes, and across bridges and other forms of infrastructure. The reasons for collecting tolls have varied over time, from funding infrastructure to raising revenue for governments and rulers.

In ancient times, tolls were often collected by city-states or kingdoms along trade routes. In Greece, tolls were collected on ships traveling through the Bosphorus and Dardanelles straits, which connected the Mediterranean and Black Seas. In the Roman Empire, tolls were collected on roads and bridges, and even on ships traveling along the rivers that crossed the empire. The Roman government used tolls to fund the construction and maintenance of roads, bridges,

and aqueducts. During the Middle Ages, tolls were collected by feudal lords and local governments. In Europe, tolls were levied on bridges, roads, and rivers, and were often used to fund the construction of castles and fortifications. In some cases, tolls were also used to restrict trade and protect local merchants from competition. For example, the Hanseatic League, a powerful group of merchants and traders in northern Europe, levied tolls on goods passing through their territory, which helped to maintain their economic power and influence.

With the rise of modern nation-states in the early modern period, toll collection became more centralized and organized. Governments began to levy tolls on roads and bridges to fund the construction and maintenance of infrastructure. In some cases, tolls were also used to raise revenue for the state or to protect domestic industries from foreign competition. For example, in the 18th and 19th centuries, the British government levied tolls on imported goods to protect British manufacturers and raise revenue for the state.

In the 19th and 20th centuries, toll collection became even more important as transportation infrastructure expanded rapidly. Tolls were collected on roads, bridges, and tunnels, and were used to fund the construction and maintenance of highways and other forms of transportation infrastructure. In some cases, tolls were also used to reduce congestion and encourage the use of public transportation. For example, many cities around the world have implemented tolls on cars entering the city center, which helps to reduce traffic and air pollution.

Today, toll collection continues to be an important aspect of transportation infrastructure. Many highways, bridges, and tunnels around the world still charge tolls to fund their construction and maintenance. In some cases, tolls are collected electronically, using technologies such as transponders and license plate recognition. This has made toll collection more efficient and streamlined, while also reducing the need for toll booths and manual toll collection.

In conclusion, toll collection has been an important aspect of human history for thousands of years. From ancient times to the modern era, tolls have been levied on goods and people traveling along trade routes, through mountain passes, and across bridges and other forms of infrastructure. The reasons for collecting tolls have varied over time, from funding infrastructure to raising revenue

for governments and rulers. Today, toll collection continues to be an important aspect of transportation infrastructure, and will likely remain so for the foreseeable future.

Electronic toll collection (ETC) systems are becoming more and more popular around the world due to their ability to reduce traffic congestion and improve transportation efficiency. GPS based ETC systems are one such system that uses GPS technology to track the vehicle's location and automatically deducts the toll amount from the user's account.

A GPS-based ETC system consists of several components, including a GPS device, a transponder, and a backend system. The GPS device is installed in the vehicle and is responsible for transmitting the vehicle's location to the backend system. The transponder is a small device that is placed on the windshield of the vehicle and is used to communicate with the toll plaza. The backend system is responsible for processing the toll payment and maintaining the user's account information.

The GPS-based ETC system works by using GPS technology to track the vehicle's location and determine whether it has entered a toll zone. When the vehicle enters a toll zone, the transponder communicates with the toll plaza and deducts the toll amount from the user's account. The backend system then processes the payment and updates the user's account balance. One of the major advantages of GPS-based ETC systems is their ability to reduce traffic congestion. Traditional toll collection methods involve vehicles stopping at toll booths to pay the toll amount, which can cause long queues and traffic congestion. With GPS-based ETC systems, toll payment is automated, and vehicles do not have to stop at toll booths, thereby reducing traffic congestion.

Another advantage of GPS-based ETC systems is their convenience. With traditional toll collection methods, drivers have to carry cash or toll tokens to pay the toll amount. With GPS-based ETC systems, toll payment is linked to the user's account, and the toll amount is automatically deducted from the account, making the process more convenient for drivers.

GPS-based ETC systems also offer greater accuracy in toll collection. With traditional toll collection methods, toll plaza attendants may miscount the number

of vehicles passing through the toll booth, leading to inaccuracies in toll collection. With GPS-based ETC systems, toll payment is automated, and the system can accurately track the number of vehicles passing through the toll zone, ensuring accurate toll collection.

One of the potential drawbacks of GPS-based ETC systems is the cost of installation. GPS-based ETC systems require the installation of GPS devices in vehicles and the installation of transponders at toll plazas, which can be costly. However, the long-term benefits of reduced traffic congestion and increased transportation efficiency can outweigh the initial installation costs.

In conclusion, GPS-based ETC systems are becoming increasingly popular around the world due to their ability to reduce traffic congestion, improve transportation efficiency, and offer greater accuracy in toll collection. While there may be some initial installation costs, the long-term benefits of GPS-based ETC systems can make them a worthwhile investment for toll authorities and drivers alike.

1.1. OBJECTIVE

The GPS-based E-Toll gate system, if implemented in India, would have the following objectives:

1. Improve the efficiency of toll collection: With the use of GPS-based technology, toll collection would become faster and more efficient. This would reduce the waiting time at toll booths and improve the overall traffic flow on highways.
2. Eliminate the need for physical toll booths: The GPS-based E-Toll gate system would eliminate the need for physical toll booths, reducing the cost of infrastructure and maintenance.
3. Reduce cash transactions: The use of digital payments through the GPS-based E-Toll gate system would reduce the need for cash transactions, making the system more secure and transparent.
4. Improve revenue collection: The GPS-based E-Toll gate system would improve revenue collection by reducing leakages and ensuring that all vehicles pay tolls.

5. Reduce environmental impact: The reduction in waiting time and fuel consumption at toll booths would result in a significant reduction in carbon emissions and environmental impact.
6. Improve safety: The GPS-based E-Toll gate system would improve safety by reducing congestion and eliminating the need for drivers to stop and pay tolls manually.
7. Most importantly, our main objective is to enable a traveller to pay proportional to the distance he/she travelled in taxable roads.

Overall, the implementation of a GPS-based E-Toll gate system in India would result in a more efficient, transparent, and sustainable toll collection system.

India has one of the largest road networks in the world, with over 5.8 million kilometers of roads. However, the country's transportation infrastructure has been struggling to keep up with the demands of its growing population, leading to congestion, delays, and poor road conditions. One of the key challenges faced by India's transportation system is the inefficient toll collection process, which results in long wait times, congestion, and lost revenue. The GPS-based E-Toll gate system has the potential to address these challenges and transform India's toll collection system into a more efficient, transparent, and sustainable model.

One of the main objectives of implementing the GPS-based E-Toll gate system in India is to improve the efficiency of toll collection. The current toll collection process in India is largely manual, with toll booths and collectors stationed at various points on the highway. This can lead to long wait times, particularly during peak travel periods, and can result in congestion and delays. With the use of GPS-based technology, toll collection would become faster and more efficient. This would reduce the waiting time at toll booths and improve the overall traffic flow on highways.

Another objective of the GPS-based E-Toll gate system is to eliminate the need for physical toll booths. The use of physical toll booths requires a significant amount of infrastructure and maintenance, which can be costly for the government. By implementing a GPS-based system, toll collection can be

automated, eliminating the need for physical toll booths and reducing the cost of infrastructure and maintenance.

Another key objective of the GPS-based E-Toll gate system is to reduce cash transactions. The use of digital payments through the GPS-based E-Toll gate system would reduce the need for cash transactions, making the system more secure and transparent. With the use of digital payments, toll collection can be tracked and monitored more effectively, reducing the likelihood of fraud and revenue leakage.

Improving revenue collection is another important objective of the GPS-based E-Toll gate system. The current toll collection system in India is prone to revenue leakage, with many vehicles avoiding tolls or paying less than the required amount. The GPS-based E-Toll gate system would improve revenue collection by reducing leakages and ensuring that all vehicles pay tolls. With the use of GPS technology, toll collection can be tracked and monitored in real-time, reducing the possibility of fraud and revenue leakage.

The GPS-based E-Toll gate system also has the potential to reduce the environmental impact of toll collection. The reduction in waiting time and fuel consumption at toll booths would result in a significant reduction in carbon emissions and environmental impact. With the use of GPS-based technology, toll collection can be automated, eliminating the need for physical toll booths and reducing the amount of fuel consumed by vehicles on the road. This, in turn, can lead to a reduction in greenhouse gas emissions and other pollutants that contribute to air pollution.

Improving safety is another key objective of the GPS-based E-Toll gate system. The current toll collection system in India requires drivers to stop and pay tolls manually, which can be dangerous, particularly on busy highways. With the implementation of the GPS-based E-Toll gate system, drivers can pass through the toll gate seamlessly, without any interruption to their journey. This reduces the risk of accidents and improves safety on the roads.

The most important objective of the GPS-based E-Toll gate system is to enable a traveller to pay proportional to the distance he/she travelled in taxable roads. The system calculates the distance travelled by a vehicle and charges a

proportional fee based on that distance. This method has several advantages over traditional toll payment methods and can benefit society in many ways.

In conclusion, the implementation of the GPS-based E-Toll gate system in India would result in a more efficient, transparent, and sustainable toll collection system. The system has the potential to address many of the existing problems.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE SURVEY

As per S.Nandini and P.Premkumar, tollgate systems around the world make use of Dedicated Short-Range Communication (DSRC). Here, a mobile application is used for sending transaction details. An automated toll gate system is present in this system. Here message is sent to the vehicle owner. In this project we make use of GPS. Automated toll collection has always helped in improving traffic flow's efficiency. This has also been proven to be the easiest way to clear traffic. Every owner should have his/her bank account registered with the RFID, in the present system. An amount is automatically deducted from the account. This is not based on the distance the traveller travelled, but is based on pre-set amounts. And as per the research of Widad Ismail and Khadijah Kamarul Azizi, their work again talks about RFID usage in toll collection.

As per the work done by, Ramya, V., Palaniappan, B. and Karthick K, The obstacle sensor in their proposed system, an IR module, is installed in front of the automobile, where it senses the distance between barriers, which is typically 3 feet, and informs the microcontroller about the difficulties ahead. The microcontroller then sounds an alarm to warn the driver and stops the car. In a similar manner, a gas sensor is installed inside the car so that it can detect the presence of gases there and alert the microcontroller if the quantity of harmful gases rises. The microcontroller then sounds an alarm and sends a text message to the driver and passengers inside the car.

From the work done by Pany, J.K. and Choudhury, R.D, we come to know that their article discusses the design and development of an embedded system that is employed to stop or restrict car theft. A GSM-based embedded system underlies the created instrument. The instrument is mounted within the car's engine. In order to deliver the message to the owner's mobile device, a GSM interface modem is additionally linked to the microcontroller. By inputting a secure password, this device's primary goal is to prevent unwanted entry to the car while also using GSM communication technology to update the authorised person (owner) on the state of the same vehicle. In this system, the idea of network security is addressed. The

primary idea behind this design is integrating mobile communications with embedded system

The work done by Nagaraja, B.G., Rayappa, R., Mahesh, M., Patil, C.M. and Manjunath, T.C., talks about the design and development of a theft control system for automobiles. An embedded system built on GSM technology is used by the created system. The created and developed system is mounted in the car. The microcontroller, which is linked to the engine, is also connected to a mobile interface. The information is utilised by the owner of the stolen vehicle for further processing after the theft. The data is sent to the central insurance processing system, where they phone a certain number from a remote location to connect to the mobile device that is connected to the hardware kit that is placed in the car. One can lock the engine's ignition or force it to stop right away by interpreting the signals the mobile device receives. After providing a safe password, it will return to its original state. The central processing system and the vehicle's owner will both be aware of this safe password. This design's core idea is to integrate mobile communications with embedded systems. The created unit is very affordable simple. On a single chip, the complete planned device is housed. When a car is stolen, the owner may report it to the central processing system. From there, they may halt the vehicle by simply calling a secret number and using SIM tracking to find the vehicle's position and report it to the local police or prevent it from moving further

By studying the work of Joshi, B., Bhagat, K., Desai, H., Patel, M. and Parmar, J.K, one could conclude that, they compare some of the current automatic toll collecting systems to traditional toll collection. Many of the automatic toll collection methods mentioned in this article include RFID (Radio-Frequency Identification) technology is used by FASTag. Another automated tax collection device known as the Automated Toll Collection System (ATCS) attaches a distinctive RFID tag to the vehicle's windscreen in order to automatically collect taxes. Here, we also suggest an image processing-based automated toll collecting system. Automated Toll payment system is used to give flexibility and dependability in paying toll amount at toll plaza

As found by El Hussein, H.M., El Meligy, B. and Hassan, M., "Cairo-Alexandria desert roadway" was used as the subject of a descriptive case study that was customised for the research. In-depth interviews with two parties were conducted in order to examine the application of the ITS. The first party was the "Arab Constructors Company," which built the highway, and the second party were the trucking businesses, who utilise the route. Also, a focus group with freight forwarding firms was held to confirm the present issues on the Cairo-Alexandria desert highway and the best solutions to address them. They have finally demonstrated that there are several difficulties in implementing ITS in Egypt's transportation system, despite claims from others that doing so would greatly benefit a variety of industries

Conclusions of Ahmed, S., Tan, T.M., Mondol, A.M., Alam, Z., Nawal, N. and Uddin, J., tell us Bangladesh must be digitalized in every manner possible to keep up with its ongoing development and economic progress. In order to address traffic issues and preserve system transparency, the RFID-based Automatic Toll Collection System is introduced in this study. The proposed system attempts to create a digital toll collecting system that can end delays on toll highways, bridges, and tunnels without using currency or needing vehicles to stop. This study focuses on an electronic toll collection system that identifies a vehicle particularly for toll collection using radio frequency identification (RFID) technology. The suggested RFID system makes use of tags that are attached to the digital number plates of the cars, allowing RFID readers to access the data that is stored on the tags. In this approach, it is feasible to lessen the requirement for car owners and toll collecting agencies to physically distribute tickets and collect tolls. The owners of the vehicles and the toll authority may readily share information on the toll payment. Consequently, with less manual effort and human mistake, toll payment transparency may be guaranteed. As a result, designing a smart transportation system will be simpler.

Study by Balamurugan, K., Elangovan, S., Mahalakshmi, R. and Pavithra, R., tell us that nowadays, the process of inspecting a vehicle for a licence, insurance, and RC book causes a great deal of difficulties for the people. It causes traffic congestion, which extends time and increases fuel consumption at toll gates. Nowadays, the automatic toll accumulation mechanism is quite effective. The

Automatic Toll Collection and Check-Post System Using Radio Frequency Identification (RFID) and GSM Module is the subject of this study. Passive radio frequency guiding allows for successful recognition. An RFID tag that is connected to the car for this project stores vehicle specifics like the unique ID. If a computer has successfully observed all the criteria, they can be saved in a data bank for cyclic gaps such as time and date. Users alone secure the individual ID for their automobiles. As a vehicle passes through the toll plaza, the scanner reads the tag, and the tax amount is determined by using an RFID and GSM module to check the account balance. A GSM network must be connected to the ATmega328 Arduino controller for a user to be able to manage the system by sending an SMS or placing a call, as well as to prevent car theft.

2.2 SUMMARY OF LITERATURE SURVEY

The text discusses the importance of effective communication in business organizations. Communication is essential for businesses to succeed, as it allows employees to work together and coordinate their efforts towards a common goal. The authors argue that effective communication can help companies achieve higher levels of employee engagement, better decision-making, and improved customer satisfaction.

The authors also note that there are various challenges to effective communication in the workplace. For example, communication can be hindered by language barriers, cultural differences, and differences in work styles. In addition, communication can be negatively impacted by technology, such as emails and instant messaging, which can lead to misunderstandings and misinterpretations.

To overcome these challenges, the authors suggest that companies need to establish clear communication protocols and provide training to employees on effective communication strategies. This includes using active listening techniques, clarifying expectations and goals, and ensuring that messages are delivered clearly and concisely.

Another key element to effective communication is trust. Employees need to trust their colleagues and leaders in order to communicate effectively. This means creating a culture of openness and transparency, where employees feel

comfortable sharing their thoughts and ideas without fear of judgment or retaliation.

The authors also emphasize the importance of feedback in communication. Feedback allows employees to understand how their actions are perceived by others, and can help to identify areas for improvement. It also allows employees to recognize and celebrate their successes.

Finally, the authors note that effective communication requires ongoing effort and attention. Companies need to regularly assess their communication practices and adjust as necessary. This includes soliciting feedback from employees and customers, and continuously improving communication strategies.

In conclusion, effective communication is essential for businesses to succeed. Companies that prioritize communication and invest in training and protocols are more likely to achieve higher levels of employee engagement, better decision-making, and improved customer satisfaction.

CHAPTER 3

METHODOLOGY

3.1 EXISTING SYSTEM

The GPS based E-toll gate system is a modern technology that aims to automate the toll collection process at highways and toll plazas. The following are some of the existing systems used in GPS based E-toll gate systems:

1. **RFID-based System:** This system uses an RFID (Radio-Frequency Identification) tag attached to the vehicle's windshield. As the vehicle passes through the toll gate, the RFID reader reads the information stored on the tag, and the toll amount is deducted from the prepaid account. This system requires the installation of RFID readers at the toll plaza, and the RFID tags need to be purchased and attached to the vehicle.
2. **DSRC-based System:** DSRC (Dedicated Short-Range Communication) is a wireless communication technology used in toll collection systems. This system uses a DSRC tag attached to the vehicle's windshield that communicates with the DSRC reader installed at the toll gate. The toll amount is deducted from the prepaid account linked to the DSRC tag.
3. **ANPR-based System:** ANPR (Automatic Number Plate Recognition) is a technology that uses optical character recognition to read the number plate of a vehicle. In this system, cameras installed at the toll plaza read the number plate of the vehicle, and the toll amount is deducted from the prepaid account linked to the vehicle's registration number.
4. **GPS-based System:** In this system, the vehicle's GPS coordinates are used to track the vehicle's movement, and the toll amount is deducted from the prepaid account based on the distance travelled. This system eliminates the need for physical toll gates and toll plaza infrastructure, making it a more convenient and cost-effective solution.
5. **Hybrid System:** A hybrid system combines two or more of the above systems to improve the accuracy and reliability of toll collection. For example, a hybrid system may use an

RFID-based system for fast-moving vehicles and an ANPR-based system for slow-moving vehicles.

Overall, GPS-based E-toll gate systems have revolutionized the toll collection process, making it faster, more efficient, and less prone to errors. With the integration of advanced technologies such as RFID, DSRC, ANPR, and GPS, toll collection systems have become more reliable, secure, and convenient for both the toll operators and the commuters. All these system which exist collect toll gate charges randomly.

3.2 OPEN PROBLEMS IN EXISTING SYSTEM

The existing toll gate money collection system has various drawbacks, which include long queues and waiting times, manual cash transactions, and potential security risks. These drawbacks can result in loss of time, revenue, and productivity, as well as increased incidents of fraud and theft. Additionally, the current system does not take into account the actual distance traveled by each vehicle, resulting in some travelers paying more than they should, while others pay less. This can lead to unfairness and dissatisfaction among travelers.

To address these issues, the use of GPS technology to calculate a traveler's distance and deduct money proportionally to their actual distance traveled is an ideal solution. The GPS system can accurately track the distance covered by each vehicle and the toll fees can be charged accordingly. This will eliminate the need for manual cash transactions and significantly reduce the waiting time for travelers. In addition, the use of GPS technology will ensure that travelers pay the exact amount for the distance they have traveled, thereby eliminating the potential for fraud and theft.

The implementation of a GPS-based toll collection system can also offer other advantages. For instance, it can provide real-time data on the number of vehicles passing through a toll booth, their direction of travel, and their speed. This information can be used to optimize traffic flow, reduce congestion, and improve road safety. It can also help authorities to monitor and manage the condition of roads, bridges, and other infrastructure, enabling timely maintenance and repair.

Furthermore, the GPS-based system can be integrated with other systems, such as vehicle tracking and electronic payment gateways, to provide a seamless and efficient travel experience for travelers. With electronic payment gateways, travelers can make payments through their mobile phones or other digital devices, eliminating the need for cash transactions and reducing the waiting time further.

Overall, the adoption of a GPS-based toll collection system offers numerous benefits over the existing manual cash system. It provides a more efficient, secure, and fair system for travelers, and also helps authorities to manage traffic flow, maintain infrastructure, and improve road safety. The use of GPS technology is not only practical but also cost-effective in the long run, as it eliminates the need for manual labor and reduces the potential for errors and fraud.

In conclusion, the integration of GPS technology in toll gate money collection can revolutionize the transportation system by making it more efficient and secure for travelers while enabling authorities to manage traffic flow, maintain infrastructure, and improve road safety. The advantages of a GPS-based system are numerous, and it is high time that governments and transportation authority's consider implementing this technology for toll gate money collection.

3.3 PROBLEM MANAGEMENT STRATEGY:

A problem management strategy for a GPS based E toll gate collection system that uses GPS to calculate the distance travelled by a vehicle to deduct money proportional to what the vehicle has travelled should include the following steps:

1) Establish a Problem Management Team: Establish a team responsible for managing and addressing problems that arise with the system. This team should be cross-functional and include members from all relevant departments, such as IT, customer service, and operations.

2) Identify Potential Problems: Analyse the system design, user requirements, and feedback from end-users to identify potential problems that may arise with the system.

3)Define Problem Management Procedures: Define the problem management procedures in detail, including how problems will be reported, how they will be tracked, how they will be escalated, and how they will be resolved.

4)Create a Communication Plan: Develop a communication plan to keep all stakeholders informed about the status of any problems that arise. This plan should include regular updates and status reports.

5)Establish Problem Prioritization: Establish a method for prioritizing problems based on their severity and impact on the system. This will help ensure that the most critical problems are addressed first.

6)Establish Root Cause Analysis: Establish a process for conducting root cause analysis to identify the underlying cause of problems and prevent them from recurring.

7)Establish Problem Resolution and Recovery: Develop a process for resolving and recovering from problems that arise with the system. This should include clear guidelines for identifying, tracking, and resolving problems, as well as procedures for restoring system functionality as quickly as possible.

By following these steps, a problem management strategy for a GPS based E toll gate collection system that uses GPS to calculate the distance travelled by a vehicle to deduct money proportional to what the vehicle has travelled can help minimize the impact of problems on the system and ensure smooth operations.

3.4 OUR PROPSAL BASED ON DISCUSSED PROBLEMS

A proposed system for GPS based E toll gate collection that charges travelers proportionally to the distance they travel would include the following components:

1. GPS tracking devices installed in vehicles: Each vehicle will be required to have a GPS tracking device installed, which will track the distance traveled by the vehicle.

2. Toll gates equipped with GPS receivers: The toll gates will be equipped with GPS receivers that will receive the location information from the GPS tracking devices installed in the vehicles.
3. Distance calculation: The system will calculate the distance traveled by each vehicle using the GPS location information. The system will use this information to determine the toll fee.
4. Toll calculation: The toll fee will be calculated based on the distance traveled by the vehicle. The system will use a pre-determined toll rate per kilometre to calculate the toll fee.
5. Payment collection: The toll fee will be collected electronically from the vehicle owner's account. The vehicle owner will be required to register their vehicle and payment information with the system.
6. Account management: The system will maintain a record of the toll fees collected from each vehicle owner's account. The vehicle owners will be able to access their account information to view their toll payment history.
7. Data storage and analysis: The system will store the data collected from the GPS tracking devices and toll gates. This data can be used for analysis and reporting purposes.
8. Security measures: The system will have security measures in place to ensure the integrity and confidentiality of the data collected. This will include measures such as data encryption, access control, and monitoring.

GPS-based e-toll gate system is a system that uses GPS (Global Positioning System) technology to track the movement of vehicles and calculate toll charges based on the distance travelled by the vehicle on highways¹. Under this system, vehicles will be fitted with an electronic device that can track movement of the vehicle¹. Highways will be geo-fenced, creating virtual boundaries¹. When a GPS-enabled vehicle enters a toll plaza, the system will detect it and toll will be charged based on the distance travelled at the highway's exit point¹. The implementation of GPS-based tolling system is expected to eliminate traffic jams on Indian highways. Overall, a GPS-based E toll gate collection system that charges travellers proportionally to the distance they travel can provide a more fair

and efficient method of toll collection. The use of GPS tracking devices and toll gates equipped with GPS receivers enables accurate distance calculation, which can lead to more accurate toll fee calculation. Additionally, the use of electronic payment collection and account management can streamline the toll payment process for vehicle owners.

3.4.1. Flowchart of the proposed model

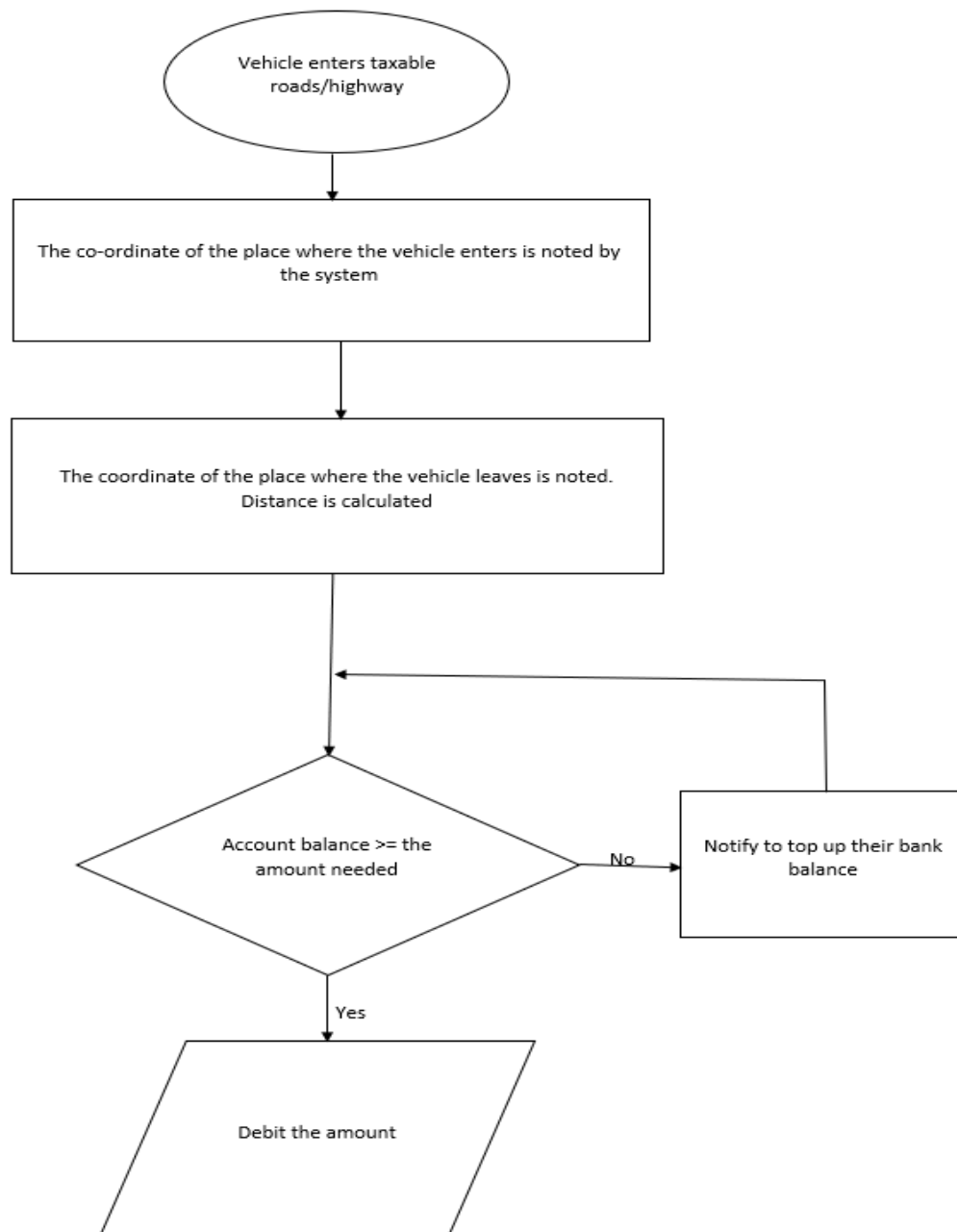


Fig 3.1: Flowchart of the proposed System

3.5 WORKING OF PROPOSED MODEL

This project proposes charging a traveller on the highway by calculating the coordinates of the his/her travel and deducts an amount, proportional to the distance of travel. Initially, when the vehicle enters the highway, The coordinates are marked and saved. When the vehicle leaves the highway, again coordinates at that point is noted. Distance is calculated and fee is deducted accordingly.

The GPS based E-Toll gate system is a cutting-edge project that implements state-of-the-art technology to offer a seamless and efficient experience to travellers. This project is built on a foundation of advanced algorithms and computing techniques that enable it to accurately calculate the distance travelled by a vehicle on the highway and determine the corresponding toll fees.

The system relies on Global Positioning System (GPS) technology to track the location of the vehicle as it moves along the highway. The GPS receiver, which is installed in the vehicle, continuously receives signals from satellites orbiting the earth and uses them to determine the exact position of the vehicle in terms of latitude and longitude. The co-ordinates of the location where the vehicle enters the highway are recorded and saved by the system.

As the vehicle travels along the highway, its location is continually tracked by the GPS receiver. When the vehicle exits the highway, the co-ordinates of the exit location are also recorded and saved. The distance travelled by the vehicle is then calculated by the system using the difference between the entry and exit co-ordinates.

This system is designed to use advanced mathematical algorithms to accurately calculate the distance travelled by a vehicle, even when it takes a non-linear path or changes lanes. The system uses sophisticated algorithms to filter out any inaccuracies in the GPS readings due to factors such as atmospheric conditions or signal interference.

The toll fee charged by the system is calculated based on the distance travelled by the vehicle. The fee is determined by a pre-determined rate that is set by the authorities. The system automatically deducts the toll fee from the user's account, which is linked to their vehicle registration number.

The implementation of this project involves several engineering concepts and principles. It uses advanced computing techniques such as data filtering, signal processing, and mathematical modeling. The system is designed to be highly reliable and efficient, with a low margin of error in calculating the toll fees.

One of the key benefits of this system is that it eliminates the need for physical toll booths, which can cause traffic congestion and delays. This project uses advanced technology to provide a seamless and hassle-free experience for travellers, while also ensuring that the toll fees are calculated accurately and efficiently.

In conclusion, the GPS based E-Toll gate system is a cutting-edge project that utilizes advanced engineering concepts and technology to offer a seamless and efficient experience to travellers. The system uses GPS technology to accurately calculate the distance travelled by a vehicle and determine the corresponding toll fees. The implementation of this project involves advanced computing techniques such as data filtering, signal processing, and mathematical modeling, making it a highly reliable and efficient system.

3.6 FINANCIAL REPORTING ON THE COST

The GPS based E-toll gate system offers several financial benefits to users. Firstly, it eliminates the need for physical toll booths and the associated costs of building, maintaining, and staffing them. This leads to significant cost savings for toll operators, which can be passed on to users in the form of lower toll rates.

Secondly, the GPS based E-toll gate system allows for more efficient toll collection, reducing traffic congestion and associated costs such as fuel consumption and time wasted by drivers. This increased efficiency can also help to reduce air pollution and carbon emissions, providing additional benefits to society as a whole.

Thirdly, the system allows for easy and convenient payment of tolls, without the need for cash or physical toll tickets. This can help to reduce transaction costs and eliminate the need for users to carry cash, making it more accessible to financially backward people.

Finally, the components used in the GPS based E-toll gate system are relatively cheap compared to traditional toll collection systems. The system typically requires a GPS receiver, an onboard unit (OBU), and a communication network. The cost of these components has decreased significantly in recent years, making it more affordable for toll operators to implement and more accessible to users.

We spent a very minimal amount in implementing the project. Software components, since open source, was available for free, and components costed us only around 3000. Using these to implement the project helps and is available to all classes of the society.

In summary, the GPS based E-toll gate system offers several financial benefits to users and toll operators alike. It eliminates the need for physical toll booths, reduces traffic congestion and associated costs, provides easy and convenient payment options, and uses relatively cheap components, making it affordable even for financially backward people.

3.7. PROJECT SETUP AND BLOCK DIAGRAM

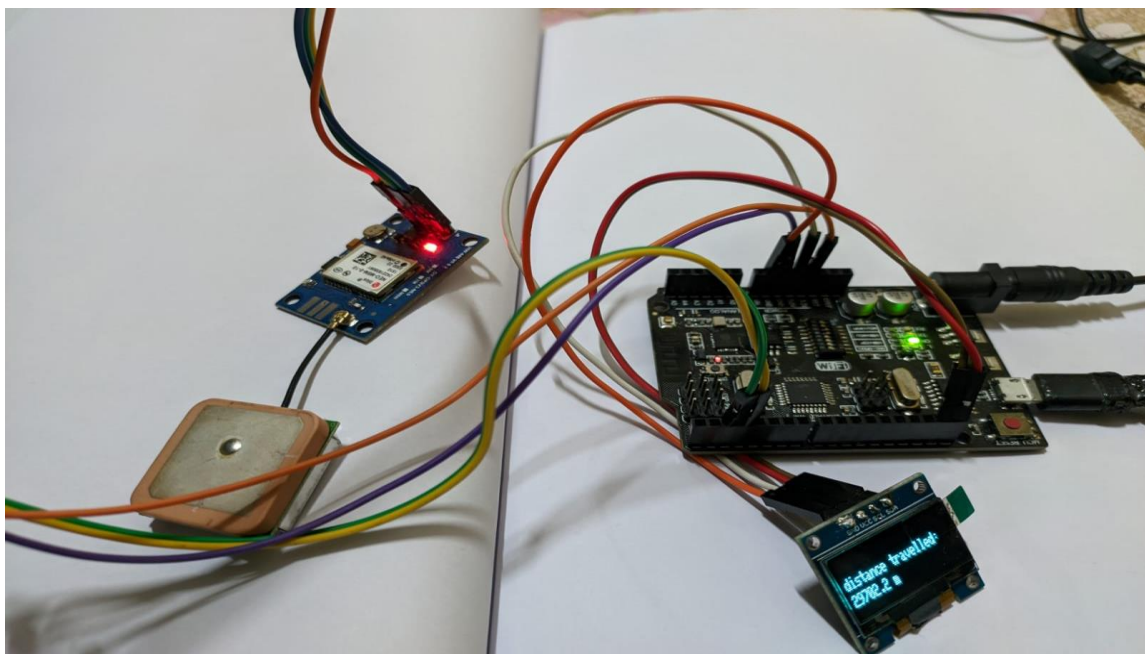


Fig 3.2: Overall Hardware setup

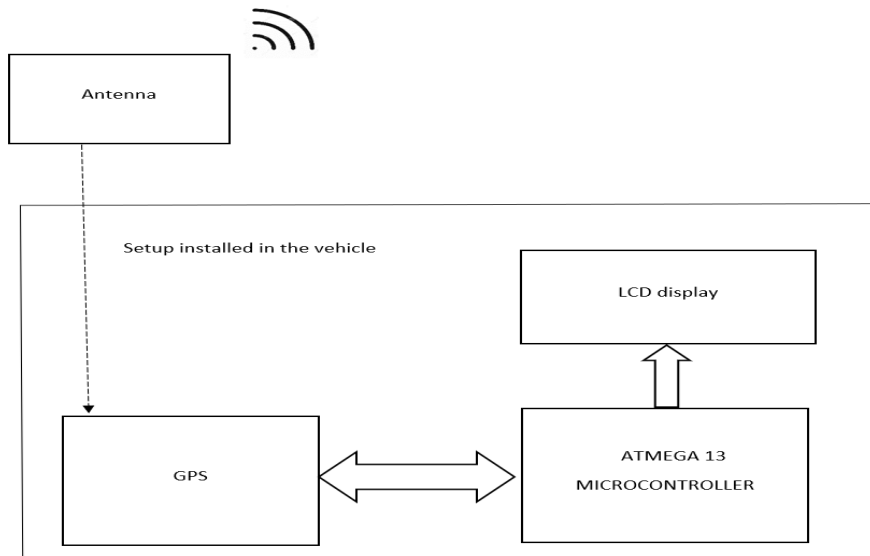


Fig 3.3: Block diagram of the proposed system

The block diagram shows how receiver antennas on the surface of the Earth are used to gather positioning data from GPS satellites. After being encrypted, this data is subsequently sent to a microcontroller for additional processing. When a vehicle enters a taxable road and when it departs, the system is set up to capture location data twice. The distance the vehicle went is determined using the difference between the beginning and final coordinates. The total charge is then computed and shown on an LCD display based on a predetermined amount per kilometer.

The Global Positioning System (GPS), a satellite-based navigation system that gives position and time information everywhere on or near the Earth, is not complete without receiver antennas on the planet's surface. The GPS relies on a system of satellites in orbit to send signals to GPS receivers on Earth. The signals are used by these receivers to determine their specific position and time. The GPS data is encrypted and sent to a microcontroller, a tiny computer that manages several aspects of the system. To calculate how far the car went on the taxable route, the microcontroller analyses the data and makes the relevant computations.

The length between two locations in space is known as distance, and it is a basic idea in physics. In this scenario, computing the difference between the beginning and end coordinates yields the vehicle's journey distance.

The amount that the vehicle owner is expected to pay for using the taxable road is referred to as the charge under this system. The term "charge" is used in the context of taxes. The fee is determined using a predetermined sum specified by the government per kilometre, a unit of measurement for distance equivalent to 1000 metres.

Liquid crystal displays, sometimes known as LCDs, are a class of electronic displays that use liquid crystals to show data. The computed fee is shown to the car owner using this system's LCD display.

3.8. SOURCE CODE AND ITS EXPLANATION

Here is the source code that we used for the project's implementation

3.8.1. The actual code

```
#include <Adafruit_SSD1306.h>

#include <TinyGPS++.h>

#include <SoftwareSerial.h>

#define OLED_RESET 4

Adafruit_SSD1306 display(OLED_RESET);

static const int RXPin = 9, TXPin = 10;

static const uint32_t GPSBaud = 9600;

TinyGPSPlus gps;

SoftwareSerial ss(RXPin, TXPin);

float lat1 = 0.0, lon1 = 0.0, lat2 = 0.0, lon2 = 0.0;

float distance = 0.0, totalDistance = 0.0;

float pricePerKm = 5.0;

void setup()

{

display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
```

```

display.clearDisplay();

display.setTextColor(WHITE);

display.setTextSize(1);

display.setCursor(0,0);

display.print("starting..");

display.display();

display.clearDisplay();

display.setTextColor(WHITE);

display.setTextSize(1);

display.setCursor(0,0);

display.setCursor(0,0);

display.print("Distance: ");

display.print(totalDistance, 4);

display.println(" km");

display.print("starting..");

display.display();

Serial.begin(9600);

ss.begin(GPSBaud);

}

void loop()

{

while (ss.available() > 0) {

gps.encode(ss.read());

}

}

```

```

if (gps.location.isUpdated()) {
    lat2 = gps.location.lat();
    lon2 = gps.location.lng();
    if (lat1 != 0.0 && lon1 != 0.0) {
        distance = TinyGPSPlus::distanceBetween(lat1, lon1, lat2, lon2) / 1000.0;
        totalDistance += distance;

        float price = totalDistance * pricePerKm;

        display.clearDisplay();
        display.setCursor(0,0);
        display.print("Distance: ");
        display.print(totalDistance, 4);
        display.println(" km");
        display.clearDisplay();
        display.setTextColor(WHITE);
        display.setTextSize(1);
        display.setCursor(0,0);
        display.print("starting..");
        display.display();

        display.setCursor(3,10);
        display.print("Price: Rs ");
        display.print(price, 2);
        display.display();

        //String gps_speed = String(gps.speed.kmph());

        display.setCursor(75, 20);

```

```

display.setTextSize(1);

display.print("speed:");

display.print(gps.speed.kmph());

display.setCursor(16, 50);

display.setTextSize(1);

display.print("km/h");

}

lat1 = lat2;

lon1 = lon2;

}

}

double calculateDistance(double lat1, double lon1, double lat2, double lon2) {

double radius = 6371000; // Earth's radius in meters

double deltaLat = (lat2 - lat1) * PI / 180;

double deltaLon = (lon2 - lon1) * PI / 180;

double a = sin(deltaLat / 2) * sin(deltaLat / 2) +

cos(lat1 * PI / 180) * cos(lat2 * PI / 180) *

sin(deltaLon / 2) * sin(deltaLon / 2);

double c = 2 * atan2(sqrt(a), sqrt(1-a));

double distance = radius * c;

return distance;

}

```

3.8.2.Explanation of the Code

Code used in our project has a lot of user defined functions and some lines which might be hard to understand. Let's see a brief explanation of the code.

```
#include <Adafruit_SSD1306.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
```

Fig 3.4: Code-part-1

The libraries needed for the programme to function are imported in this area of the code. The TinyGPS++ library, the Adafruit SSD1306 library, and the Software Serial library are used to operate the OLED display, decode the GPS data, and establish serial contact with the GPS module, respectively.

The ones that have pre-set functions are those. It includes function definitions that may be imported or included using the pre-processor instruction `#include`. This pre-processor directive instructs the compiler that processing the header file is required before compilation.

```
#define OLED_RESET 4
Adafruit_SSD1306 display(OLED_RESET);
```

Fig 3.5: Code-Part-2

Next, we specify the Adafruit SSD1306 library and set the OLED RESET pin to 4 to initialise the display object.

```
static const int RXPin = 9, TXPin = 10;
static const uint32_t GPSBaud = 9600;
TinyGPSPlus gps;
SoftwareSerial ss(RXPin, TXPin);
```

Fig 3.6: Code-Part-3

The GPS module's baud rate is set to 9600 in this section, and the RX Pin and TX Pin are defined for Software Serial connection with the GPS module. We initialise the Software Serial object and define the GPS object using the “TinyGPSPlus” library.

```
float lat1 = 0.0, lon1 = 0.0, lat2 = 0.0, lon2 = 0.0;
float distance = 0.0, totalDistance = 0.0;
float pricePerKm = 5.0;
```

Fig 3.7: Code-Part-4

The variables we will utilise in the programme are declared and initialised in these lines. The distance was calculated using the GPS values lat1, lon1, lat2, and lon2. Total Distance is the overall distance travelled, whereas distance is the separation between two sets of GPS coordinates. Based on the distance travelled, the total cost is determined using price Per Km.

```

void setup()
{
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C);
  display.clearDisplay();
  display.setTextColor(WHITE);
  display.setTextSize(1);
  display.setCursor(0,0);
  display.print("starting..");
  display.display();

  Serial.begin(9600);
  ss.begin(GPSBaud);
}

```

Fig 3.8:Code-Part-5

When the application first launches, the setup function is called once. We initialise the OLED display, configure the text's colour and size, and show the opening message in this part. Also, we choose the baud rate for the serial communication between the GPS module and Arduino.

```

void loop()
{
  while (ss.available() > 0) {
    gps.encode(ss.read());
  }
}

```

Fig 3.9: Code-Part-6

The loop function is used a lot when the programme is running. In this section, we determine whether the GPS module has any available data and, if it does, use the TinyGPS++ library to decode it.

```

if (gps.location.isUpdated()) {
    lat2 = gps.location.lat();
    lon2 = gps.location.lng();

    if (lat1 != 0.0 && lon1 != 0.0) {
        distance = TinyGPSPlus::distanceBetween(lat1, lon1, lat2, lon2) / 1000.0;
        totalDistance += distance;
        float price = totalDistance * pricePerKm;

        display.clearDisplay();

        display.setCursor(0,0);
        display.print("Distance: ");
        display.print(totalDistance, 4);
        display.println(" km");
        display.setCursor(3,10);
        display.print("Price: Rs ");
        display.print(price, 2);
        display.display();

        display.setCursor(75, 20);
        display.setTextSize(1);
        display.print("speed:");
        display.print

```

Fig 3.10:Code-Part-7

In the last section of the code, a function called calculate Distance is defined. Given two locations on a sphere and their latitude and longitude coordinates, this function determines the great-circle distance between them.

The latitude and longitude of the two sites are two of the four parameters that the function requires. The Haversine formula, which accounts for the curvature of the Earth's surface, is used to determine the separation between the two sites. Trigonometric computations employing the sine, cosine, and tangent functions are used in the formula.

The determined distance, which is given in metres, is then returned by the function. The radius of the Earth, which was calculated using a value of 6371000 metres, is considered to be average.

This code reads GPS location data from a TinyGPS++ module and calculates the distance traveled using the Haversine formula. It then displays the total distance and the price based on a given price per kilometer on an OLED display using the Adafruit_SSD1306 library.

The setup function initializes the OLED display, sets the baud rate for serial communication with the GPS module, and initializes the GPS object.

The loop function reads GPS data and calculates the distance traveled and the total distance. It then displays the results on the OLED display. The distance is calculated using the distanceBetween function provided by the TinyGPS++ library. The calculateDistance function is not used in this code and can be removed.

Overall, the code provides a simple example of how to read and process GPS data and display the results on an OLED display using Arduino.

3.8.3. Code's time and space complexity

The time and space complexity of the provided code is as follows:

1. The setup() function initializes the GPS module and the OLED display. It takes constant time to execute and has a space complexity of $O(1)$.
2. The loop() function runs continuously until the program is stopped. It first checks for new GPS data, which takes $O(1)$ time. If new GPS data is available, it calculates the distance between the current and previous locations using the TinyGPSPlus::distanceBetween() method. This method has a time complexity of $O(1)$. The loop() function then updates the OLED display, which takes constant time and has a space complexity of $O(1)$.
3. The calculateDistance() function is defined but not used in the provided code. It calculates the distance between two points on the Earth's surface using the Haversine formula. The function has a time complexity of $O(1)$ and a space complexity of $O(1)$.

Overall, the time complexity of the provided code is $O(1)$ for each loop iteration, and the space complexity is also $O(1)$.

3.9.THE FORMULA USED- HAVERSINE FORMULA

3.9.1. General Facts about Haversine formula

The Haversine formula is a mathematical formula used to calculate the distance between two points on a sphere, such as the Earth. It takes into account the latitude and longitude coordinates of both points and calculates the great-circle distance, which is the shortest distance between two points on the surface of a sphere.

The formula is:

$$d = 2r * \arcsin(\sqrt{\sin^2((\text{lat2}-\text{lat1})/2) + \cos(\text{lat1}) * \cos(\text{lat2}) * \sin^2((\text{lon2}-\text{lon1})/2)}))$$

where:

d is the distance between the two points in the same units as the radius (usually kilometers or miles),

r is the radius of the sphere (earth's radius is approximately 6,371 kilometers or 3,959 miles),

lat1 and lat2 are the latitudes of the two points in radians,

lon1 and lon2 are the longitudes of the two points in radians,

Note that the formula assumes that the Earth is a perfect sphere, which is not entirely accurate, but still provides reasonably good results for most practical applications.

3.9.2. A Model calculation for Haversine Formula

For this example, let us say that we want to calculate the distance between two cities: New York City (latitude: 40.7128° N, longitude: 74.0060° W) and Los Angeles (latitude: 34.0522° N, longitude: 118.2437° W).

First, we need to convert the latitudes and longitudes from degrees to radians:

New York City: latitude = 40.7128° N, longitude = 74.0060° W

Los Angeles: latitude = 34.0522° N, longitude = 118.2437° W

Latitude in radians

New York City: 40.7128° N = 0.7102 radians

Los Angeles: 34.0522° N = 0.5949 radians

Longitude in radians

New York City: 74.0060° W = -1.2915 radians

Los Angeles: 118.2437° W = -2.0614 radians

Next, we can use the Haversine formula to calculate the distance between the two cities

$$d = 2r \arcsin(\sqrt{\sin^2((\text{lat2} - \text{lat1})/2) + \cos(\text{lat1}) * \cos(\text{lat2}) * \sin^2((\text{lon2} - \text{lon1})/2)})$$

where:

d = distance between the two points

r = radius of the Earth (mean radius = 6,371km)

lat1, lon1 = latitude and longitude of point 1 (New York City)

lat2, lon2 = latitude and longitude of point 2 (Los Angeles)

Plugging in the values:

$$\begin{aligned} d &= 2 * 6,371\text{km} * \arcsin(\sqrt{\sin^2((0.5949 - 0.7102)/2) + \cos(0.7102) * \cos(0.5949) * \sin^2((-2.0614 - -1.2915)/2)}) \\ &= 3,959 \text{ miles (approximately)} \end{aligned}$$

Therefore, the distance between New York City and Los Angeles is approximately 3,959 miles.

CHAPTER 4

HARDWARE DESCRIPTION

4.1 COMPONENTS REQUIRED

We implement the proposed system, using both software and hardware.

Software components:

1. Arduino IDE (Used the C++ programming language)

Hardware components:

1. GPS Module
2. Microcontroller (Arduino UNO WIFI R3)
3. LED Display

4.1.1 Software Components Description:

4.1.1.1 Arduino IDE:

The Arduino Integrated Development Environment (IDE) is a software platform designed for programming and developing applications with Arduino boards. The Arduino IDE is a user-friendly tool that makes it easy for beginners and experts alike to write, upload, and run code on Arduino boards. The IDE comes with a rich set of features that enable users to create a wide range of projects, from simple LED blink programs to complex robotic systems.

One of the key advantages of the Arduino IDE is its ease of use. The interface is clean and intuitive, and the coding environment is simple and straightforward. The IDE also features a built-in library manager that makes it easy to access and integrate third-party libraries into your projects. Additionally, the IDE supports a wide range of programming languages, including C, C++, and Java, making it accessible to developers with a variety of backgrounds and skill levels.

The Arduino IDE is widely used for prototyping, experimentation, and education. Its simplicity and ease of use make it a popular choice for beginners who want to learn how to code and build electronic projects. Arduino boards are also widely used in the maker community for building DIY projects, robotics, and home automation systems.

Despite its many advantages, the Arduino IDE does have some limitations. One of the biggest drawbacks is that it lacks some of the advanced features found in other programming environments, such as code completion and debugging tools. Additionally, the IDE can be slow and resource-intensive when working with large projects.

Overall, the Arduino IDE is a powerful and user-friendly tool that is widely used for developing a wide range of electronic projects. Its ease of use and broad compatibility make it an excellent choice for beginners and experts alike. However, its limitations may make it less suitable for larger or more complex projects, where more advanced tools may be required.

The programming language used is C++. C++ is a powerful programming language that has been around for several decades. It is widely used in a variety of fields, including system programming, game development, and robotics. C++ is a high-level language that allows developers to write complex programs with ease. It is an extension of the C programming language and includes several additional features such as classes, templates, and exceptions.

C++ is a compiled language, which means that the code is converted into machine language before execution. This makes C++ programs faster and more efficient than interpreted languages such as Python or Ruby. However, C++ is also a more complex language than these interpreted languages and requires more knowledge and expertise to use effectively.

One of the main advantages of C++ is its ability to interface with low-level hardware. This makes it an ideal language for system programming and embedded systems such as Arduino projects. Arduino is an open-source electronics platform that uses C++ to control various devices such as sensors, motors, and lights. C++ allows developers to write code that interacts directly with the hardware, making it easier to create complex projects.

Compared to other languages used for Arduino projects such as Python or Java, C++ is faster and more efficient. This is because C++ code is compiled into machine language, which can run directly on the hardware without any overhead. Python, on the other hand, is an interpreted language, which means that the code needs to be converted into machine language on the fly, which can slow down the execution of the program.

In addition to its speed and efficiency, C++ is also a more versatile language than Python. C++ allows developers to create object-oriented programs, which can be more modular and easier to maintain than procedural programs. Object-oriented programming allows developers to encapsulate code into objects, which can be reused in other programs. This makes it easier to create complex programs with many interdependent parts.

C++ is also a more secure language than Python. Because C++ code is compiled into machine language, it is more difficult for hackers to exploit vulnerabilities in the code. Python, on the other hand, is an interpreted language, which means that the code can be easily read and modified by anyone with access to the source code.

C++ is a powerful programming language that is widely used in a variety of fields. It is an ideal language for system programming and embedded systems such as Arduino projects. Compared to other languages such as Python or Java, C++ is faster, more efficient, and more versatile. C++ allows developers to create complex programs that can interface directly with low-level hardware, making it easier to create complex projects. If you are interested in learning programming, C++ is a great language to start with, and it will provide a solid foundation for our future programming endeavours.

Using C++ in Arduino offers several advantages over other programming languages. First and foremost, C++ is a powerful and flexible language that allows for efficient and effective programming, making it an ideal choice for embedded systems like Arduino.

C++ is also an object-oriented language, which means that it enables programmers to organize code into reusable and modular units called objects. This makes it easier to write and maintain complex programs, which is particularly useful in the context of Arduino projects.

Additionally, Arduino has a simplified version of C++ called the Arduino Programming Language, which makes it easier for beginners to get started with programming. The language includes built-in libraries that simplify tasks such as controlling LEDs, reading sensor data, and communicating with other devices. Finally, because C++ is a widely used language, there is a large community of developers and resources available for those working with Arduino. This makes it

easier to find help and information when needed, and can accelerate the development process.

4.1.2 Hardware Components Description

4.1.2.1 Arduino Board:

Arduino boards are microcontroller-based platforms that are commonly used in the development of electronic projects, from simple robotics to complex automation systems. These boards are designed to provide an easy-to-use interface for both beginners and experts in the field of electronics, allowing them to create and program custom electronic devices without the need for advanced knowledge of electronics.

Usage:

One of the main advantages of Arduino boards is their versatility in application. They can be used for a wide range of projects, including robotics, automation, IoT, and even wearable devices. Their simple programming language and wide range of available sensors and modules make them a popular choice among hobbyists, students, and professionals alike.

Arduino boards also provide an easy-to-use platform for prototyping new projects. They are equipped with a range of input and output pins, allowing users to connect various sensors, motors, and other devices to the board, making it possible to create custom electronic circuits quickly and easily.

PIN Details

Arduino Uno is the most standard board available and probably the best choice for a beginner. We can directly connect the board to the computer via a USB Cable which performs the function of supplying the power as well as acting as a serial port.

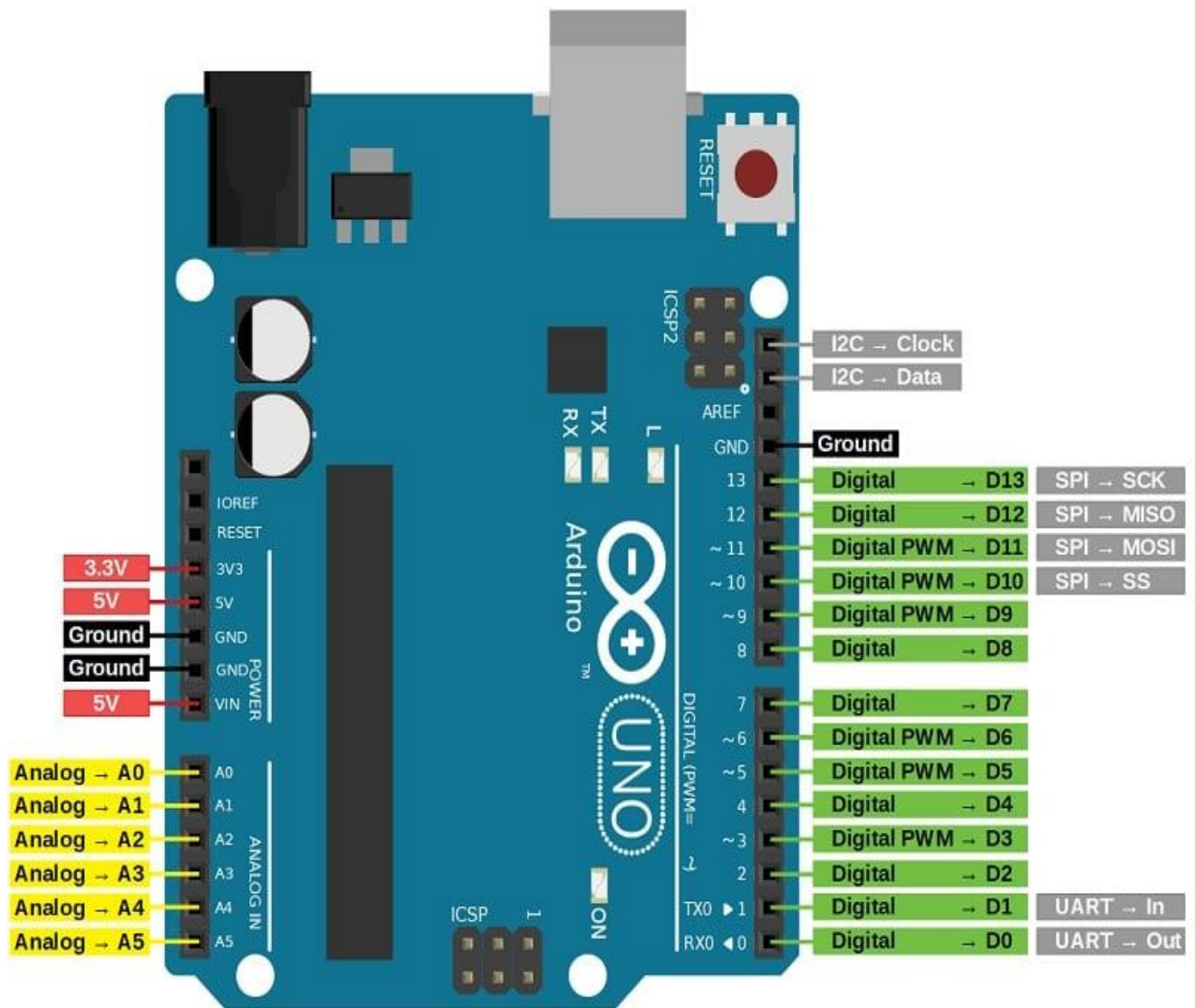


Fig 4.1: Aurdino UNO WIFI R3

Vin: This is the input voltage pin of the Arduino board used to provide input supply from an external power source.

5V: This pin of the Arduino board is used as a regulated power supply voltage and it is used to give supply to the board as well as onboard components.

3.3V: This pin of the board is used to provide a supply of 3.3V which is generated from a voltage regulator on the board

GND: This pin of the board is used to ground the Arduino board.

Reset: This pin of the board is used to reset the microcontroller. It is used to Resets the microcontroller.

Analog Pins: The pins A0 to A5 are used as an analog input and it is in the range of 0-5V.

Digital Pins: The pins 0 to 13 are used as a digital input or output for the Arduino board.

Serial Pins: These pins are also known as a UART pin. It is used for communication between the Arduino board and a computer or other devices. The transmitter pin number 1 and receiver pin number 0 is used to transmit and receive the data resp.

External Interrupt Pins: This pin of the Arduino board is used to produce the External interrupt and it is done by pin numbers 2 and 3.

PWM Pins: This pin of the board is used to convert the digital signal into an analog by varying the width of the Pulse. The pin numbers 3,5,6,9,10 and 11 are used as a PWM pin.

SPI Pins: This is the Serial Peripheral Interface pin, it is used to maintain SPI communication with the help of the SPI library. SPI pins include:

1. SS: Pin number 10 is used as a Slave Select
2. MOSI: Pin number 11 is used as a Master Out Slave In
3. MISO: Pin number 12 is used as a Master In Slave Out
4. SCK: Pin number 13 is used as a Serial Clock

LED Pin: The board has an inbuilt LED using digital pin-13. The LED glows only when the digital pin becomes high.

AREF Pin: This is an analog reference pin of the Arduino board. It is used to provide a reference voltage from an external power supply.

4.1.2.2 GPS Module (GPS Neo M8M)

Global Positioning System (GPS) is a satellite-based navigation system that provides precise location and time information anywhere on or near the Earth's surface. GPS is widely used for navigation, mapping, and tracking purposes. GPS modules are electronic devices that receive GPS signals from the satellites and provide location data in real-time. In this passage, we will discuss the working principle, advantages, and disadvantages of GPS modules.

Working Principle of GPS Module

A GPS module consists of a receiver that receives signals from at least four GPS satellites orbiting the Earth. The receiver calculates the distance between the GPS module and the satellites based on the time taken for the signals to travel. This distance is known as the 'pseudo range'.

GPS modules are powerful tools for location tracking, navigation, and monitoring applications. They provide highly accurate and reliable location data, making them essential for a wide range of industries. However, GPS modules also have their limitations, such as signal interference and vulnerability to hacking. As GPS technology continues to advance, it is likely that these limitations will be addressed, and GPS modules will become even more versatile and useful for various applications.

GPS Working

GPS, or Global Positioning System, is a technology that allows users to determine their precise location, as well as track the movement of objects, vehicles or people with high accuracy. It uses a network of satellites orbiting the earth and ground control stations to provide this information. In this article, we will explore how GPS works in-depth.

The GPS system consists of three segments - the space segment, the control segment, and the user segment. The space segment comprises a constellation of 24 satellites in orbit around the Earth at an altitude of approximately 20,000 km. These satellites are spread out in six orbital planes with

four satellites in each plane. The control segment consists of a network of monitoring and control stations that track the satellites and make necessary adjustments to their orbits and clocks. Finally, the user segment is made up of the GPS receivers that are used by individuals, businesses, and government agencies to receive signals from the satellites and determine their precise location.

Each GPS satellite continuously broadcasts signals containing information about its position and time. The signals are transmitted at a frequency of 1575.42 MHz and travel at the speed of light. The GPS receiver uses these signals to calculate its distance from the satellite based on the time it takes for the signal to reach the receiver.

To understand how this distance calculation is done, it's important to first understand how GPS signals are structured. Each GPS signal contains two codes - a coarse acquisition (C/A) code and a precise (P) code. The C/A code is a publicly available code that provides low-precision positioning information. The P code, on the other hand, is an encrypted code that provides high-precision positioning information but is only available to authorized users.

When a GPS receiver is turned on, it begins searching for signals from at least four GPS satellites. Once it receives signals from at least four satellites, the receiver uses a process called trilateration to determine its precise location. Trilateration is a method of determining the location of an object by measuring the distance to three or more reference points.

To calculate its distance from a GPS satellite, the receiver first determines the time it took for the satellite's signal to travel from the satellite to the receiver. This is done by comparing the time the signal was transmitted by the satellite, which is included in the signal itself, with the time the signal was received by the receiver. The difference between these two times is called the signal travel time.

To determine its distance from the satellite, the receiver multiplies the signal travel time by the speed of light, which is approximately 299,792,458 meters per second. This gives the distance between the receiver and the satellite in meters.

Since the GPS receiver knows the precise position of the GPS satellites in orbit, it can calculate its position by performing trilateration using the distances to at least three satellites. This involves drawing spheres around each satellite with a radius equal to the distance between the satellite and the receiver. The point where these spheres intersect is the precise location of the receiver.

However, the GPS signals can be affected by various factors that can cause errors in the position calculation. These include atmospheric effects, such as ionospheric and tropospheric delays, as well as multipath errors, which occur when the GPS signals bounce off objects and arrive at the receiver from different directions. To correct for these errors, the GPS receiver uses a process called differential GPS.

Differential GPS involves using a second GPS receiver at a known location to measure the errors in the GPS signals and transmit correction information to the GPS receiver being used to determine the position. This allows for more accurate positioning information to be obtained, with errors reduced to less than a meter.

In conclusion, GPS technology uses a network of satellites, ground control stations, and GPS receivers to determine precise locations and track movement.

Practice of calculating the latitude

Latitude is a measure of a location's position relative to the equator, which is an imaginary line that circles the earth at 0 degrees latitude. Latitude is expressed in degrees, with values ranging from 0 degrees at the equator to 90 degrees at the poles.

There are various methods used to calculate latitude, but the most common and accurate method is based on the angle between the observer and the celestial equator, which is an imaginary line that circles the earth's celestial sphere and is an extension of the earth's equator.

One of the most widely used instruments for measuring this angle is the sextant, which uses mirrors to reflect the image of a celestial body, such as the

sun or a star, into the observer's line of sight. The observer can then measure the angle between the celestial body and the horizon.

To calculate latitude using the angle between the observer and the celestial equator, it's important to understand the concept of the zenith, which is the point directly overhead the observer's location. The zenith is important because the angle between the celestial equator and the observer's position is equal to the angle between the zenith and the celestial body.

When the sun is at its highest point in the sky, its angle above the horizon is equal to the observer's latitude. This is because the sun is directly overhead the observer when it reaches its highest point, which is known as solar noon. Therefore, by measuring the angle between the sun and the horizon at solar noon, the observer can determine their latitude.

However, the angle between the sun and the horizon varies throughout the day and depends on the observer's location and the time of year. Therefore, to calculate latitude using the angle between the sun and the horizon, it's necessary to make corrections for these factors.

One way to do this is to use a table of corrections, such as the Nautical Almanac, which provides corrections for the observer's location, the date, and the time of day. These corrections take into account the earth's rotation, the angle between the observer and the celestial equator, and the obliquity of the ecliptic, which is the angle between the earth's axis of rotation and the plane of its orbit around the sun.

Once the necessary corrections have been applied, the observer can calculate their latitude by subtracting the angle between the sun and the horizon from 90 degrees. For example, if the angle between the sun and the horizon is 45 degrees, the observer's latitude would be 45 degrees north or south, depending on their location.

In addition to using the angle between the sun and the horizon, latitude can also be calculated using other celestial bodies, such as stars or planets. However, these methods require more advanced astronomical knowledge and specialized

instruments, such as a chronometer or a star chart. Overall, calculating latitude using the angle between the observer and the celestial equator is an important and accurate method that has been used for centuries by sailors, astronomers, and other navigators to determine their position on the earth's surface.

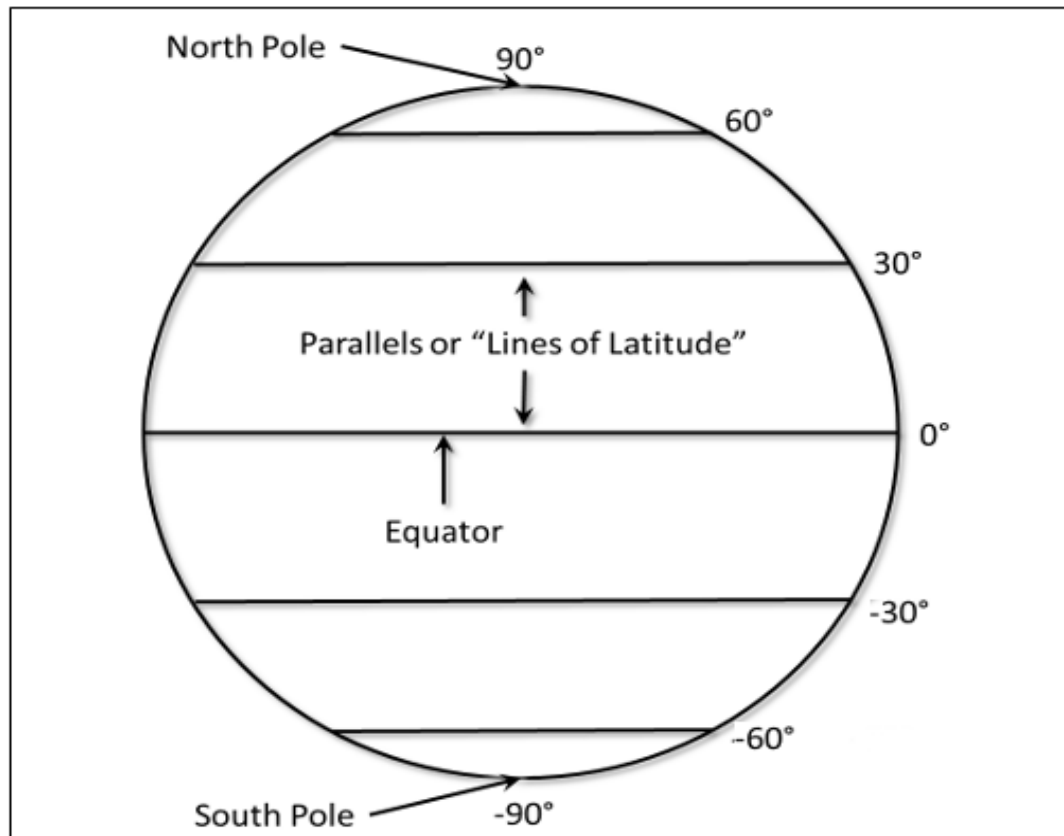


Fig 4.2 : Latitude

Practice of calculating Longitude

Longitude is a measure of a location's position relative to the Prime Meridian, which is an imaginary line that circles the earth from the North Pole to the South Pole and passes through the Royal Observatory in Greenwich, England. Longitude is expressed in degrees, with values ranging from 0 degrees at the Prime Meridian to 180 degrees east or west.

Unlike latitude, which can be determined using the angle between the observer and the celestial equator, longitude cannot be directly measured using astronomical observations. Instead, it is necessary to use a time reference to calculate longitude.

The key to calculating longitude is the fact that the earth rotates 360 degrees in 24 hours, which means that the earth rotates 15 degrees per hour or one degree every four minutes. This rotation can be used to determine the difference in time between two locations, which in turn can be used to calculate their difference in longitude.

To calculate longitude, it is necessary to compare the local time at the observer's location with the time at a reference location, which is usually the Prime Meridian. The difference in time between the two locations is then converted into a difference in longitude, using the fact that one hour of time difference corresponds to 15 degrees of longitude.

One of the most important instruments used for determining longitude was the marine chronometer, which was invented in the 18th century by John Harrison. A marine chronometer is a highly accurate timekeeping device that can be used on board a ship to determine the ship's longitude at sea.

The marine chronometer works by measuring the time elapsed since a fixed reference time, such as noon at the reference location. By comparing the time on the chronometer with the local time at the observer's location, it is possible to determine the difference in time, and therefore the difference in longitude.

In addition to the marine chronometer, other methods have been developed for calculating longitude, such as radio navigation systems, such as the Global Positioning System (GPS), which uses a network of satellites to provide precise time and position information.

Overall, calculating longitude is a complex process that requires accurate timekeeping and a reference location for comparison. While technological advances have made it easier to determine longitude in modern times, the history of navigation is filled with tales of sailors and explorers who used their ingenuity and skill to navigate the world's oceans and accurately determine their position using only the tools and knowledge available to them.

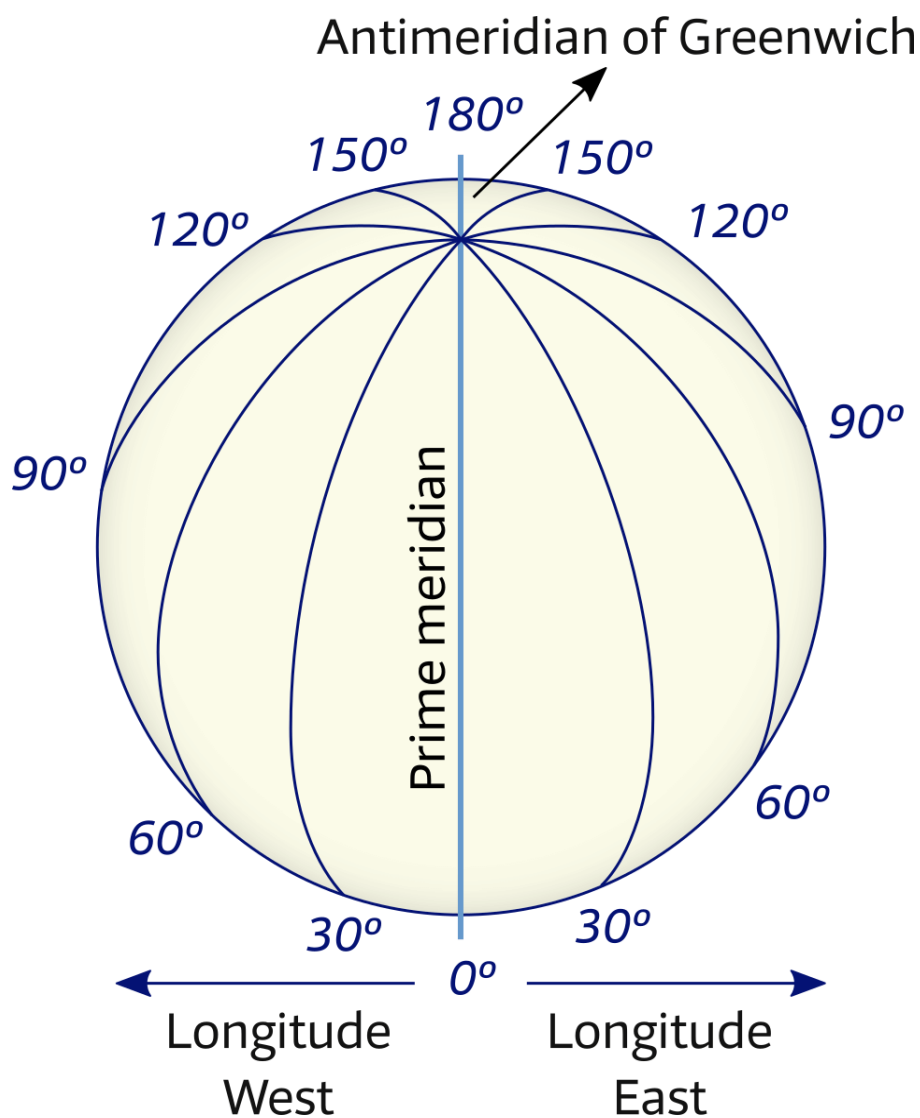


Fig 4.3: Longitude

How latitude and longitude help us to locate something on the surface of the earth

Latitude and longitude are the two coordinates that are used to specify any point on Earth's surface. Latitude is the angular distance measured north and south of the equator, which is an imaginary line that circles the Earth at 0 degrees latitude. Longitude is the angular distance measured east and west of the Prime Meridian, which is an imaginary line that runs from the North Pole to the South Pole and passes through the Royal Observatory in Greenwich, England, at 0 degrees longitude.

The use of latitude and longitude to determine the location of any point on Earth is based on the idea of spherical geometry. The Earth is approximately a

sphere, and its surface can be divided into a series of circles, each of which is defined by a particular latitude and longitude.

To understand how latitude and longitude help us calculate the exact location, let's start with latitude. The equator is the line of 0 degrees latitude, and it divides the Earth into two equal halves: the Northern Hemisphere and the Southern Hemisphere. The latitude of any point on the Earth is measured in degrees north or south of the equator, with the maximum value being 90 degrees at the poles.

For example, the latitude of New York City is approximately 40 degrees North, while the latitude of Rio de Janeiro is approximately 23 degrees South. The latitude of a place is important because it affects the climate, the length of daylight, and the angle of the sun's rays.

Longitude is the angular distance measured east or west of the Prime Meridian. The Prime Meridian is the line of 0 degrees longitude, and it passes through Greenwich, England. Longitude is measured in degrees east or west of the Prime Meridian, with the maximum value being 180 degrees.

For example, the longitude of New York City is approximately 74 degrees West, while the longitude of Tokyo is approximately 139 degrees East. The longitude of a place is important because it determines the time difference between that place and the Prime Meridian.

To calculate the exact location of any point on Earth, we need to know both its latitude and longitude. This can be done using a variety of methods, including GPS (Global Positioning System), maps, and celestial navigation. GPS is a satellite-based system that uses a network of satellites to determine the location of a receiver on the Earth's surface.

GPS receivers receive signals from these satellites and use triangulation to determine the receiver's latitude, longitude, and altitude.

Maps are also an important tool for determining the location of a point on the Earth's surface. Maps are often based on a grid system that uses latitude and longitude as coordinates. By using a map and knowing the latitude and longitude of a place, we can find its exact location.

Celestial navigation is another method for determining the location of a point on the Earth's surface. Celestial navigation involves using the position of the stars to determine latitude and longitude. By using a sextant to measure the angle between the horizon and a particular star, and by knowing the time of day, it is possible to determine the latitude and longitude of a ship or aircraft.

In conclusion, latitude and longitude are two coordinates that are used to specify any point on Earth's surface. They are important because they help us determine the location of a place, and they affect the climate, the length of daylight, and the angle of the sun's rays. We can determine the exact location of any point on Earth using a variety of methods, *including GPS and maps*.

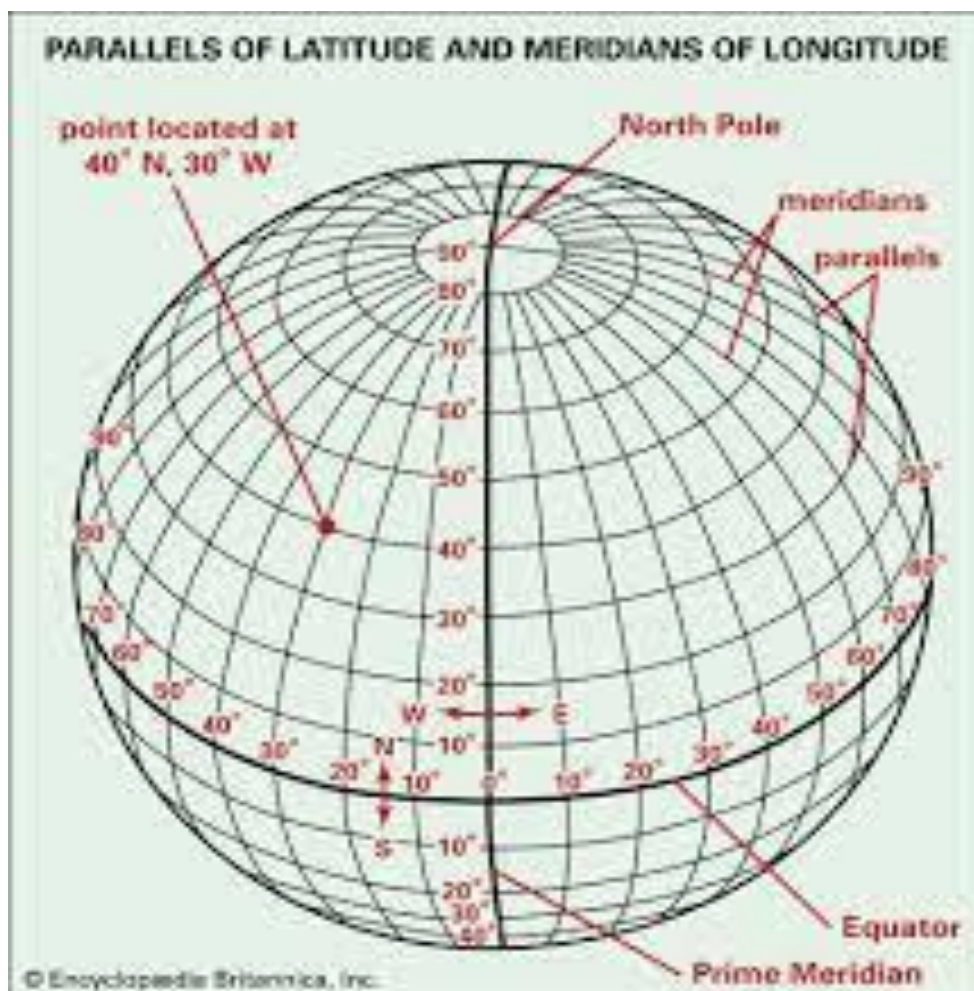


Fig 4.4: Depiction of how each point in Earth's surface have different points

Role of all satellites for correct identification of coordinates

The Global Positioning System (GPS) is a satellite-based navigation system consisting of a network of satellites in orbit around the Earth. GPS allows users to determine their precise location, velocity, and time anywhere on the Earth's surface or in its atmosphere.

The GPS system uses a constellation of at least 24 operational satellites in medium Earth orbit (MEO) at an altitude of approximately 20,200 kilometers (12,550 miles) above the Earth's surface. The system requires signals from a minimum of four satellites to accurately calculate a user's position and velocity. The four satellites provide four measurements of distance between the receiver and each of the satellites. These measurements are used to solve for the three-dimensional location of the receiver (latitude, longitude, and altitude) and its velocity.

Each GPS satellite transmits a unique signal that is received by GPS receivers on the ground. The receiver calculates the distance to each satellite by measuring the time it takes for the signal to travel from the satellite to the receiver. The receiver then uses these distance measurements to determine its position using a process called trilateration.

The four satellites involved in calculating the coordinates of the GPS are:

1. Satellite 1: This is the first satellite in the chain, which transmits a signal that is received by the GPS receiver. The receiver uses the time it takes for the signal to travel from the satellite to the receiver to calculate the distance between them.
2. Satellite 2: This is the second satellite in the chain, which also transmits a signal that is received by the GPS receiver. The receiver uses the time it takes for the signal to travel from the satellite to the receiver to calculate the distance between them.
3. Satellite 3: This is the third satellite in the chain, which also transmits a signal that is received by the GPS receiver. The receiver uses the time it takes for the signal to travel from the satellite to the receiver to calculate the distance between them.

4. Satellite 4: This is the fourth satellite in the chain, which also transmits a signal that is received by the GPS receiver. The receiver uses the time it takes for the signal to travel from the satellite to the receiver to calculate the distance between them.

Once the distances to the four satellites have been calculated, the GPS receiver uses a mathematical algorithm to solve for the three-dimensional position and velocity of the receiver. The GPS receiver may also use additional data from other satellites or sources, such as ground-based transmitters or inertial navigation systems, to improve the accuracy and reliability of its position and velocity estimates.

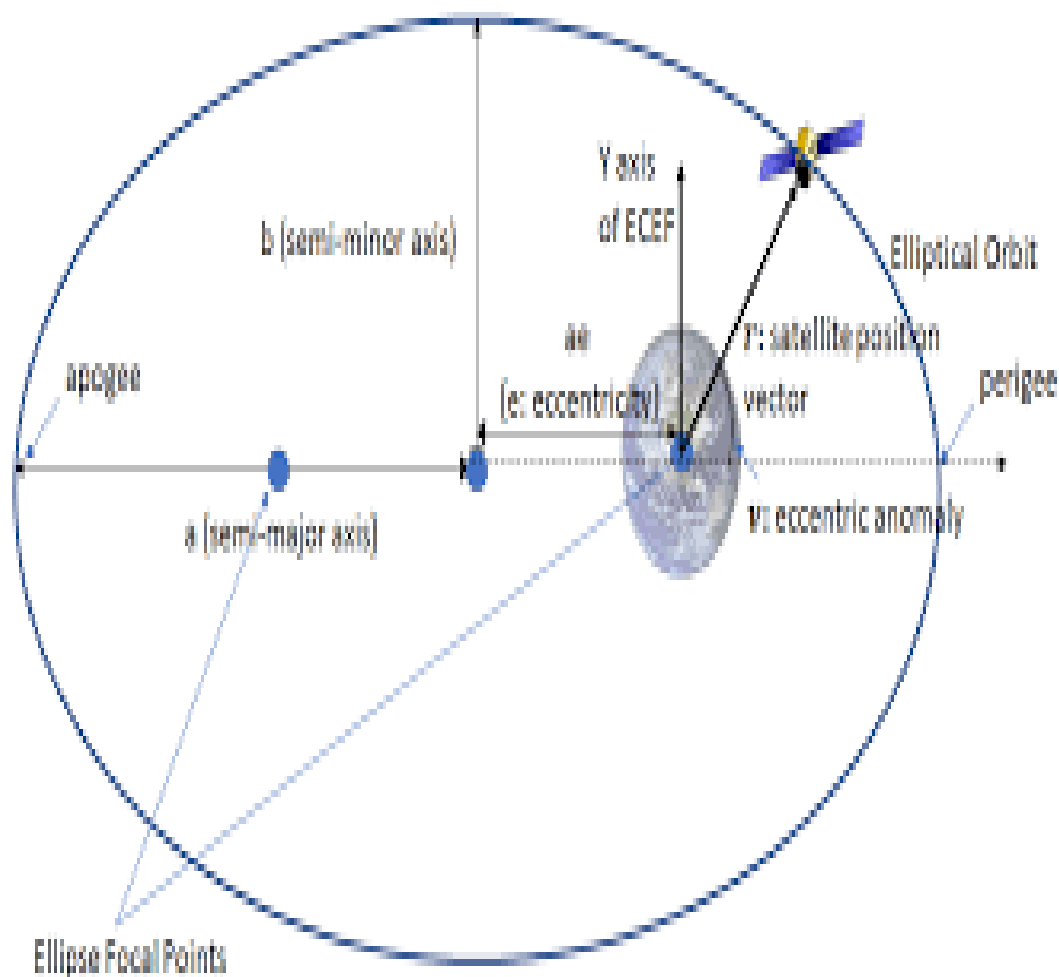


Fig 4.5: Image describing how satellites actually locate a co ordinate

Parameter	Description
Category	<u>RF/IF and RFID</u> <u>RF Receivers</u>
Frequency	1.575GHz
Sensitivity	-167dBm
Modulation or Protocol	BeiDou, Galileo, GLONASS, GNSS, GPS
Current – Receiving	21 mA
Voltage - Supply	1.65V ~ 3.6V
Mounting Type	Surface Mount

Table 4.1: Features of GPS Neo M8M

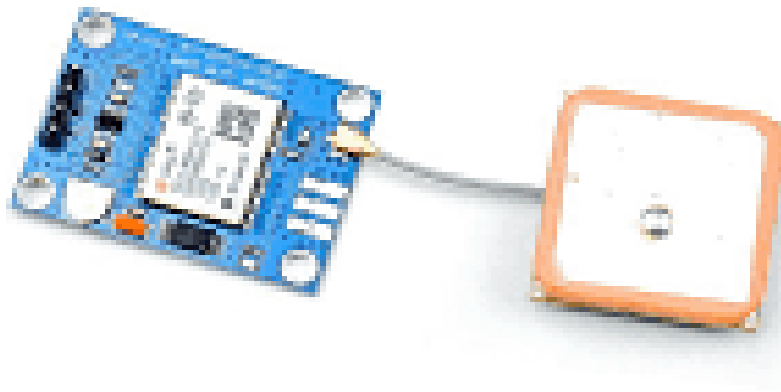


Fig 4.6: GPS Neo M8N module.

Pin Details of the GPS

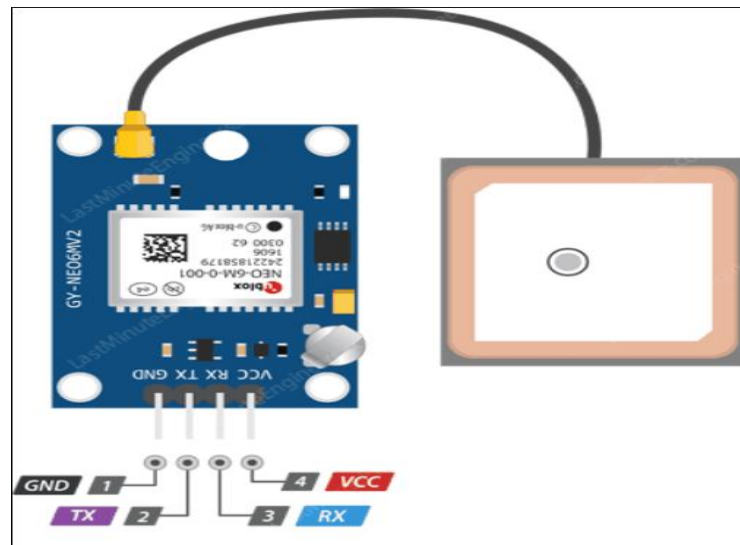


Fig 4.7: Pin Layout of GPS

Advantages of GPS:

Precise Location Tracking: GPS modules provide highly accurate location data, which makes them suitable for a wide range of applications, such as vehicle tracking, asset tracking, and wildlife monitoring.

Easy to Use: GPS modules are easy to install and use. They require minimal programming and can be interfaced with a wide range of devices, including microcontrollers, computers, and smartphones.

Global Coverage: GPS modules can provide location data anywhere on or near the Earth's surface, making them ideal for applications that require tracking or navigation across large distances.

Low Power Consumption: GPS modules consume very little power, which makes them suitable for battery-powered applications such as remote monitoring and wildlife tracking.

Disadvantages of GPS Module:

Cost: GPS modules can be expensive, especially if they require high levels of accuracy or features such as real-time kinematics (RTK).

Signal Interference: GPS signals can be blocked or interfered with by tall buildings, trees, and other obstacles. This can affect the accuracy of the location data.

Limited Indoor Use: GPS signals are weak and cannot penetrate most building materials, making GPS modules unsuitable for indoor use.

Vulnerability to Hacking: GPS signals can be jammed or spoofed by malicious actors, which can affect the accuracy of the location data and potentially cause safety issues.

GPS modules are powerful tools for location tracking, navigation, and monitoring applications. They provide highly accurate and reliable location data, making them essential for a wide range of industries. However, GPS modules also have their limitations, such as signal interference and vulnerability to hacking. As GPS technology continues to advance, it is likely that these limitations will be addressed, and GPS modules will become even more versatile and useful for various applications.

4.1.2.3 LED display

Led stands for light emitting diode

Working of LED Display:

LED displays work by lighting up individual LEDs arranged in a specific pattern to form characters or symbols. They typically have a common cathode or anode connection for each row or column of LEDs, which is connected to an Arduino microcontroller. The microcontroller then sends signals to each LED to turn them on or off as needed, creating the desired display.



Fig 4.8: LED Display

LED displays are an excellent choice for many Arduino projects due to their low power consumption, high brightness, and affordability. However, their limited resolution, color options, and complex circuitry may limit their usefulness in some applications.

Pin Details of the LCD display used in Arduino:

VSS	GND
VCC	5V
VEE	POTENTIO
RS	12
RW	11
E	11
D4	5
D5	4
D6	3
D7	2
LED+	5V
LED-	GND

Table 4.2: LCD display Description

Advantages of LCD Display in Arduino Projects:

1. Low Power Consumption: LCD displays consume less power , making them ideal for portable or battery-powered Arduino projects.
2. High Brightness: LCDs have high brightness and are visible even in bright sunlight, making them suitable for outdoor applications.
3. Longevity: LCD displays have a longer lifespan than other display technologies
4. Easy to Interface: LCD displays are easy to interface with an Arduino microcontroller as they require only a few digital pins to control.

5. Cost-Effective: LCD displays are relatively inexpensive, making them an affordable choice for many Arduino projects.

Disadvantages of LCD Display in Arduino Projects:

1. Limited Resolution: LCD displays have limited resolution and can display only a limited number of characters or symbols.
2. Limited Colour Options: LCD displays are available in a limited range of colours, making them unsuitable for applications that require color display.
3. Complex Circuitry: Large LCD displays with multiple rows and columns can require complex circuitry to interface with an Arduino, making them more challenging to work with.
4. Heat Generation: LCD displays can generate heat, especially when displaying bright colours or when used continuously for an extended period. This heat can affect the lifespan of the LCDs or the performance of other components in the circuit.

Overall, LCD displays are an excellent choice for many Arduino projects due to their low power consumption, high brightness, and affordability. However, their limited resolution, color options, and complex circuitry may limit their usefulness in some applications.

CHAPTER 5

RESULTS AND DISCUSSIONS

The project describes the implementation of a project that aims to revolutionize the way we pay for toll roads. The project utilizes a sophisticated system that tracks the distance travelled by a vehicle on a taxable highway and automatically deducts a set amount of money per kilometre. This innovative approach replaces the traditional toll gate system, which can be a source of congestion and inefficiency.

The system is designed to be fair and proportional to the distance travelled, ensuring that travellers pay only for what they use. This is achieved through the use of an LED display that shows the distance travelled and the amount deducted from the traveller's account. The system is designed to be user-friendly and easy to use, reducing the burden of paying for toll roads.

The use of a distance-based pricing model has several advantages. Firstly, it can help to reduce congestion at toll gates, which can be a major source of delays and frustration for travellers. This is because the system does not require physical toll gates, and the process of paying for tolls is streamlined and simplified.

Moreover, the distance-based pricing model can help to reduce the overall cost of using toll roads. This is because it ensures that travellers only pay for the distance they travel, rather than a fixed amount set by the government. This can be especially beneficial for frequent travellers, who may be able to save money over time.

However, it is important to note that the success of the system is contingent on the amount set for one kilometre. If the amount is set too high, it may discourage travellers from using the toll road, resulting in a decrease in revenue. On the other hand, if the amount is set too low, the system may not generate enough revenue to cover the costs of maintaining the road.

In conclusion, the implementation of a distance-based pricing system for toll roads can have several benefits, including reduced congestion, streamlined payment processes, and cost savings for frequent travellers. However, it is important to carefully consider the amount set for one kilometre to ensure that the

system is financially sustainable and attractive to travellers. The use of modern technology, such as LED displays and automated payment systems, can help to make the system more user-friendly and efficient.

The following were seen at the end of implementing the project. Figure below is the screen appearance before travelling on the taxable highway. For experimentation purposes, It is set an amount of 5 rupees per kilometer. In other words, for every kilometer travelled, an amount of rupees 5, will be deducted from the traveler's account, after the traveler has finished travelling. Figure 7 shows the display after the vehicle has travelled for 10 km, and a price of 50 rupees has been deducted in total. This helps a traveler pay proportionally to the distance Figure 11. LED Display of travel and not any random amount set by the government. It is found that the amount spent for toll gates would be decreased by a great amount. Since there is no physical toll gate, congestion at these points is also avoided. It is very crucial to focus on the amount set for one kilometer. The total amount paid might increase, above the existing amount, if it is set high.



Fig 5.1: Initial screen before travelling



Fig 5.2: Final screen displaying the output. Output consists of distance, and the price.

CHAPTER 6

CONCLUSION

The proposed idea can permanently eliminate the need to have toll gates and ease the payment process. It ensures transparency, safety, and reliability. The driver can ensure the driver can add money to his bank balance and money gets automatically deducted. In future, we can include some parameters like over-speed detection and prevention. Also, it is possible to track cars in the event of an emergency or accident. The methodology, proposed above, was implemented and is used to find the distance that the vehicle travelled, thereby deducting the amount proportionally. This has made the traveler pay only according to the distance, hence a passenger/car owner pays less than what he is supposed to pay, as per the current system.

The GPS-based E-Toll gate system is a highly effective solution for managing toll payments on highways and other roads. By using GPS technology, the system calculates the distance travelled by a vehicle and charges a proportional fee based on that distance. This method has several advantages over traditional toll payment methods and can benefit society in many ways.

Firstly, the GPS-based E-Toll gate system reduces traffic congestion and the time spent waiting in toll lines. It eliminates the need for drivers to stop and pay at a physical toll booth, which can cause backups and delays, especially during peak travel times. With the GPS-based system, drivers can pass through the toll gate seamlessly, without any interruption to their journey. This reduces travel time and can make a significant contribution to reducing traffic congestion.

Secondly, the GPS-based E-Toll gate system improves efficiency in toll collection and helps prevent fraud. Traditional toll collection systems rely on manual collection of toll fees, which can be subject to errors and manipulation. The GPS-based system, on the other hand, automates the collection process and ensures that the correct amount is charged for each journey. This not only reduces errors but also eliminates the possibility of toll fraud, which can result in lost revenue for the government.

Thirdly, the GPS-based E-Toll gate system can have a positive impact on the environment by reducing fuel consumption and air pollution. By reducing traffic

congestion and travel time, the system can reduce the amount of fuel consumed by vehicles on the road. This, in turn, can lead to a reduction in greenhouse gas emissions and other pollutants that contribute to air pollution. Moreover, the system can also encourage the use of more fuel-efficient vehicles and promote the adoption of cleaner transportation technologies.

Finally, the GPS-based E-Toll gate system can generate significant revenue for governments, which can be used to fund infrastructure development and other public services. By automating toll collection and preventing fraud, the system can ensure that the correct amount of revenue is collected for each journey. This can result in a significant increase in revenue for governments, which can be used to fund important projects that benefit society as a whole.

In conclusion, the GPS-based E-Toll gate system is a highly effective and efficient toll collection system that has the potential to benefit society in many ways. By reducing traffic congestion, improving efficiency in toll collection, promoting environmental sustainability, and generating revenue for governments, the system can contribute to the development of better infrastructure and public services. With its numerous benefits, the GPS-based E-Toll gate system is a valuable addition to modern transportation systems and should be considered for implementation on a wider scale.

CHAPTER 7

FUTURE SCOPE AND DEVELOPMENT

GPS-based E-toll gate systems are already in use in many countries and have significantly reduced the waiting time at toll booths, improved traffic flow, and increased transparency in toll collection. However, there is still scope for further development and improvement in the following areas:

1. Integration with other systems: GPS-based E-toll systems can be integrated with other systems like traffic management systems, public transportation systems, and emergency services to improve overall traffic management and safety.
2. Dynamic pricing: The toll rates can be dynamically adjusted based on the time of day, traffic volume, and other factors to reduce congestion during peak hours and encourage off-peak travel.
3. Multi-lane toll plazas: Multi-lane toll plazas can be developed to improve the efficiency of toll collection and reduce waiting time for vehicles.
4. Real-time traffic information: GPS-based E-toll systems can provide real-time traffic information to drivers to help them make informed decisions about their route and travel time.
5. Mobile payment options: Mobile payment options can be introduced to make toll payment more convenient and reduce the use of cash.
6. Automatic vehicle identification: Automatic vehicle identification technologies like RFID tags and license plate recognition systems can be integrated with GPS-based E-toll systems to improve accuracy and reduce errors in toll collection.
7. Green tolling: Green tolling options can be introduced to incentivize the use of environmentally friendly vehicles and reduce air pollution.

Overall, the future of GPS-based E-toll systems is promising, and further development and innovation in this field can lead to improved traffic management, reduced congestion, and increased safety and convenience for drivers.

REFERENCES:

- [1] Dhurat, B., Ranmale, M., Mahajan, D., Kondke, R. and Todmal, S.R., Online Toll Payment System Using Image Processing.
- [2] Kumawat, A. and Chandramore, K., 2014. Automatic toll collection system using RFID. *International Journal of Electrical and Electronics Research*, 2(2), pp.67-72.
- [3] Kamarulazizi, K. and Ismail, D.W., 2010. Electronic toll collection system using passive RFID technology. *Journal of Theoretical and Applied Information Technology*, 2.
- [4] Ramya, V., Palaniappan, B. and Karthick, K., 2012. Embedded controller for vehicle In-Front obstacle detection and cabin safety alert system. *International Journal of Computer Science Information Technology (IJCSIT)* Vol, 4.
- [5] Pany, J.K. and Choudhury, R.D., 2011. Embedded automobile engine locking system, using GSM technology. *International Journal of Instrumentation, Control and Automation (IJICA)*, 1(2).
- [6] Nagaraja, B.G., Rayappa, R., Mahesh, M., Patil, C.M. and Manjunath, T.C., 2009, January. Design development of a GSM based vehicle theft control system. In *2009 International conference on advanced computer control* (pp. 148-152). IEEE.
- [7] Leo, L.M., Yogalakshmi, S., Simla, A.J., Prabu, R.T., Kumar, P.S. and Sajiv, G., 2022, February. An IoT Based Automatic Waste Segregation and Monitoring System. In *2022 Second International Conference on Artificial Intelligence and Smart Energy (ICAIS)* (pp. 1262-1267). IEEE.
- [8] Leo, L.M., Tummala, K. and Raju, R.P.K., 2019, July. IoT based Centralized System for Emergency Vehicle Passing With Authentication. In *2019 International Conference on Communication and Electronics Systems (ICCES)* (pp. 1543-1547). IEEE
- [9] Joshi, B., Bhagat, K., Desai, H., Patel, M. and Parmar, J.K., 2017. A comparative study of Toll Collection Systems in India. *International Journal of*

- Engineering Research And Development, 13(11). [10] Veeramuthu, A., Kalist, V., Joe, A.A.F., Leo, L.M. and Yogalakshmi, S., 2022, March. Point of Interest Assisted Dynamic Travel Route Suggestion Model using Keyword Representation Logic. In 2022 6th International Conference on Computing Methodologies and Communication (ICCMC) (pp. 1581-1586). IEEE
- [11] El Hussein, H.M., El Meligy, B. and Hassan, M., 2017. The opportunities and challenges of applying intelligent transport systems (ITSS) on road transport in Egypt: a case study on Cairo/Alexandria desert road. The Business Management Review, 8(5), pp.100-110.
- [12] Alexander, T. Jerry. "An implementation of mobile control room environment in android platform for industrial applications." In 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], pp. 1-4. IEEE, 2015.
- [13] Ahmed, S., Tan, T.M., Mondol, A.M., Alam, Z., Nawal, N. and Uddin, J., 2019, October. Automated toll collection system based on RFID sensor. In 2019 International Carnahan Conference on Security Technology (ICCSST) (pp. 1-3). IEEE
- [14] Balamurugan, K., Elangovan, S., Mahalakshmi, R. and Pavithra, R., 2017, September. Automatic check-post and fast track toll system using RFID and GSM module with security system. In 2017 International Conference on Advances in Electrical Technology for Green Energy (ICAETGT) (pp. 83-87). IEEE.
- [15] Wolf, J., Guensler, R. and Bachman, W., 2001. Elimination of the travel diary: Experiment to derive trip purpose from global positioning system travel data. Transportation Research Record, 1768(1), pp.125-134.