FUEL LEVEL DETECTION AND TRACKING SYSTEM FOR VEHICLE FUEL THEFT PREVENTION

By

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Approved by

Project Supervisor	Department Chairperson
Dr. Farhana Parveen	Dr. Mohammad Ryyan Khan

Dedication

We are dedicating this project to our beloved parents and teachers. Their motivation and support inspired us on this project journey. A special thanks to our supervisor, Dr. Farhana Parveen, Assistant Professor, Department of EEE, East-West University, who has supported and encouraged us throughout the project. We are grateful to all of them.

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Sabbir Ahmed

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EXECUTIVE SUMMARY

The proposed capstone project, "Fuel level detection and tracking system for vehicle fuel theft prevention" is a proper project that will detect the fuel level in abnormal fuel consumption situation and notify the fuel level with the vehicle location also. The project is a complex engineering problem. It involves with fuel monitoring system and identify the fuel abnormal consumption with unethical fuel theft incident happened. The project started with considering the social impact, doing literature review, stakeholder survey to priorities their need and expectation, designing a prototype for testing and making a comprehensive final design of the proposed project. According of survey and stakeholder requirements specifications were set. Accordingly, an economic analysis was conducted to assess the project financial stability, including development, implementation and selling. For designing the project device, standard code of practices, environmental impact, health and safety issues were taken to consideration. After designed and building the prototype evaluated according to required evaluation was done and set the final design of the device. The device overall accuracy is 95.46% which satisfy the stake holder one of the most valuable requirements that accuracy must be more than 60%. Sending text to the phone at any distance with vehicle location tracking accuracy is 100%. Implementation of the final design of the project is done in such way that it is user friendly and has the features the stakeholders wanted while being financially profitable. The main revenue of the fuel theft detection system will come from selling device while secondary revenue after selling the product a regular maintenance charge. The final design includes Arduino, Buck boost converter, GPS, GSM and T-O-F sensor all module integrated together. By giving location tracking feature with fuel level instant fuel level indication with comparative lower price attracted the users.

PART-A

This part contains the concept and the project proposal as prepared on EEE400A.

Chapter 1 Project Concept and Proposal

1.1 Project introduction

The goal of this project is to prevent vehicle fuel theft by utilizing fuel level detection and GPS & GSM based tracking system. The entire world has gone digital in order for us to easily understand simple systems. Digital vehicle fuel meters are a common feature of modern vehicle systems, yet they only show the actual fuel level, but we want to introduce our project fuel level detection with digital number like 1 liter fuel remaining. So how much fuel is actually present in the fuel tank will easily determine. Once in a while, customers fill up on petrol or oil digitally, but our vehicle lacks a digital system. So, sometimes petrol or oil filling pump owners cheat on customers, and they get the benefits of doing this continuously to customers. Sometimes a car owner's driver does unethical work, such as stealing fuel. On the other hand, a thief steals fuel from the car or bike. The vehicle owner has no idea about this situation. Many times, we've heard of fuel theft from vehicles or bikes, and some of us have even seen it ourselves. The owner of the car or the motorcycle is not aware of the fuel theft. The next time he rides his bike, he will have many difficulties due to fuel theft.

In our country, the number of vehicles on the road is increasing rapidly, so thinking about this situation and solving this problem or avoiding such a problem, we want to develop a vehicle tracking system for fuel theft prevention and fuel level detection.

The main things we are planning to do in our system are monitoring a vehicle's fuel level; monitoring fuel level by level indicator; using GPS to track the location of vehicles where the fuel level will be changing unconventionally; using GSM module to get real-time notification of fuel level on the phone. With this system, we will get information from vehicles every day. So, the main concept of this project is fuel theft prevention. In our

project, we expect that we will quickly monitor fuel level by using a level indicator. All vehicles have a digital indicator system, but the digital indicator doesn't show the main amount of fuel in the tank. We mostly measure the amount of fuel in terms of bars rather than digits like liters. For this reason, in our project, we want to develop a digital fuel level indicator system. Next, we will be using GPS to efficiently help consumers monitor the condition of their vehicle location through the satellite. Also, in our system, we will use a GSM system that sends the message to the owner by using this system when the fuel theft shows up. For this system, we will also need a SIM card.

So, our project will be a complex engineering problem because to success this project we have to do simulation of the overall system and programing those logically, we have to design circuits with required equipment like Arduino, GSM module, GSM module, level detector etc. For project implementation know we have to research on it and existing technology. We will also find 3-4 alternative solution of this project that also full fill the project requirements like auto shut off, alarm-based, telemetry based, IOT based etc. We will need to be programming for Arduino code and also on GSM module that successfully fuel level unconventional change massage send to the phone. Lastly, our project will depend on electronics and programing based. After designing the hardware section, we will need software programing in Arduino IDE. So, it's an interdependence project.

1.2 Literature review

Nowadays, in the world, the price of fuel is increasing daily. Drivers around the world are allegedly selling large amounts of fuel oil to syndicates every day, and there are sometimes fuel leaks in the vehicle's fuel tank. There are many ways to prevent this

problem. In this section, we are going to review several methods developed by other groups.

The Omnicom LLS fuel level sensor is the first capacitive fuel sensor in history. Invented by a group of specialists in 2003, inspired by the CEO of the company [1]. Mr. M. Saravanan, Mr. T. Krishnapriya, Mr. S.R. Lavanya, and Mr. P. Karthikeyan they proposed a system in 10 Oct 2018[2]. There are a couple of ways to keep a check on the fuel level, including dipsticks, level sensors, analog and digital meters. Dipsticks are frequently utilized, and the work is manual. This method addresses this problem by determining the volume of the tank using GSM and an ultrasonic sensor to signal the level in cases of theft and full or empty conditions. The drawbacks noted here include the need for ongoing electricity for the signal's creation and presentation. Only extremely low voltage indicators are available here from the gauge itself, approximately millivolts, Because of this it also needs an amplification circuit for the display. Materials that are very reactive or corrosive are prohibited because they could damage the gauge. Plastic diaphragms cannot be utilized to detect extremely high pressures.

A different system was created by Mr. P. Senthil Raja and Dr. B.G. Geetha they proposed this system in April-June,2016 [3] utilized embedded design and a vehicle area network (VAN). Under the proposed system, the height of the fuel tank when it is open and closed, as well as any opening or closing of the fuel tank by the operator or a fuel trader, are immediately communicated to the vehicle's owner. Through a wireless link, the device monitors the car's location. The process involves detecting the fuel level, gathering the data, and sending it to the server for further detection. The numeric lock's biggest drawback in this project is that it can only be unlocked after multiple attempts, which takes a lot of time. The suggested system is also very expensive. There is still room for improvement in sensors.

In order to monitor and protect an automobile, Mr. Heda Venkata Sai Ajith1 and Mr. Pinjala Sai Kiran they proposed this system April-2018. [4] have designed an embedded

GSM system that is used in an anti-theft security system. The system texts the car owner when a theft attempt is made and immediately sounds an alarm using an integrated buzzer. The sensors are frequently useless and installing them inside the fuel tank is problematic.

Another system was created by Ms. Nandini Hiremath, Ms. Mrunali Kumbhar1, and Ms. Aakriti Singh Pathania they proposed this system in March-April 2016[5]. The system consists of a GPS module, Microcontroller, GSM module, LCD, and Keypad. Utilizing the coordinates that the GPS module transmits, the microcontroller converts the data before sending it in text format to the user. This reducing technique helps fuel use around-the-clock, alerts users when fuel drains, and quickly finds storage tank problems. The only problem here is the size of the model. It's not ideal to fit into little tanks.

P. Sharma 1, Komal2, Akansha3, Rajit4, Niharika5 they build a system in 31/May/2020[6]. In this method users can effectively monitor the condition of the vehicle online using this way. With the help of a system of connected intelligent sensors, this technology, sometimes referred to as a wireless sensor network primarily detects and monitors. They have decided to adopt Node MCU because it has an included Wi-Fi module that can be used to connect to the internet and receive user commands. The device will monitor its surroundings using a number of sensors and the internet, and it will use Wi-Fi to send data to a server. The server will represent the data in JSON after receiving it from a specified IP address (JavaScript Object Notation). and it will monitor the Google Graph information. The latest data sent by the device will be represented by a unique graph for each sensor.

Srinivas M, Shadakashari H L, Chetan Kumar K P, Vikram S J, they come up with a system in 3, July 2020[7]. First off, this method uses GSM technology and the ARMLPC2148 to build and employ a low-cost circuit to detect attempted fuel theft. The recommended strategy will assist in reducing fuel theft. As a result, it provides full

protection and prevents accidental fuel or vehicle theft. Therefore, the main purposes of digital fuel meters are to prevent fuel theft and to digitally show the amount of fuel that is currently in the tank. Thanks to the PIC microprocessor, this meter offers more advantages than an analog meter. Fuel theft can be reported to the bike's GSM owner through buzzer or SMS. Fuel filling stations are able to increase the amount of measurement for their system because of the digital fuel meter's capacity to stop customer fraud by fuel retailers and enhance system performance.

Nandini Hiremath, Mrunali Kumbhar, Aakriti Singh Pathania they proposed a system in 09, September-2015[8]. The requirement for tracking fuel theft is critical given the rising cost of fuel. As a result, the smart system activates if the fuel level is unsatisfactory, giving the owner a crystal-clear indication of the vehicle's fuel level. Security is the main objective of this effort, and the GPS and GSM modules' operation makes security possible. In this analysis, Endurance, a novel and cost-effective aim for fuel security has been proposed. It can be positioned in a tight area that is challenging to access. The special benefit of this software is that it keeps texting the owner until they reply.

Due to the fact that there are several methods in use, most of them cost a lot of money. Signal transmission over long distances is unsuccessful, the design is complex, and it takes up more space. Last but not least, advanced sensors, SIM, and microcontrollers can be used to make advancements.

1.3 Standards and codes of practices

Codes of conduct can be documents that supplement occupational health and safety laws and regulations by providing specific practical guidance on how to comply with legal obligations and may be equivalent or superior to health and safety standards. should be

done when other approaches with being a document issued by a self-regulatory body with the same purpose and followed by its members or others; Codes of conduct issued by governments generally follow them but do not replace health and safety laws and regulations.

In short, code is a collection of generally accepted rules that define what should be done. There is no specific standard or code of practice for this device as it is not yet commercially available in our country. However, some guidelines, standards, and codes have been set by the Bangladesh government for the components used to build the device. These Guidelines and Standards and Norms for this Professional.

Standards for Battery:

The power source for our device is a battery. Use Li-ion or Lead Acid batteries. Following charging, standards ensure effective charging and longer battery life. In the "Lithium-ion Batteries Technical Handbook" [9] published by Panasonic, we were able to locate instructions for charging Li-ion batteries. Similarly, we were able to locate instructions for charging Lead Acid batteries in the "Power Sonic" [10] publication. For both types of batteries, the most crucial rule is to charge them with constant current and constant voltage to increase their lifespan.

Standards of GSM:

From Bangladesh's perspective view GSM module is only eligible for 2G/3G/4G/LTE network transmission. There are some other countries that are eligible for 5G network transmission. Since this is a test in Bangladesh, we will follow the Bangladesh Telecommunication Regulatory Commission rules. Every GSM network uses one channel as a guard channel, which reduces the number of channels available for traffic by one [15]. We will receive data from the GPS and Level indicator in the Arduino and this data will

send by the GSM module in the vehicle owner's phone when he wants to see the position and unconventional change of fuel.

Standard of GPS:

GPS receivers receive a series of data from the satellite and give single line output. In our device, we use a GPS receiver to locate the device. GPS calculate the position of GPS receiver by calculating distance from the visible satellite using the triangulation method. We will get single-line output from our GPS receivers and we will use the appropriate code for receiving the single-line output [16].

Standard of Plastic:

In our project, we use plastic bodies. After the end of the project lifetime, the plastic body will be recycled maintaining all the safety precautions. We are using recyclable plastic in our project [17].

Standards for Importing:

Bangladesh Customs and Tariff (BCT) should uphold the standards and regulations for importing parts for this project, and this project will pay all applicable taxes [11].

1.4 Stakeholders' expectations/requirements

We selected three groups of stakeholders which are given below:

- Users of vehicles fuel who are related to this device (drivers, car owners, rent a car business owner, car modifier, car importer/seller).
- A company that has multiple vehicles for their official and product delivery work. (North End coffee roasters private limited).
- A company who are providing digital device and apps service for vehicle fuel monitoring, vehicle tracking, route playback, automated alerts, etc. (EasyTrax).

- BRTA (Bangladesh Road Transport Authority) to get the device placement requirement.

We have surveyed several vehicle owners, companies, and drivers. We got general feedback that we can summarize like this:

The device "Fuel level detection and GPS based tracking system for vehicle fuel theft prevention" should not be complex to handle and that should not create any impact on the vehicle's internal function. The device should be safe and reliable. The device should be designed in a way that no one can excess or manually turn ON-OFF and also it should be set or placed in the inner part of the vehicle body.

We took feedback from the rent-a-car business owner who did not use anything like that but if the product is reliable, easy to handle (hassle-free), and cost-effective they are interested to use that kind of product.

We also took feedback from the company (North End coffee roasters private limited) which is trying to use that kind of device, but they still could not find anything that gives the expected accuracy. They already use a device that gives the estimate of fuel mileage, vehicle tracking, and location update. That is basically used for vehicle protection, not fuel. We initially approached about fuel theft protection. But they said they tried some devices which are related to that but those could not give the proper accuracy and were also inconvenient. The overall opinion is

- The device should be able to give standard accuracy (more than 60%) and realistic data update
- Simple in the build-up and easy to handle.
- The product must be durable, safe (well protected), cost-effective, and reliable.

We also asked the car modifier workshop for the standards and code of practice they suggested researching different vehicle fuel tank levels, internal functions & space of the different types of vehicles. Also, give us suggestions which are:

For bike fuel level detection, we have to build a level detector which can easily detect 15L fuel and maximum device body should be length 10 inches, width 4.5 inches and height 3.75 inches.

For private car maximum fuel level detection capacity should be 50L and maximum body structure be length 12 inches, width 4.5 inches and height 3.75 inches.

For 25-ton truck the tank fuel tank capacity is 110 litter almost and the device body structure will same as previous.

Also, the company (North End coffee roasters) suggested us to build the level detector by own not use anything in the market which locally available because the performance is not satisfying.

To placed the device in the vehicle body BRTA authority suggested us to follow the safety issue of vehicle. The suggested us 2 requirements. First one is the fuel level measurement sensor should be placed minimum 3 inches upper level to fuel tank body (only for truck fuel tank). Second one is to cut the fuel tank body need to take permission from BRTA for authorized vehicles with documents also show the reason why need to install this device (with device specifications) in the vehicles. After all that if safety and fitness test successfully passed BRTA will give permission and do an agreement for few years with terms and condition.

They also suggested us that the body material should be high heat proof and if we will select any sensor the sensor must be high performing and reliable. Now to identify available sensors and device capability for a particular vehicle which will help us for finalizing the project requirements.

1.5 Project requirements

Project requirements are the elements, procedures, and tasks that must be carried out for a project to be successful. The stakeholder gives us a clear idea of what they want in the project feature. In this part, we will discuss the functional requirements, which expectations of stakeholders are met, and which are not met citing justification, and technical requirements of the project.

1.5.1 Functional requirement:

The key feature of our project is to get real-time updates on the vehicle fuel. This project system must offer all the relevant data for the parameters the real-time fuel level update and send the SMS to the vehicle owner. Fig 1.1 shows the functional requirements that are necessary for us to make the functional device.

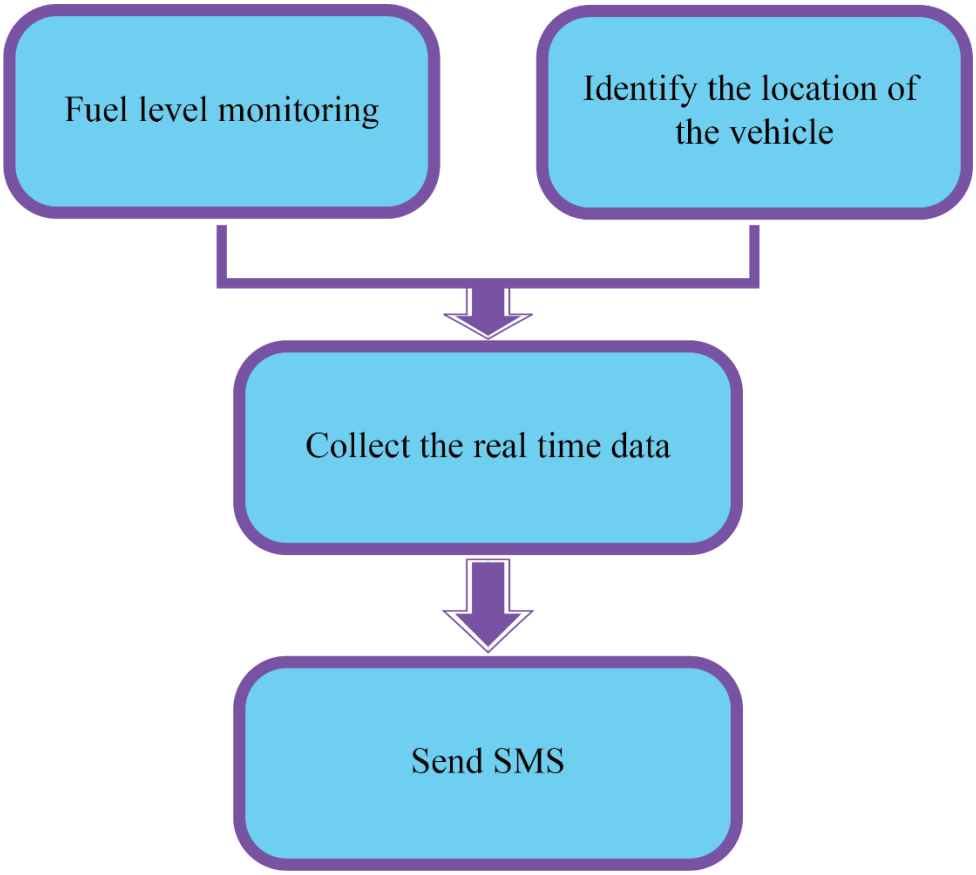


Fig 1.1 Project functional requirement.

We can describe our project in 3 sections such as 1. Fuel level monitoring and identifying the location of the vehicle, 2. Collect the real-time data, 3. Send SMS.

Section 1.

Fuel level monitoring and identifying the location of the vehicle: we will measure or monitor the fuel level by the fuel level indicator like "1 liter fuel remaining" and identify the location of the vehicle by the GPS module where it changes. We will monitor the fuel level and location at all times.

Section 2.

Collect the real-time data: Our device will monitor the real-time data all the time. Our device has no storage unit for saving the data, but it will monitor the data all the time.

Section 3.

Send SMS: Our device system gets the notification from the section and sends an SMS to the customer's phone. This system will send the SMS when the vehicle owner wants to see and when any abnormal change will happen notified in fuel level.

If any situation unconventionally changes fuel level than level detector will identify the fuel level, GPS module will identify the location then all command will be programed by Arduino and that command will go to owner's phone by GSM module by using mobile network. Message: "Fuel level: 1.2L fuel remaining, location: East west university". But before this unconventional change occurs, the fuel level has 5 liters remaining. After these unconventional changes, the message will show "Fuel level: 1.2L fuel remaining, location: East West University."

1.5.2 Justification of Stakeholder's expectations and requirements:

We are able to meet most of our stakeholder's expectations, some of our stakeholders are using a device for monitoring their vehicle mileage. But they did not get any real-time updates from their device. When we share our project idea with them, they are very interested in our project and they advise us that the accuracy of the GPS location tracking must be greater than 60%. We hope to achieve more than 70% accurate at location tracking.

They desire an extremely user-friendly and straightforward device. Our device has some complex parts but at the customer end, we expect it will be very easy to run or handle.

We expect it will be well-protected, durable, safe, and cost-effective. Our device will attach inside the car so that everyone cannot reach out there and cannot shut down the device.

1.5.3 Technical Requirement:

Our device has some modules and sensor. We will make our device with the combination of a GSM and GPS module and a Level indicator to show the volume of fuel in litter. We will use lithium ion or led acid battery for power supply. Our system will very portable and set up the vehicle reachable body part. We will assume a certain time for the battery life after that period any vehicle service center can change the battery easily. We expected that the power assumption of our system will not too much and the system will run for a long day. We will also use a microcontroller for data processing. Our device technical diagram will get a proper idea of our project requirements.

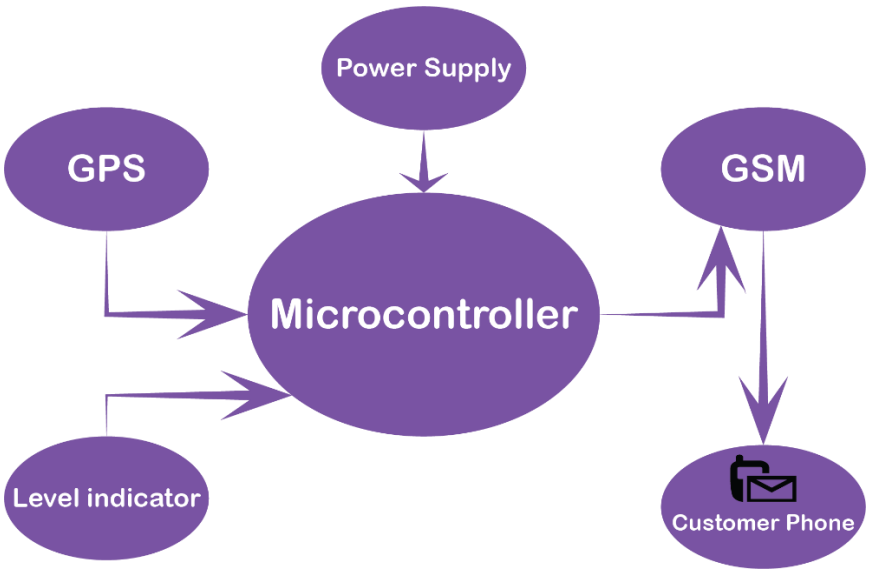


Fig 1.2 Project technical requirement.

1.6 Project Management

1.6.1 Project plan

All the activities that we need to complete in the whole project we have identified. The activity table which contains milestones and time duration is given below,

Table 1.1 Project activity list

Activity No.	Activities	Duration (Days)	Predecessor
	PART A		
1	Finalizing topic after initial research	15	-
2	Identify the stakeholders and making questionnaires for them.	3	1
3	Review and requirement collection from stakeholders **[Milestone 1]**	10	2
4	Literature review	15	1
5	Preparing Project plan **[Milestone 2]**	10	1
6	Risk assessment finding	3	5
7	Standard and codes of practice determination	7	3
8	Finalizing project requirements **[Milestone 3]**	5	3,4,7
9	Researching local market for specifications	3	8
10	Preparing resources (hardwire & softwire) list and budget	4	9
11	Projected product lifecycle	2	8
12	Impact analysis of the project	2	8
13	Preparing project report and submission **[Milestone 4]**	12	6,10,11,12
	PART B		
14	Initial project design	10	13
15	Finding alternative solutions and analysis	15	13
16	Preparing design of internal process	30	14,15
17	Design of frame block according to internal components and design completion. **[Milestone 5]**	15	16
18	Designing prototype according to selected model **[Milestone 6]**	20	17
19	Preparing project report and submission **[Milestone 7]**	20	18

	PART C		
20	Prototype development for selected model	30	19
21	Performance evaluation of prototype against the requirements and finalize design **[Milestone 8]**	20	20
22	The modern engineering tools used	7	21
23	Review of Milestone Achievements and Revision of Schedule	15	21
24	Preparing bill of materials cost of solution	7	21
25	Economic analysis **[Milestone 9]**	3	24
26	Verification of complex engineering problem and objective meets	6	25
27	Preparing project report and submission **[Milestone 10]**	10	22,23,26
28	Final project presentation **[Milestone 11]**	7	27

Critical Path Method (CPM):

The critical path method is a technique to identify the project tasks necessary to complete a project. The sequence of CPM helps to visualize the project with predecessors.

CPM attribution:

ES = Early start

EF = Early finish

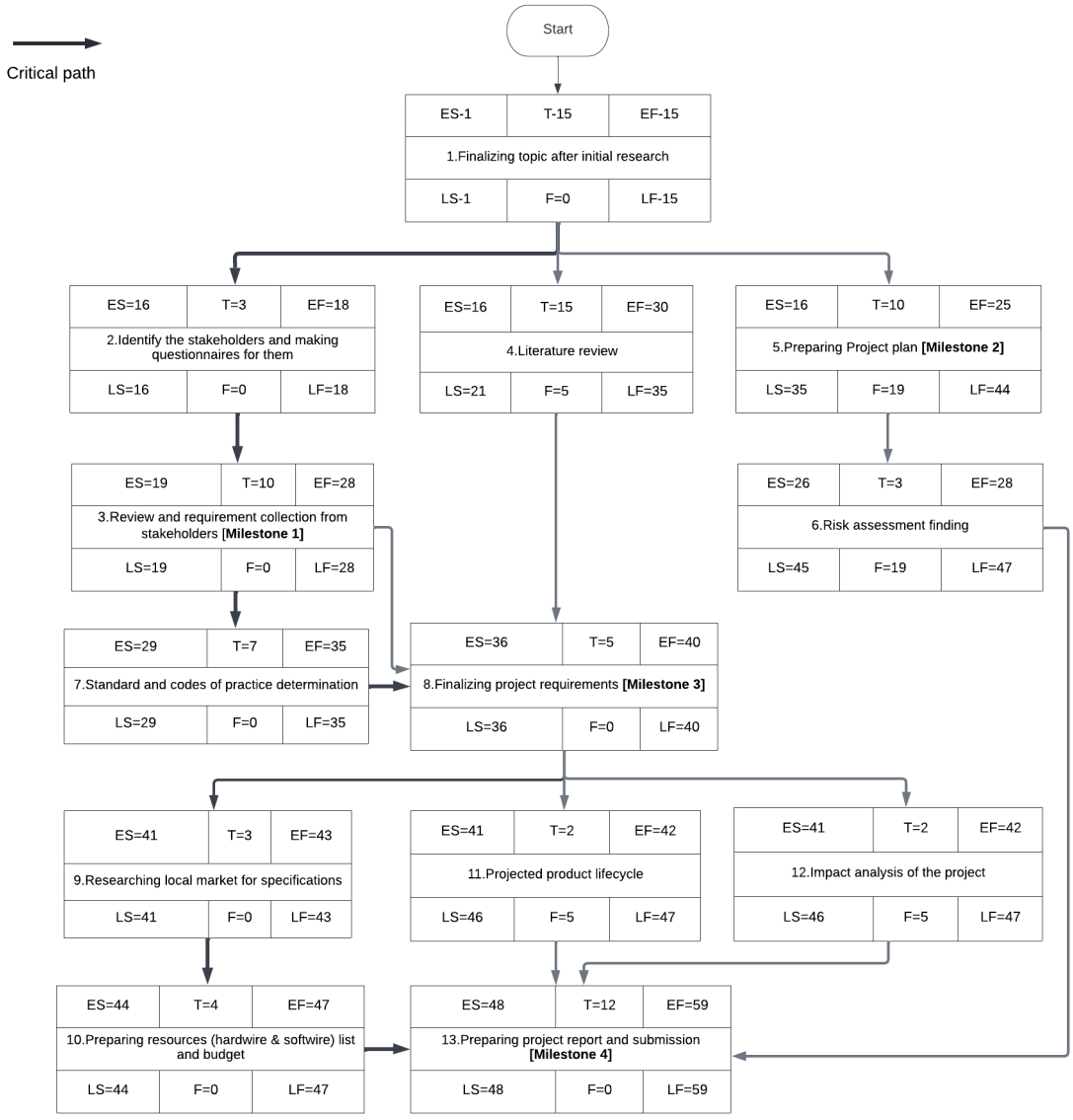
LS = Late start

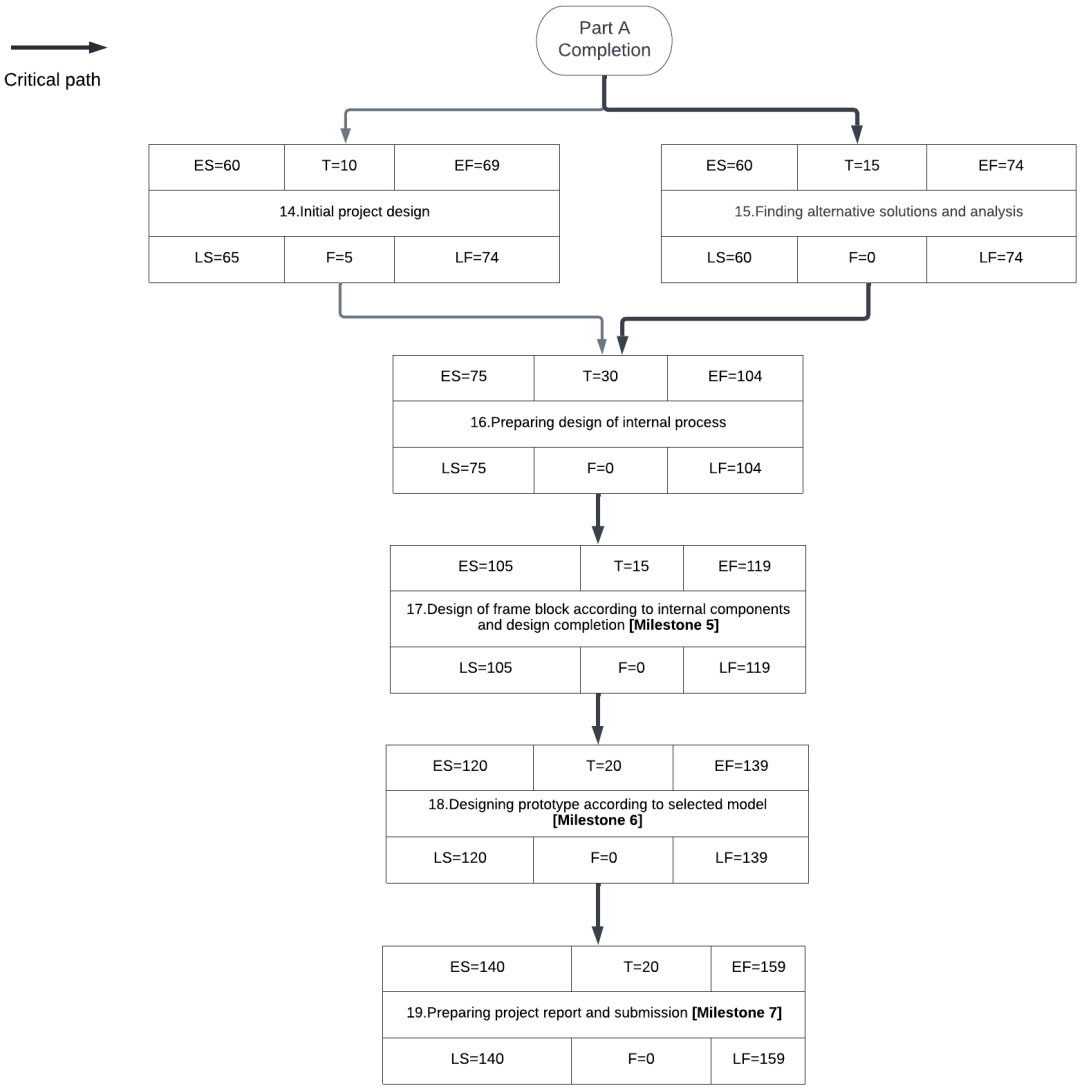
LF = Late finish

T = Duration/completing time

F = Float

Arrow indicates critical paths




Critical path
Part A Completion
ES=60
T=10
EF=69
14.Initial project design
LS=65
F=5
LF=74
ES=60
T=15
EF=74
15.Finding alternative solutions and analysis
LS=60
F=0
LF=74
ES=75
T=30
EF=104
16.Preparing design of internal process
LS=75
F=0
LF=104
ES=105
T=15
EF=119
17.Design of frame block according to internal components and design completion [Milestone 5]
LS=105
F=0
LF=119
ES=120
T=20
EF=139
18.Designing prototype according to selected model [Milestone 6]
LS=120
F=0
LF=139
ES=140
T=20
EF=159
19.Preparing project report and submission [Milestone 7]
LS=140
F=0
LF=159

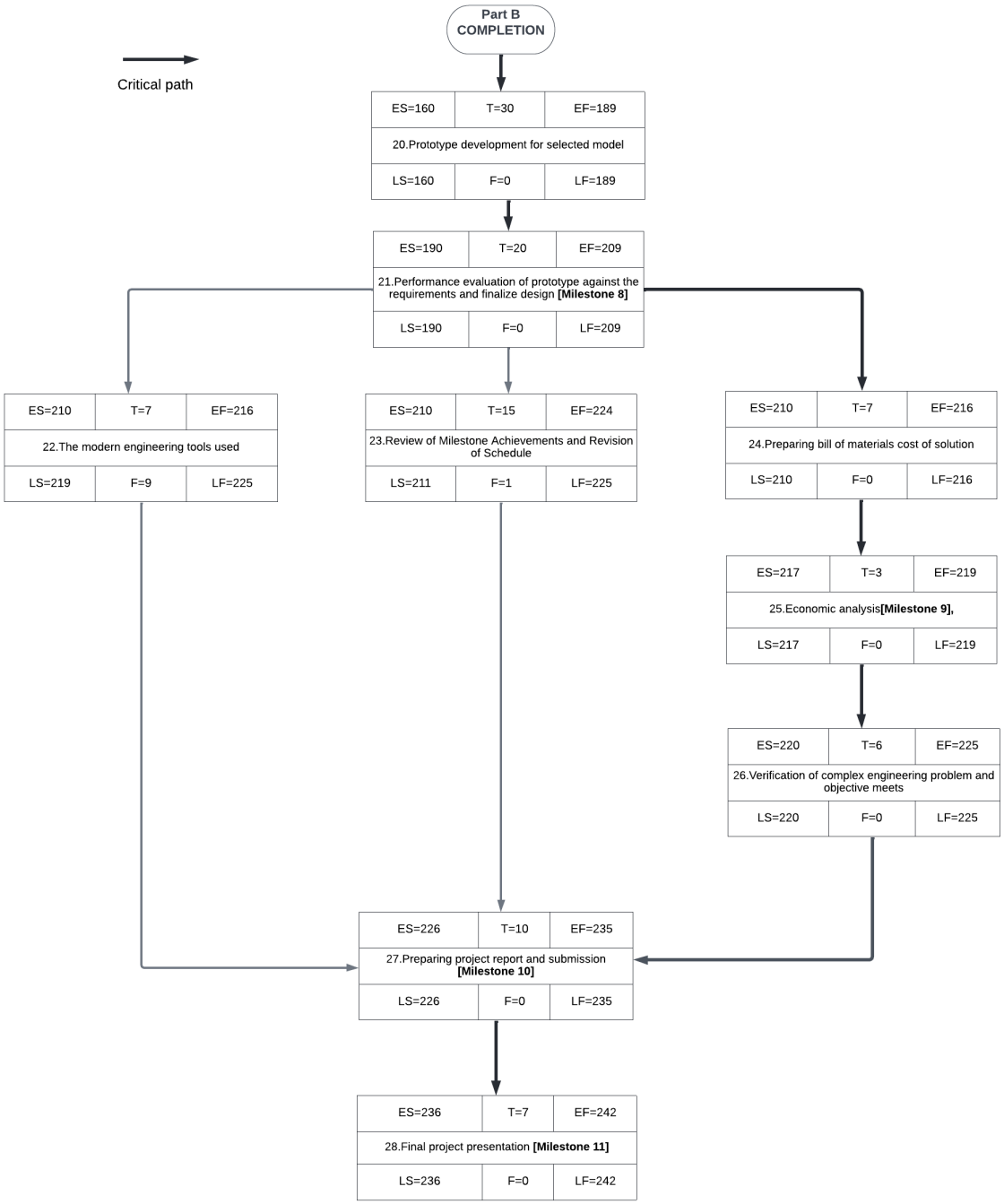
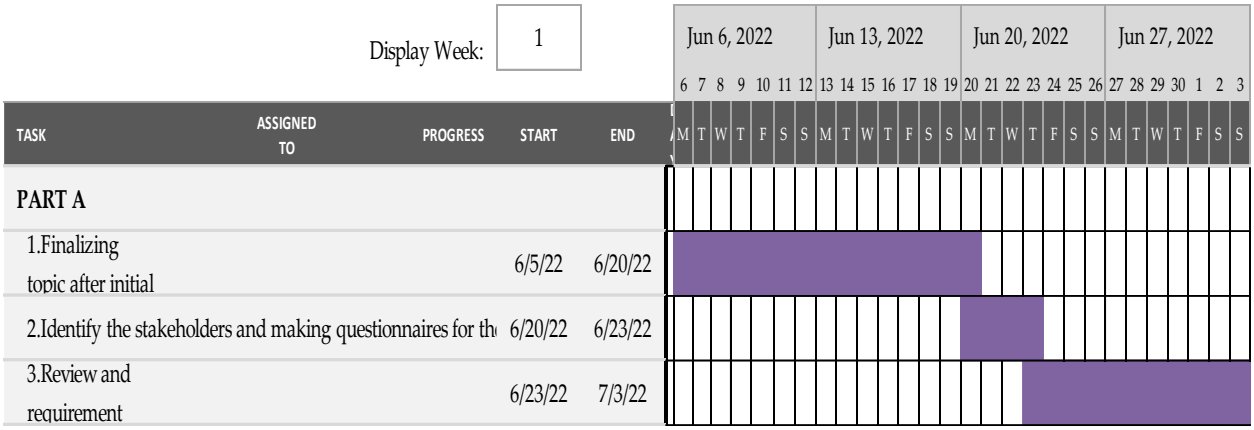


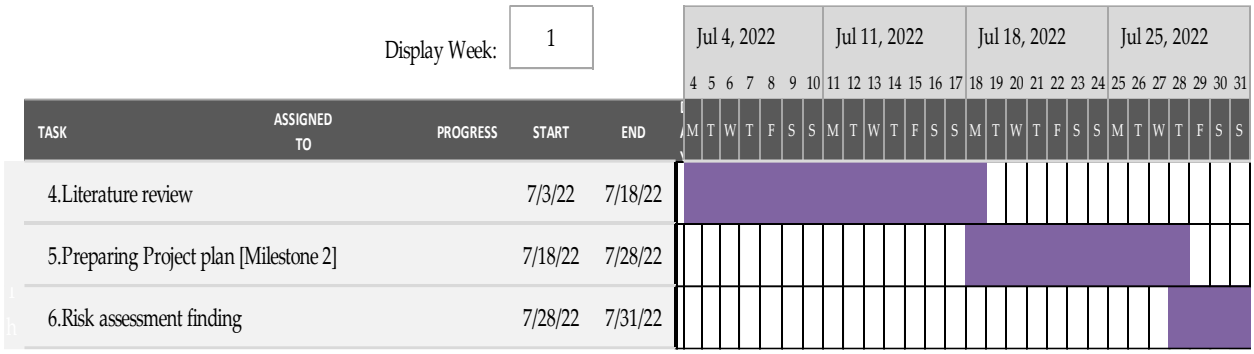
Fig 1.3 CPM diagram

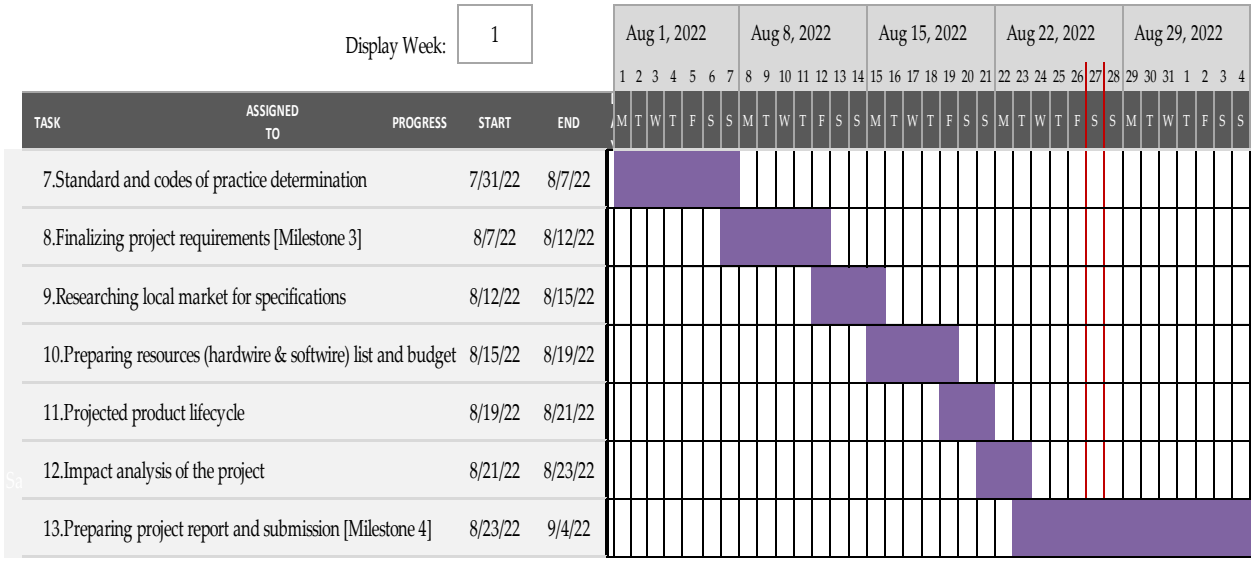
Critical path: 1-2-3-7-8-9-10-13-15-16-17-18-19-20-21-24-25-26-27-28

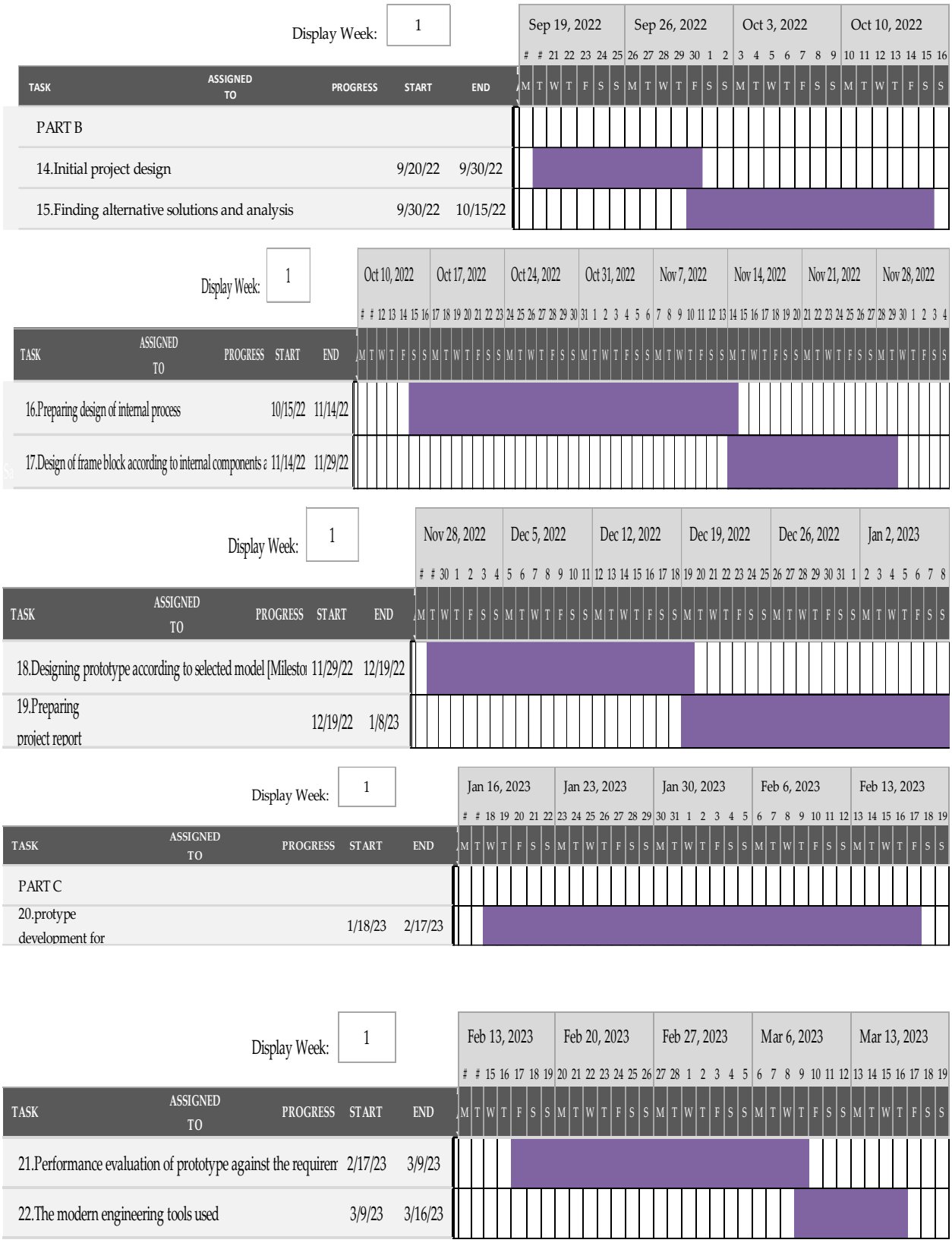
Total working days: 242 days

Gantt chart:








Display Week: 1
Sep 19, 2022
Sep 26, 2022
Oct 3, 2022
Oct 10, 2022
TASK
ASSIGNED TO
PROGRESS
START
END
PART B
14.Initial project design 9/20/22 9/30/22
15.Finding alternative solutions and analysis 9/30/22 10/15/22
Display Week: 1
Oct 10, 2022
Oct 17, 2022
Oct 24, 2022
Oct 31, 2022
Nov 7, 2022
Nov 14, 2022
Nov 21, 2022
Nov 28, 2022
TASK
ASSIGNED TO
PROGRESS
START
END
16.Preparing design of internal process 10/15/22 11/14/22
17.Design of frame block according to internal components a 11/14/22 11/29/22
Display Week: 1
Nov 28, 2022
Dec 5, 2022
Dec 12, 2022
Dec 19, 2022
Dec 26, 2022
Jan 2, 2023
TASK
ASSIGNED TO
PROGRESS
START
END
18.Designing prototype according to selected model [Mileston 11/29/22 12/19/22
19.Preparing project report 12/19/22 1/8/23
Display Week: 1
Jan 16, 2023
Jan 23, 2023
Jan 30, 2023
Feb 6, 2023
Feb 13, 2023
TASK
ASSIGNED TO
PROGRESS
START
END
PART C
20.protype development for 1/18/23 2/17/23
Display Week: 1
Feb 13, 2023
Feb 20, 2023
Feb 27, 2023
Mar 6, 2023
Mar 13, 2023
TASK
ASSIGNED TO
PROGRESS
START
END
21.Performance evaluation of prototype against the requiremen 2/17/23 3/9/23
22.The modern engineering tools used 3/9/23 3/16/23

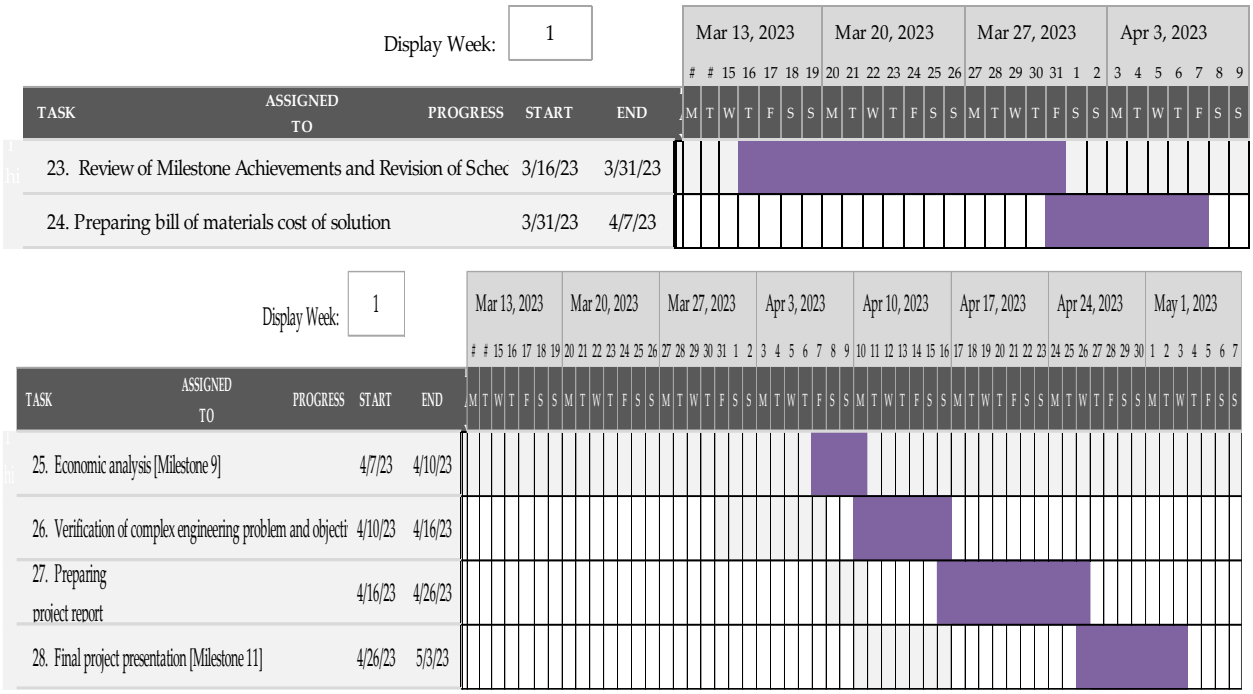


Fig 1.4 Gantt chart

Total project duration including breaks = 306 days

We have selected 11 milestone of our project. The milestone table which contains serial number of milestone and milestone name is given below:

Table 1.2 Project milestone list

Milestone No	**Milestone Name**
1	Review and requirement collection from stakeholders
2	Preparing Project plan
3	Finalizing project requirements
4	Preparing project report and submission for Chapter-A
5	Design of frame block according to internal components and design completion.
6	Designing prototype according to selected model
7	Preparing project report and submission for Chapter-B
8	Performance evaluation of prototype against the requirements and finalize design
9	Economic analysis
10	Preparing project report and submission for Chapter-C
11	Final project presentation

1.6.2 Risk management

A project's risk management process is essential for determining potential threats to the project. We can prevent project loss and take the necessary steps to maintain the device if we can identify the risk at an early stage of the project. The loss can be reduced, and the device will perform well if the proper measures are taken on time. For our project, we have identified some potential risks that might arise, and we have also considered potential solutions for those risks.

The risk management process can be shown below the figure.

Fig 1.5 Risk management process

We identify some risks that can happen and delay our project. We give a short explanation of identified risk:

1. **Scheduling Risk:**

The risk that project tasks and activities might take longer to finish than expected thanks to inadequate preparation is understood because the schedule risk. value or money risk is concerning schedule risk since delays within the schedule will increase costs, impede project benefits, and keep at bay deadlines, erasing no matter the initial competitive edge the project may have had.

2. **Cost Risk:**

In the present situation in our country product prices are increasing. The value of our currency is also decreasing. We do not know if the price of the product we are using in our project will remain the same in the future. If the product prices increase this will impact our project cost. It will be very difficult to implement the project in the future.

3. **Resource Risks:**

Resource risk is one of the most common risks. The component we are using in our project can be stocked out in the market. If this happens our project will not be implemented or we may not complete all requirements of our project.

4. **Market Risk:**

Market risk is unpredictable. As the cost of raw materials used to build this system increases, so does the cost of the system. This can threaten the marketing of the product. These risks refer to resource risks and financial risks.

5. **Technology risk:**

Technology risk has two parts of risk one is performance risk and another is operational risk:

A. **Performance Risk:**

Performance risk is simply the risk that the project will not deliver the results and benefits described in the project specifications. Even if we keep costs within budget and on

schedule, a performance risk can mean we've wasted time and money on a project that ultimately didn't work out as intended.

B. **Operational Risk:**

When a project will not deliver proper output lack of proper planning and implementation. This project risk is part of the performance risk because the expected result does not happen or does not happen as we expected.

6. **Planning Risk:**

Perfect planning of the project is the most important part. The most common reason for project failure is a lack of proper planning and project goal. If we do not make a proper plan for our project, we may fail to fail to reach our project milestone.

7. **Communication Risks:**

Communication between group members is crucial for the completion of a successful project. Somehow one of our group members maybe get sick and he is not able to complete his assigned part. This will impact our project.

8. **The limited engagement of stakeholders:**

It's important that all project stakeholders have the same vision. Uninvolved clients can cause problems in the project's final stages, so it's important to consider their feedback and keep them updated.

9. **Unrealistic deadlines:**

Impossible deadlines are another challenge that can seriously compromise the quality of the final product. We need to know the ability of the project team members, prioritize project deadlines and tasks, and determine the project schedule.

Mitigation Plan:

Risk mitigation is the process of finding a way to prepare for disasters and mitigate their adverse effects.

Developing a mitigation plan can help reduce risk and ensure project success. Now that we have complete our risk analysis. We can develop a mitigation plan to avoid this risk and complete our project.

Different stakeholders have different ideas, and they have different needs. For solving this conflict, we need to contact them listen to their idea and share our idea so that they fully understand our idea and we can fully understand their needs. After meeting with them we may get to the final goal of our project.

In terms of budget, we allocate an additional 20% to backups. So, if financial or cost risks arise, we are prepared to face them. Start by gathering the equipment we need to complete our project early and make sure we have everything before the deadline. After the end of its useful life, it can be recycled to reduce environmental risks. We can order parts from our online store or we can go to the local market. We can also contact resellers who import parts from other countries and bring parts through third parties if the supplier is not available.

For technical risks, we may need to repurchase ingredients from online stores, visit our local store in town to find a suitable location, or use other options.

We'll get ahead by working over the semester break, too. In order for us to avoid the scheduling risk. To reduce the environmental impact of E-waste, we will recycle it and, if necessary, dispose of it. By implementing such strategies, we will be able to avoid potential risks and meet our deadlines on schedule.

Contingency Plan:

Contingency plans help to think different ways. Contingency plan like “Plan B” if our plan failed to meet all the requirements or may not be built properly this plan will help to complete this project. Every project has contingency plan because we do not have all resources available all the time because our project equipment depends on the market. When we are building this project, it will possible the one of our equipment is stock out. That why we need to think differently so that we can met the project requirement in time.

1.6.3 Required resources and budget

Our project in an interdependent project. To complete this project, we need to work on electronics part and programing part. So, for both part we need different types of resources like hardware resources for implementation the project and software resources for to performance testing and simulation the program. In our project we need expertise car modifier manpower to build the prototype body frame and design for different car body.

The hardware and software resources list table are given below:

Table 1.3 Resources list

Hardware Resources	**Software resources**
Frame	Arduino IDE
Arduino UNO	Codebooks
Breadboard	MATLAB
Battery	Proteus
Resistance	Microsoft excel
GMS module	Microsoft project
GPS module	
Button	
Wire	
Transistor	

Mention that the resources and specifications can be vary to our project requirements. The reason behind it that the main detail design is not finalized yet.

Project Budget: In our project we will going to use two major module those are GPS (Global positioning system) module and GSM (Global system for mobile communication) module. So, the budget for the total project with additional all cost which related to the project and that is given below:

Table 1.4 Budget list (Overall)

Equipment	Price (Tk)	Quantity	Total cost (Tk)
Frame	1500	01	1500
Arduino UNO	1000	01	2200
Breadboard	90	02	180
Battery	80	01	80
Resistance	02	10	20
GSM module	2300	01	2300
GPS module	800	01	800
Button	50	01	50
Wire	05	25	125
Transistor	20	06	120
Level indicator wire	10	10	100
Transportation cost			500
Total			6775 Tk

For contingency, we are estimating 20% of total cost which is 8130 Tk only.

The cost can be change after finalizing the main project design.

1.7 Projected product lifecycle

The theme of product lifecycle is very essential part of a project. The meaning of "product life cycle" is the time duration between when a product is launched to the market and when it is taken off from the market.

While managing the four stages of the life cycle can help maximize profits and increase revenue, failure to do so can prevent a product from realizing its potential and shorten its useful life [12].

To keep our product in business we need to address the four stage of product life cycle which is given below:

Market introduction and development: Developing a market strategy throughout this stage of the merchandise life cycle entails pin money on marketing and advertising to tell consumers about the merchandise and its advantages. Sales are typically slow at now as

demand is being built. counting on the complexity of the merchandise, how novel and original it's, how well it meets client wants, and whether there's any market competition, this stage may take it slow to complete. there's much evidence that goods can fail at this stage, preventing stage two from ever being reached, but a brand-new development that's tailored to client needs is more likely to succeed. Because of this, many businesses want to imitate an innovative trailblazer [12].

Market growth: A product is prepared to move on to the growth stage of its life cycle if it successfully completes the market introduction stage. The growing demand should stimulate an increase in production and, as a result, a wider distribution of the product. As the product takes off, the gradual expansion that characterized the market introduction and development stage suddenly accelerates. At this stage, rival companies might launch their own versions of your product on the market, either as exact replicas or with minor improvements. As the consumer has the option to shop elsewhere, branding becomes crucial to maintaining your position in the market. In the face of escalating competition, product availability and pricing become crucial considerations in sustaining sales [12].

Market maturity: Market maturity: At this point, as the product is already well-established in the market, the cost of producing and selling it will decrease. The product life cycle has reached an advanced stage, which indicates the beginnings of market saturation. To sustain a market share after a significant number of customers have purchased the product and competitors have appeared, branding, price, and product differentiation are even more important. Retailers will become stockiest and order takers rather than attempting to market your goods as they might have in stage one [12].

Market decline: The life cycle will eventually start to decline as competition increases and other businesses try to imitate your success by adding more features to their products or lowering their prices. When fresh innovations replace current product, this is another factor that causes a downturn. For example, horse-drawn carriages fell out of favor when the automobile replaced them. Since there is no longer any opportunity for profit due to market saturation, many businesses will start to move on to new endeavors. Of sure, some businesses may endure the downturn and keep selling the goods, but manufacturing will probably be on a smaller scale, and costs and profit margins may decrease. Additionally, consumers may choose to avoid a product in favor of a fresh substitute [12].

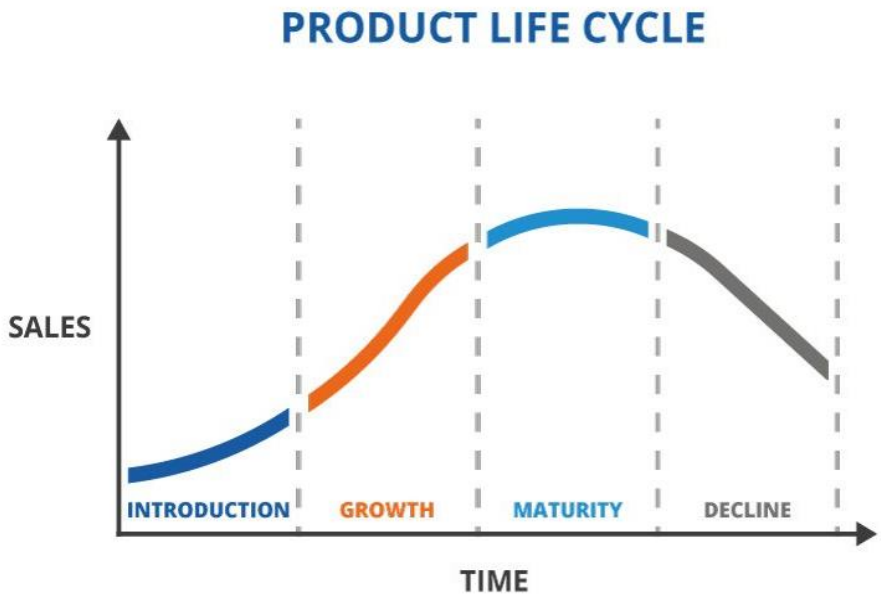


Fig 1.6 product lifecycle [12]

These stages suggest that in order to start a business, we must first promote our products to consumers. We are confident that our technology will be adopted very rapidly because there is a large market for fuel waste or theft prevention. After a year of usage, our

product will encounter calibration problems due to the several different types of modules and elements. However, it can be quickly repaired, and other components will last longer if used carefully. As a result, we are able to offer a one-year warranty and customer support for greater service. The preceding stages taught us that every product goes through a mature stage as well. As a result, our product will eventually reach the mature stage. Prices may decrease at this point due to a number of factors like including competition or a drop in demand. The product may then enter a period of decline before being phased out unless a redesign is possible. As a result, the prototype can be improved upon before it reaches the decline stage. We can recommend certain changes to grave attention of customers, such as switching out rechargeable batteries with solar-powered rechargeable ones. Auto shut off technology will help the prototype function more reliably. Our goal is to ensure that the project can be maintained sustainably and with the least amount of waste possible in addition to making it usable. The definition of the term "product lifetime" differs slightly when it comes to sustainability. Product lifecycle management that minimizes any adverse effects is known as "product lifecycle sustainability"[13]. To achieve product lifecycle sustainability, certain stages of a product's lifecycle must be taken into consideration.

Designing purpose: The stage of product design has the biggest influence on the lifespan and overall environmental effect of a product. Environmental sustainability should be considered during production in addition to the item's price and quality [14]. In our project we will try to use reusable product that might not create more hamper in environment and also, we will try to avoid those products. For the body frame we will be use wood rather than plastic.

Raw material extraction: The vital resources humans require are all found in the rock, atmosphere, oceans, and living things of the Earth. These minerals' extraction has a number of negative environmental effects, such as the depletion of finite resources and

the loss of habitats [14]. The raw material that we will uses in our project that might be create some extraction of gases like CFC, CO2 other greenhouses gases. So, we need to be careful about the disposal about the raw materials of the equipment's.

Manufacturing of product: Manufacturing products can have a number of detrimental effects on the environment, especially when it comes to polluting industrial waste (emitted into rivers or the atmosphere) [14].

Distribution and Packaging: Transporting the finished product and the raw ingredients used to make it both demand energy. Depending on the mode of transportation utilized and the distance traveled, different amounts of pollutants are released into the atmosphere. The product's packaging uses resources and could produce too much waste [14].

Uses of product: A product's kind determines how it will affect the environment as it is used [14].

End of Life (Disposal or Recycling): A product can either be recycled or disposed off when it has served its purpose. By limiting the waste of potentially valuable materials and reducing the usage of fresh raw resources, recycling lowers energy consumption, air pollution, and water pollution [14].

Fig 1.7 Product Lifecycle Sustainability [13]

We realized from the conversation above that we should consider sustainability while we develop the prototype. Most of the parts we'll utilize in our prototype are recyclable. Nearly every component and module device that is connected to our project has a recycling advantage. It is challenging to recycle the microcontroller after its useful life because it is a type of PCB board and also some others element. However, we must properly dispose of trash in order to hurt the environment as little as possible. Additionally, we must use this method to get rid of all non-recyclable materials. The least expensive and environmentally harmful batteries must be used if we want to store energy in batteries. Unfortunately, the expense of environmentally friendly batteries like Li-ion drives up the overall cost of the prototype. Therefore, we need to consider utilizing Lead-Acid batteries with a smaller number but greater capacity. The product paperwork may include the instruction to "use the battery appropriately," implying that doing so will lengthen the battery's lifespan and reduce pollution.

1.8 Impacts of the project

1.8.1 Impacts on society

Bangladesh is a developing country and also a populated country. In our country, the fuel theft problem is abating day by day. That is becoming a major problem in our country. We should rein this misdemeanor. For this, our project will be helpful for our society.
In recent years, this sort of crook activity has come to be such a huge and essential subject matter that scientific studies of the trouble have begun to appear everywhere in the international. A few organizations have begun to maintain facts as unique as possible to determine the global impact of fuel theft from vehicles. The cost of fuel is rising continuously in the current world. We have to maintain the wastage of fuel in many ways.

People are now becoming more aware of their vehicle's fuel. For monitoring the fuel system, they can use our device. After implementing this device this problem can be solved easily. The device will track the vehicle and also will monitor the fuel in time.

The device will be cost-friendly and portable too. It will be needed in daily work. It can be used easily. The method of the system will be so simple that anyone can easily maintain the system easily. It will be simple to operate the device. Any type of person will be able to understand the device measurement. The people of the society will be interested if the system is easily solved their problems. The Vehicle's owner can easily see how much fuel has been transferred to the fuel tank from the fuel station. They can be aware of other people if they get enough benefit from this device. Foremost this device will have a great impact on society. It also has some inexcusable problems. As this device is portable, one can easily remove it from the vehicle. We have to ensure the security of that device too. If we omit the negative impacts the device can make a good and positive impact on society.

1.8.2 Effects on environment and sustainability

Every project has bad and good impacts on the environment. Our project is not different from that. In our project, we are going to use many sensors and micro-controller. It will also have a frame to setup. The frame must be environmentally friendly. This device will be eco-friendly. If we produced this device on a wide scale there will be less impact on the environment. There will be no gas emissions in our project. So, it will be suitable for the environment.

Our Project will also have some wicked impacts on the environment. As we are going to use a lead acid battery for the source power. So, after the end of the battery life cycle, we

will have to dispose of it. If we dispose of it, it will have a bad impact on the environment like water and soil. Because of the toxic substances, the soil in the area where this disposal system is installed will become toxic, and no trees or crops will be able to grow there. For this reason, disposal of this equipment should be done by following proper standards. We have to make sure that the project will have a less sluggish impact and a favorable impact on the environment.

1.8.3 Health and safety issues

Health:

Our project will be so simple. As it will be so easy process and simple, it will not hamper human life. Their low voltage battery will be used for the source so it will be safe for humans. Also, this device will not produce any kind of harmful things. It will be safe for any age of people. The device will be made of some sensors and microcontrollers, so we have to dispose of these things after the lifetime has ended. We have to take proper steps to ensure that disposing of it will not harm human life.

Safety issues:

We have to be careful while implementing this project. We have to ensure the project's safety first. We have to use some sensors and a microcontroller in this device. To protect this project or device we have to make a good shield and sealed frame which will protect the device from many things like water as it is an electrical device, it can be hampered by water. Also, it can be disconnected internal connections, the product's sudden breaking or damage, water spillage over the product So we have to take extra care about this matter. The consumers will also have to follow the proper rules which will be given by the producer and also should follow the manual instruction carefully. We have to prop up this device nicely in the vehicle. We have to ensure that the equipment is not shoddy. We

will use good quality equipment for the project. However, the device will be setup safely for use.

PART-B

This part includes the design, analysis and optimization of the project as prepared in EEE400B.

Chapter 2 Project Design

2.1 Functional design

Consideration of the objectives, requirements, constraints:

1. To get continuously updated latitude and longitude the GSM module should have the best network connection.
2. To get a continuous supply of electricity the energy will be stored in a battery. Lead-acid batteries will be used as it has some benefits like overcharging, discharging and sustainability. Also, to get better and durable power the device will get power from the vehicle's power supply.
3. Vehicle's owner will be notified when fuel level is changing inconveniently.
4. The devise surface will not be so large or weighty that it will create any impact in vehicle internal function or decrease vehicle speed.
5. The device should be low in price, safe and sustainable.

Consideration of applicable standards, codes of practice:

As people's interest in this technology grows daily, the ISO (International Organization for Standardization) has finalized some standards to ensure the device's safety and reliability.[18]

Some of the commonly used standards are discussed in detail below:

1. Under any unfavorable conditions, the device should be able to maintain connectivity.
2. The device needs to be placed in the car such that thieves will have difficulty locating it.
3. The connection and wire rating should be designed in such a way that it can withstand the vehicle heat issue.

4. The area where the car is located must support the used SIM network. Additionally, because the GSM bandwidth differs from nation to nation, the GSM module should be created for their specific territory.
5. The device should have a secure, hazard free and effective design.
6. It must be able to draw power from a vehicle's internal fuel supply. In order to prevent more lead pollution.
7. To use GPS tracker the Bangladesh telecommunication regulatory commission (BTRC) guidelines will be followed. According to Bangladesh telecommunication regulatory commission guidelines for vehicle tracking services in the Bangladesh telecommunication Act, 2001 (Act no. XVIII of 2001), the said commission is empowered to issue license service to any person or organization and also give required instructions or conditions to the license for the public safety and in accordance with the national Telecommunication Policy, 1998 and ILDTS Policy, 2008. [19]

8. To use GSM technology (BTRC) publish their authorized GSM module provider and frequency range. According to their announcement the 900 MHz and 1800 MHz bands of spectrum are designated for second-generation mobile service, according to NFAP. Five providers currently offer this GSM-based second-generation mobile service. Among these, Airtel offers its 2G service in the ITU-designated E-GSM band. It should be noted that after rearranging the spectrum, 15.60 MHz of the GSM 1800 MHz band were left empty. This spectrum can now be given to a new operator, which will generate significant cash for the government. In our project to demonstrated prototype we have use that range GSM module from the government authorized otherwise it doesn't work in our country. [20]

Health, safety, and environmental considerations:

Any kind of technology should conform to this objective in light of our current worry over the state of the climate. That means that our device must also accomplish this objective. Here are some major points to consider:

1. Our device is not hazardous to our health or the environment because it uses GSM-based communication, which is safe for human use.
2. Our device includes a GPS module. With the help of satellite communication, it provides accurate position. It has no environmental

problems as of use. From that reason, our device is safer to use and has no negative effects on the environment or human health.

3. Our device is primarily based on the Atmega328p, it is well-known for its low power consumption and efficient design. As a result, and our device has also become environmentally friendly.
4. Since we use the vehicle power supply, so we don't need external power sources like Li-ion or lead-acid batteries, therefore there won't be any additional lead or chemical waste in the environment.
5. Our device is longer lasting and fully PCB (Printed circuit board) based, it requires less replacement, produces less waste, and is safer for the environment.
6. To avoid having a negative influence on the environment, the materials should be disposable or recyclable.

By considering all the above factors the functional block diagram can be represented as,

Block Diagram

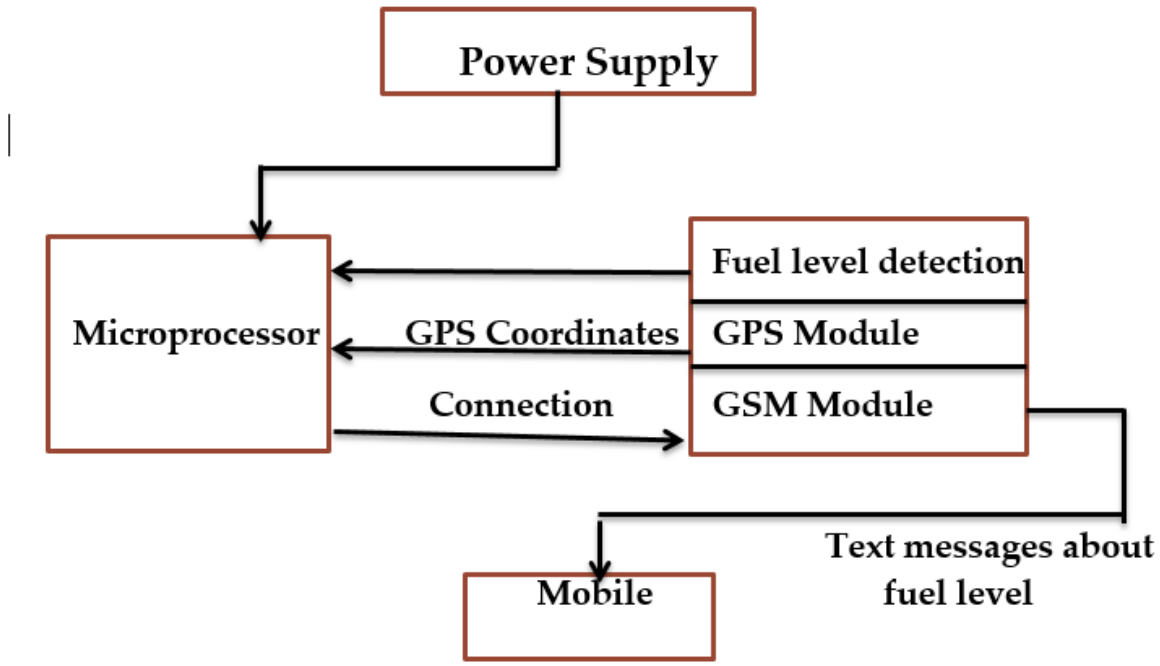


Fig 2.1 Block diagram of Fuel level detection and tracking system for vehicle fuel theft prevention

Power supply: To run the microprocessor, we need a power supply.

Micro-controller: All of the module values are inputted into the microcontroller, which processes the data and outputs it in accordance with user-defined commands.

GPS Module: GPS receiver in tracking device is the main element since it gets the geographical Coordinates from the satellites. Here, it is used identify where fuel level is changed inconveniently.

GSM Module: The GSM module transmits the vehicle's location and fuel level update data in real time to the designated phone.

Fuel level sensor: Fuel level detector will identify the fuel level changes rapidly.

Mobile: Here mobile phone is used to send command, receive Google map link and get update notification about fuel level changes.

2.2 Analysis of alternate solutions

After analysis and research, we find 3 alternative solutions of this project. Those are

1. Automation system for monitoring fuel theft prevention system on telecommunication tower sites.
2. Telemetry and application-based fuel theft prevention system.
3. Fuel level detection and tracking system for vehicle fuel theft prevention.

The comparison of alternative solutions should be based on couple of parameters. We mainly focus on cost, simplicity, networking issues of these methods in section 2.2.1.

Method 01:

Automation system for monitoring fuel theft prevention system on telecommunication tower sites

In this process the fuel theft detection system work by using data server control panel mobile networking tower system.

Flowchart:

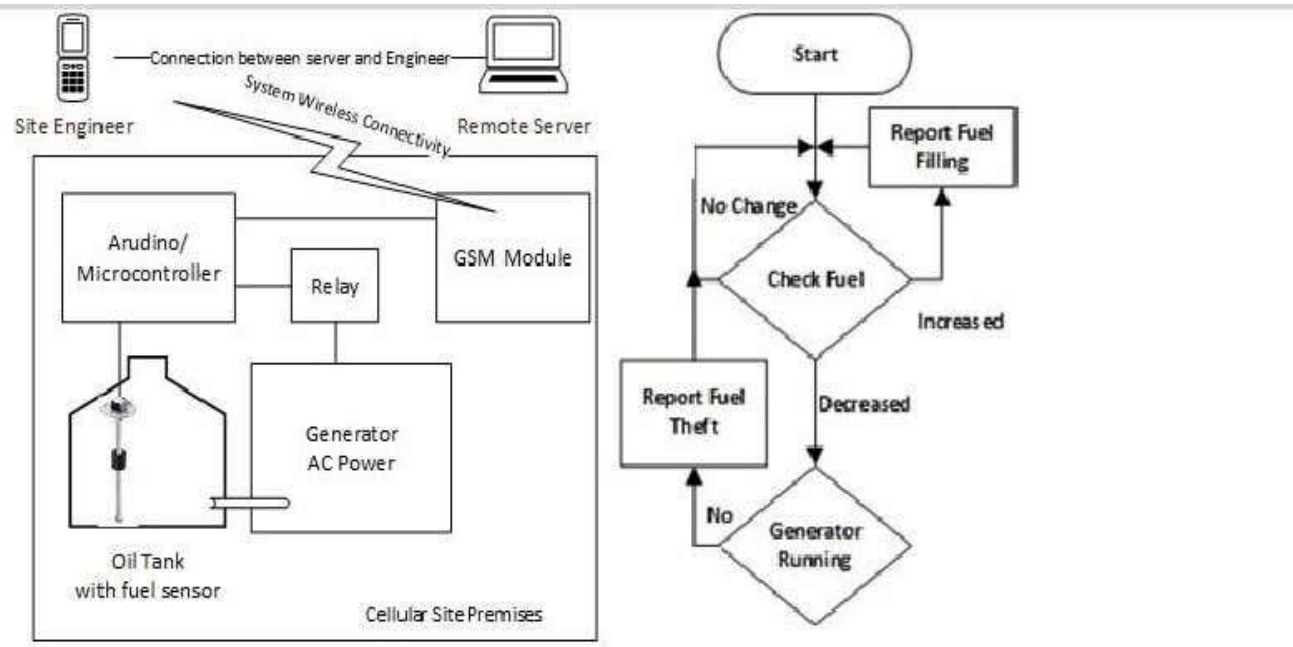


Fig 2.2 Method 01 flow diagram of fuel theft detection [21]

Working process:

1) Fuel sensor will detect the fuel level of the tank and monitoring it [21].

2) Microcontroller process the data [21].

3) Give the data to the server and server is connected to the phone notification (SMS or Email) [21].

4) GSM module used to send data form device to network system server [21].

Results:

Automation system for monitoring fuel theft prevention system on telecommunication tower sites was done both intentionally and randomly in a variety of ways, was caught by the system of fuel theft. The system recorded and reported numerous fuel-related behaviors, including fuel theft, generator operation, and gasoline filling by monitoring the fuel level data increasing and decreasing rate. Here two days are considered 9 AM to 8 AM duration with 45 litter fuel tank. When vehicle is stop there is no changes of vehicle fuel level (9AM to 1 AM, when fuel level is decreasing rapidly (about 15 litter decreasing) in a short period it means fuel theft is detected (1PM to 4PM) and vehicle is ON at 11PM to 4AM when fuel also decreasing conveniently about 11 litter. Here at long time fuel decreasing rate is low so, no fuel theft is detected [21].

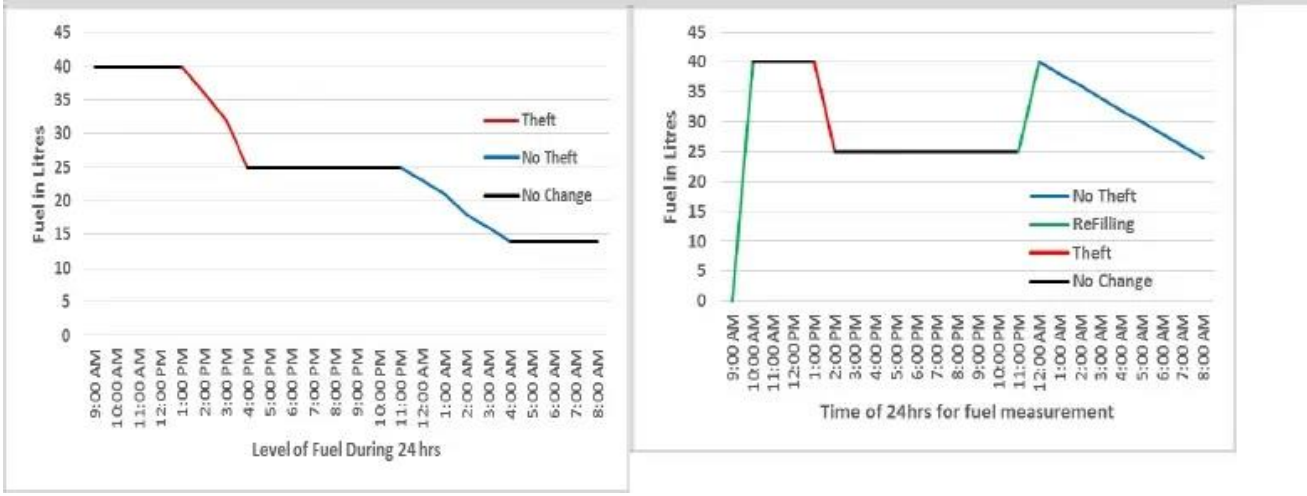


Fig 2.3 fuel theft detection process [21]

Advantage:

1. The system's commercial viability is very high. [21]
2. The system can prevent fuel theft and reduce the cellular operator's significant OPEX. [21]
3. The system will decrease sensitive electronic device faults, which are typically caused by power shutdown. [21]

4. One of the main advantages of the suggested approach is the improvement in site availability, as there is less likelihood of a downed site with adequate fueling. [21]
5. This system also lowers security costs, which businesses often spend on investigating fuel theft. [21]
6. This system will also increase the filling teams' mobility in the event that the fuel level reaches a certain threshold, and the teams arrive at the site before the site goes dark. [21]
7. With this system in place, fuel audits will be simpler and more accurate. [21]

Disadvantage:

1. In the absence of internet, the system cannot function. [22]
2. SMSs which are more easily accessible than emails are not used in by notification system. This may cause a delay in supervision. [22]
3. This process is not enough cost efficient, and simplicity is low**. (**Mention in section 2.2.1.)

Method 02:

Telemetry and application-based fuel theft prevention system,

In this process the fuel theft detection system is working by ultrasonic sensor then process the data of fuel level changing send via Bluetooth Low Energy (BLE) layer and telemetry technology. Finally show the output in smartphone application.[23]

Flowchart:

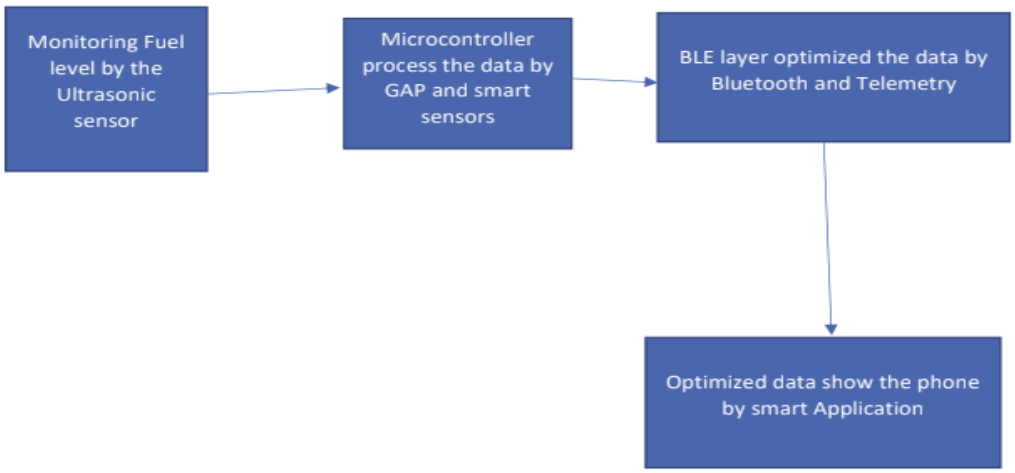


Fig 2.4 Method 2 flow diagram of fuel theft detection [23].

Working process:

1. Ultrasonic sensor will detect the fuel level of the tank and monitoring it [23].
2. Microcontroller process the data by GAP and smart sensors [23].
3. BLE layer optimized the data by Bluetooth and Telemetry network technology [23].
4. Optimized data show the phone by smart Application [23].

Calculation:

For different type of vehicle there are different type of fuel tank. Here in Telemetry and application-based fuel theft prevention system,600L fuel tank is considered and fuel level indicator is designed which is given below:

The fuel tank types differ between truck models. The analysis is performed on a tank with rectangular geometry, as shown in Figure 4-6. The fuel tank volume is set to 600 L. The tank's dimensions are determined by the height of the fuel level sensor. The tests were carried out at a height of 800 mm. To be on the safe side, the tank cannot be completely

filled. The tank c has a height of 0.77 m, a width (b), and a length (a) of 0.624 m and 1.248 m, respectively. The length is twice as long as the width [23].

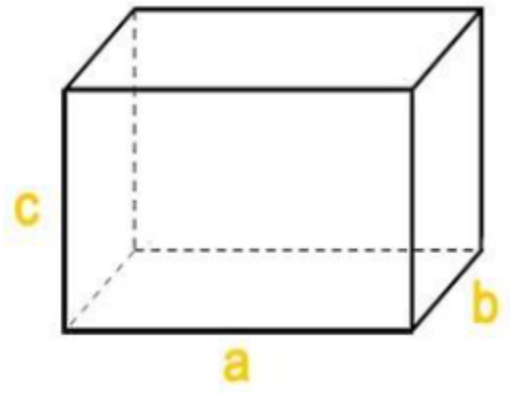


Fig 2.5 600L vehicle fuel tank [23].

The fuel level sensor is 800 mm in length. The tank is filled with diesel fuel up to 755 mm, the height required to fill the tank. Three different hole diameters are tested: 3 mm, 5 mm, and 10 mm. This tank connects a hole of three different diameters to an atmospheric pressure location. The issue was resolved by developing an algorithm based on the fuel level. The flow equation states [23] (Makina Mühendisliinde Sk Kullanlan Pratik Bilgiler, n.d.) [23].

$$dQ = \sqrt{2gh}\, C_d A \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [23]$$

$$-S.d.h = \sqrt{2gh}.C_d.A.dt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [23]$$

$$C_d = 0.61 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [23]$$

$$\int dt = \frac{1}{\sqrt{2g}.C_d.A}\int_{ho}^{h1}(-S\frac{dh.\sqrt{h}}{\sqrt{h}}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [23]$$

$$T = \frac{S}{\sqrt{2g}.C_d.A}\int_{h0}^{h1} h^{-1/2}dh \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [23]$$

$$T = \frac{S}{\sqrt{2g}.C_d.A}\frac{h^{1/2}}{1/2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots [23]$$

$$T = \frac{S\sqrt{\frac{2}{g}}}{C_d.A}(\sqrt{h_0} - \sqrt{h_1} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots [23]\ )$$

$c = 770\ mm = 0.77\ m$

a×b×$c = 0.6\ m3$

$a = 2b$

$2bxbx0.77 = 1.54xb2 = 0.6\ m3$

$b = 0.624\ m = 624\ mm$

$a = 2b = 1.248\ m = 1248\ mm$

$V = 600\ L$

Now,

$dQ = \sqrt{2gh}C_dA$

$C_d = 0.61$

$\int dt = \frac{1}{\sqrt{2g}.C_d.A}\int_{h_0}^{h_1}(-S\frac{dh.\sqrt{h}}{\sqrt{h}})$

Here fuel theft detection devices is prepared to considering the specific 600L fuel tank. It can be change for different size and designed fuel tank. Calculations and graphics of 3mm of hole diameter are listed below.

$S = 1.248\ m * 0.624\ m = 0.77\ m^2$

$C_d = 0.61$

A=π(D)^2/4 =(0.003)^2*π/4 =7.068*10^-6 m^2

$g = 9.81$ $h_0 = 0.77\ m$

$T = 2\ minutes = 120\ seconds$

$49 * 10^{-3} = (\sqrt{0.77} - \sqrt{h_1})$

$h_1 = 0.76\ m$

$Volume\ (V) = (0.77 - 0.767)0{,}77\ m^2 = 2.01 * 10^{-3}\ m^3 = 2.01\ liter$

The total discharge volume in 2 minutes is 2.01 liters. It means that 2.01 liter is discharged from the 600-liter tank in 2 minutes. So, if the fuel decreasing rate is more than that then fuel changing rate in inconvenient and fuel theft happened.

Table 2.1 Volume changing for different diameter fuel level detector [22]

D(mm)	V(m^3)	V(L)
3	2.01*10^-3	2.01
5	5.58*10^-3	5.58
10	0.0288	28.8

For, 3mm diameter fuel tank 2.01L fuel dressing rate in 2minutes, for 5mm 5.58L in 2 minutes and for 10mm 28.8L in 2 minutes. More then this rate fuel decreasing rate is high and fuel theft happened.

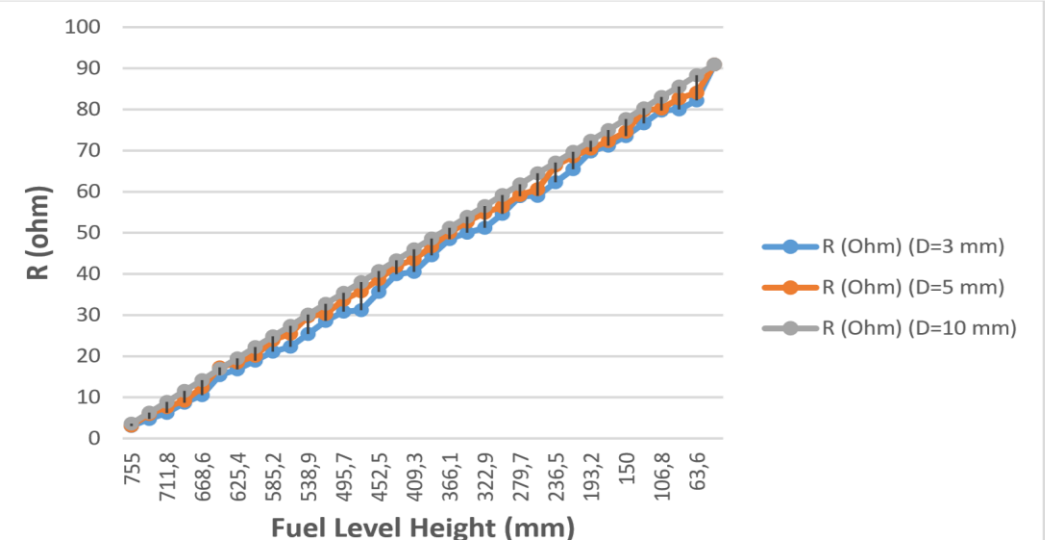


Fig 2.6 Fuel level height changing monitoring in the fuel tank [23].

Advantage:

1. Very high accuracy [23].
2. Monitoring fuel level at anywhere easily [23].
3. Could be designed for any kind of vehicle fuel tank [23].
4. Smart and detail update about fuel level changing [23].

Disadvantage

1. Without networking hub this system does not work [23].
2. BLE technology depend on the network issue. The system might delay to send notify the fuel level change [23].
3. Without required application this system does not work [23].
4. For smart application need internet to operate [23].
5. Operating process not easy to all and complex [23].
6. Not enough cost effective. (Explain in section 2.2.1)

Method 03:

Fuel level detection and tracking system for vehicle fuel theft prevention

Vehicle tracking is a crucial function for personal vehicles such as cars and bicycles.

It can be used to track its current location. If the vehicle is misplaced in some way, it can notify its owner. The owner is informed of the thief's current location.

This tracker is a car tracking system that employs GPS and a GSM device. GPS (Ground Positioning System) is essentially an electrical integrated circuit that uses satellite technology to detect location. GSM communication module is used here. GSM is essentially a communication device that can broadcast and receive location data, keeping the owner informed of the vehicle's location. A microcontroller connects and controls both GPS and GSM devices (Arduino). A security alarm system will also be installed, which is activated by a text message sent to the recipient. The entire system has been

fitted in the vehicle. For an acceptable range of operation, it can be applied for autos or any moving object. After a while, the GSM device will transmit SMS to keep the receiver informed of the vehicle's current location. The SMS will include a Google Maps URL link so we may check the vehicle's location. For method we consider 110L fuel tank (truck fuel tank)

Flow chart of Fuel level detection and tracking system for vehicle fuel theft prevention:

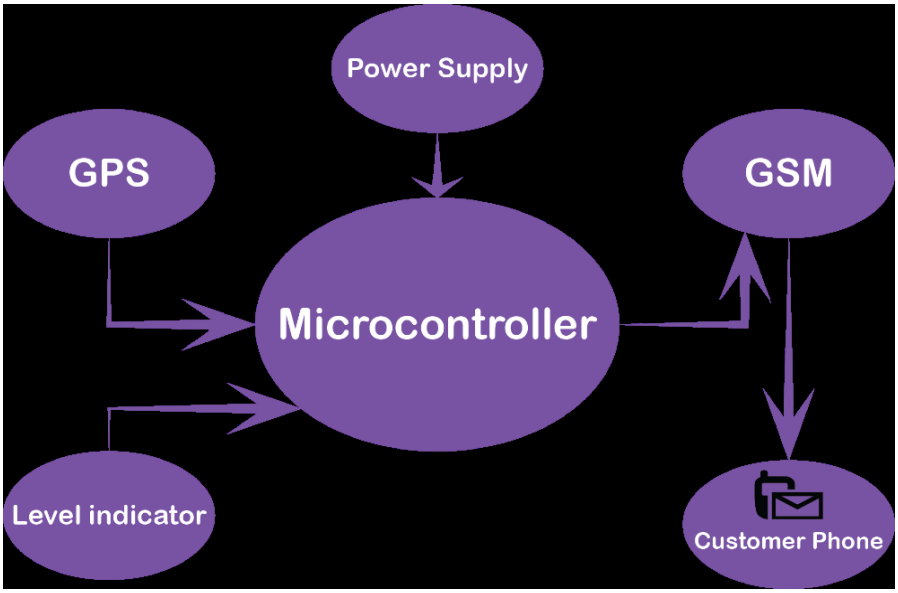


Fig 2.7 Method 03 flow diagram of fuel theft detection.

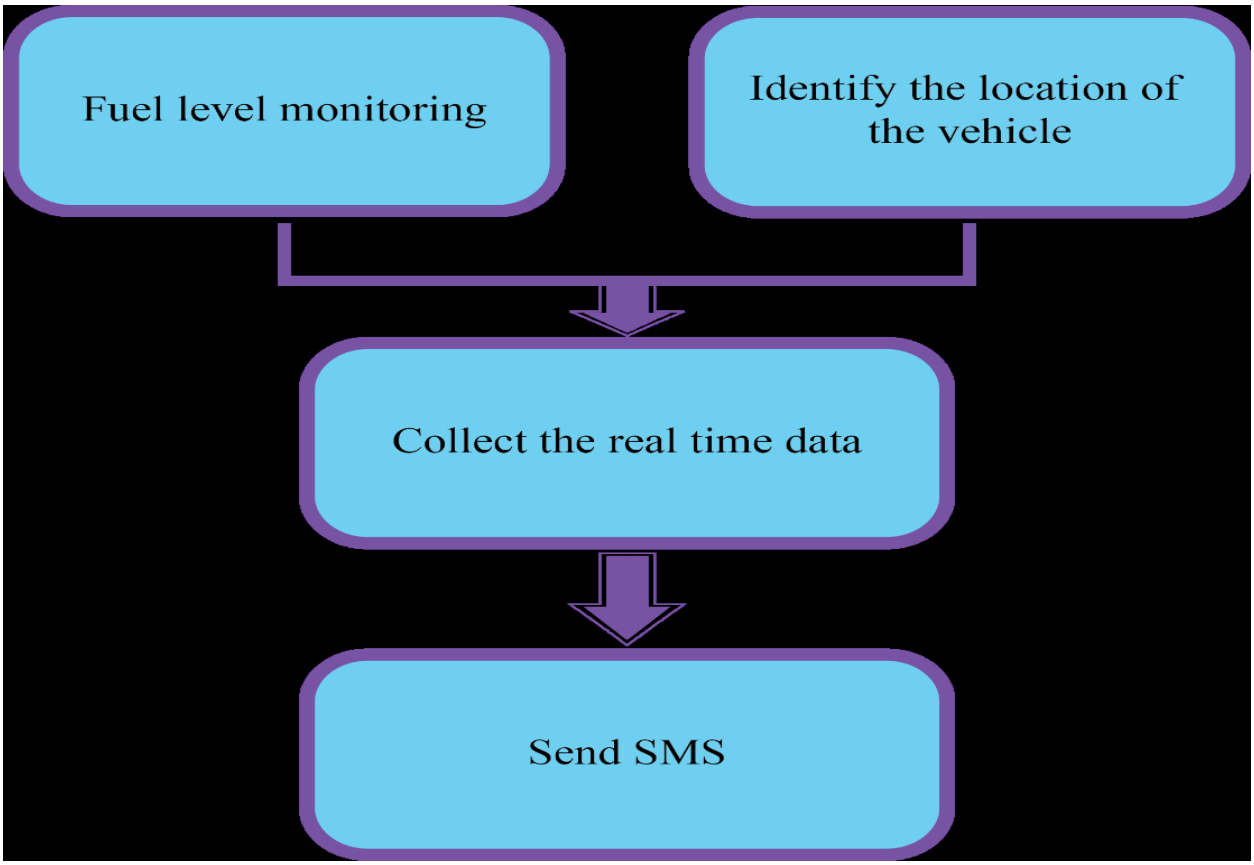


Fig 2.8 Method 03 flow diagram of fuel theft detection.

Step by step working system:

1. Fuel level monitoring and identifying the location of the vehicle: we will measure or monitor the fuel level by the fuel level indicator like "1 liter fuel remaining" and identify the location of the vehicle by the GPS module where it changes. We will monitor the fuel level and location at all times.
2. Collect the real-time data: Our device will monitor the real-time data all the time. Our device has no storage unit for saving the data, but it will monitor the data all the time.
3. Send SMS: Our device system gets the notification from the section and sends an SMS to the customer's phone. This system will send the SMS when the vehicle

owner wants to see and when any abnormal change will happen notified in fuel level.

4. If any situation unconventionally changes fuel level than level detector will identify the fuel level, GPS module will identify the location then all command will be programed by Arduino and that command will go to owner's phone by GSM module by using mobile network. Message: "Fuel level: 1.2L fuel remaining, location: East west university". But before this unconventional change occurs, the fuel level has 5 liters remaining. After these unconventional changes, the message will show "Fuel level: 1.2L fuel remaining, location: East West University."

Advantage:

1. In the absence of internet this system can function by GSM module. By using GSM module this system can send SMS anytime. This system needs a SIM card for sending a SMS in owner phone. So, this a great advantage for this method.
2. This method has much simplicity then method 2. In method 2 because of Bluetooth Low Energy ((BLE) it has some delay problem for sending notification. But this method SMSs easily accessible.
3. This system doesn't need any required application.
4. This will work with the SIM module network, it will be able to send messages with minimal network coverage, unless network blackout.
5. This strategy is user-friendly and simple to implement. Because, this system operating process is easy to all and no complex at all and also has no network issue problem.
6. This system is enough cost effective then other 2 methods. (Mention in 2.2.1)

Disadvantage:

1. By using the device there have a privacy hamper issue.

2.2.1 *Comparing among these three methods*

However, we are able to track a vehicle's whereabouts using these 3 methods. We can notice the differences between these strategies when we take our costs into consideration.

Cost Analysis for Automation system for monitoring fuel theft prevention system on Telecommunication tower sites:

We need Arduino, Relay, GSM Module, and Oil tank with fuel sensor, Generator AC Power.

Table 2.2 Equipment list and Cost for method 1

No	Equipment	Price (TK)
1	Arduino	3497
2	Relay	242
3	GSM Module	800
4	Holykell RS485 submersible diesel fuel level sensor oil level meter [29]	8500

Total cost for this method 13,039 Taka

This project is for a particular point. This device in not for a moving vehicle or an object. This project has less component but high cost. However, this project is easy to use.

Cost Analysis for Telemetry and application-based fuel theft prevention system:

Table 2.3 Equipment list and Cost For method 2

No	Equipment	Price (TK)
1	Ultrasonic Sensor for volume measurement	870
2	Microcontroller	2500
3	Telemetry	3999
4	Smart application (maintenance cost)	4000

Total cost for this method is 11,369Taka.

In this project, for a particular distance need communication point. If vehicle traveling area is large cost will increase. For each communication point we need manpower for maintain the communication point. For manpower we need extra cost. This project cannot be controlled by one person. This project is complex. For controlling the telemetry communication, we need smart application. For developing a smart application is costly because it has a maintenance cost annually. The user must pay a certain amount of money. It could be 15% to 20% of its making cost. If the smart application making cost is 100000 TK, then the maintenance cost will be 15000 TK to 20000 TK. Since the application making cost is fixed so the making cost will not include in the Product cost. Assume the number of customers will be 50. Each customer has to pay 400 TK for maintenance cost annually. For 10 years they will pay 4000 TK only. This will be added to the product cost.

Cost Analysis for Fuel level detection and tracking system for vehicle fuel theft prevention:

Table 2.4 Equipment list and Cost For method 3

Equipment	Price (TK)	Quantity	Total cost (TK)
Frame	1500	01	1500
Arduino UNO	1000	01	2200
Breadboard	90	02	180
Battery	80	01	80
Resistance	02	10	20
GSM module	2300	01	2300
GPS module	800	01	800
Button	50	01	50
Wire	05	25	125
Ultrasonic liquid sensor	499	01	400
Total			6,455 TK

For this method of total cost which is 6,455 Tk only.

We chose the for-Fuel level detection and tracking system for vehicle fuel theft prevention method from these three options.

In method 1 the system cannot work in the absence of internet access and also the notification system does not use SMSs, which are more easily accessible than emails. This could result in a delay in supervision. This approach is inefficient in terms of cost and simplicity.

In method 2 this system is useless without a networking hub. For the smart application net internet to function. The operating process is difficult and complex network issue for everyone. Insufficient cost-effectiveness.

In method 3, according to the estimated cost table, the Fuel level detection and tracking system for vehicle fuel theft prevention has the lowest cost when compared to others. The implementation system of Fuel level detection and tracking system for vehicle fuel theft prevention method is the easiest method of other methods. Because the device sends latitude and longitude through SMS, it will function even in poor network conditions. Unless network blackout. For this method it has low making cost than the other two methods. It is suitable for low/high populated density areas. This method's component is widely available in the Bangladeshi market.

Table 2.5 Alternative solution Compare table

Solutions	Cost (TK)	Simplicity	Network issue
Method 1	13,039	Easy	Medium
Method 2	11,369	Complex	High
Method 3	6,455	Easy	Low

From the compare table 2.5 we choose Method 3 (Fuel level detection and tracking system for vehicle fuel theft prevention) because its cost effective, easy to use and very low network issue compare to other two methods.

2.3 Refined design

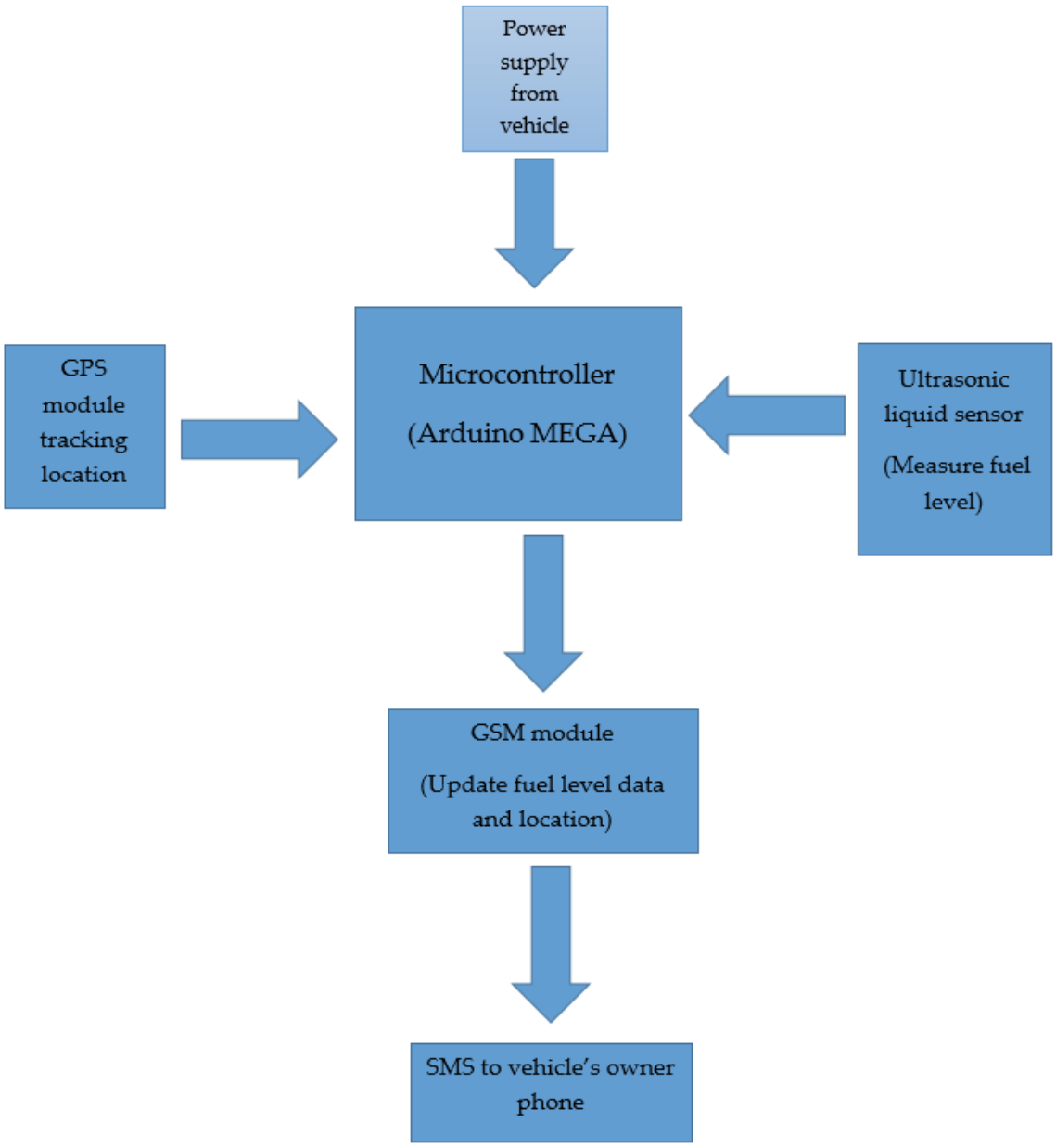


Fig 2.9 Refined Block diagram Fuel level detection and tracking system for vehicle fuel theft prevention.

From the alternative solution analysis and comparison, we have decided that we will select method 03: Fuel level detection and tracking system for vehicle fuel theft prevention.

Final design circuit diagram connection:

1. Arduino will get input power with 12V vehicle battery. Battery Vin pin is connected battery positive side and negative in the GND pin.
2. Ultrasonic sensor Vin is connected to Arduino 5V pin and GND is connected to Arduino GND pin. Also, sensors trigger and echo pin accordingly connected to Arduino 5 & 6 pin.
3. GSM module will get power from vehicle battery because SIM 900 need 9V,12V supply voltage and peak time 2A current. GSM module software serial 0,1 pin is connected to Arduino 7, 8 pin and ground is connected to common GND pin of Arduino.
4. GPS NEO 7M module's RX and Tx is connected to Arduino 3 & 4 pin. Vin is connected Arduino 5V pin and GND common ground.

Fuel tank capacity calculation:

Fig 2.10 Truck fuel tank measurement.

Truck fuel tank capacity,

Length, L =37inch = 0.9398 m

Wide, W =14.8inch = 0.37.58 m

Hight, H = 12.5inch =0.3175m

Volume of fuel tank will be = (L*W*H) m^3

= 0.112 m^3

Here, 0.112 m^3 is equal to 112L. But in real life capacity is 110L. so, we have to choose the sensor that distance measurement range should be up to 0.3175m(for height distance)

Here is our proposed design hardware description step by step:

2.3.1 *Hardware Part*

GPS module:

Fig 2.10 GPS module [24]

GPS (Global Positioning System) is a navigation system based on the network of 24 satellites initially and positioned into trajectory or orbit. The technology was adopted by the US military force (American Department of Defense, DOD) and known as the creator of the GPS. The satellites send signals or data to the GPS receiver on the earth to find the [24] position, time, speed, and direction on any point on the planet. GPS works without any subscription fee at any situation regardless of weather conditions everywhere in the world at any time. The system is worldwide accepted by aviation, navy, civilians, land survey and many more.

SIM900A GSM MODULE:

The SIM900A GSM Module is the small and the most cost-effective GPRS/GSM module on the market. It is the most embedded application uses GPRS/GSM

technology to communicate with a mobile sim. It operates on the 900 and 1800 MHz frequency bands and allows users to make [25] and receive phone calls as well as send text messages.

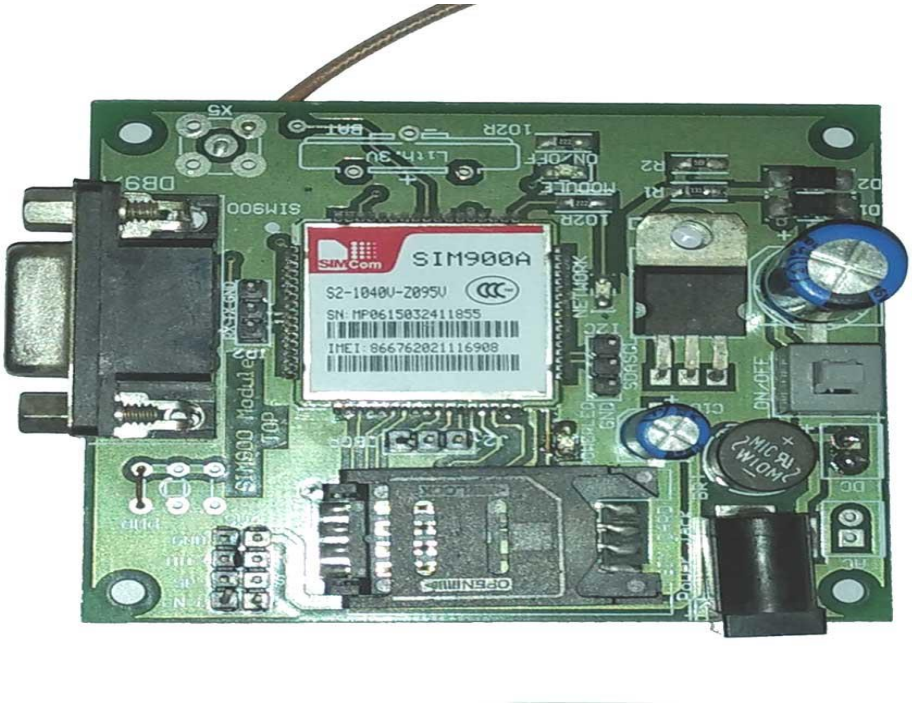


Fig 2.11 GSM module [25]

- Single supply voltage: 3.4V – 4.5V
- Power saving mode: Typical power consumption in SLEEP mode is 1.5mA
- Frequency bands: SIM900A Dual-band: EGSM900, DCS1800. The SIM900A can search the two frequency bands automatically. The frequency bands also can be set by AT command.
- GSM class: Small MS
- GPRS connectivity: GPRS multi-slot class 10 (default), GPRS multi-slot class 8 (option)
- Transmitting power: Class 4 (2W) at EGSM 900, Class 1 (1W) at DCS 1800
- Operating Temperature: -30ºC to +80ºC
- Storage Temperature: -5ºC to +90ºC
- DATA GPRS: download transfer max is 85.6KBps, Upload transfer max 42.8KBps
- Supports CSD, USSD, SMS, FAX
- Supports MIC and Audio Input

- Speaker Input
- Features keypad interface
- Features display interface
- Features Real Time Clock
- Supports UART interface
- Supports single SIM card
- Firmware upgrade by debug port
- Communication by using AT commands

Arduino UNO:

In our project, we will use Arduino Uno as the brain of our project. All the device will enter into the Arduino Uno as inputs and microcontroller will processing data and give output according to user defined commend. There are two main parts in Arduino Uno

1. Hardware
2. Software.

Fig 2.12 Arduino uno [26]

Hardware part for Arduino Uno:

The most reliable, widely used, and well-documented board in the Arduino family is Arduino UNO, the first series of USB Arduino boards and the platform's reference model.

It is a small open-source microcontroller board based on the AVR family's ATMEGA328P microcontroller. From 0 to 13, there are 14 digital I/O pins. PWM output is provided by the six digital pins marked with a tilde (), which are pins 3, 5, 6, 9, 10, and 11. Additionally included are the power and analog sockets with six analog input pins (A0-A5) on the analog plugs. The USB connector on the UNO board lets you connect to a computer to either send data, upload the sketch, or supply power. The operating voltage is 5V, while the recommended input voltage is 7-12V. However, the input voltage is limited to 6-20V, and the clock speed is 16 megahertz. The board has a separate power connector for connecting an external power supply. The risk of hardware damage is decreased when the appropriate voltage is supplied to the appropriate digital I/O pins.

When pressed, the Arduino UNO's reset button restarts the system in the event of a technical issue. As can be seen in the image above, when data is received or sent between the Arduino and other attached devices via USB or the serial port, LEDs labeled TX and RX illuminate inside the blue bracket. LED L uses its own digital PIN 13 connection. During data transmission, the USB interface between the Arduino and the computer is controlled by the tiny microcontroller contained within the orange bracket. The UART for serial communication on the Arduino UNO enables it to communicate with a computer via USB or another external serial device. Data is received by PIN 0 (RX) and sent by PIN 1 (TX). Serial communication at 5V TTL is used by the ATmega328P microcontroller.[27]

Software Part for Arduino Uno:

Open-source development software called Arduino IDE (Integrated Development Environment) was introduced by Arduino.cc. It is used to write and compile programs before uploading them to any Arduino shield. The Arduino IDE software can be used with a different operating system that supports both C and C++ programming languages, such as Windows, Linux, or a Mac. The Arduino IDE can be used online or offline. Setup

() and loop () are the two primary components of the Arduino IDE. The Setup () function starts when the power is turned on or the reset button is pressed.

Ultrasonic liquid Sensor:

Fig 2.13 Waterproof Ultrasonic liquid module sensor [28].

The basic working principle:

1. Using IOTRIGTrigger ranging, to at least 10us high-level signal [28].
2. The module automatically sends8A 40khz square wave, automatically detect whether there is signal return [28].
3. There is a signal return via IOECHOOutput oneAHigh, high duration is the time from the launch of the ultrasound to the return. Test distance = (high time * sound speed (340M / S)) / 2. The use of this module is simple, a control mouth made a 10US above the high level, you can wait for the reception of high-level output. An output can be opened timer time, when the mouth becomes low when you can read the value of the timer, this time for the distance of time, can

calculate the distance. Such a continuous cycle measurement, which can be measured to achieve the value of your move [28].

Diagram Of Proteus Simulation:

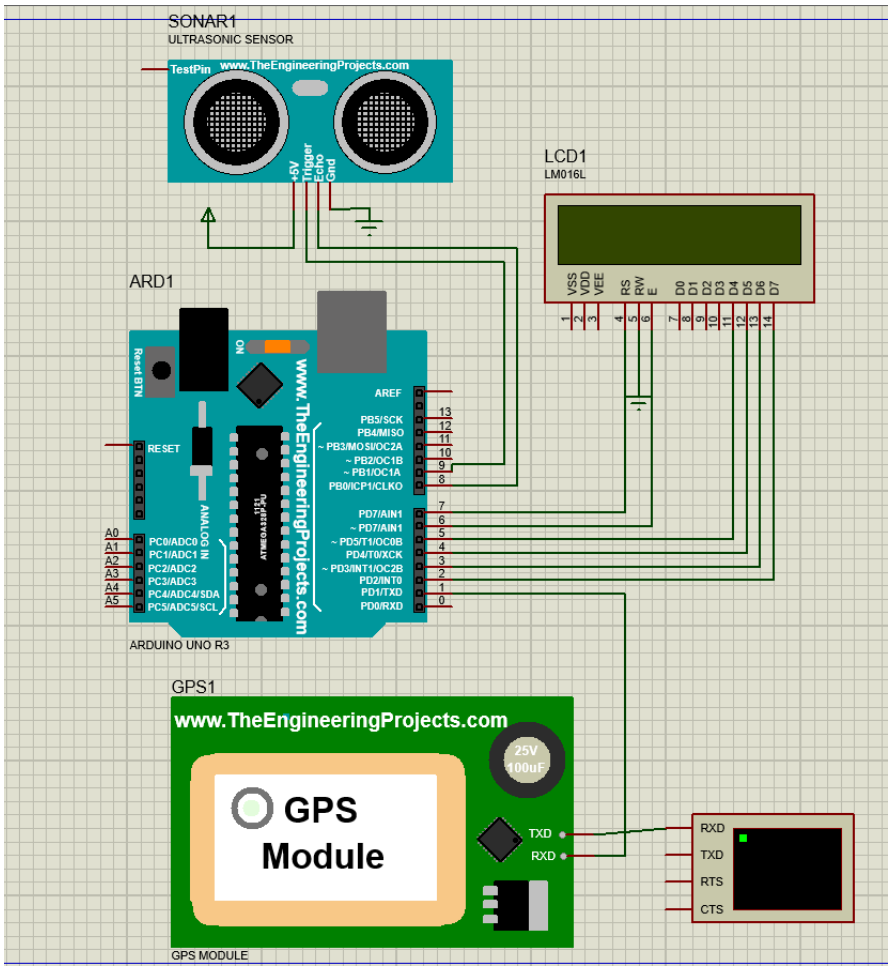


Fig 2.14 Simulation circuit Diagram

<u>Simulation Description & limitation:</u>

This diagram is only for simulation. Some of our project components such as (GSM Module, fuel sensor) cannot be simulated. Because it is not possible to send SMS

through the GSM module to the mobile phone. We cannot change the fuel level in simulation. We read data from the ultrasonic sensor (since fuel sensor is not available in the proteus so we use ultrasonic sensor instead of fuel sensor) and GPS module using Arduino UNO and we see the result in the display. We can see that the virtual terminal is operating. This virtual terminal shows the GPS coordinates. Since the GSM module cannot be simulated. That's why we use a 16x2 LCD display to see the operations of the project. We set the water sensor value maximum 5 liter and the reading data is displayed in five steps 1L, 2L, 3L, 4L and 5L. What we will see on the display that will be our sent massage to the vehicle owner.

PART-C

This part includes the implementation, finalized design, and analysis of economic viability of the project.

Chapter 3 Demonstration of Implemented Solution and Finalization of Design

3.1 Development of the prototype

As we did not describe 400B in detail, when we began thinking about building our prototype, we realized that we needed to change some components. We began building the prototype after purchasing the essential equipment from the local markets. We developed the prototype using the prototype design mentioned in section 2.3, with minor changes of circuit diagram and equipment to improve performance and achieve the desired result. Figure 3.1 and table 3.1 lists all of the changes.

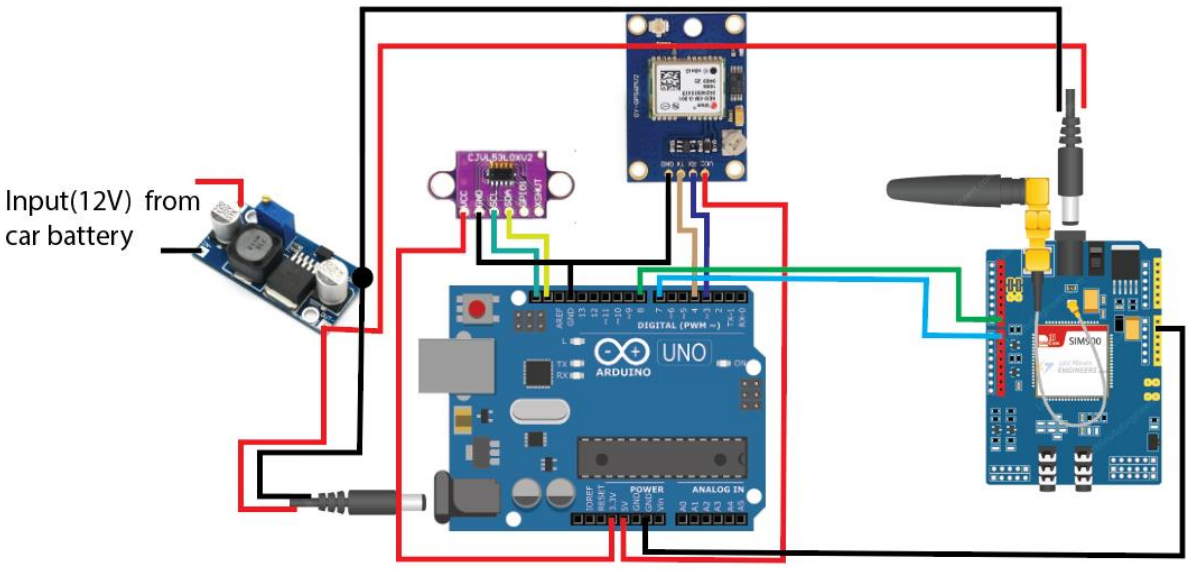


Fig 3.1 Modified prototype circuit diagram.

3.1.1 *Changed parameters and reasons for changing*

Table 3.1 Changed parameters and reasons for changing.

Equipment used in prototype	**Equipment mentioned in section 1.3**	**Key specifications of the equipment used in prototype**	**Reasons**
Sim 900GSM Module	Sim 900A GSM Module	V_{DC}= 3.4~4.4V I (peak to peak) = 2A [34]	As we didn't get Sim 900A GSM Module in local market, we took the Sim 900 GSM Module
GPS NEO 6m module	GPS NEO 7m module	V_{DC}= 3.3~5V Maximum consuming current I = 45mA 22 satellite connected with 50 channels, tracking sensitivity – 161dB. [35]	As we could not connect the neo 7M to the satellite. Then brought neo 6M.
GY-VL53L0XV2V VL53L0X Time-of-Flight Distance Sensor Breakout Module	Ultrasonic liquid Sensor	Input voltage range Vin=2.8V to 5V, Output voltage is Vo= 2.8V Distance measurement range up to 2m(6.6ft) Maximum power	As we try with the ultrasonic SR-04 sensor because we don't get ultrasonic liquid level sensor in market. When we test the prototype, we didn't get any accurate result of the ultrasonic sensor. The sensor

		consumption in operation mode is 20mW. [36]	given data was not same as the real data. The output result of the ultrasonic sensor was not fixed. The sensor result fluctuated all the time. Then for the better accuracy and to get minimum level of fixed value we used TOF sensor.
Mobile phone (Personal used phone)	Mobile phone	Any brand of smart phone.	As we have smart phone to use for message option. So, we didn't buy any smart phone.
Adapter	Battery	Vin= 100-220V Vout= 12V Iout= 2A	We have made this prototype with the plugged-in system. That's why instead of battery we used an adapter to power up the GSM module through the AC source. Most. Importantly, lack of battery's power supply all time like as truck battery, we used adapter.

Box	Frame	Length 10inch, Width 4.5inch, height 3.5inch	For placement of the device and safety of the device.
Xl6009 DC – DC buck boost converter	Not mentioned	Input Range:3.8V -32V Output Range:1.25V-35V Input Current:3A (max) Output Current:4A (max). [37]	To get stable 12 V output from vehicle battery to used that converter.

Initial Construction of device:

Voltage conversion: According to the voltage requirements of the project equipment's used in this project, the power demand of our microcontroller is 7 to 12 volts, yet we only used 12 volts for the controller section, 5 volts for the GPS module (NEO 6M) and 12 volts the SIM900 module. We have to used mainly truck battery connection to get power supply. Usually, in real life truck 12V battery we get 12.6-12.8V. When the engine is running, these measurements should be 12.4V. So, for the stable 12V input power we used Xl6009 DC-DC buck boost converter. As, we couldn't have opportunities to attach the device truck battery directly, so we just use bike battery for prototype instant of truck battery and converted that to stable 12 V. When we collecting voltage level data the vehicle was stopped and no electrical vehicle function were operated. When all the head light, indication lights are operated and some others operation like horn use etc will be happened

voltage level will be decrease. Also, there is another issue of battery charging and discharging. When it discharges there will be change to decreasing voltage level. For considering all facts we used buck boost converter.

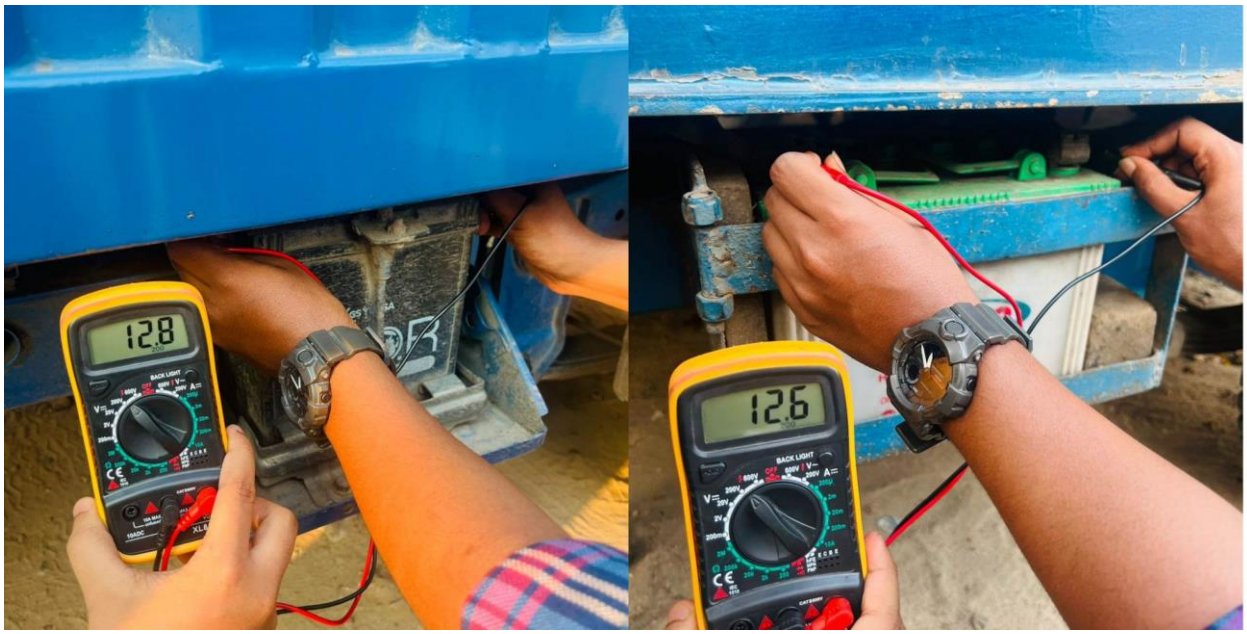


Fig 3.2 Different truck battery voltage level measurement.

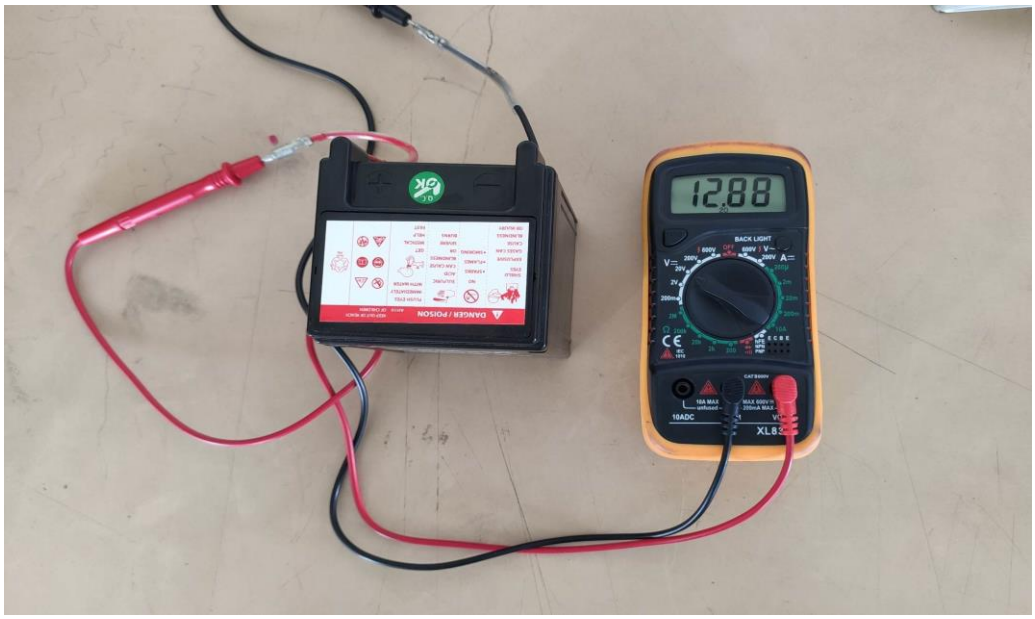


Fig 3.3 Prototype (bike battery) voltage measurement before using converter.

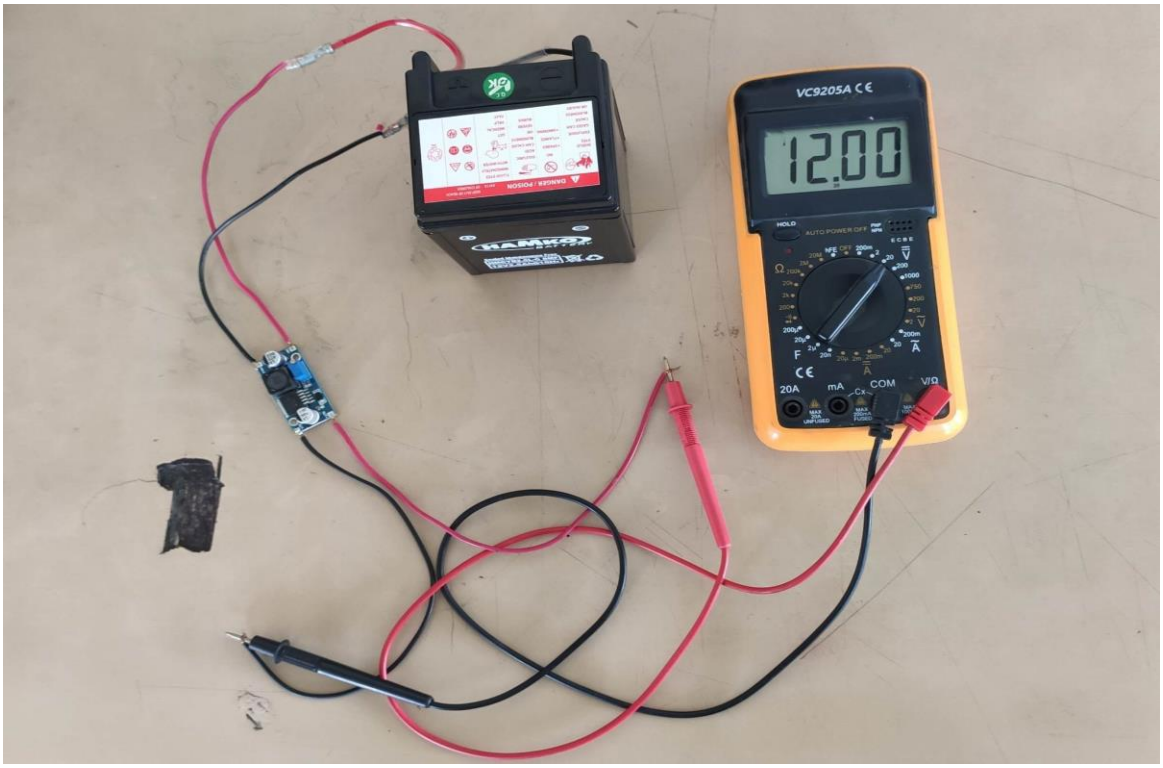


Fig 3.4 prototype (bike battery) voltage measurement after using converter.

Construction of the entire circuit showing the components:

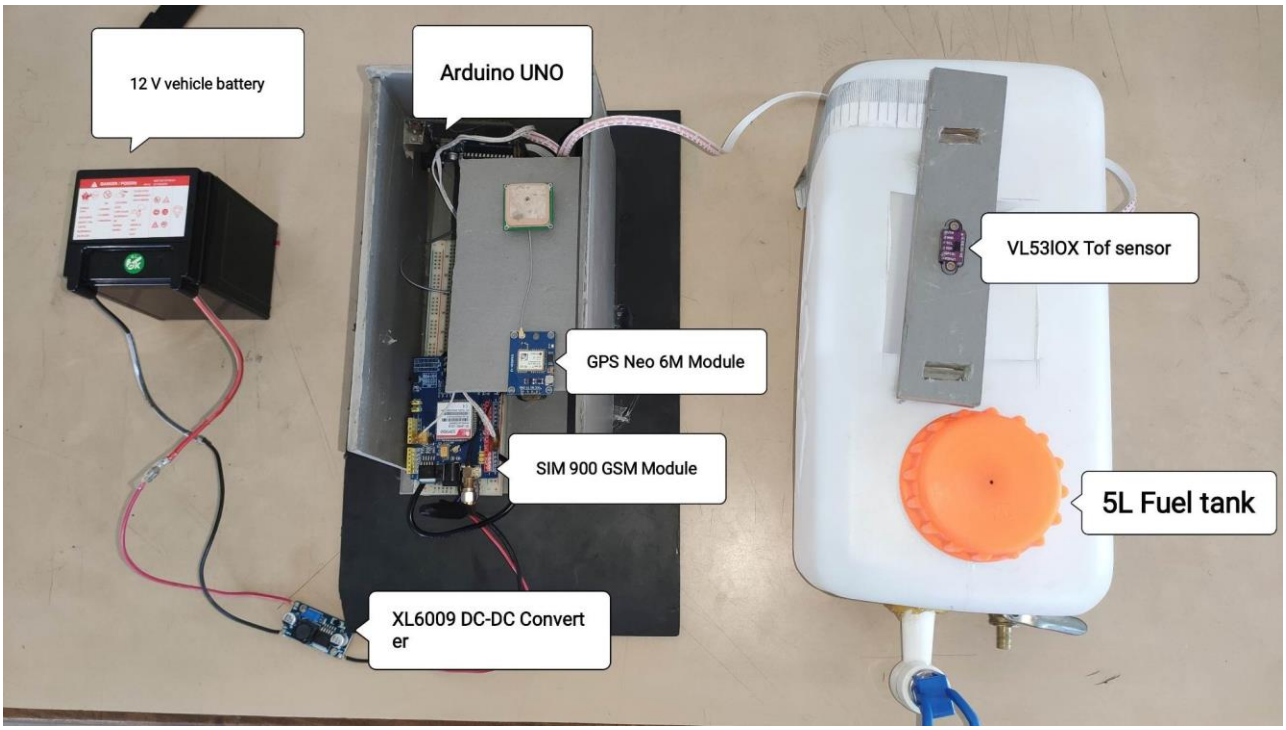


Fig 3.5 Implemented circuit of our device.

At first Arduino is activated with 12V power supply. For this power supply in our main project vehicle's main 12V battery will be used. But for the prototype we used 12V (bike battery) battery. Battery positive and negative is connected to Xl6009 DC-DC buck boost converter's input side positive and negative port. And Xl6009 DC-DC buck boost converter's output side positive is connected to Arduino Vin pin and negative is connected to Arduino GND pin. Then GPS Neo 6M Vcc is connected to Arduino 5V volt pin. Rx and Tx are accordingly connected to Arduino pin 3 and 4. Then VL53l0X T-O-F distance sensor's Vcc pin is connected to the Arduino 3.3V pin. Sensor's SCL (level shifted clock line) and SDA (level shifted data line) pin are connected Arduino I2C SCL (serial clock line) and I2C SDA (serial data accusation) pin accordingly. Then SIM 900 GSM module software serial pin 0

& 1 are connected Arduino pin 7 & 8. Also, for the power supply in SIM 900 GSM module we used 12 V adapter directly or by using adapter plug another parallel connection from Xl6009 DC-DC buck boost converter's output. We used both way for the prototype performance testing. But in main project vehicle's 12 V battery will supply the power through Xl6009 DC-DC buck boost converters to GSM module. Finally, T-O-F sensor, GPS and GSM ground are connected to the Arduino common ground.

Placement of the device:

For better and safety of the device, we constructed a box with PVC board where we put our device and the box will be attach with vehicles where the user wants. According to stake holder requirement the box is standard size (Length 10inch, Width 4.5inch, height 3.5inch) for this prototype. However, the box frame may need to be change for commercialization and vehicle's body structure. So. Now we only focus on the truck as our desire vehicle and we designed for that in our prototype. For better observation we have attached the close pictures of the box below.

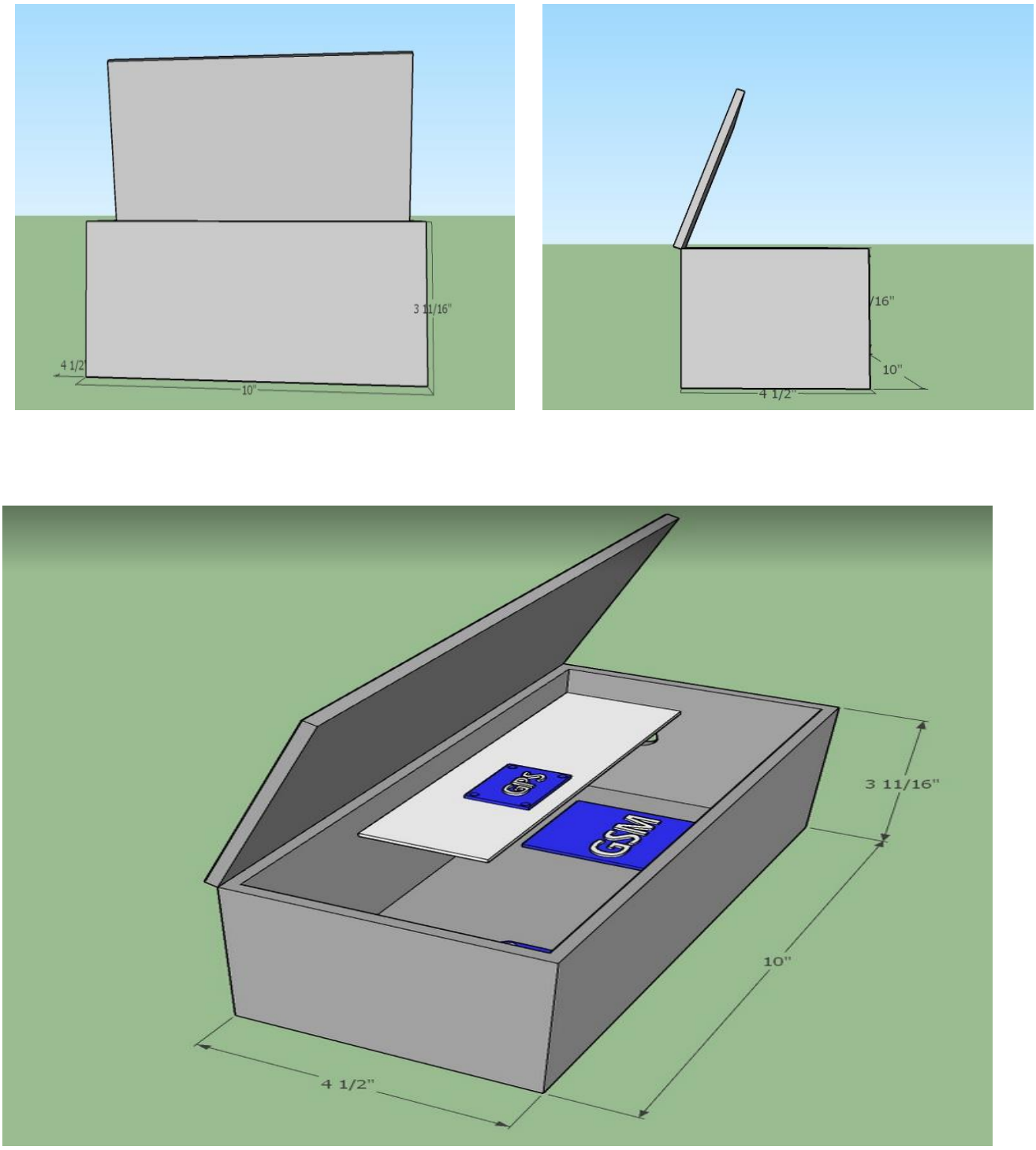


Fig 3.6 3D view of the box with front, side and top.

We constructed the box manually for the device after observing it in 3D. The manual prototype box is as follows:

Fig 3.7 Prototype box with circuit (front, side and top view).

Here, we used PVC board to make this box. For the batter virtualization we separate the top part and take picture. Its only for prototype testing. when it will become commercialized, then it should be locking system for the safety and it might replace wood or fiber board instant of PVC board.

3.2 Performance evaluation of implemented solution against design requirements

After creating and finishing our prototype, we carried out specific tasks to evaluate the performance of our project. We evaluated each component separately to determine whether it was operating according to specification. To verify the prototype, we ran a number of experiments. The following table 3.2 mentioned every test that was performed.

Prototype working procedure:

Firstly, if vehicle is moving, then engine will take fuel from the fuel tank. Here, we build this project for considering truck as vehicle. So, the fuel consumption rate is 0.842 milliliter per second.[30]

In our project, the system will consider abnormal fuel consumption when the fuel rate of consumption is greater than 0.842ml/s. Also, our prototype fuel tank is 5L only. But the capacity of a 25 Ton truck is 110litter with 0.110 m^3 volume approximal.

Fig 3.8 110 litter truck fuel tank.

Fig 3.9 5.2 litter fuel tank for prototype.

At first VL53l0X T-O-F distance sensor collecting the data continuously. When the fuel consumption rate is >0.842mililitter/second and fuel level is decreasing. It will take the distance level data within maximum 5 second. Then the sensor passes the data to Arduino and Arduino will convert the data into a litter level. At the same time NEO 6M GPS module will tracking the device location by latitude and longitude. It also sends the location data to Arduino. Then the both fuel level data and location information will send by the SIM 900 GSM module to vehicle owner phone. Our system will give two texts in every abnormal fuel consumption operation. When the fuel is started to decreasing at high rate (more than 0.842mililitter per second). It gives the initial fuel level text with abnormal warning and location. After that when the fuel abnormal consumption is stopped and fuel consumption rate come to regular rate or no changes, that time our system will give second and final text. The delay time of detecting abnormal fuel consumption and send text to mobile phone is 2 second.

After receiving the message if we click the link, Google map will be open, and we can see the location clearly where abnormal fuel consumption happened and also

get the direction from Google map. Also, we can see the distance between vehicle owner and vehicle's by using Google map.

Output results:

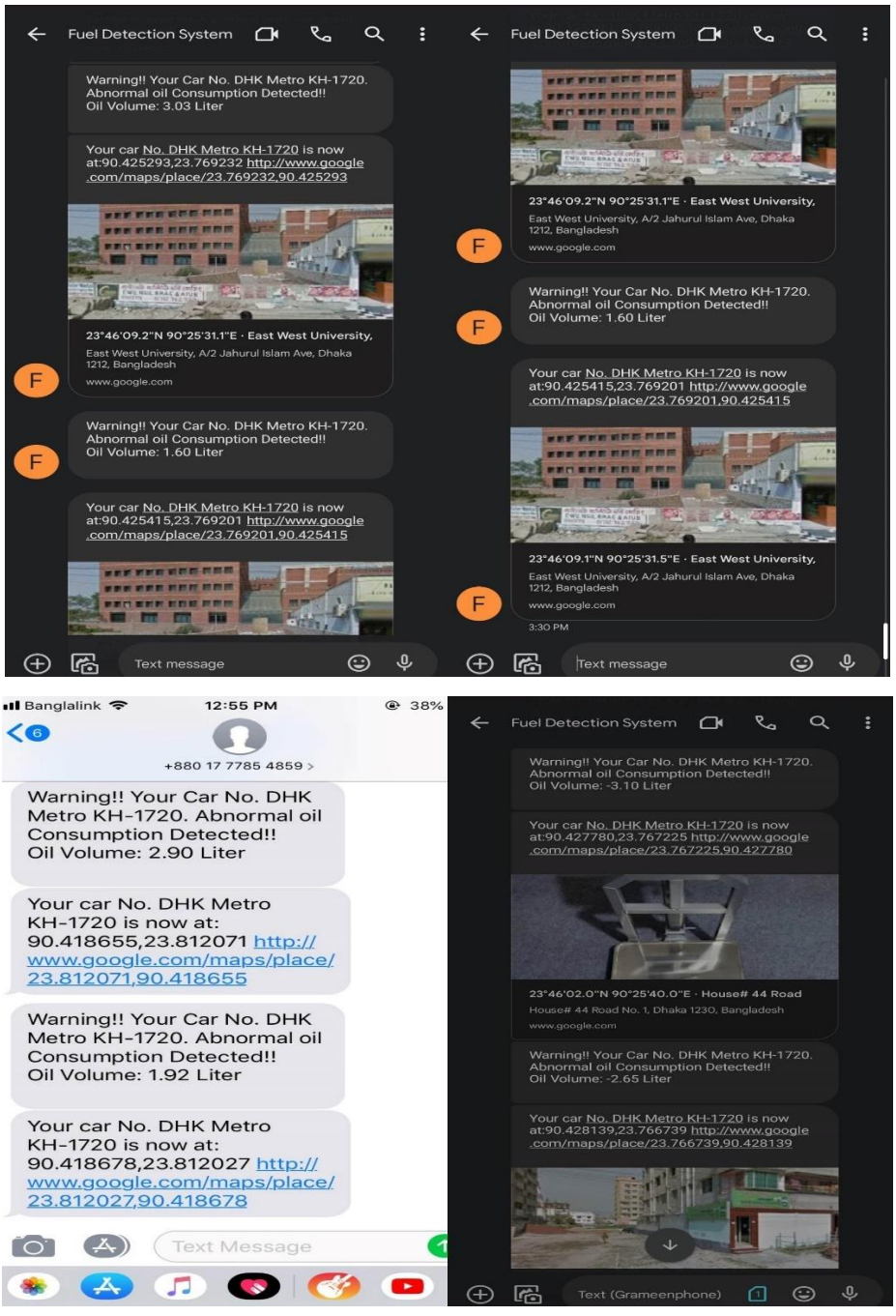


Fig 3.10 Screen shots text during abnormal fuel consumption in different level.

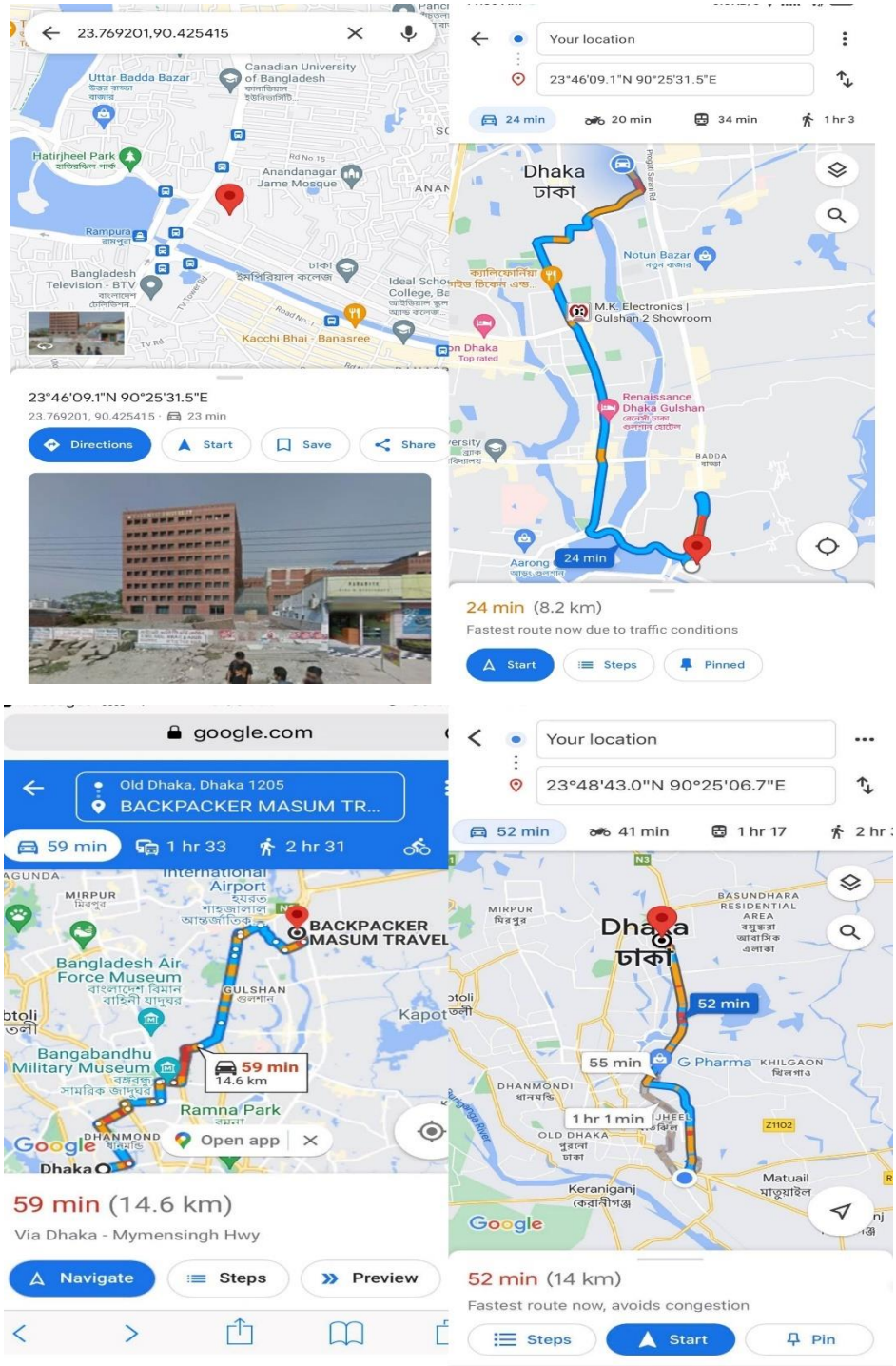


Fig 3.11 Screen shots after clicking the Google map link in different places.

After that we took the device different place and try to get the exact fuel level consumption data with location. We successfully find the expected results but there is very negligible delay time with network problem of used SIM between user location and device location. We took our system 5 different place's location and record the testing parameters with respect to scenario.

Table 3.2 Output testing parameters.

Scenario name	Device location	Owner location	Distance between device location and owner location (Km)	Fuel theft operation duration (sec)	Delay time during data transfer (sec)	Error $(\frac{Device\ data - Actual\ data}{sensor\ data} \times 100)$ %
A	Bashundhora	Aftabnagar	15.1	8.4	2.1	6.80
B	Aftabnagar	Banssree	6.7	4.7	3	2.96
C	Aftabnagar	Mugda	11.2	5.3	2.7	9.09
D	Bashundhora (Indoor)	Dhanmondi	15.2	8	4.30	2.12
E	Bashundhora (Indoor)	Doyagonj	19	6.3	3.29	1.73

Here,

Device location = Main device with fuel tank located also vehicle location

Owner location = Vehicle owner location with output receiving device (Mobile phone).

Distance = how far the main device and receiving device.

Fuel theft operation = how many times abnormal fuel consumption happened.

Delay time = late time period fuel level indication data transfer to receiver phone.

Device data = Fuel level measurement data by the system with sensor measurement.

Actual data = Manually calculated fuel level after decreasing every time.

Output result parameters graphical representation:

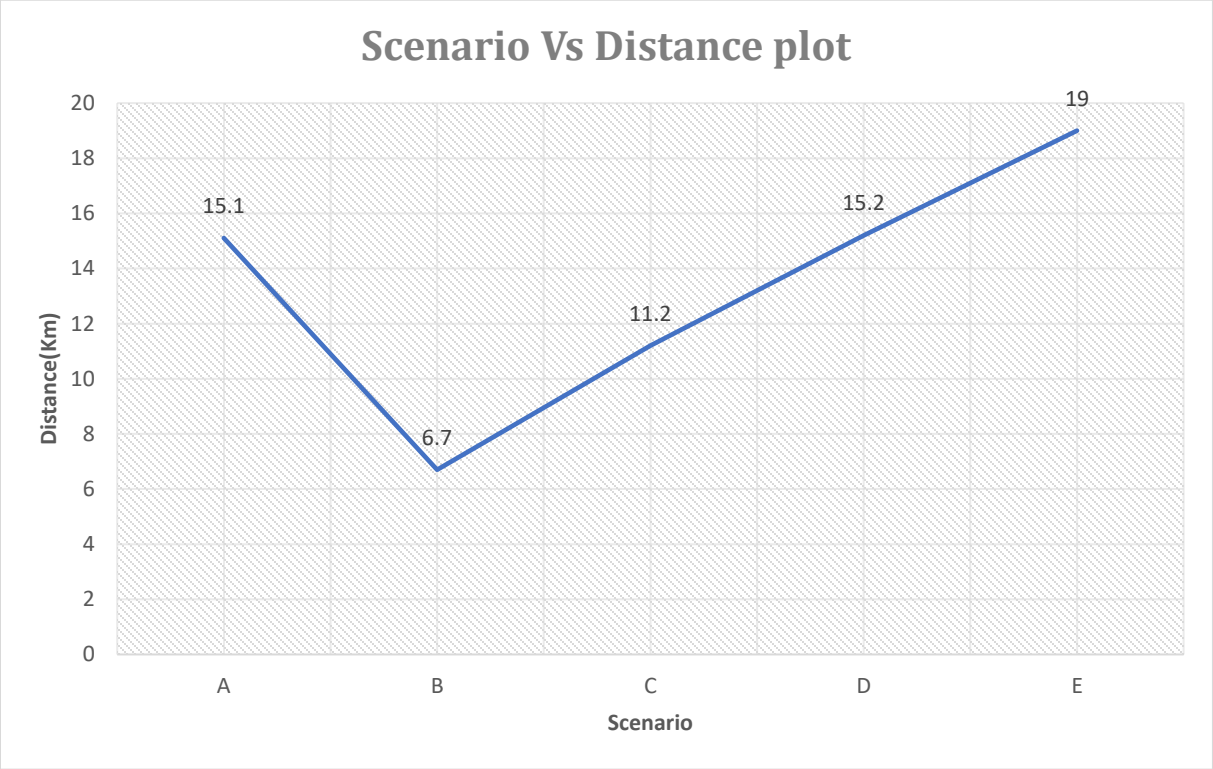


Fig 3.12 Scenario Vs Distance (km) plot.

This graph indicated the 5 different scenario of distance level between vehicle location and receiving device (vehicle owner phone) location.

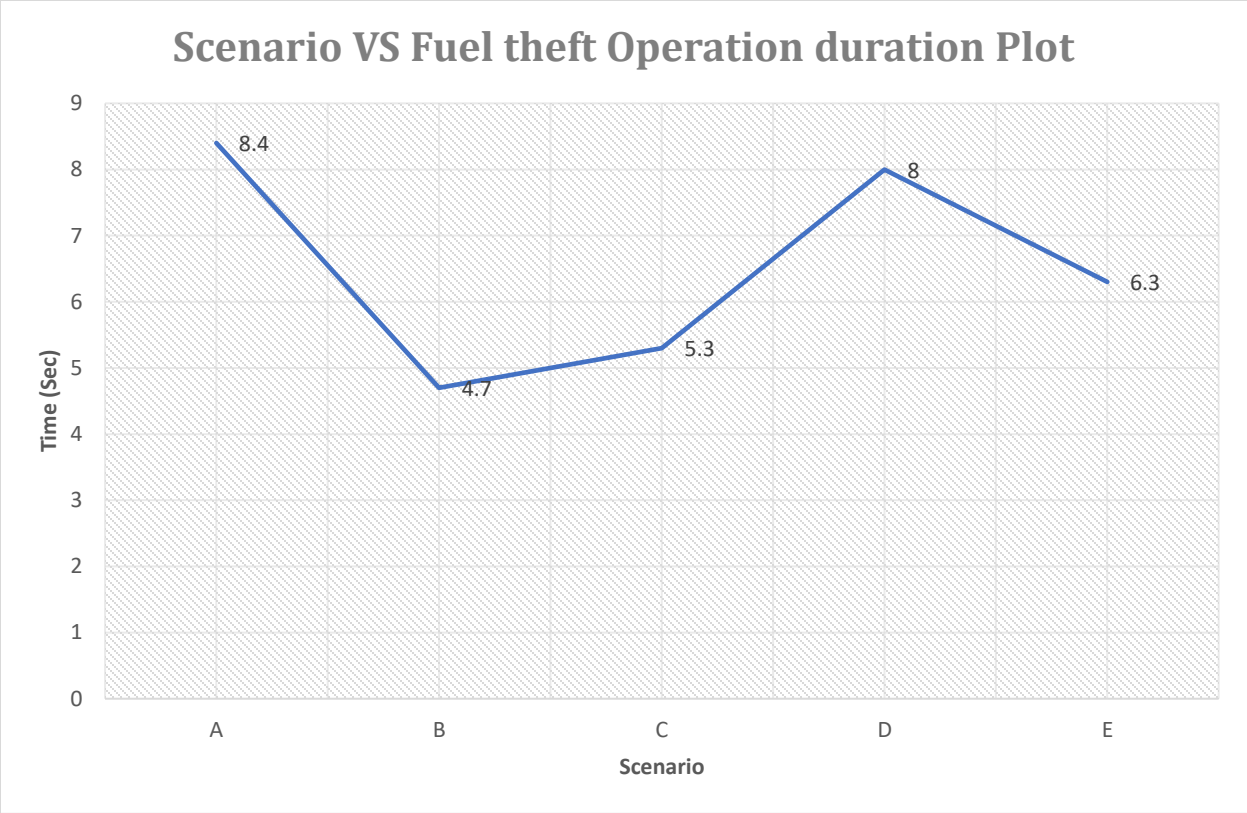


Fig 3.13 Scenario Vs Fuel theft operation duration (sec) plot.

This graph indicated the abnormal fuel consumption or fuel theft operation time duration in different scenarios.

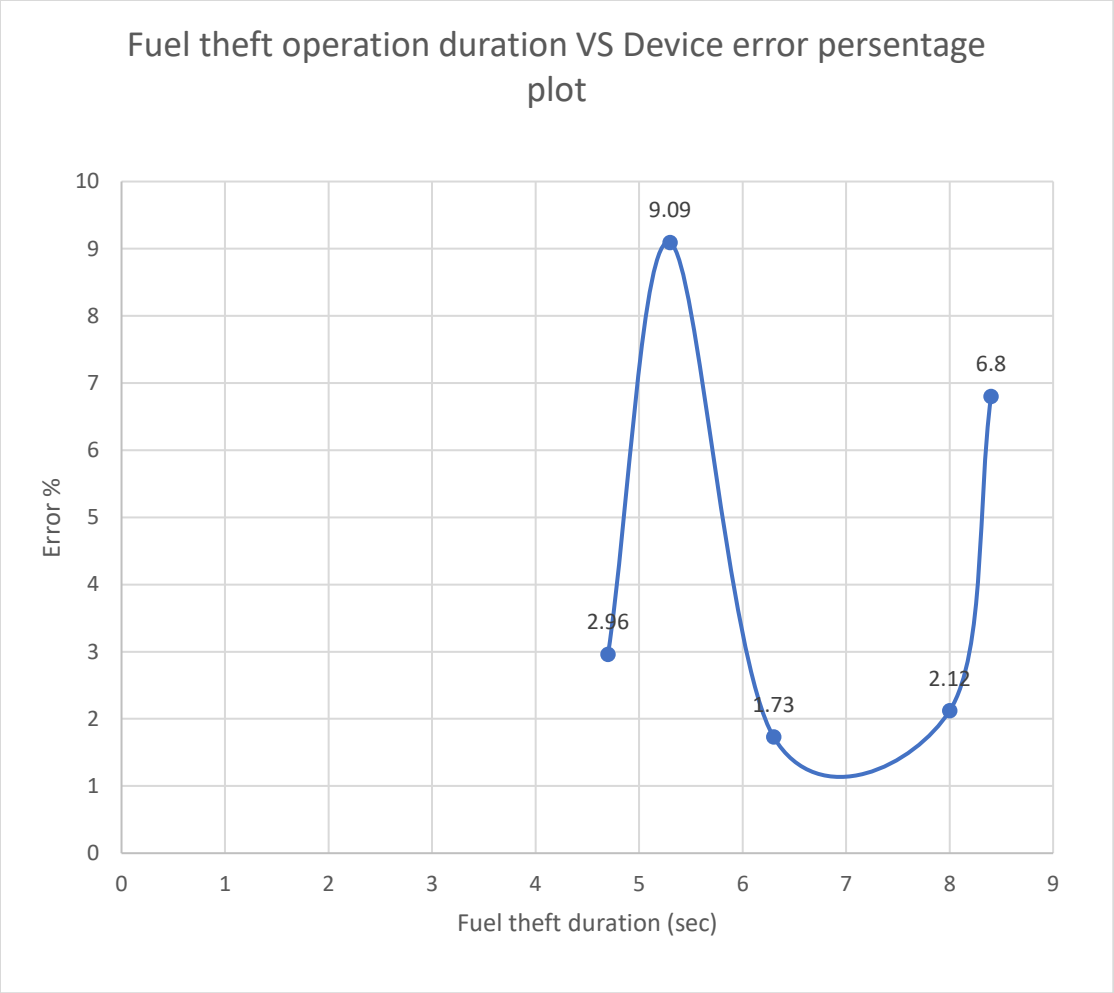


Fig 3.14 Fuel theft operation time duration VS device error percentage plot.

This graph show that how much times takes to fuel theft or abnormal fuel consumption and what is the error percentage of device data measurement & sending to vehicle owner phone. The lowest error is at 6.3 sec time duration and highest error at 5.3 sec time duration.

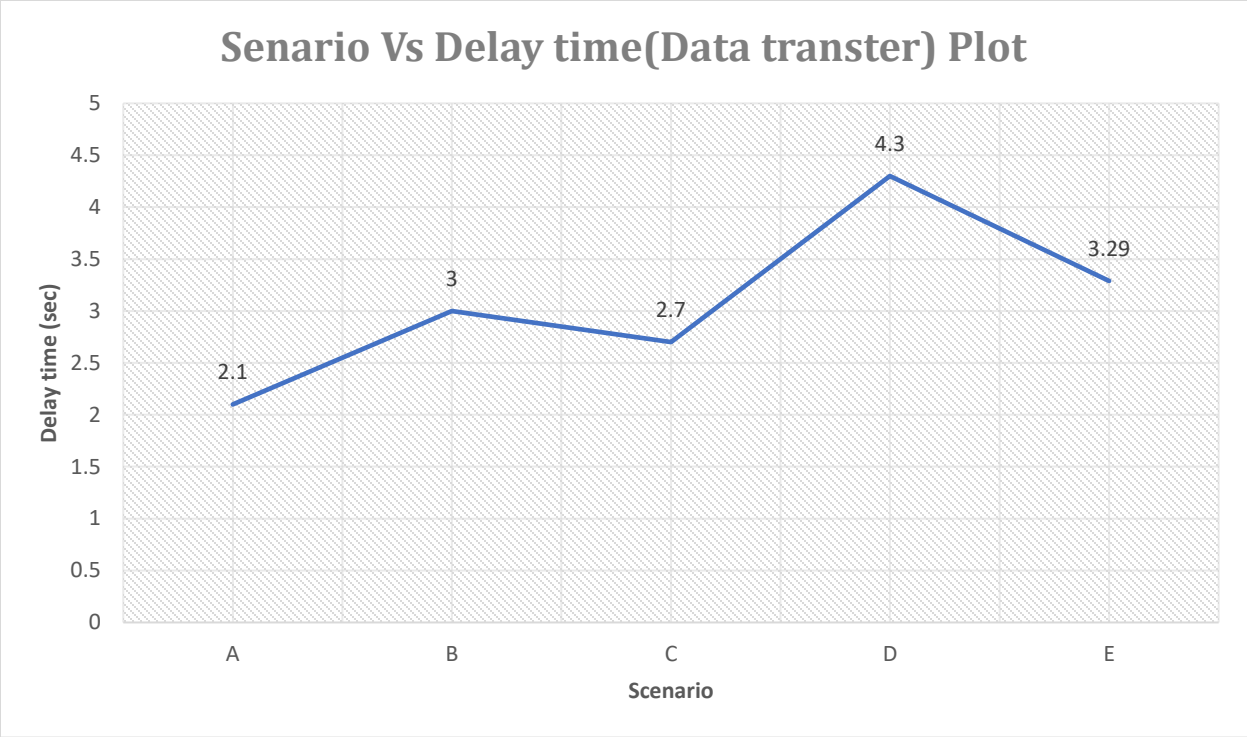


Fig 3.15 Scenario Vs Data transfer delay time (sec) plot.

Here, in scenario D and E the device location is indoor so that's why the delay time is comparatively little bit high.

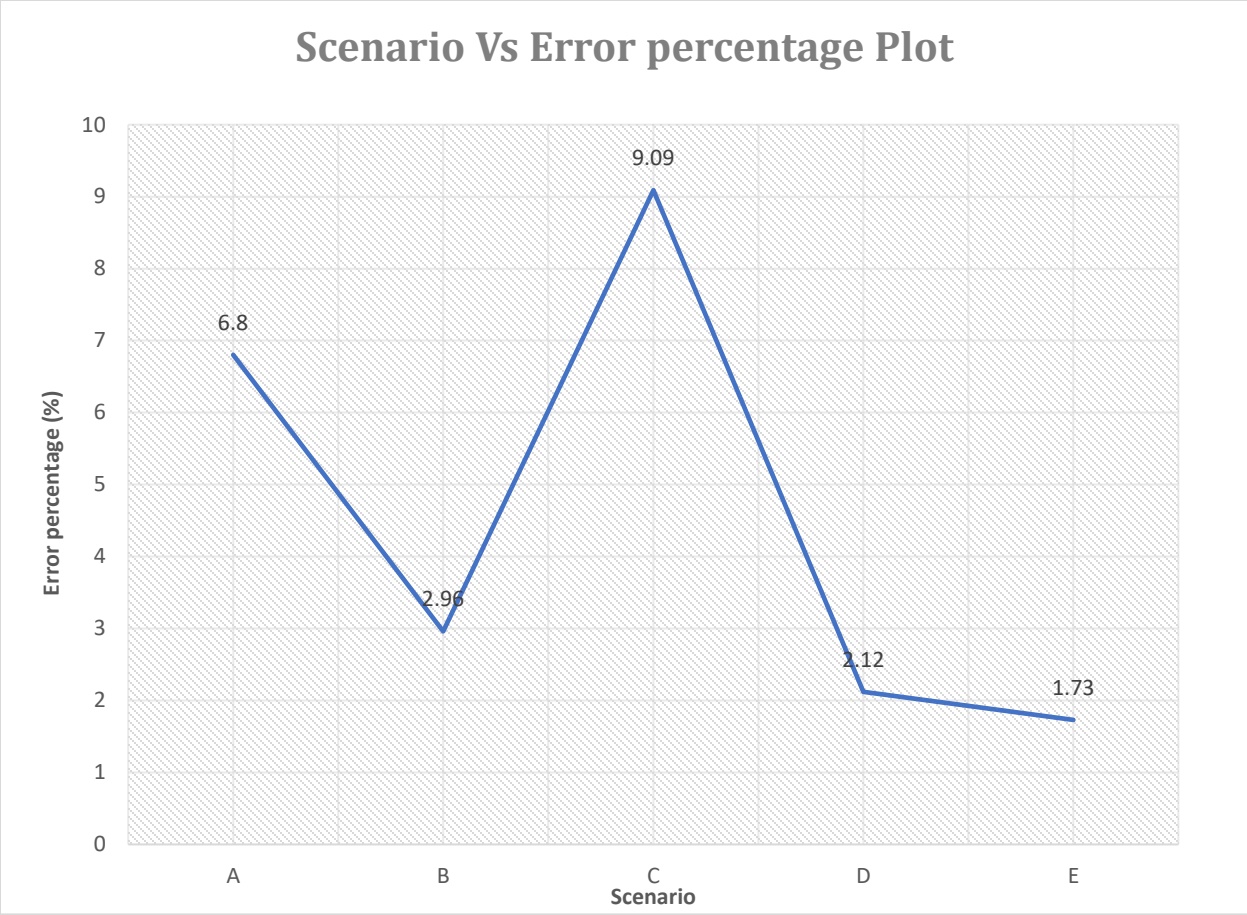


Fig 3.16 Scenario Vs Error percentage plot.

This error percentage indicated the whole system error data. From the graph we get the average error of the system is 4.54%.

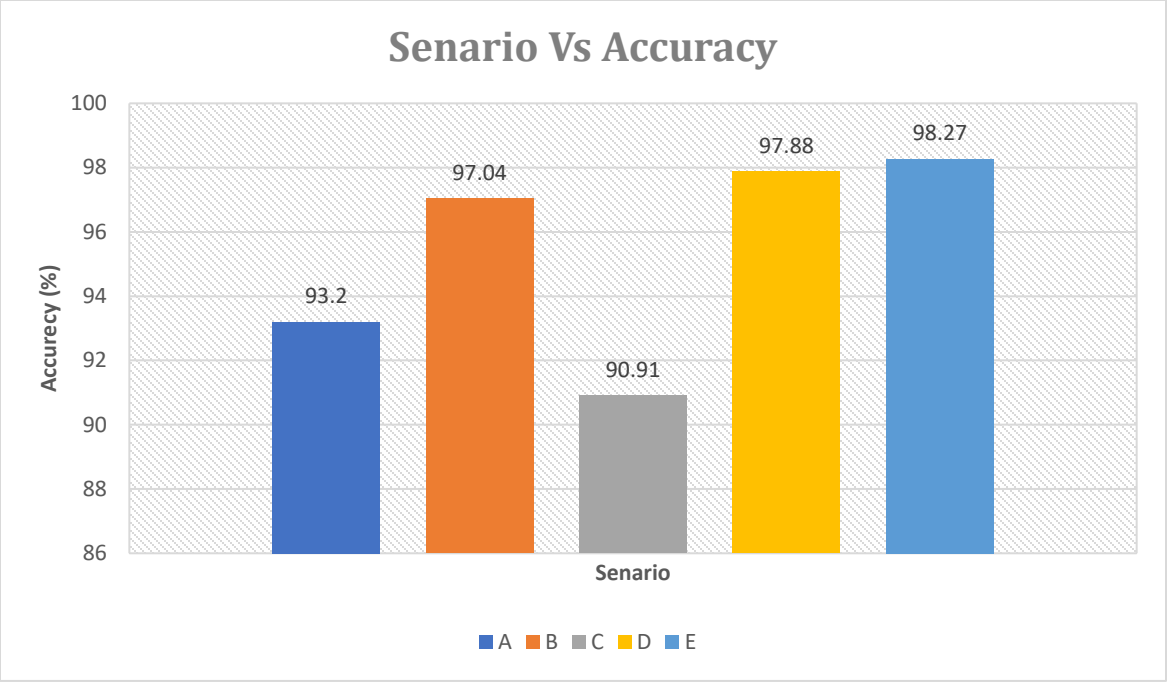


Fig 3.17 Scenario Vs Accuracy plot.

Calculation of Accuracy:

For, Scenario A device fuel level measurement and manually measurement difference error percent is 6.8.

Accuracy = 100% - 8.8%

= 93.2%

Similarly for scenario B, C, D&E we get 97.04%, 90.91%, 97.88% & 98.27% accuracy.

Over all accuracy = (total accuracy/total number of scenarios) %

= (477.3/5) %

= 95.46%

So, the system overall accuracy is 95.46%.

Here we follow two different ways to measure the actual fuel level,

Process 01: We attached a level scale in the prototype fuel tank body and after the fuel level down we compare the fuel level in the tank with the scale. The measurement table is given bellow:

Table 3.3 Prototype fuel tank measurement.

Fuel level (Ltr)	Distance (from bottom of the fuel tank) (Cm)
1	2.5
2	5
3	7.5
4	10
5	12.5

Process 02: We converted the fuel in kilogram to litter. After every time we finished the fuel theft operation, we take the fuel tank in a weight scale and convert the weight of fuel into litter. Here, we want to mention that we used water as liquid fuel because the real fuel is costly, difficult to buy without vehicle, inconvenience and sometimes dangerous. That's why for prototype performance tasting we used water. We consider 1 kg of water is equal to 1 litter (as fuel).

System false data measurement and limitation:

Here, we set up our device in the vehicle (CNG) placed the fuel tank with fuel and trial with 3 times with different level of road condition, different level of speed limit. If there are a vibration of vehicle and speed breaker up-down happened then it should be negligible with near about 1.60inch limit. The average speed breaker height limit in Bangladesh is 1.57 inch. But in our country the road condition is not so good to avoid high level of shaking or vibration. Practically if the vibration level is less then near 1.5 inches, then our device doesn't send any false data. It's also

related with the speed limit of vehicle, average vibration limit of engine and mostly the road condition.

Fig 3.14 False data testing.

Table 3.4 Different scenario false data measurement

Trial test name	Speed Limit(km/h)	Travelling distance (Km)	Number of actual False SMS	Vibrometer Max. MMI rate
A	20-25	0.21	2	6.81
B	30-35	0.216	2	6.30
C	40-50	0.35	1	5.23

*MMI = Modified Mercalli Intensity sacle. It basucally used to measure the vibration level of the surface. To place new mechines or equipment in the new place its use to measure the intensity of shaking produced.

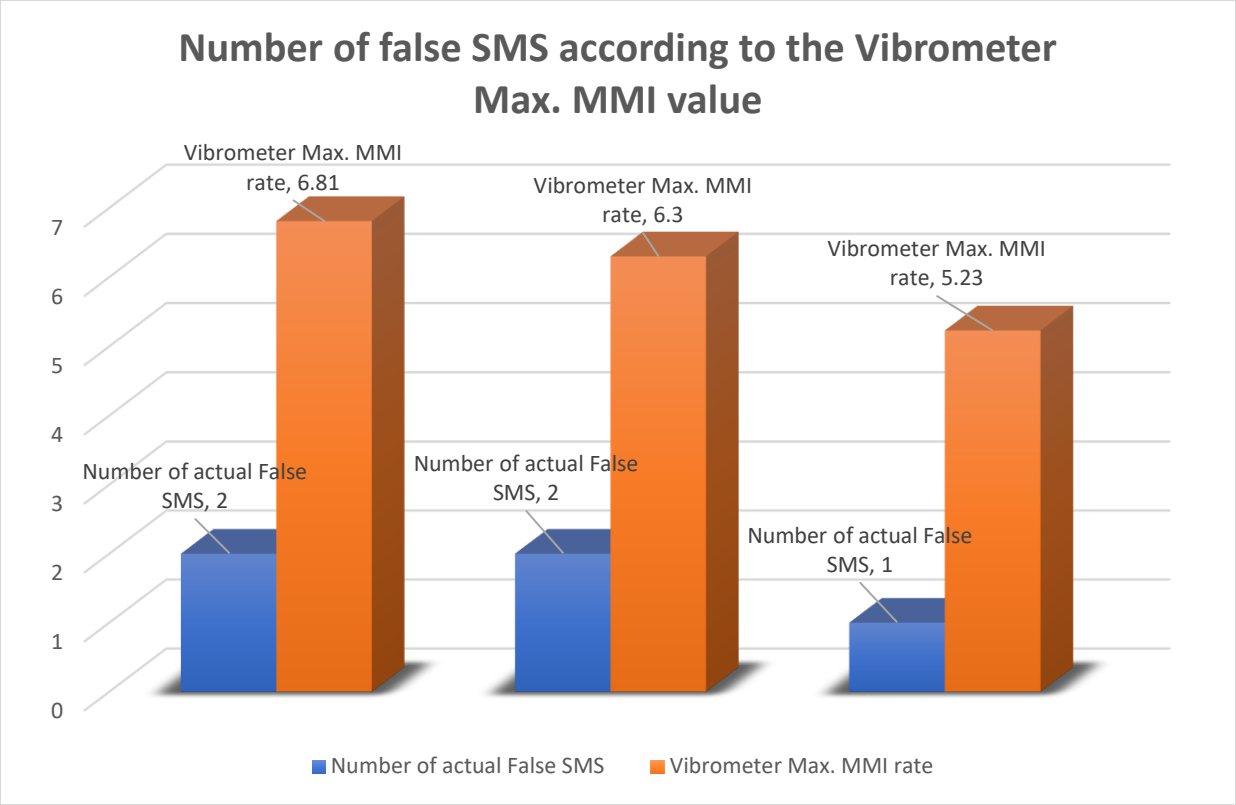


Fig 3.15 False data plot according to vibrometer Max. MMI value.

We get 2 times false data in trail a with max. mmi limit 6.81. Similarly, for B and C get 2 and 1 false data with 6.30 and 5.23 max mmi limit. To measure vibration, we use smartphone vibrometer because to buy real vibrometer is so expensive and for limitations level it's difficult to fully consider that issue with accurate data and measurement. But we try our level best to consider that issue. In future avoid false data issue volume float sensor, Capacitance sensors and pressure sensor can be used but also those have particular drawbacks like Float sensor – gives incorrect reading when the fuel level is inclined due to shaking. Capacitive sensor – you can remove the above problem of float sensor using multiple capacitive sensors, but multiple sensors are needed. And parasitic capacitance with the tank wall makes the result incorrect. Pressure sensor – it will require to keep the fuel tank on it. But the fuel tank is usually fixed with the vehicle body. So, it may not be able to let the fuel tank be placed on a pressure sensor. So, we will recommend

to avoid that false data and vibration issue to used weight machine sensor named “Load-Cell or sensor (for 100kg digital scale weight machine.” It will measure the weight of the particular fuel tank part and converted that weight to liter level. If shaking or vibration happed the weight level remain same and it will able to solve those issues.

3.3 Finalization of design

The hardware prototype's real implementation and the simulation's design as proposed in 400B differ slightly. In order to replicate the final circuit diagram in 400B, we used the "Proteus" software. A few library functions were omitted from the software database due to proteus software's restrictions. We could not show fuel level changing randomly because there was no option like that but by inputting voltage level, we showed that. Also, in proteus software GPS module activation showed to us but we did not get latitude and longitude value. Because it’s need to physically connected to satellite. As a result, we had to create a fresh method of simulating our idea. We had to simplify the design due to time restrictions and for better performance, which led to a circuit diagram that was different from the original. The modifications are described below:

- **Using SIM 900 GSM Module Instead of SIM 900A GSM Module:** As previously stated, we planned on using a SIM 900A GSM Module in 400B; however, we were unable to get a SIM 900A GSM Module in the local market, therefore we had to decide to use a SIM 900 GSM Module instead.
- **Using GPS NEO 6M Module Instead of GPS NEO 7M Module:** As previously stated, we planned on using a GPS NEO 7M Module in 400B; however, we were unable to activated the GPS 7M module after a lot of trials then we had to decide to use GPS 6M module and we will able to activated this properly.

- **Using VL53l0x T-O-F distance measurement sensor instant of Liquid level Ultrasonic sensor:** As previously stated, we planned on using a Liquid level Ultrasonic sensor in 400B. But changed our plan to use SR-04 ultrasonic sensor for our prototype the reading data was not stable and most of the time measurement was not correct. Also, we were unable to manage the liquid level ultrasonic sensor also. For those reasons we had decided to use VL53l0x T-O-F distance measurement sensor instant of Liquid level Ultrasonic sensor.
- **Using Xl6009 DC-DC buck boost converter:** We didn't mention about the buck boost converter for our system in 400B. In 400C when we implement our device, we the different level of voltage from battery. But for our devise safely and continuous stable power supply we need to supply stable 12 V input power. That's why supply the input voltage through Xl6009 DC-DC buck boost converter
- **Box:** We didn't mention about the specific box for the system in 400B though we considered a budget for a device frame. For the implementation of prototype, we made a box as 400A stakeholder requirement length 10-inch, Width-4.5 inch and height 3.5-inch for placement of the device and safety of the device.
- **Mitigation of Delay time and Required time:** We can see that in table 3.2 there are very little delay in scenario D and E. To minimize these situations, we can use NEO-7M GPS instead of NEO-6M GPS and we can also use SIM900A instead of SIM900.These 2 modules are capable to receive low signal compared to used module. We ignore NEO-7M for technical issue and SIM900A module because of unavailable in local market and high price.

- **Process:** In 400B we did not mention about the device working process in detail. We said that when the fuel level is suddenly changed our device detect that then it will send text to the owner phone with the location tracking parameters. In 400C when we demonstrated it then we have to considered the voltage rating of vehicle battery to stable that and same rate of power supply we added XL6009 buck boost converter. Usually, truck engine consumes 0.842 milliliter per second fuel. So that we have to do programming considering this logic. Otherwise, it will give false data at normal condition. We converted the fuel volume level to distance level because our VL50l0x tof sensor measure distance level (in millimeter range). Also, we have to assure minimum 12V power supply with minimum 2A current rating connection to SIM 900 GSM module because to send text or call it need that voltage and current rating at peak time. Finally, NEO 6M GPS module to satellite connection creates big barrier to us. Because for the activation it takes more time and its outdoor type module. But when it activated and connected then it works at indoor also. For the activation there is a specific way otherwise it will kill a long time.

  At the end, we successfully overcome our sensors difficulty and module problem, logic implementation and 400B simulation limitation. We finally build our project design and get the required output according 400B planning as we already mentioned.

Table 3.4 Comparison between our system and other commercial system

Our system	Other commercial system
Get instant data when fuel theft operation happened or abnormal fuel consumption happed.	Get the data manually operation.
Automatic notification system.	Input text feedback notification system.

Vehicle's fuel theft operation exact tracking system feature available.	Only vehicle tracking system available.
Don't show any millage parameter datasheet.	User can get millage data sheet after a period of time.
Accuracy level more than 90%	Accuracy level 50-55%
Price comparatively lower than the other devices.	Price higher than our device.
Can be upgraded or modified for different type of vehicle or fuel tank.	Fixed designed for fixed vehicle.
Different type of vehicle modification cost is very low.	For, Different type of vehicle price variation is high.

3.4 Use of modern engineering tools

For our project, hardware and software tools are needed. The description is given below:

Software tools:

Proteus: Proteus 8 is the best simulation program for a variety of microcontroller designs. It is popular due to the availability of practically all microcontrollers in it. As a result, it is a useful tool for electronics enthusiasts to test programs and embedded systems. We utilize this proteus software to mimic our planned system. The proteus program includes all of the necessary equipment for the design of our system. We test the design system with simulation by interconnecting all of the equipment in the designed system.

Arduino IDE: Arduino created the open-source programming tool known as the Arduino IDE (Integrated Development Environment), which is used to write, compile, and upload programs to any Arduino shields. Here, we uploaded the code to the Arduino platform using the Arduino IDE.

Sketchup: We used different types of software and modern engineering tools to implement and simulate our circuit properly. We also used the 'Sketchup' for generating a 3d model of our device's placement. That is given in Fig. 3.4

Hardware tools:

Arduino Uno: A microcontroller functions similarly to the brain. It regulates each element of the circuit.

SIM 900 GSM module: This device's main function is to communicate with a remote network using GSM mobile technology.

GPS NEO 6M module: The longitude and latitude of the vehicle are retrieved together with its location. The GPS provides the system with time and geographic position data.

Xl6009 DC-DC buck boost converter: This device is used to convert the voltage level step up and step down.

VL53l0x T-O-F distance measurement sensor: T-O-F sensors operate by sending out a light signal and timing how long it takes for the signal to return from an obstacle in its path. The VL53L0X can measure distances up to 2 meters (6.6 ft) away with a millimeter of accuracy by using infrared light for this purpose. This sensor used infrared (IR) laser technology to measure distance. It emits short bursts of IR laser light and measures the time it takes for the light to bounce back off a nearby object and return to the sensor.

Chapter 4 Review of Milestone Achievements and Revision of Schedule

Normally our spring semester start January first week end April last week. But spring 2023 semester start first week of February and end the last week of May.

That's why we need to revised our project plan. So, we need to modify the date and time duration of the project plan for part C.

Table 4.1 Revised project plan.

Activities	Start date	End date	Duration (days)
Performance evaluation of prototype against the requirements and finalize design. **[Milestone 8]**	27 March 2023	16 April 2023	20
Economic analysis. **[Milestone 9]**	2May 2023	6 May 2023	3
Preparing project report and submission. **[Milestone 10]**	29 April 2023	8 May 2023	12

After discussion at the initial stage of this project, we have set some milestones.

Table 4.2 shows the expected completion date and the attainment date of the milestones.

Table 4.2 Review of the milestones.

Milestone	**Expected completion date**	**Attained date**
Review and requirement collection from stakeholders	03/07/2022	03/07/2022
Preparing Project plan	28/07/2022	28/07/2022
Finalizing project requirements	12/08/2022	12/08/2022
Preparing project report and submission for Chapter-A	04/09/2022	04/09/2022

Design of frame block according to internal components and design completion.	29/11/2022	29/11/2022
Designing prototype according to selected model	19/12/2022	19/12/2022
Preparing project report and submission for Chapter-B	08/01/2023	05/01/2023
Performance evaluation of prototype against the requirements and finalize design	09/03/2023	16/04/2023
Economic analysis	10/04/2023	06/05/2023
Preparing project report and submission for Chapter-C	16/04/2023	08/05/2023
Final project presentation	25/05/2023	25/05/2023

Remedial action:

Among the 11 milestones, we have missed only 3 milestone to meet the deadline, Name of the milestone is- 'Performance evaluation of prototype against the requirements and finalize design, Economic analysis, preparing project report and submission for Chapter-C' and We have taken remedial action and revised the schedule for this milestone which is described below:

Performance evaluation of prototype against the requirements and finalize design, Economic analysis and preparing project report and submission for Chapter-C: We finalized our project design at the beginning of 400C. But we build it up we could not get our required output. Some equipment's were not working properly that's why we had to preplace some equipment model like GPS module, VL53l0x T-O-F distance measurement sensor instant of liquid level ultrasonic

sensor. Also, we have to add new equipment Xl6009 DC-DC buck boost converter to get stable voltage at output from vehicle battery. For those reason we are unable to achieved 'Performance evaluation of prototype against the requirements and finalize design' and another two milestone are depended on it. But when we start to getting required data, we divided the work among us and parallelly started economic analysis and final project report writing. We used Eid vacation to complete the work on time.

Chapter 5 Cost of Solution and Economic Analysis

5.1 Bill of materials cost of solution

We had to buy a variety of materials to create the prototype. We used a variety of tools for simulation, analysis, and personal mobile phones throughout the project and so on. We do not need to pay any costs for the software. The price of the prototype is listed below:

Table 5.1 Prototype Cost.

No.	Equipment	Unit price (BDT)	NO. of equipment required	Total retail (BDT)
1	Arduino UNO	800	1	800
2	Sim 900	1800	1	1800
3	NEO-6M GPS	800	1	800
4	Jumper Wire	50	2	100
5	SIM	210	1	210
6	VL53L0X Time-of-Flight Distance Sensor	1050	1	1050
7	Breadboard	90	1	90
8	Adapter	150	1	150
9	Frame	500	1	500
10	12V Battery (Bike bettery)	1000	1	1000
11	5L Fuel tank	1250	1	1250
12	Xl6009 DC-DC buck boost converter	90	1	90
			Total cost	7,840

The prototype cost is 7840 Tk. Main system cost will different from the protype cost. In the prototype we need to buy 12V battery and a 5L fuel tank but in the main system we used car battery for our system and we do not need extra fuel tank because car has their own fuel tank. The cost of our main system is as follow.

Table 5.2 Main system cost.

No.	**Equipment**	**Unit price (BDT)**	**NO. of equipment required**	**Total retail (BDT)**
1	Arduino UNO	800	1	800
2	Sim 900	1800	1	1800
3	NEO-6M GPS	800	1	800
4	Jumper Wire	50	2	100
5	SIM	210	1	210
6	VL53L0X Time-of-Flight Distance Sensor	1050	1	1050
7	Breadboard	90	1	90
8	Adapter	150	1	150
9	Frame	500	1	500
10	Xl6009 DC-DC buck boost converter	90	1	90
			Total cost	5,590

So, 5590 is the retail cost in the current market. The wholesale price is different from the retail price. So, wholesale price = Retail price × 0.6 [31]

= 5590× 0.6

= 3354 Taka

5.2 Economic analysis

In order to develop a bigger corporation and sell our items on the open market, we need to go through economic analysis. As a result, we must calculate the Net Present Value (NPV) of our commercially successful product. Our system's projected monthly operating and maintenance expenses are indicated below.

Table 5.3 Monthly operating and maintenance cost (O &M cost)

Employee	Salary(taka)	Quantity	**Total** (taka)
Manager	30,000	1	30,000
Bookkeeper	15,000	1	15,000
Technician	16,000	3	48,000
Salesperson	14,000	2	28,000
Security	2,000	1	2,000
Office Rent	25,000	1	25,000
Others	5,000	-	5,000
Total Cost			1,53,000

Our device's durability is mainly dependent on the microcontroller, sensor, GPS and GSM, which represent the majority of its components. Arduino's usual warranty duration is 2-3 years, so for the GSM module is almost 3 years, for GPS module duration is 2 years and also VL53L0X Time-of-Flight Distance Sensor 2 years.

Each component has a lifetime that is twice as long as its warranty duration. As a result, the lifespan of our product is around 4 years. We had to do some study to figure out how many units we would create. We only examine freshly registered autos every year, not

old registered vehicles. So, we used data from 2022 because we didn't find the full year consumer list of vehicles of 2023 as the govt did not release it.

Table 5.4 Vehicle's owner customer list in 2022. [32]

Customer	Registered Quantity in Bangladesh every year	Device quantity that we want to provide
Private Passenger Car owner	16049	1000
Pick up (Double/Single cabin) owner (product delivery used)	10897	2000
Truck owner (Big shipment product delivery)	5789	1500
Total		4500

We selected our device need to produce as the fuel theft incident happened parentage. From our research on field level. We came to know most of the incident happened with product delivery covered van or pick up, rent a car business with private car and mostly any company's shipment product delivery in big margin. For those reasons, we selected how many devices we need to provide in a year.

So, we need to produce a total of 4500 pieces of the prototype.

Total annual expenditure, P = Office Cost per year + Production cost of 4500 pieces

= 1,53,000 ×12 + 3354 × 4500

= 1,69,29,000 $Taka$

Selling Price of a Single module = 2 × whole sale price = 6708 ≈6700 taka (as device selling price is double to wholesale price)

Annual sell = 4500 $units$× 6700 Taka = 3,01,50,000Taka

The present Value Function is used to know the value of the money in the future in today's price.

Present Value Function:

PVF (d,n) = $\frac{(1+d)^n-1}{d(1+d)^n}$

Interest rate, Discount rate from Bangladesh Bank.

Product life time, n=4

Discount Rate, d= 4% [39]

Interest Rate, i= 9% [33]

Source of Information: 'Bangladesh Bank'

So, PVF (4%,4) = $\frac{(1+0.04)^4-1}{0.04(1+0.04)^4}$ =3.629

Annualizing the investment:

Interest rate and discount rates were found from the Bangladesh Bank,

Annual Loan Payment, A= P × CRF (i,n)

Here, CRF: Capital Recovery factor

CRF (i,n) = $\frac{i(1+i)^n}{(1+i)^n-1}$

Interest Rate, i= 9%

CRF (9%,5) = $\frac{i(1+i)^n}{(1+i)^n-1}$=$\frac{0.09(1+0.09)^4}{(1+0.09)^4-1}$= 0.308

Total annual expenditure, P= 1,69,29,000 taka

Annual Loan Payment, A = CRF × P

= 0.308× 1,69,29,000

= 52,14,132 Tk/Year

Annual sell = 4500$units$× 6700 Taka = 3,01,50,000 Taka

Annual Savings, ΔA = Annual sell - Annual Loan Payment - Total annual expenditure

= 3,01,50,000- 52,14,132 - 1,69,29,000

= 80,06,868 Tk

First Cost, ΔP = 1,69,29,000 Tk

Simple payback period $= \frac{\Delta P}{\Delta A}$

$= \frac{16929000}{8006868}$

= 2.11 years

Life (years)	9%	11%	13%	15%	17%	19%	21%	23%	25%	27%	29%	31%	33%	35%	37%	39%
1	0.92	0.90	0.88	0.87	0.85	0.84	0.83	0.81	0.80	0.79	0.78	0.76	0.75	0.74	0.73	0.72
2	1.76	1.71	1.67	1.63	1.59	1.55	1.51	1.47	1.44	1.41	1.38	1.35	1.32	1.29	1.26	1.24
3	2.53	2.44	2.36	2.28	2.21	2.14	2.07	2.01	1.95	1.90	1.84	1.79	1.74	1.70	1.65	1.61
4	3.24	3.10	2.97	2.85	2.74	2.64	2.54	2.45	2.36	2.28	2.20	2.13	2.06	2.00	1.94	1.88
5	3.89	3.70	3.52	3.35	3.20	3.06	2.93	2.80	2.69	2.58	2.48	2.39	2.30	2.22	2.14	2.07
6	4.49	4.23	4.00	3.78	3.59	3.41	3.24	3.09	2.95	2.82	2.70	2.59	2.48	2.39	2.29	2.21
7	5.03	4.71	4.42	4.16	3.92	3.71	3.51	3.33	3.16	3.01	2.87	2.74	2.62	2.51	2.40	2.31
8	5.53	5.15	4.80	4.49	4.21	3.95	3.73	3.52	3.33	3.16	3.00	2.85	2.72	2.60	2.48	2.38
9	6.00	5.54	5.13	4.77	4.45	4.16	3.91	3.67	3.46	3.27	3.10	2.94	2.80	2.67	2.54	2.43
10	6.42	5.89	5.43	5.02	4.66	4.34	4.05	3.80	3.57	3.36	3.18	3.01	2.86	2.72	2.59	2.47
15	8.06	7.19	6.46	5.85	5.32	4.88	4.49	4.15	3.86	3.60	3.37	3.17	2.99	2.83	2.68	2.55
20	9.13	7.96	7.02	6.26	5.63	5.10	4.66	4.28	3.95	3.67	3.43	3.21	3.02	2.85	2.70	2.56
25	9.82	8.42	7.33	6.46	5.77	5.20	4.72	4.32	3.98	3.69	3.44	3.22	3.03	2.86	2.70	2.56
30	10.27	8.69	7.50	6.57	5.83	5.23	4.75	4.34	4.00	3.70	3.45	3.22	3.03	2.86	2.70	2.56

[a]Enter the row corresponding to project life, and move across until values close to the simple payback period, $\Delta P/\Delta A$, are reached. IRR is the interest rate in that column. For example, a 10-year project with a 5-year payback has an internal rate of return of just over 15%.

Fig 5.1 Chart to estimate the Internal Rate Return.[38]

Here, simple payback period is 2.11 year which is near 2.13. So, according to fig 5.1 we get

IRR=31% for n=4years.

PVF (4%,4) = $\frac{(1+0.04)^4-1}{0.04(1+0.04)^4} = 3.629$

Our Net present Value (NPV), NPV = ΔA×PVF (d, n) - ΔP

= 80,06,868×3.629 - 1,69,29,000

= 12127923.97Taka

=1,21,27,924Taka

Comment: From the calculation we can see that NPV is positive, so this project will be profitable.

Chapter 6 Conclusion

6.1 Verification of complex engineering problem

This project has four characteristics of the complex engineering out of the seven complex engineering. which are P1, P3, P4, and P7. Below we have described these things in details.

Depth of knowledge required (P1): The project contains depth knowledge of microcontroller engineering, Proteus, and Solid-works knowledge, we had to do financial engineering as well as economic analysis. Here we have used our knowledge of circuit design. This part contains K3(Knowledge of electrical engineering fundamentals). The project also contains GPS tracker and GSM module that will dispatch data to the owner number and this part fulfils the K5(Engineering Design Knowledge). Here we have to use the knowledge of microcontroller as we have used Arduino IDE. How to use the Arduino IDE software and how it works. How to use SIM 900 and how it works as well as we have known how to use and the characteristics VL53L0X Time-of-fight distance sensor. This part is related to K8(Knowledge of modern engineering tools). We have analysed many research paper and we got different ideas about the project, this part required K8(Research Knowledge). We used the knowledge Sketchup, 3D (modern engineering tool) software for the simulation. From various research papers, we have taken research-based knowledge to understand more about Arduino, GPS and GSM modules and TOF sensor.

Depth of analysis required (P3): We can solve our project goal in varies way which we have mentioned earlier. Between those multiple solution we have selected fuel level detection and vehicles tracking system-based solution. Others solution already mentioned in section 2.2 in details. We have got our desirable result from our design system and we can also see from our economic analysis that our project is commercially successful.

Familiarity of issue (P4): In this project, we used computer engineering knowledge. Here we have to use some programming skills to implement the device logically and for these, we need computer engineering knowledge which was not a part of our regular knowledge. Also, we used mechanical engineering knowledge to build and calculate the fuel tank design as compare to truck main fuel tank design.

Interdependence (P7): We have divided the project into many subproblems which we mentioned in section 2.1 in details. There we have provided the functional diagram of the subproblems and described the whole process step by step. By solving these subproblems we have made our desire project.

6.2 Meeting the project objectives

Our main goal is to prevent vehicle fuel theft by utilizing fuel level detection with GPS & GSM based tracking system to identify where the fuel theft happened instantly. We can track the fuel theft or abnormal fuel consumption location and send that reading instantly by using various latitude and longitude from GPS and GSM module. We have described these in the preceding chapter and Appendix C.

Table 6.1 Project objective.

Requirements	Achieved	Partially achieved	Not achieved
Fuel level monitoring	✓		
Identify the location of the device	✓		
Collect the real time data	✓		
Send SMS	✓		

we had also set some requirements which are described in section 1.5. We have completed the project goal by fulfilling these requirements. The prototype and the model meet each other halfway vehicle's location finding attributes and also the fuel level. We have hardly tried to make the device safe, sustainable, low price and user friendly as possible. The goal of our project is meet by using this device. It will predict the location of the vehicle and also monitories the fuel level carefully. We can use this device both in commercial and residential needs. We hope that this device will reduce the social problem from our society.

APPENDIX A. ACTIVITY CHART

Part-A

Date	Participants	Activity Description	Approx. hrs. spent
5/06/2022	Everyone	Confirmed final topic	10 hours
12/06/2022	Everyone	Identify the alternative solution	4 hours
14/06/2022	Everyone	Identify the complex engineering problem	2 hours
18/06/2022	Everyone	Meeting and discuss with the supervisor	1 hour
20/06/2022	Mehedi, Sayed	Preparing proposal presentation	3 hours
23/06/2022	Mehedi, Sayed	Modified the presentation after supervisor feedback	1 hour
25/06/2022	Everyone	Taking preparation and practice for the presentation	1.5 hour
30/06/2022	Everyone	Modified the topic after presentation	1 hour
28/06/2022	Everyone	Literature review for fuel theft prevention	5 hours
20/06/2022	Mehedi	Identify the stakeholders	4 hours
21/06/2022	Mehedi	Prepare questionnaires for stakeholders	4 hours
22/06/2022	Mehedi	Modified the questionnaires	3 hours
23/06/2022	Mehedi	Meeting with stakeholders and collect requirements	6 hours
03/07/2022	Mahir, Sabbir	Literature review for project equipment	4 hours
31/07/2022	Sayed	Finding standards and code of practices	3 hours
07/08/2022	Sayed	Finalized project requirement	3 hours
08/08/2022	Mehedi	Select project milestone	3 hours
09/08/2022	Mehedi	Prepare activity list for the project	2 hours
10/08/2022	Sayed	Literature review for coding and programing	3 hours
11/08/2022	Everyone	Literature review for the working principle of the project	3 hours
13/08/2022	Mehedi, Sayed	Preparing equipment list	4 hours
13/08/2022	Mehedi, Sayed	Modify project requirement	3 hours
14/08/2022	Sayed	Wrote section 1.5	3 hours
15/08/2022	Everyone	Preparing budget for the project	4 hours
16/08/2022	Mehedi	Modify product budget	3 hours
17/08/2022	Everyone	Modify project plan	6 hours

17/08/2022	Mehedi	Preparing hardware and software equipment list	2 hours
22/08/2022	Sabbir	Preparing CPM	4 hours
22/08/2022	Sabbir	Preparing Gant chart	3 hours
22/08/2022	Sabbir	Wrote section 1.1	2 hours
15/07/2022	Mahir, Sabbir	Wrote section 1.2	7 hours
22/08/2022	Mahir	Find the impact on society	2 hours
22/08/2022	Mahir	Wrote section 1.3	2 hours
22/08/2022	Sayed	Preparing risk management analysis	3 hours
22/08/2022	Mehedi	Wrote section 1.6.1	2 hours
23/08/2022	Mehedi	Wrote section 1.6.3	2 hours
23/08/2022	Mehedi	Analysis of the project product lifecycle	2 hours
23/08/2022	Sayed	Wrote section 1.6.2	2 hours
23/08/2022	Mehedi	Wrote section 1.7	2 hours
23/08/2022	Mahir	Finding the effect of the environment	2 hours
23/08/2022	Mahir	Analysis on sustainability	2 hours
24/08/2022	Mahir	Wrote section 1.8.1	3 hours
24/08/2022	Mahir	Wrote section 1.8.2	3 hours
25/08/2022	Mehedi	Preparing pie chart and bar chart for analyzing percentage of stakeholder's response	4 hours
25/08/2022	Mehedi	Wrote section 1.4	3 hours
25/08/2022	Mahir	Analysis on health and safety issue	3 hours
25/08/2022	Mahir	Wrote section 1.8.3	3 hours
25/08/2022	Mehedi	Prepare the required figure and table	3 hours
27/08/2022	Sayed	Prepare references as IEEE format	2 hours
27/08/2022	Everyone	Recheck the report and correction the minor mistakes	4 hours
27/08/2022	Everyone	Revised the whole reports	8 hours
31/08/2022	Mehedi	Modify activity list, CPM, Gantt chart	3 hours
31/08/2022	Mehedi	Finding standards code of practice	4 hours
03/09/2022	Everyone	Modified the report after the feedback	4 hours
04/09/2022	Everyone	Final report correction and submission	6 hours

Part-B

Date	Participants	Activity Description	Approx. hrs. spent
10/10/2022	Everyone	Meeting with supervisor	1 hours
12/10/2022	Everyone	Discuss with group how to do the work	2 hours
14/10/2022	Everyone	Intial project Design	6 hours
18/10/2022	Everyone	Discussed our individual work in detail and finalized the work for each member	2 hours
20/10/2022	Everyone	Alternative solution analysis	72 hours
23/10/2022	Everyone	Intial Project Design	4 hours
25/10/2022	Sabbir,Mehedi	Alternative solution analysis	12 hours
29/10/2022	Mehedi, Sayed,Mahir	Finalized the functional device	8 hours
2/11/2022	Mehedi,Mahir	Started report writing	3 hours
5/11/2022	Sayed, Mahir	Alternative solution analysis	8 hours
7/11/2022	Everyone	Research for simulation	4 hours
15/11/2022	Sayed,Sabbir	Research Simulation	12 hours
18/11/2022	Everyone	Code debug and Development	8 hours
25/11/2022	Everyone	Simulation	3 hours
28/11/2022	Mehedi,Mahir	Started Writing Alternating Solution	4 hours
3/12/2022	Mehedi,Mahir	Started Writing alternative solution	3 hours
8/12/2022	Eveyone	Meeting With the supervisor	30 minutes
15/12/2022	Mahir,Sayed,Mehedi	Started writing Alternative solution	8 hours
20/12/2022	Mahir,Mehedi	Started writing Refined design	2 hours
27/12/2022	Everyone	Final report draft 1 Submission	6 hours
01/01/2023	Everyone	Final report draft 1 correction	6 hours
04/01/2023	Everyone	Meeting With the supervisor about correction	1 hours
05/01/2023	Everyone	Final report revision and submission	4 hours

Part-C

Date	Participants	Activity Description	Approx. hrs. spent
29/01/23	Everyone	Discussed about part C.	10 hours
30/01/23	Everyone	Prepared revised project plan for part C.	6 hours
31/01/23	Everyone	Our plan was discussed with our supervisor.	1 hours
04/02/23	Everyone	We went to the market to buy components.	9 hours
07/03/23	Mehedi	We started searching and ordered fuel tank equipment on online.	2 hours
09/03/23	Everyone	We have started the implementation of our device.	6 hours
16/03/23	Everyone	We took preparation for prototype testing.	3 hours
16/03/23	Sayed, Mehedi	Testing our Arduino, GPS, GSM and Sensor	27 hours
20/03/23	Sayed, Mehedi	Small discussion with supervisor about the prototype.	0.5 hours

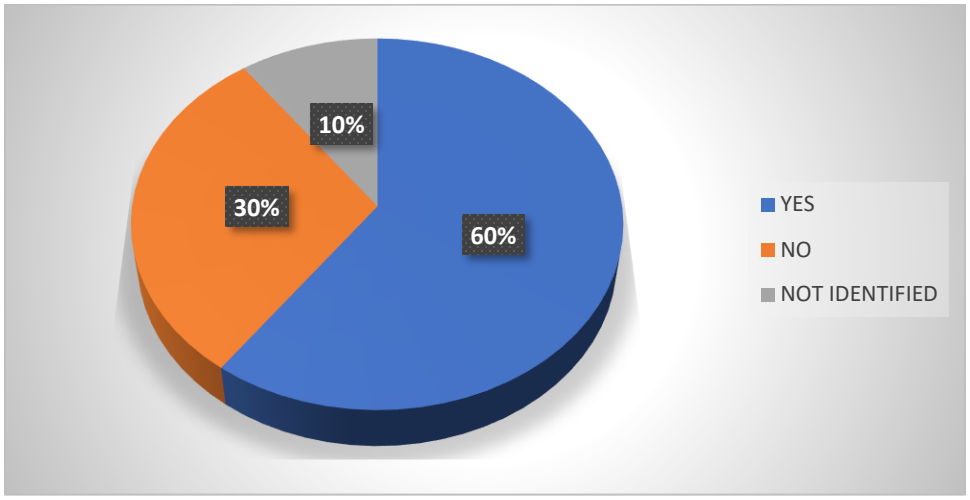
22/03/23	Sayed	Soldering some of our equipment.	2 hours
26/03/23	Sayed, Mehedi	Trying to implement, but finding some difficulties.	8 hours
27/03/23	Everyone	Meeting with our supervisor.	0.5 hours
17/04/23	Everyone	Finished the implementation of our device	4 hours
19/04/23	Everyone	Started our prototype testing.	12 hours
26/04/23	Mehedi	Wrote section 3.1	1 hours
01/05/23	Mehedi	Wrote section 3.2	1.5 hours
01/05/23	Mehedi	Completed section 3.1	1 hours
02/05/23	Mehedi	Completed section 3.2	2 hours
02/05/23	Mehedi	Wrote section 3.3	4 hours
02/05/23	Mehedi	Wrote section 3.4	6 hours

Date	Participants	Activity Description	Approx. hrs. spent
03/05/23	Mehedi	Completed section 3.3	1 hour
03/05/23	Mehedi	Completed section 3.4	0.5 hours
04/05/23	Mehedi	Wrote appendix D	1 hours
04/05/23	Mehedi	Wrote chapter 4	2 hours
04/05/23	Mehedi	Wrote modern engineering tools	4 hours
04/05/23	Sayed, Sabbir	Wrote section 5.1	6 hours
05/05/23	Sayed, Sabbir	Wrote section 5.2	4 hours
05/05/23	Mehedi	Finished wrote appendix D	0.5 hours
05/05/23	Mehedi	Wrote modern engineering tools	4 hours
06/05/23	Mahir	Wrote section 6.1 and 6.2	5 hours
07/05/23	Mehedi, Sayed	Revised and modified report (Part C)	4 hours

07/05/23	Everyone	Final report Draft submission 400C	2 hours
11/05/23	Mehedi, Sayed, Sabbir	Final report submission 400C	8 hours

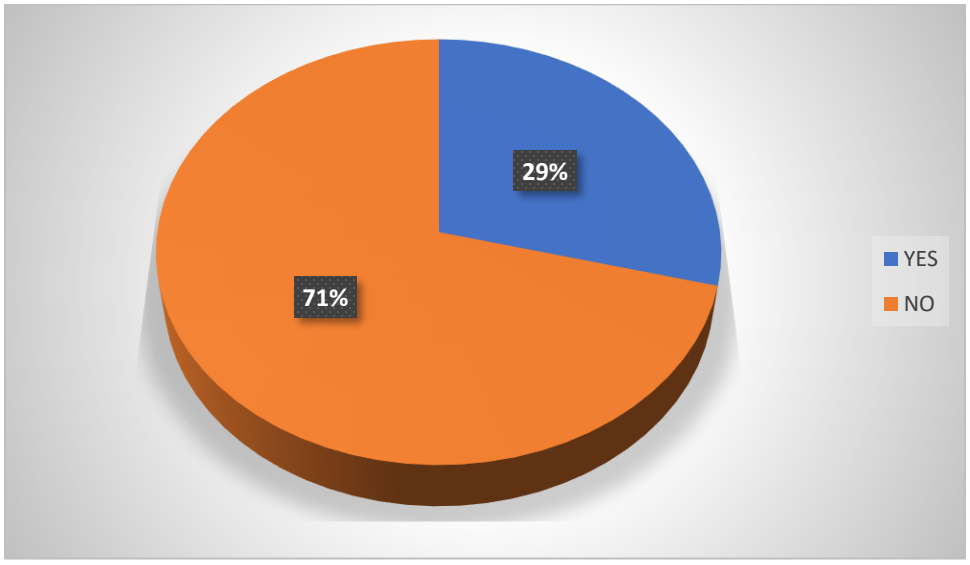
APPENDIX B. OTHER TECHNICAL DETAILS STAKEHOLDER SURVEY QUESTION AND ANSWER PERCENTAGE:

1. Do you face fuel theft problems or unconventional fuel waste in your vehicle?



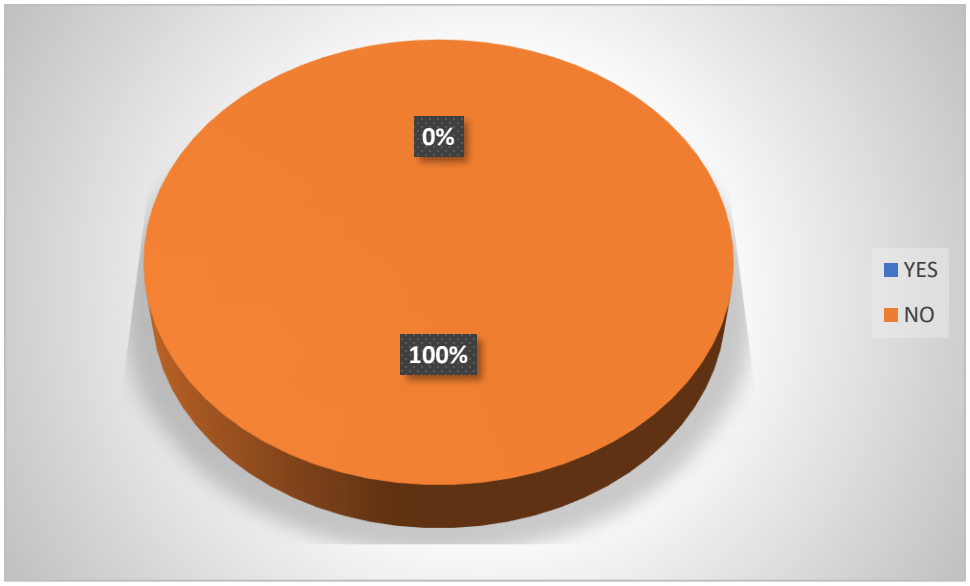
Responses 1

2. Do you use any kind of device for fuel monitoring only?



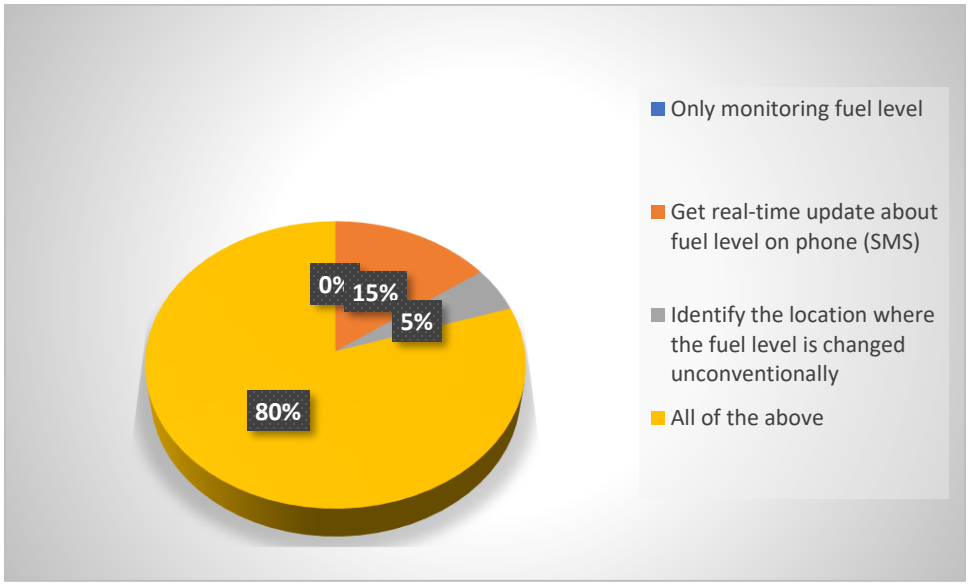
Responses 2

3. Is that kind of device give you real-time updates on fuel level anywhere you stay?



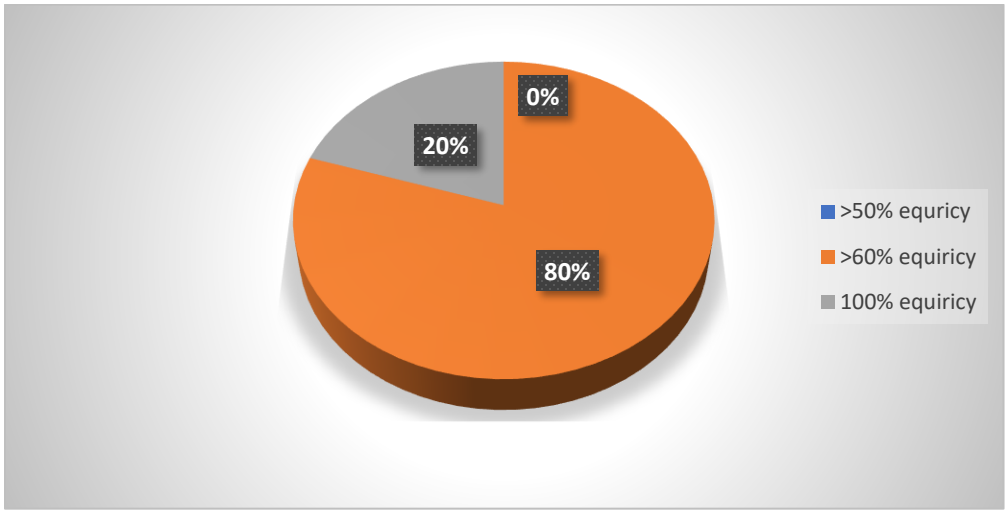
Responses 3

4. What kind of feature do you want from a fuel theft or waste prevention system?



Responses 4

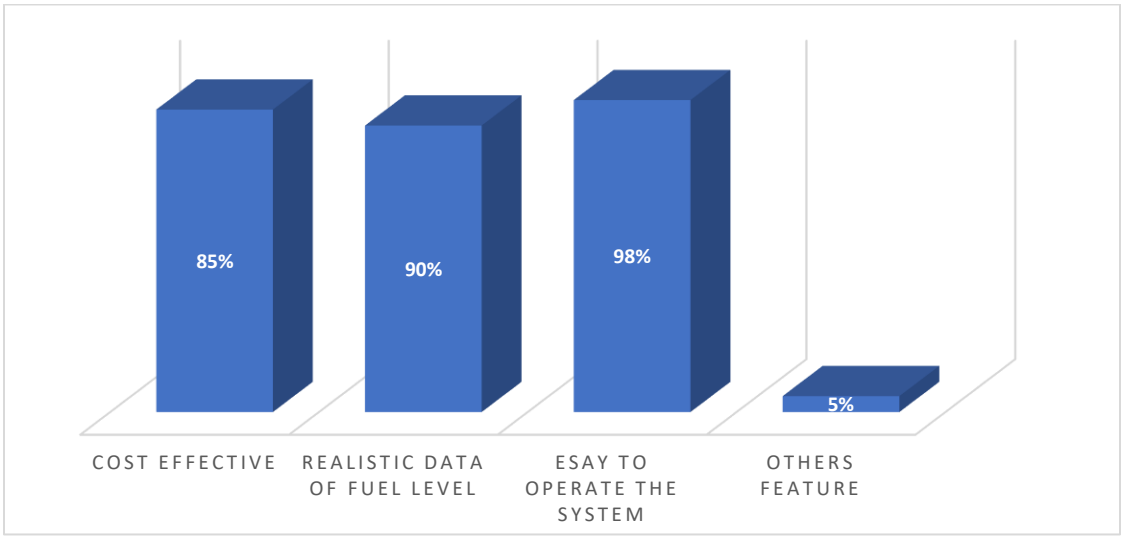
5. If the device gives you fuel monitoring, real-time update of fuel level on phone Bia SMS, indent the location of fuel level changed all feature, then how much accuracy you expected from that device?



Responses 5

6. What will be the advice for this fuel theft prevention system?

*About 90%+ stakeholders suggested that the device will be cost-effective, have realistic update fuel level data, and be easy to operate or maintain the system.



Responses 6

7.If we want to placed our device fuel level measurement sensor in truck fuel tank then how much height will be minimum requirement? (BRTA)

- Minimum 3 inches. Depends on sensor specifications.

8.Which those things are related to commercially lunched our device? (BRTA)

- Safety issue
- Device uses reason validity.
- Maintaining modification rules and fitness test.
- Permissions and agreements with terms and condition.

Part -B Code:

```
#include <Wire.h>
#include <SR-04.h>
#include <TinyGPS++.h> // Include the TinyGPS++ library
#include <SoftwareSerial.h>

VL53L0X sensor;

SoftwareSerial gpsSerial(3,4);//rx,tx
SoftwareSerial gsmSerial(7,8);//rx,tx

TinyGPSPlus tinyGPS; // Create a TinyGPSPlus object

#define GPS_BAUD 9600 // GPS module baud rate. GP3906 defaults to 9600.
```

```
#define gpsPort gpsSerial

//String update_msg = "Your car No. DHK Metro KH-3464 is now at:";
float latitude=0, longitude=0;

String serialDataIn = " ";
char inbyte;
//String number = "+8801767790448";
String number = "+8801767790448";



int  FirstDistance=0;
int SecondDistance=0;
double speed=0;
int distance=1;
float  Time = 1.0;
float delayedtime = 100*Time;

double w_cm = 10;
double h_cm = 25;

void setup()
{
  Serial.begin(9600);
  Wire.begin();
  gsmSerial.begin(9600);
  gpsPort.begin(GPS_BAUD);
```

```
  delay(500);



  sensor.setTimeout(500);
  if (!sensor.init())
  {
    Serial.println("Failed to detect and initialize sensor!");
    while (1) {}
  }

  // Start continuous back-to-back mode (take readings as
  // fast as possible).  To use continuous timed mode
  // instead, provide a desired inter-measurement period in
  // ms (e.g. sensor.startContinuous(100)).
  sensor.startContinuous();
}
int sum = 0;
void loop()
{

  GetSpeed();


}

float GetDistance(){

  for(int i=0; i<25; i++){
```

```
   sum = sum+sensor.readRangeContinuousMillimeters();
   delay(10);
   }

  int average = sum/25;
  sum = 0;
  //Serial.print(average);
  if (sensor.timeoutOccurred()) { Serial.print(" TIMEOUT"); }

  //Serial.println();

//calculating distance
//distance= duration*0.034/2;

//Prints the distance on the Serial Monitor
//Serial.print("Distance in cm : ");
//Serial.println(distance);

return  average;

}


void GetSpeed(){

   FirstDistance = GetDistance();  //get the first distance
   delay(delayedtime);
```

```
  SecondDistance = GetDistance();


  speed = (FirstDistance - SecondDistance)/Time;



 //Serial.print("the  speed (mm/s) is  :  ");
 //Serial.println(speed);

    if(speed<=-5){
    Serial.println("Warning!! Abnormal oil consumption!!");
    double d_cm = (GetDistance()/10);
    double volume_liter = (5-((d_cm*w_cm*h_cm)/1000));
    Serial.print("Measured Volume is: ");
    Serial.print(volume_liter);
    Serial.println(" Liter");


    //send message code
    gsmSerial.println("AT+CMGF=1");
    delay(1000);  // Delay of 1 second
    //mySerial.println("AT+CMGS=\"+8801767790448\"\r");
    gsmSerial.println("AT+CMGS=\"" + number + "\"\r");
    delay(1000);
    gsmSerial.println("Warning!! Your Car No. DHK Metro KH-1720. Abnormal oil
Consumption Detected!!");
```

```
    gsmSerial.print("Oil Volume: ");
    gsmSerial.print(volume_liter);
    gsmSerial.println(" Liter");
    delay(100);
    gsmSerial.println((char)26);//
    delay(5000);

    Serial.println("Warning message sent to phone");

    updateMessage();

     } else Serial.println("Everything is okay");


}



static void readGps()
{
  unsigned long start = millis();
  do
  {
    while (gpsPort.available())
      tinyGPS.encode(gpsPort.read()); //
  } while (millis() - start < 1000);
  latitude = tinyGPS.location.lat();
```

```
  Serial.print("Lat: "); Serial.println(latitude, 6);
  longitude = tinyGPS.location.lng();
  Serial.print("Long: "); Serial.println(longitude, 6);
  //TinyGPSTime::minute()
  //minutes = tinyGPS.time.minute();
  //Serial.print("Minute: "); Serial.println(minutes);
}

void updateMessage()
{
  //latitude=0, longitude=0;
  readGps();
  readGps();
  //Serial.println ("Sending Message");
  gsmSerial.println("AT+CMGF=1");    //
  delay(1000);
  //Serial.println ("Set SMS Number");
  gsmSerial.println("AT+CMGS=\"" + number + "\"\r"); //Mobile phone number to send
message
  delay(1000);


  String SMS = "Your car No. DHK Metro KH-1720 is now at:";
  SMS+= String(longitude, 6);
  SMS+= ",";
  SMS+= String(latitude, 6);
  SMS+= " http://www.google.com/maps/place/";
```

```
  SMS+= String(latitude, 6);
  SMS+= ",";
  SMS+= String(longitude, 6);
  gsmSerial.println(SMS);
  delay(100);
  gsmSerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
  Serial.println("Location message sent to phone");
  delay (10000);
}
```

Part -C Code:

```
#include <Wire.h>
#include <VL53L0X.h>
#include <TinyGPS++.h> // Include the TinyGPS++ library
#include <SoftwareSerial.h>

VL53L0X sensor;

SoftwareSerial gpsSerial(3,4);//rx,tx
SoftwareSerial gsmSerial(7,8);//rx,tx

TinyGPSPlus tinyGPS; // Create a TinyGPSPlus object
```

```
#define GPS_BAUD 9600 // GPS module baud rate. GP3906 defaults to 9600.

#define gpsPort gpsSerial

//String update_msg = "Your car No. DHK Metro KH-3464 is now at:";
float latitude=0, longitude=0;

String serialDataIn = " ";
char inbyte;
//String number = "+8801767790448";
String number = "+8801767790448";



int  FirstDistance=0;
int SecondDistance=0;
double speed=0;
int distance=1;
float  Time = 1.0;
float delayedtime = 100*Time;

double w_cm = 10;
double h_cm = 25;

void setup()
{
  Serial.begin(9600);
  Wire.begin();
```

```
  gsmSerial.begin(9600);
  gpsPort.begin(GPS_BAUD);
  delay(500);


  sensor.setTimeout(500);
  if (!sensor.init())
  {
    Serial.println("Failed to detect and initialize sensor!");
    while (1) {}
  }

  // Start continuous back-to-back mode (take readings as
  // fast as possible).  To use continuous timed mode
  // instead, provide a desired inter-measurement period in
  // ms (e.g. sensor.startContinuous(100)).
  sensor.startContinuous();
}
int sum = 0;
void loop()
{

  GetSpeed();


}

float GetDistance(){
```

```
  for(int i=0; i<25; i++){
    sum = sum+sensor.readRangeContinuousMillimeters();
    delay(10);
    }

  int average = sum/25;
  sum = 0;
  //Serial.print(average);
  if (sensor.timeoutOccurred()) { Serial.print(" TIMEOUT"); }

  //Serial.println();

//calculating distance
//distance= duration*0.034/2;

//Prints the distance on the Serial Monitor
//Serial.print("Distance in cm : ");
//Serial.println(distance);

return  average;

}


void GetSpeed(){
```

```
  FirstDistance = GetDistance();  //get the first distance
  delay(delayedtime); //waits 2 seconds depending  on the time declared above ,, we can change the value dependng on the resolution  of sensor
  SecondDistance = GetDistance(); //gets the second distance


  speed = (FirstDistance - SecondDistance)/Time; // now calculating the  difference


//printing the speed on the serial monitor

 //Serial.print("the  speed (mm/s) is  :  ");
 //Serial.println(speed);

    if(speed<=-5){
    Serial.println("Warning!! Abnormal oil consumption!!");
    double d_cm = (GetDistance()/10);
    double volume_liter = (5-((d_cm*w_cm*h_cm)/1000));
    Serial.print("Measured Volume is: ");
    Serial.print(volume_liter);
    Serial.println(" Liter");


    //send message code
    gsmSerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
    delay(1000);  // Delay of 1 second
    //mySerial.println("AT+CMGS=\"+8801767790448\"\r"); // system's mobile number
```

```
    gsmSerial.println("AT+CMGS=\"" + number + "\"\r"); // sim's mobile number
    delay(1000);
    gsmSerial.println("Warning!! Your Car No. DHK Metro KH-1720. Abnormal oil Consumption Detected!!");// The SMS text you want to send
    gsmSerial.print("Oil Volume: ");
    gsmSerial.print(volume_liter);
    gsmSerial.println(" Liter");
    delay(100);
    gsmSerial.println((char)26);// ASCII code of CTRL+Z for saying the end of sms to  the module
    delay(5000);

    Serial.println("Warning message sent to phone");

    updateMessage();

     } else Serial.println("Everything is okay");


}



static void readGps()
{
  unsigned long start = millis();
  do
```

```
  {
    // If data has come in from the GPS module
    while (gpsPort.available())
      tinyGPS.encode(gpsPort.read()); // Send it to the encode function
    // tinyGPS.encode(char) continues to "load" the tinGPS object with new
    // data coming in from the GPS module. As full NMEA strings begin to come in
    // the tinyGPS library will be able to start parsing them for pertinent info
  } while (millis() - start < 1000);
  latitude = tinyGPS.location.lat();
  Serial.print("Lat: "); Serial.println(latitude, 6);
  longitude = tinyGPS.location.lng();
  Serial.print("Long: "); Serial.println(longitude, 6);
  //TinyGPSTime::minute()
  //minutes = tinyGPS.time.minute();
  //Serial.print("Minute: "); Serial.println(minutes);
}

void updateMessage()
{
  //latitude=0, longitude=0;
  readGps();
  readGps();
  //Serial.println ("Sending Message");
  gsmSerial.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
  delay(1000);
  //Serial.println ("Set SMS Number");
```

```
  gsmSerial.println("AT+CMGS=\"" + number + "\"\r"); //Mobile phone number to send
message
  delay(1000);



  String SMS = "Your car No. DHK Metro KH-1720 is now at:";
  SMS+= String(longitude, 6);
  SMS+= ",";
  SMS+= String(latitude, 6);
  SMS+= " http://www.google.com/maps/place/";
  SMS+= String(latitude, 6);
  SMS+= ",";
  SMS+= String(longitude, 6);
  gsmSerial.println(SMS);
  delay(100);
  gsmSerial.println((char)26);// ASCII code of CTRL+Z
  delay(1000);
  Serial.println("Location message sent to phone");
  delay (10000);
}
```

APPENDIX C. JUSTIFICATION OF COMPLEX ENGINEERING PROBLEM

This table prepared in EEE400A justifies the proposed project as a complex engineering problem

Attribute	**Complex Engineering Problems** have characteristic P1 and some or all of P2 to P7:	**Covered in the project? (Y/N)**	**Explain/justify**
Depth of knowledge required	P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8, which allows for a fundamentals-based, first principles analytical approach	Y	The simulation of the programming part is required (K3, K6). Design circuit diagram and build-up required in this project (K5). Research, implementation, and knowledge of existing technology are required (K8).
Range of conflicting requirements	P2: Involves wide-ranging or conflicting technical, engineering and other issues	N	N/A
Depth of analysis required	P3: There is no obvious solution, and abstract thinking and originality in analysis are required to formulate suitable models	Y	3 to 4 alternative solutions are possible, such as – auto shut-off, alarm-based, telemetry-based, IOT-based monitoring
Familiarity of issues	P4: Involves infrequently encountered issues	Y	Will required computer programing skills to implement this project.
Extent of applicable codes	P5: Are outside problems encompassed by standards and codes of practice for professional engineering	N	N/A
Extent of stakeholder involvement and conflicting requirements	P6: Involves diverse groups of stakeholders with widely varying needs	N	N/A
Interdependence	P7: High level problems including many component parts or sub-problems	Y	This project is an interdependent project. It has two parts electronics part and programming part.

APPENDIX D. JUSTIFICATION OF COMPLEX ENGINEERING ACTIVITIES

This table prepared in EEE400C describes the complex engineering activities in the project

Attribute	**Complex activities mean (engineering) activities or projects that have some or all of the following characteristics:**	**Covered in the project? (Y/N)**	**Explain**
Range or resources	A1: Involves the use of diverse resources (for this purpose, resources include people, money, equipment, materials, information and technologies)	Y	In our project, we have used a variety of resources, including charge controllers and buck boost converters. We have also employed cutting-edge programs like AutoCad, Proteus, Sketchup and many more. Additionally, we had to pay for the purchase of various parts and the assembly of the prototype. Information has been acquired from industry experts and our stakeholders.
Level of interaction	A2: Requires resolution of significant problems arising from interactions among wide-ranging or conflicting technical, engineering, or other issues	Y	We struggled to choose between using AC power or DC power to operate the device. We desired a battery system, however due to our plug-in system's availability, we performed the task in a plug-in system. However, both AC and DC bruising is not possible with our circuit architecture. We could only keep one choice as a result. We tested our prototype with adapter and battery also. There is a both options.
Innovation	A3: Involves creative use of engineering principles and research-based knowledge in novel ways	Y	Researching earlier work on the problem, creating a simulation, and creating a prototype were the methods we employed in our project, which we implemented using engineering principles and information based on research.
Consequences for society and the environment	A4: Has significant consequences in a range of contexts; characterized by difficulty of prediction and mitigation	Y	It will have a big impact on vehicle fuel security as well as the economy by lowering security charges.

Familiarity	A5: Can extend beyond previous experiences by applying principles-based approaches	N	

APPENDIX E. RUBRICS

Rubrics for EEE400

Table 1: Rubrics for assessment of PO9 (Individual work and teamwork)

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
Individual skills	Actively participates in group discussions and decision making, contributes useful ideas, completes assigned responsibilities thoroughly on time	Participates in group discussions and decision making, contributes ideas, completes assigned responsibilities mostly on time	Somewhat participates in group discussions and decision making, sometimes contributes ideas, completes some of the assigned responsibilities on time	Does not participate in group discussions and decision making, does not contribute relevant ideas, does not complete assigned responsibilities on time
Team skills	Always collaborates with others, always promotes constructive team atmosphere, always identifies and responds to conflicts promptly and positively	Usually collaborates with others, usually promotes constructive team atmosphere, usually identifies and responds to conflicts positively	Sometimes collaborates with others, sometimes promotes constructive team atmosphere, sometimes identifies and responds to conflicts positively	Does not collaborate with others, does not promote constructive team atmosphere, does not identify and respond to conflicts
Leadership skills	Always provides direction to achieve goals, always respects and listens to other members, always plans for improvement, always motivates others	Usually provides direction to achieve goals, usually respects and listens to other members, usually plans for improvement, usually motivates others	Sometimes provides direction to achieve goals, sometimes respects and listens to other members, sometimes plans for improvement, sometimes motivates others	Does not provide direction to achieve goals, does not respect and listen to other members, does not plan for improvement, does not motivate others
Multidisciplinary activities	Fully understands and appreciates the multidisciplinary nature of the project activities, shows interests and participates in activities in disciplines outside of own	Mostly understands and appreciates the multidisciplinary nature of the project activities, participates in activities in disciplines outside of own	Somewhat understands and appreciates the multidisciplinary nature of the project activities, participates in some activities in disciplines outside of own	Does not understand or appreciate the multidisciplinary nature of the project activities, does not participate in activities in disciplines outside of own

Table 2: Rubrics for assessment of PO8 (Ethics)

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
Equity	Always approaches situations with consideration of equity, always behaves inclusively	Mostly approaches situations with consideration of equity, mostly behaves inclusively	Sometimes approaches situations with consideration of equity, sometimes behaves inclusively	Does not approach situations with consideration of equity, does not behave inclusively
Accountability	Always understands about accountability and personal responsibility, always assumes responsibility of own actions	Mostly understands about accountability and personal responsibility, mostly assumes responsibility of own actions	Sometimes understands about accountability and personal responsibility, sometimes assumes responsibility of own actions	Does not understand about accountability and personal responsibility, does not assume responsibility of own actions
Proper use of others' works	Always recognizes the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and acts accordingly	Mostly recognizes the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and mostly acts accordingly	Sometimes recognizes the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and sometimes acts accordingly	Does not recognize the need for due acknowledgment of others' works, intellectual property and copyrighted materials, and does not act accordingly
Professionalism	Fully understands the role of the engineer in protecting public interests, fully understands and is aware of relevant codes of ethics	Mostly understands the role of the engineer in protecting public interests, mostly understands and is mostly aware of relevant codes of ethics	Somewhat understands the role of the engineer in protecting public interests, somewhat understands and is somewhat aware of relevant codes of ethics	Does not understand the role of the engineer in protecting public interests, does not understand or is not aware of relevant codes of ethics

Rubrics for EEE400A

Table EEE400A: Rubrics for assessment of the project concept and proposal

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
PCP_PI1: Able to identify a suitable complex engineering design problem (1a) [sec-1.1, Appendix C] **(CO1/PO12, P1)**	Demonstrates an ability to explore a topic thoroughly, and to identify a suitable complex engineering problem	Demonstrates an ability to explore a topic, and to identify a reasonably suitable complex engineering problem	Demonstrates an ability to somewhat explore a topic, and to identify a somewhat suitable complex engineering problem	Demonstrates minimal or no ability to explore a topic, or to identify a suitable complex engineering problem
PCP_PI2: Engages to stay up to date on the relevant topic (2b) [sec-1.2] **(CO1/PO12, P1)**	Demonstrates thorough engagement to stay up to date on the relevant topic	Demonstrates engagement to stay up to date on the relevant topic	Demonstrates some engagement to stay up to date on the relevant topic	Demonstrates minimal or no engagement to stay up to date on the relevant topic
PCP_PI3: Identifies the regulatory requirements, standards, and codes of practice (2a) [sec-1.3] **(CO2/PO3, P5)**	Identifies all the relevant regulatory requirements, standards, and codes of practice	Identifies most of the relevant regulatory requirements, standards, and codes of practice	Identifies some of the relevant regulatory requirements, standards, and codes of practice	Does not identify any of the relevant regulatory requirements, standards, and codes of practice
PCP_PI4: Explains the objectives, project requirements and constraints of the solution considering the expectations of the stakeholders (2c) [sec-0, 1.5] **(CO2/PO3, P2, P6)**	Clearly explains the objectives, project requirements and constraints taking into account all the expectations of the stakeholders	Explains the objectives, project requirements and constraints taking into account most of the expectations of the stakeholders	Somewhat explains the objectives, project requirements and constraints fully taking into account some the expectations of the stakeholders	Does not explain the objectives, project requirements and constraints and/or does not take into account any expectation of the stakeholders
PCP_PI5: Prepares project management plan, setting up milestones and considering risks and contingencies (2d) [sec-1.6.1, 1.6.2] **(CO3/PO11)**	Prepares a comprehensive project management plan, clearly sets up milestones, thoroughly considers risks and contingencies	Prepares a project management plan, sets up milestones, considers risks and contingencies	Prepares a project management plan, sets up a few milestones, attempts to considers risks and contingencies	Prepares a unclear/incomplete project management plan, does not set up milestones, does not consider risks and contingencies
PCP_PI6: Identifies required resources and prepares a realistic budget (2e, 2g) [sec-1.6.3] **(CO3/PO11)**	Identifies all resources and prepares budget that covers all applicable areas of the project including room for contingency	Identifies most resources and prepares budget that covers most applicable areas of the project including room for contingency	Identifies some resources and prepares budget that covers some applicable areas of the project	Cannot identify resources and cannot prepare a budget addressing major applicable areas of the project

PCP_PI7: Explains how to sustain and maintain the product/service in business if the solution is successfully commercialized. (2h) [sec-1.7]	Clearly explains how to sustain and maintain the product/service in business if the solution is successfully commercialized.	Explains how to sustain and maintain the product/service in business if the solution is successfully commercialized.	Somewhat explains how to sustain and maintain the product/service in business if the solution is successfully commercialized.	Does not explain how to sustain and maintain the product/service in business if the solution is successfully commercialized.
PCP_PI8: Considers the impact of the solution on society including health, safety, cultural, and legal issues (2f) [sec-1.8.1, 1.8.3] **(CO4/PO6)**	Considers all the impacts on society including health, safety, cultural and legal issues	Considers most of the impacts on society including health, safety, cultural and legal issues	Considers some of the impacts on society including health, safety, cultural and legal issues	Does not consider any impact on society including health, safety, cultural and legal issues
PCP_PI9: Considers the impact of the solution on environment and sustainability over the entire product life cycle. Proposes mitigating solution if needed. (2f) [sec-1.8.2] **(CO5/PO7)**	Considers all the impacts on environment and sustainability. If necessary, proposes solutions to mitigate negative impact	Considers most of the impacts on environment and sustainability. If necessary, identifies impacts which need mitigation	Considers some of the impacts on environment and sustainability	Minimal or no consideration of impacts on environment and sustainability

P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8, which allows for a fundamentals-based, first principles analytical approach

P2: Involves wide-ranging or conflicting technical, engineering and other issues

P4: Involves infrequently encountered issues

P6: Involves diverse groups of stakeholders with widely varying needs

Rubrics for EEE400B

Table 1: Rubrics for assessment of the Design Report

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
DR_PI1: Develops a functional design considering applicable standards, codes of practice, health, safety, and environmental considerations. (1a) [sec-2.1] **(CO2/PO3, P2, P7)**	Appropriately partitions the problem into sub-problems, considers all relevant engineering standards and codes where applicable, involves all health, safety, and environmental issues in design	Partitions the problem into sub-problems, considers most relevant engineering standards and codes where applicable, involves major health, safety, and environmental issues in design	Partitions the problem into sub-problems to some extent, considers some relevant engineering standards and codes where applicable, involves some health, safety, and environmental issues in design	Does not usefully partition the problem into sub-problems, does not consider relevant engineering standards and codes, health, safety, and environmental issues not involved in design
DR_PI2: Formulates and evaluates alternate solutions (1b) [sec-2.2] **(CO1/PO2, P1, P3)**	Effectively formulates multiple solutions that functionally meet most requirements, compares and evaluates alternate solutions, extracts valid conclusions	Formulates multiple solutions that functionally meet most requirements, partially compares and evaluates alternate solutions, conclusions in line with analysis	Formulates multiple solutions that functionally meet some requirements, attempts to compare and evaluate alternate solutions, conclusions somewhat in line with analysis	Does not formulate multiple solutions, no attempt to compare and evaluate alternate solutions, conclusions not based on analysis
DR_PI3: Prepares and refines design with analysis and/or simulation of the system for implementation (1c, 1d) [sec-**Error! Reference source not found.**] **(CO2/PO3, P1)**	Performs all design calculations, produces detailed design, analyzes and/or simulates to verify that the design satisfies all requirements. Design is skillfully refined to facilitate implementation.	Performs most design calculations, produces design with some details, analyzes/simulates to verify that the design satisfies most requirements. Design is refined to facilitate implementation.	Performs some design calculations, produces design with a few details, attempts to analyze/simulate the design to verify satisfaction of requirements. Design is somewhat refined to facilitate implementation.	Does not perform design calculations, detailed design not produced, analysis/simulation not done to verify satisfaction of requirements. Design is not refined to facilitate implementation.

P1: Cannot be resolved without in-depth engineering knowledge at the level of one or more of K3, K4, K5, K6 or K8, which allows for a fundamentals-based, first principles analytical approach

P2: Involves wide-ranging or conflicting technical, engineering and other issues

P3: There is no obvious solution, and abstract thinking and originality in analysis are required to formulate suitable models

P7: High level problems including many component parts or sub-problems

Rubrics for EEE400C

Table 1: Rubrics for Final report of EEE400C

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
FR_PI1: Discusses how the prototype of the solution is developed. [sec 3.1]	Comprehensively discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams	Discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams	Somewhat discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams	Poorly discusses how the prototype of the solution is developed with the help of appropriate figures, photos and diagrams
FR_PI2: Evaluates performance of the developed system as per requirements. Finalizes design based on performance evaluation (1a and 1b) [sec 3.2, sec 3.3] **(CO1/PO4, CO3/PO3)**	System meets all requirements or the students can identify and explain clearly when deviation from requirements occurs. Revises design with appropriate technical analysis if necessary to achieve compliance with all specification and requirements	System meets major requirements. Students can identify and explain most deviations from requirements. Revises design with technical analysis if necessary to achieve compliance with most specification and requirements	System meets some requirements. Students can identify and explain some deviations from requirements. Revises design with some technical analysis if necessary to achieve compliance with some specification and requirements	System does not meet most requirements. Students cannot identify and explain most deviations from requirements. Design not revised to achieve compliance.
FR_PI3: Finalizes design based on performance evaluation (1c) [sec 3.3] **(CO3/PO3)**	Revises design with appropriate technical analysis to achieve compliance with all requirements finalized in 400B	Revises design with technical analysis to achieve compliance with most requirements finalized in 400B	Revises design with some technical analysis to achieve compliance with some requirements finalized in 400B	Does not revise design with technical analysis to achieve compliance with any requirement finalized in 400B
FR_PI4: Selects and uses appropriate modern engineering tools for modeling, simulation and/or performance evaluation throughout the project (EEE400 A, B, C) [sec 3.4] **(CO2/PO5)**	Carefully selects and skillfully uses modern engineering tools knowing all the relevant limitations of the tools	Selects and uses modern engineering tools with some degree of care and skill knowing major relevant limitations of the tools	Selects and uses modern engineering tools knowing some relevant limitations of the tools	Selected and used modern engineering tools are mostly not appropriate. No knowledge of relevant limitations of the tools
FR_PI5: Achieve the milestones set in the project proposal or	All milestones are reached on time or corrective measures	Most milestones are reached on time or corrective measures	Milestones are somewhat reached on time or some	Milestones are mostly not reached on time. Corrective measures

revises the schedule appropriately to complete the project within the deadline (EEE400 A, B, C) [Chapter 4] **(CO4/PO11)**	are appropriately taken to revise the schedule to complete the project within deadline	are taken to revise the schedule to complete the project within deadline	corrective measures are taken to revise the schedule to complete the project within deadline	are not taken to revise the schedule to complete the project within deadline
FR_PI6: Prepares the bill of materials and estimates the cost of the system [sec 5.1] **(CO5/PO11)**	Prepares bill of materials considering all the project components and/or parts and the cost is accurately estimated	Prepares bill of materials considering most the project components and/or parts and the cost is estimated	Prepares bill of materials considering major project components and/or parts and the cost is reasonably estimated	Prepares bill of materials ignoring important project components and/or parts and the cost is not reasonable
FR_PI7: Performs economic analysis to calculate suitable economic parameter(s) to evaluate the economic prospect of the proposed project [sec 5.2] **(CO5/PO11)**	Evaluates the financial prospect of the project through detailed and thorough analysis. Interpretation is clear	Evaluates the financial prospect of the project through analysis. Provides interpretation	Evaluates the financial prospect of the project through analysis.	Does not evaluate the financial prospect of the project through analysis

Table 2: Overall rubrics on report writing

Communicates the main ideas in written form [Overall] **(CO8/PO10)**	Communicates the main ideas clearly and to the point	Communicates the main ideas	Communicates the main ideas to some extent	Does not communicate the main ideas
Uses illustrations (graphs, tables, diagrams) to support ideas, analysis and interpretation [Overall] **(CO8/PO10)**	Skillfully uses illustrations to support ideas. Illustrations enhance comprehension of analysis and interpretation	Uses illustrations to support ideas. Illustrations somewhat enhance comprehension of analysis and interpretation	Uses illustrations which are related to analysis and interpretation	Either does not use illustrations or illustrations used are not relevant to ideas, analysis and interpretation
Uses citations and references [Overall] **(CO8/PO10)**	Citations and references are effectively used to duly acknowledge prior art and other people's works	Citations and references are used to acknowledge prior art and other people's works	Citations and references are used to somewhat acknowledge prior art and other people's works	Citations and references are not used or prior art and other people's works are not acknowledged
Uses a language which is mechanically (punctuation, spelling and grammar) correct [Overall] **(CO8/PO10)**	The report is free from mechanical errors	The report contains a few mechanical errors	The report contains some mechanical errors	The report contains several mechanical errors

Table 3: Rubrics for oral presentation

Performance indicators	Outstanding (9 – 10)	Good (7 – 8)	Satisfactory (6)	Unsatisfactory (0 – 5)
Communicates appropriately targeting the society at large **(CO8/PO10)**	Communication is skillfully tailored to appropriately suit the level of target audience	Communication is tailored to suit the level of target audience	Communication is somewhat tailored to suit the level of target audience	Communication is not tailored to suit the level of target audience
Focusses on the creative aspects of the solution with clarity **(CO8/PO10)**	Creative aspects are clearly articulated and emphasized. Presentation is logically and skillfully structured	Creative aspects are articulated and emphasized. Presentation structure is logical	Creative aspects are somewhat articulated and emphasized. Presentation structure is somewhat logical	Creative aspects are not articulated or emphasized. Presentation structure is not logical
Above two PIs will assess the sales pitch part of the presentation. Following PIs are for the technical part				
Designs and integrates visual aids (illustrations, demonstrations, props, etc) to support and focus presentation **(CO8/PO10)**	Visual aids are creatively designed, skillfully used and seamlessly integrated to enhance and focus presentation	Visual aids are designed, used and integrated to enhance and focus presentation	Visual aids are designed, used and integrated to enhance and focus presentation to some extent	Visual aids are not designed, used or integrated to enhance and focus presentation
Completes presentation within the allotted time **(CO8/PO10)**	Finishes the presentation as prepared within time without rushing or skipping content	Finishes the presentation as prepared within time with rushing or skipping content occasionally	Finishes the presentation as prepared within time with rushing or skipping content a few times	Does not finish the as prepared presentation within time or skips major contents to finish within time
Listens to the questions and answers appropriately **(CO8/PO10)**	Carefully listens to the questions, answers concisely transitioning skillfully between presentation and Q/A	Listens to the questions, answers to the point transitioning well between presentation and Q/A	Listens to the questions, answers somewhat to the point transitioning between presentation and Q/A in an acceptable manner	Does not listen to the questions, answers not to the point transitioning between presentation and Q/A not in an acceptable manner

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