MONITORING FUEL OIL TANK LEVEL AT PETROL STATION

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ELECTRICAL & ELECTRONICS ENGINEERING

UNIVERSITI TEKNOLOGI PETRONAS

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Progress report/ dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

_____

(Ir. Dr. Nursyarizal M Nor)

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR, PERAK
January 2017

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NUR SYAHIRAH BINTI RADZI

ABSTRACT

Fuel oil measuring in underground tank is indispensable since the early development of petrol station and until today the manual method is still praticing. The manual method is by inserting a calibrated stick in order to get the height of the oil in the tank. Then after obtaining the height, the volume of oil can be calculated or can be obtain by referring to a tabulated chart of the respective tank design. The method is still being practice by the current petrol station but with an improvement of ready installed measuring stick in the tank with imprinted volume on the stick. The measurement are conducted every day. In the latest measuring technology,it integrates a digitize equipment which is by using magnetostrictive. To obtain the fuel oil height and volume, the operator have to activate the device in order to get the recent measurement of the fuel oil. Thus, this method will not be monitor in real time as it only operate when it is activated on turned on. Therefore, this project is to develop a real time fuel oil monitoring by applying Internet of Things (IOT) in the system. This allows the personnel to access and monitor the current fuel oil level, anywhere and anytime with the acceptance of internet availability. Aside from the easy access for the data, the system does not require a pre-installation of software because it is online monitoring. In addition, this project is proposing to introduce a non-contact device. There are a few non-contact method that are available for instance radar, infrared (IR) sensor and ultrasonic sensor. For this purpose, the ultrasonic sensor is chosen as the device to measure fuel oil due to its wide range of detection and low cost. This device is capable of detecting different type of material either solid or liquid. The ultrasonic sensor is complement with a suitable microcontroller which is capable of IOT applications. Thus the results from the overall prototype shows that real time monitoring can be achieved with an ultrasonic as a sensing device. Ultrasonic sensor percentage difference is negligible and the volume measured are almost accurate as the actual fuel oil volume.

ACKNOWLEDGEMENTS

بِسْمِ أللهِ ألرَّحْمَنِ ألرَّحِيمِ

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The appreciation also dedicated to Petron petrol station in allowing the research and visit to be conducted there. The assistance given is greatly appreciated and the outcome of the visit truly helps in order to understand more on the current and former method in oil measuring in petrol station.

Lastly, thank you to the coordinator for the endless guidance and reminder throughout FYP which ease the students on planning the project submission and project activities.

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ABBREVIATIONS AND NOMENCLATURES

IOT	Internet of Things
FYP	Final Year Project
IR	Infrared
TCP/IP	Transmission Control Protocol/Internet Protocol
Trig	Trigger
dBm	Decibels
PCV	Polyvinyl Chloride
USB	Universal Serial Bus
API	Application Program Interface
WiFi	Wireless Fidelity
VLSI	Very Large Scale Integrated
CPU	Comprises of Central Processing Unit
RAM	Random Access Memory
ROM	Read Only Memory

CHAPTER 1

INTRODUCTION

1.0 Introduction

The first chapter will provide the overview of the project, starting from the background of the project. Background of the project will explain on how the fuel oil measurement are currently been taken. Next is the objectives and the scope of study of the project. This section will narrow down the objectives and the scope of study involve throughout the project. Lastly, in the thesis outline this section will briefly explain the other subsequent chapters.

1.1 Project Background

Monitoring have been indispensable in all work field, either data monitoring, fluid level monitoring, or even pressure monitoring. It is to ensure the, precision and efficiency of the work. At petrol station, the monitoring take place for the fuel oil underground tank. Mechanism applies for monitoring does in fact varies from mechanical to electronics devices. The earliest method used by the petrol station to measure the fuel oil storage level is by manual indication. This practice commonly uses a dipstick as the indication to know the level of the oil, either full, half full or about to drain out. This method requires the person to insert the indicator stick into the underground tank until it touches the bottom of the tank and remove it. By doing so, the fuel oil level are able to determine by referring to the dipstick height and the volume can be calculated or refer to the table or chart of the respective tank design.

New petrol stations have more advanced monitoring device to measure oil fuel level. One of the digital device that was recorded is float type device, it is simpler design and easier to operate but in some cases it has its drawbacks. Petrol station or filling station similarly requires an inspection for the underground storage tank. It ensures that the fuel supplies maintain and keep up with the demand especially during festive season. The volume of an underground tank is position horizontally, thus in order to calculate the volume requires a separate calculation. The end side of the tank may be a straight vertical or rounded, or also known as flat head and hemispherical or elliptical head which depends on the design of the tank. The most recent technologies use by the new petrol station are a digitize fuel monitoring. It will operate and measures the current volume of fuel oil when the operator or personnel operate the device and it will print the results, the printing convenience may varies due to its model. Thus, the mechanism use are magnetostrictive probe buoyancy which is a contact method. This mechanism will measure the density and obtain the respective volume, nevertheless this method does occur some error. Thus, by introducing another monitoring method it can improve the measurement accuracy and ease the work for fuel oil monitoring. Sensor is known for the wide use of measuring in different application. Ultrasonic sensor are known for monitoring liquid level. Therefore by taking this approach, the quality of work can improve in terms of health and accuracy of monitoring. Hence, integrating with a real time system monitoring will bring convenience for frequent monitoring.

1.2 Problem Statement

The fuel oil level has to be observe every day, especially at night. It is possible for the person taking the respective work to be expose with hazard. For the digitized method that is available, the measuring device have no online system monitoring thus It is less convenience to analyse the daily profit as there is no real time monitoring.

i. Dipstick method causes exposure of petrol fume, which effect the health
ii. Existing digitize method are not in real time, this will allow scam to happen
iii. The error of digitize monitoring is about 20%

1.3 Objectives and Scope of Study

The objective of this project is to develop the monitoring method for fuel oil level. These objectives will achieve stage by stage, therefore this research carries the following objectives:

i. To develop an operative ultrasonic sensor device to measure fuel oil level
ii. To enhance the effectiveness of monitoring by creating a real time monitoring by using IOT

Scope of this project are comprises of:

i. Calculations for measuring the height and volume of horizontal tank
ii. Type of microcontroller with Wireless Fidelity, WiFi application
iii. Programing of microcontroller with ultrasonic
iv. Internet of Things, IOT Application

1.4 Thesis Outline

Chapter 2: Literature Review

This chapter are break down to four main topic which is the types of monitoring method, comparison between different types of microcontroller, wireless local area network (wifi) signal and fuel oil tank calculation.

Chapter 3: Methodology

Project activities throughout Final Year Project 1, FYP 1 and Final Year Project 2, FYP 2 are illustrated as well flow of operation for the program code.

Chapter 4: Results & Discussion

The results for all testing and final result from the finish integration of prototype are discuss in this chapter.

Chapter 5: Conclusion

Based from the results obtain in Chapter 4, the conclusions are deduced in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The literature context that are cover in this chapter are divided into four main topic with a total of five section. Firstly, the comparison current digitized method for monitoring. Secondly the sensor that are commonly used for monitoring method and the advantage and disadvantage. Thirdly, is the study of microcontroller for internet of things, IOT. Next is the study on WiFi signal and the best WiFi signal and lastly the calculation for horizontal tank.

2.1 Monitoring Method

Since the early 1990s, an inventory of measuring sensor was developed [16]. Some of the measuring sensor are using capacitance probes which involves of float. These sensors will convert the output to an analogue or digital display. Thus the measurement of liquid are can obtain from the display. Nevertheless, the measuring technology has developed over time. The following researched are based from the latest measuring method that are currently used.

2.1.1 Current Method for Monitoring

Magnetostrictive is a spring loaded foot whereas the magnet will be the moveable part within the spring loaded foot. These mechanism requires a focal point which uses a magnet as the reference point with a relatively fix height to the bottom of tank. The measuring are take part when the probe generate current which allow the probe to detect the distance to the magnet. The buoyancy of the probe allow the density to be measure [1]. The measurements are calculated and display to the monitoring system (TLS-350R). The system are able to deliver report which show the increase of volume, volume it dispense and actual amount. The design provide integral printer which allows to print the report.

Fueltek manage the fuel dispenser with a tankwatch, this is where probes will provide the information for example capacity, overfill alarm, leak and water detection alarm lies [2]. Based on Table 2.1 the advantage and disadvantage of both method are analysed. Gauges overfill alarms have the advantage of warning on any overfill by receiving signal through overfill alarm probe, but this method is a contact method thus it may cause a safety hazard. Besides that, the concept of real time monitoring are integrated in the system, this is realized to be a very beneficial use especially for stocking management. The work is more effective as the value of liquid level are continuously obtain. Another method is by using magnetostrictive probe, the advantage is tracking the average usage and some design have its integral printer but also this method is a contact method and some difference in measurement may cause due to weight of the device. The following Figure 2.1 shows the integral printer for the megnetostrictive probe. As for the effectiveness of the work it is deduce that the real time monitoring is the finest method for the current technology.

Table 2.1: Current Method

Device	Concept	Advantage	Disadvantage
Gauges overfill alarms	"Tankwatch" can be interfaced with management systems	.1 real time stock management .2 overfill alarm probe	1.May cause a safety hazard
Magnetostrictive probe	-buoyancy of the probe shaft is a function of the height of the fuel -automatically collects metered sales information from electronic and mechanical dispensers	3.Available with an integral printer or can be connected to a remote printer. 4.Track average daily fuel usage	2.Use a contact method (probe shaft) 3.Presence of force exerted by the spring from the weight of the probe shaft

Figure 2.1: Current Digitize Fuel Oil Monitor

2.1.2 Ultrasonic Sensor for Monitoring

To determine the level of material in tanks the system must include a comparator which is to evaluate the time from the signal is transmitted and the reflected time which it will receive back the signal. Overtime, the operation of the device has developed

[3]. Thus, few approaches can be obtain to process the signal from transducer. It allows to detect obstacle and multiple measurements by few transducer [4]. In [5] research of petrol detector, it is states that the contactless sensor such as the ultrasonic is more accurate and consume less power. In other mechanism such as gauge, it may face some problem mainly inside the vehicle tank but the upside of this mechanism is the simpler design compare with contactless method. Methodology that was used was by receiving the data or reflected signal from the sensor and fed into the microcontroller to process the data. The controller then will calculate the amount of litres left. It will then digitally display at the dashboard the amount of litres calculated. [6] Mention that the invention of ultrasonic sensor as the level detector were developed in term if the signal processing. The application of the sensor are widely practice in determining the tanks liquid volume. The function of transducer is to produce the sound wave or energy to the surface to be reflected. In [7] measuring is classified two technique of measuring which is contact and contactless. The sensors or device within contact categories are level sight gauge, float resistance tape, bubble tube and displacer. On the other hand, the contactless sensors are radar, ultrasonic and load cell. The suitability of the devices are depending on the condition and material of the matter. As shown in Table 2.2, it is the summarization of the usage and application of the system based from the research. Ultrasonic sensor have been widely use in the monitoring application [5] these method are used for vehicle tank in order to calculate the remaining of the oil. Another application that used ultrasonic sensor are for flash flood indication [8]. [17] Flash flood are due to continuous and extreme thunderstorm and also impervious geographical area. In another research, the ultrasonic sensor was used in measuring liquid [6].

The non-contact approach are used to avoid the disadvantage of contact method which is reaction between the contact method and the material such as petrol. The most appealing about ultrasonic is it is cost saving to compare with other method. Besides that, ultrasonic sensor can use to detect the distance of the material which then can use to calculate the quantity of fuel. The issue that may arise from the application is the circuitry connectivity and the maintenance required [5]. In [8] the research combine ultrasonic with other sensor to achieve better accuracy in detecting flash flood. The ultrasonic is more accurate and cheaper than other ultra wide band radar. Nevertheless,

the accuracy may deflect due to the rise and low temperature of the surrounding. The summarization of the research as shown in Table 2.3. From this topic, it can be deducted that the sensor are capable of detecting various density of material from solid to liquid which make it suitable for any application.

Table 2.2: Application of Ultrasonic Sensors

Device	Application/concept
Ultrasonic sensor	Petrol Level Detection - Digital indication of fuel in vehicle's tank - Calculate remaining fuel
Ultrasonic Sensor Infrared Sensors	Flash Flood Detection - Combination ultrasonic range finding with remote temperature sensing
Ultrasonic sensor	Ultrasonic Level detector - To determine the level of liquid material by using a transducer to generate a burst of ultrasonic energy towards the surface to be detected.

Table 2.3: Advantage and Disadvantage of Ultrasonic

Application	**Advantage**	**Disadvantage**
Petrol Level Detection (Car Tank)	1.Ultrasonic is low cost 2. Suitable for small area situation and less complex 3. Can measure from 0.03-3m 4. Helps to calculate mileage for vehicle	1. Blast may happen to the tank if short circuit occurs 2. Require regular maintenance
Flash Flood Detection	1. Cheaper and accurate	1. Unpredictable temperature affect sensors accuracy

Operation of ultrasonic sensor requires transmitter and receiver, this is being equipped inside it as shown in Figure 2.2. These components complement each other because the transmitter will send the wave to be travel by the air. After the wave hit

the obstacle, it will be reflected as echo to be pick up by receiver. The time taken for the wave to travel to the obstacle and return to the receiver can be calculated using formula in equation 2.1 and 2.2. The speed of sound is different depending the medium being used for travelling, considering the temperature of the medium itself. But the physicists already calculated the speed of sound at sea level using air as the medium as 34300cm/s [18]. The value are as the indicator for further calculation. Since the time taken is to travel from the transmitter to the obstacle and return to the receiver, the distance by two to get the actual distance between the sensor to the obstacle. Based on the calculation, after getting the reading of time taken for signal to return to the sensor, the distance can be calculated. By using the calculation in of horizontal cylinder, the volume of the tank can be obtain.

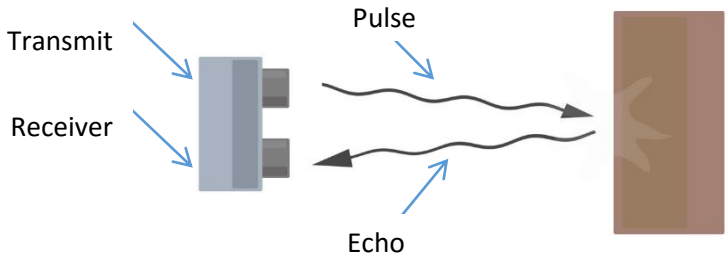


Figure 2.2: Illustration of Ultrasonic Sensor

$$Speed = \frac{Distance}{Time} \tag{2.1}$$

$$34300 = \frac{Distance}{Time/2}$$

$$17150 = \frac{Distance}{Time}$$

$$17150 \times Time = Distance \tag{2.2}$$

2.2 Comparison between Types of Microcontroller

Microcontroller are an embedded controller that fabricated through very large scale integrated (VLSI) and mostly the support circuit that is embedded in controller. With advance technologies it is viable microcontroller to have a scale of 4 bit to 128

bit different word lengths. Most of all the electronic devices that are regularly used contain a microcontroller inside it. Some devices have its own storing data and display, which is useful for prompting messages. These feature may be available for some microcontroller. Thus, the components in a microprocessor comprises of central processing unit (CPU), oscillatory circuits, random access memory (RAM), timers and counters, read only memory (ROM), input/output ports, analogue to digital converter, interfacing ports and digital to analogue converter but varies with its fabrication design. It is best fit for a programmer when the microcontroller is easy to understand, capable of Boolean functions, high performance speed, low cost and small size [9]. Other research [10] mention that projects or design using an output device or a sensor requires a communication medium to a monitor or a computer, one of the way is by using a microcontroller. Since the microcontroller have the input output port features, it is able to obtain the input from the programmer and output the command of the programme. Microcontroller enable various sensors like light sensor, heat sensor, motion or even ultrasonic sensor to interact from the surrounding. Thus, for a microcontroller of an advanced level have a simple hardware interface and programming language. In order to operate the controller must be connected either USB or serial. There are a lower level of microcontroller which requires extra work for hardware connection and programming languages. But for high level microcontroller does cost a lot more than the lower level. The high level microcontroller are similar to Programmable Interface Controller (PIC). PIC microcontroller is the complete set of microcontroller. It enables the programmer to carry out several command or task and also to simulate by using its software respectively. The important device for the user are a computer, software, USB cable and the pre-built circuit or kit [11].

As shown in Table 2.4, IOT is vastly developing the technology for varies application, there are several devices that can carry the application of IOT. One of the microcontroller with the ability to of IOT is Arduino Yun. It contain a built in Wireless Fidelity, Wi-Fi and Ethernet, therefore no external interfaces needed. The advantage is that it does not require an external shield or interface, which is requires more power. Other than that, Raspberry Pi controller also capable of the IOT application but with an external adapter to access the Wi-Fi. Both controller runs in Linux platform. The

adapter or module that is commonly used for the controller are ESP8266. The advantage of the module is it can access any microcontroller with the internet and it also stack with TCP/IP protocol [12].

Table 2.4: Different types of Microcontroller

Brand / Model	Description
Arduino Yun	1. Built-in Ethernet and Wi-Fi connectivity which powered by Atheros AR9331 2. USB communication by using ATmega32u4 . 3. External shield is not required.
Raspberry Pi 3	1. Card sized microcontroller. 2. Wired internet connectivity can access at ethernet port for. 3. Wireless connectivity needs Wifi adapters
ESP8266	1. Microcontroller can access internet by using Wi-Fi module 2. It is integrated with TCP/IP protocol. 3. GPIO pins enable specific application and sensors.

2.3 Wireless Fidelity (WIFI) Signal

Minimum signal strength must be known by the user or developer to ensure the coverage of the area. [14] The best WiFi signal may be distorted by environment, noise, busy network line and also the type of application itself. In order to show the signal strength is by using decibel (dBm) which common for WiFi adapter. Some may use Received Signal Strength Indicator (RSSI).

Measuring in dBm is not the same with the other type of measurement where there might be a positive or negative in indicating whether it is an excellent signal or not. Instead, when working with dBm to know WiFi signal strength is good or not it will always be in negatives value. Thus it has its margin, normally from -30dBm up to -90dBm. The most practical signal strength is around -70 dBm as it is able to browse

the web, sending emails and barcode scanning. But for a better signal of a certain devices like iPhone and Android engineers recommend -65 dBm but -67 dBm is sufficient enough [14] as shown in on Table 2.5. An optimal signal strength is important to ensure a smooth transferring of data.

Besides that, in the decibels scale it will not be linear and gradual as most scale. Hence, it works in algorithm or known as Rule of 3's and 10's. The loss and gain of signal strength will be either +3 dB, -3 dB, +10 dB, or -10dB. The "+" indicates times of gain in the signal and "-" indicate times of loss in the signal. This results in nonlinear gain and loss of signal.

Table 2.5: WiFi Signal Strength

Signal Strength (dBm)	**Indication**	**Packet Delivery Reliability**	**Example Minimum Required Application**
-30	No practical usage, user required to be very close to access point	-	N/A
-65 to -67	Most optimum as it is the minimum signal for most of application	✓	Video Streaming
-70	Minimum signal strength for common internet usage	✓	Web Surfing, Sending Emails
-80	Only able to make basic connection	Unreliable	N/A
-90	Most likely unable to have any functionality	x	N/A

2.4 Fuel Oil Tank Calculation

Calculation, it also varies depending on the end sides of the tank.[14] For the vertically straight ends of tank is easier to calculate the volume. Volume of a vertical cylinder may be much easier as the area of cylindrical are multiplied by the height. However, horizontal tank is more complicated as the volume are not linearly proportional to the height of increment. Figure 2.3 shows the cylindrical tank with flat head. The equation is as shown in equation 2.5. [19] The area of circle and sector are calculated by using equation 2.3 and 2.4 respectively. To obtain the segment area, equation 2.4 minus equation 2.3. Lastly the volume of the tank can be determined by multiplying the length of the tank with the area of the segment that was calculated in equation 2.5. This tank does not required addition calculation as it is a flat head tank. For other type of tank, volume calculation requires additional equation.

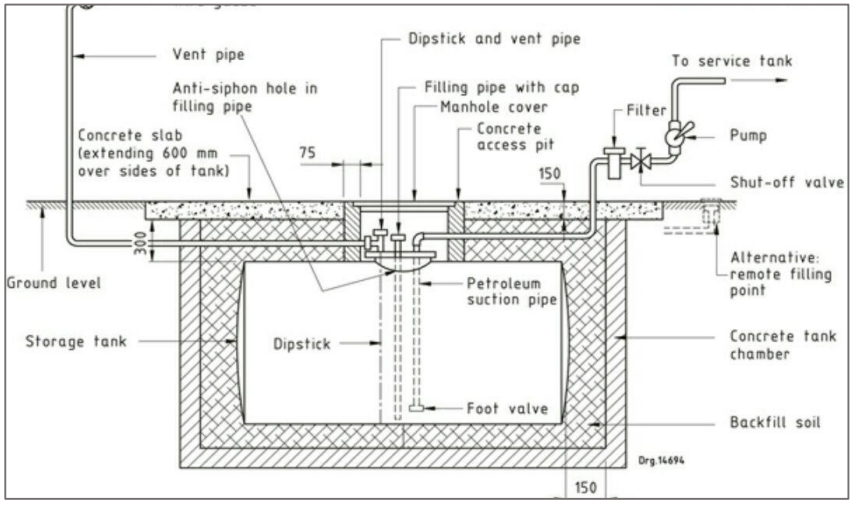


Figure 2.3: Flat Head Tank

$$\theta = 2\cos^{-1}\frac{h}{r}$$

$$\mathbf{A}\,(\text{circle}) = \pi r^2 \tag{2.3}$$

$$\mathbf{A}\,(\text{sector}) = \frac{r^2\theta}{2} \tag{2.4}$$

$$\mathbf{A}\,(\text{segment}) = \mathbf{A}\,(\text{sector}) - \mathbf{A}\,(\text{triangle}) = \frac{r^2(\theta - \sin\theta)}{2} \tag{2.5}$$

$$= r^2\cos^{-1}\frac{(r-d_f)}{r} - (r-d_f)\sqrt{2rd_f - d_f^2}$$

Volume = Length x Area Segment (2.6)

Where,

r = radius of cylindrical tank

df = height of liquid in the tank

For the rounded ends either hemispheric as shown in Figure 2.4 or elliptical head as shown in Figure 2.5, the equation of horizontal cylinder from equation 2.6 need to add with the additional heads equation. Hemispherical head shape are more rounded and the additional equation is as shown in equation 2.7. On the other hand, the third type of tank has an elliptical head, [15] the calculation that will be used are equation 2. 8.

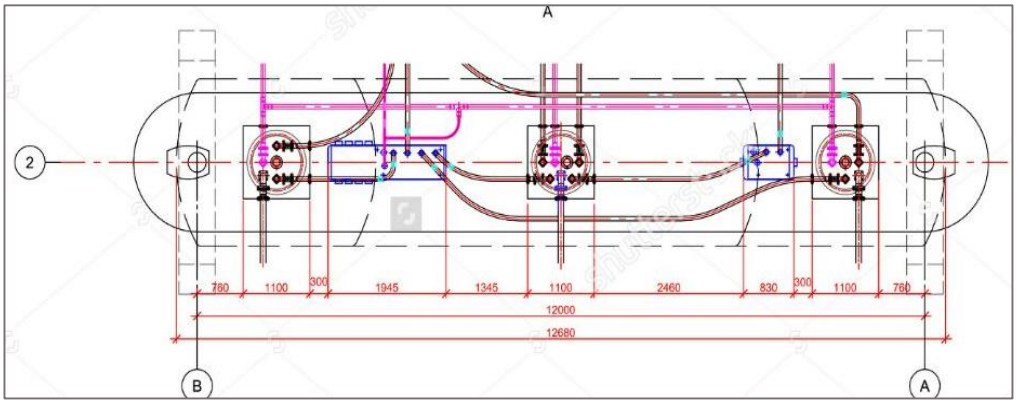


Figure 2.4: Hemispherical Head Tank

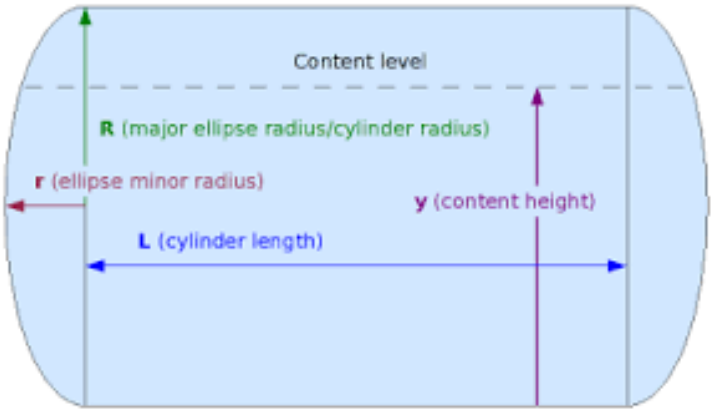


Figure 2.5: Elliptical Head Tank

$$\frac{\pi}{3}h^2(1.5D - h) \tag{2.7}$$

$$\frac{\pi}{6}h^2(1.5D - h) \tag{2.8}$$

Where,

D = Diameter of cylinder heads

h = Height of liquid in the tank

CHAPTER 3

METHODOLOGY

3.0 Introduction

In this chapter, it comprises of activities from the two trimester. The focus of Final Year Project 1, FYP1 is research work, testing device independently, integrate device and troubleshooting. For the subsequent semester Final Year Project 2, FYP 2 is improving monitoring method, improve integrated device, completing the installation and a continuous research which is more focusing on the IOT application on the project. Next this chapter will explain the flow of operation for the program which is illustrated in the diagram. Furthermore, this chapter will illustrate the timeline for both FYP 1 and FYP 2 work submission and work progress.

3.1 Project Activities

Methods use for the first activities are by collecting research papers, site visit to the petrol station, gather the calculation involve to calculate the volume. The side visit that was conducted was at Petron Station in Tronoh, Ipoh-Lumut Highway. The employees were interviewed and the monitoring method implement in the petrol station was demonstrated. Next, obtaining and purchasing the devices. The devices then were tested separately to familiarize and understand the operation. After testing device independently, the devices and controller will be integrated to function as a system. After the assembling, any error were troubleshoot which was occur during programming of the microcontroller.

The programme include calculations involve for the calculation of the tank. After having improvement on the programme of system, the monitoring method was integrated with real time programme operation as well. Lastly, will be the complete installation of the project. The overall project activities as illustrated in Figure 3.1.

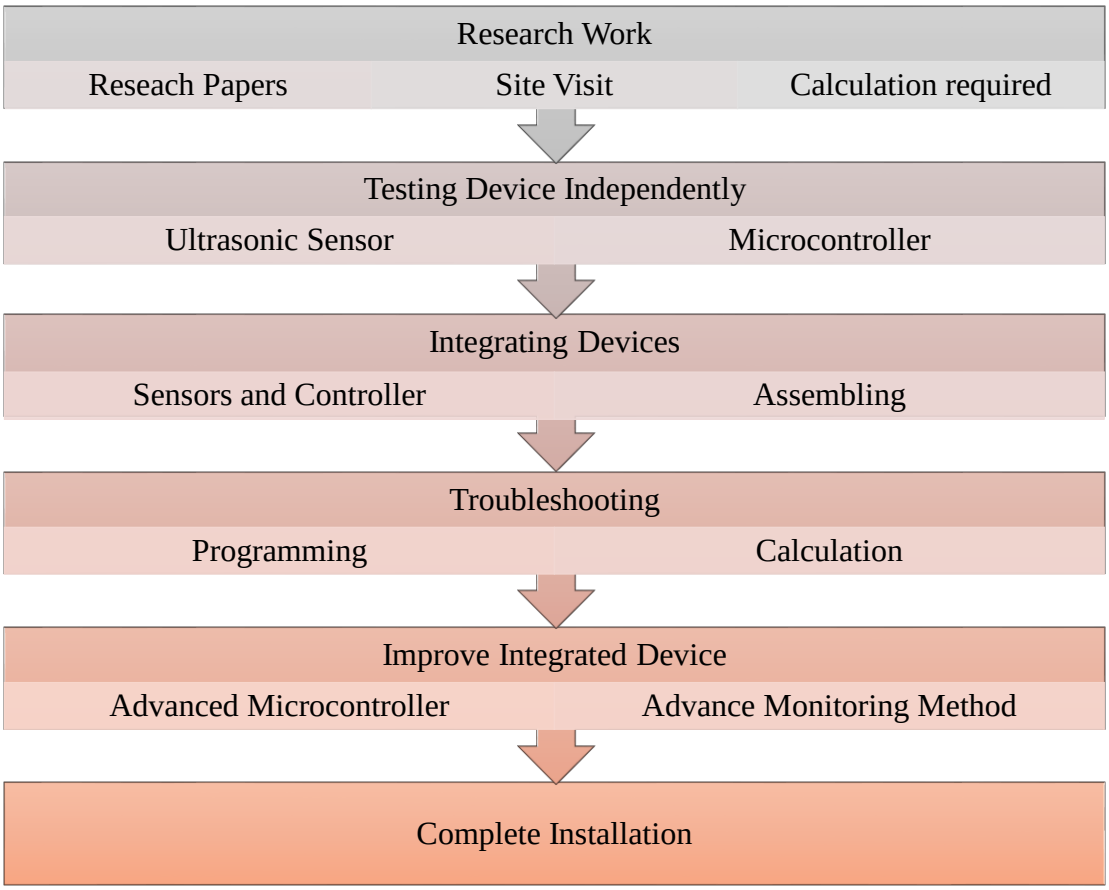


Figure 3.1: Overall Project Activity

FYP 1 project activity is to complete the physical part which is building the prototype, obtaining the calculation required and completing the programming for the microcontroller used. The first activity is sketching and design the prototype, by referring to the current underground tank with flat sides. The design requires a suitable place to position the ultrasonic and a proper base to ensure the tank is stable. Next, building the prototype of the tank and continue with the programming part of the project. The testing of ultrasonic is required to see the actual range that the ultrasonic can measure.

Lastly, writing the programming code with respect to the calculation for the prototype of the tank. Therefore, in FYP 2 the project is focusing more on the improving of the monitoring method which is implementing the online monitoring with implementing the IOT. Thus, FYP 2 required further research on IOT application which enable to receive the data from the sensor to display in the websites to achieve the online monitoring. The project activity for FYP 1 and FYP 2 are as illustrated in Figure 3.2 and Figure 3.3 respectively.

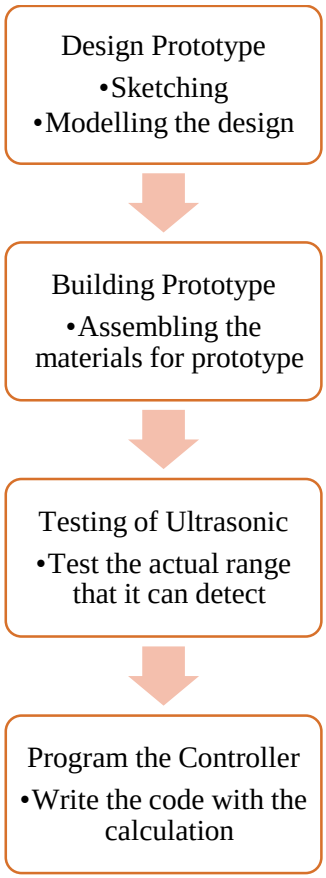


Figure 3.2: FYP 1 Project Activity

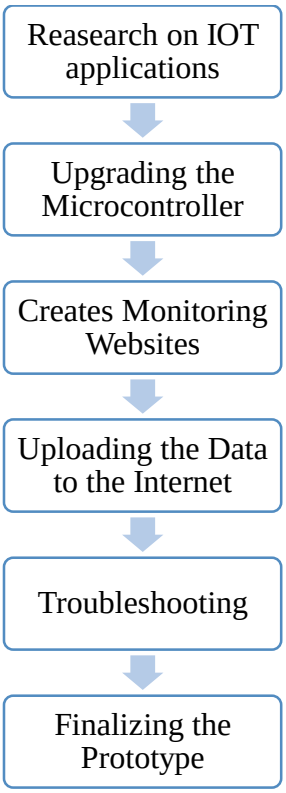


Figure 3.3: FYP 2 Project Activity

3.2 Flow of Operation

Flow chart as shown in the Figure 3.4 illustrated the operation of the programming for the project. The programme will have a predetermined and initialized application program interface, API key and WiFi. The API key are obtain from the website that have been establish and generate the API key. Other definition that was is important in the programme are the ultrasonic input and output pin number. After all constants was define, the programme can start and make connection to the WiFi, if the connection is not establish it will start back from beginning. Next after the connection have established the microcontroller will command the ultrasonic to send trigger frequency signal and wait until the receiver receive back the reflected signal. The speed value obtain by the ultrasonic are converted to distance. Then, the distance are uses to calculate the volume of current oil level by using equation 2.6. After all data was obtain, the volume are display or prompt in the serial monitor and the website will generate the graph corresponds to the volume over time.

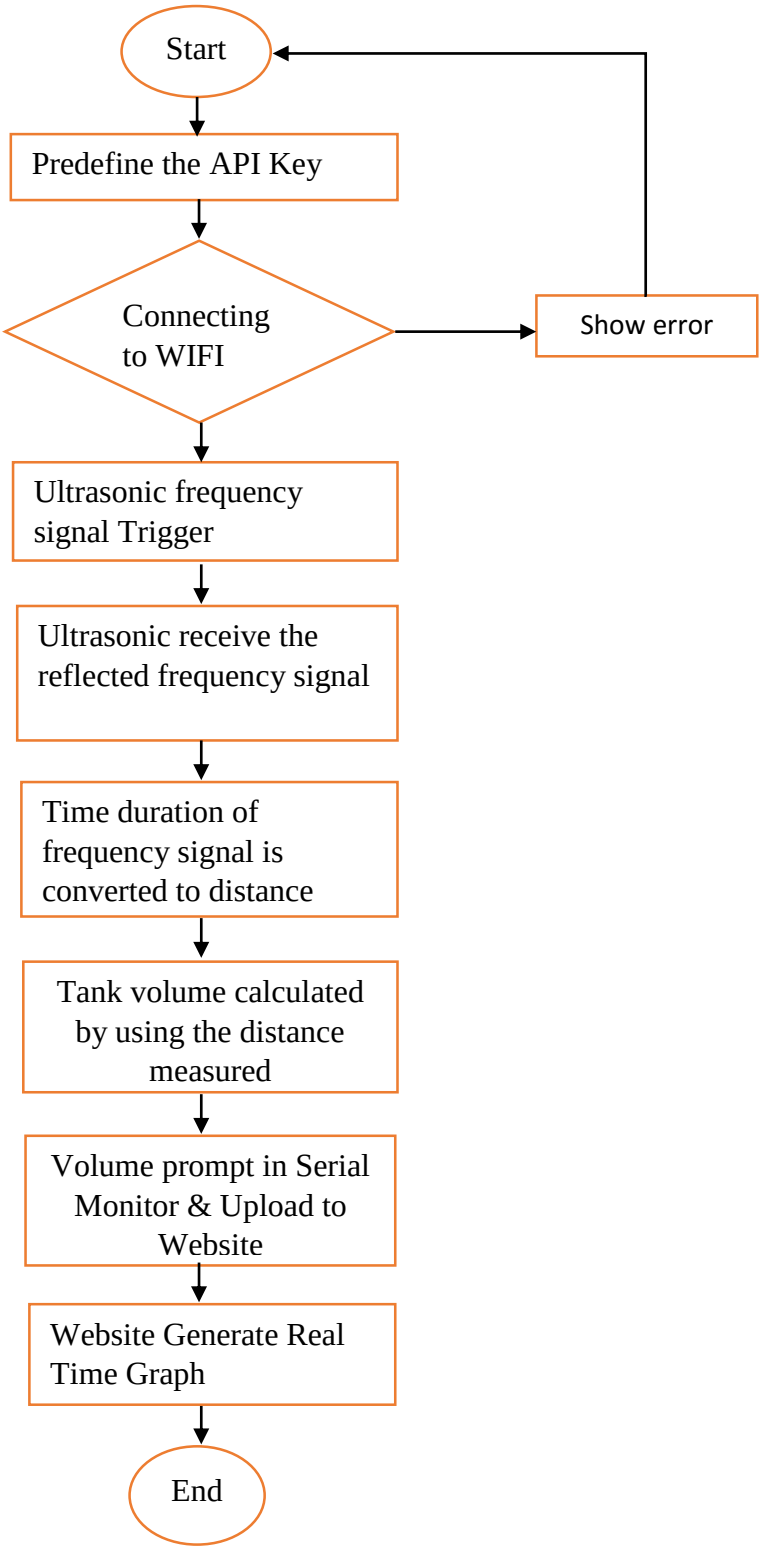


Figure 3.4: Programming Flow Chart

3.3 Gantt Chart

Table 3.1 and Table 3.2 are the overall activity and the timeline throughout Final Year Project I, FYP I and Final Year Project II, FYP II. The overall prototype was completed in the first semester, and the finalize system with the integrated coding and IOT application was accomplished on the second semester.

Table 3.1: FYP 1 Work Project Timeline

No	Details/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1.	Research Work														
2.	Submission Extended Proposal														
3.	Puchasing & obtaining items														
4.	Proposal Defence														
5.	Testing Device														
6.	Program coding with calculation														
7.	Troubleshooting														
8.	Submission of Interim Report														

Table 3.2: FYP 2 Work Project Timeline

No	Details/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Research Work Continues (IOT)															
2.	Improve Monitoring Method															
3.	Buy or Test the Free Websites															
4.	Submission of Progress Report															
5.	Testing Prototype with the Monitoring Method															
6.	Troubleshooting															
7.	Finalize the Complete Prototype															
8.	Submission of Dissertation															
9.	Submission of Technical Paper															
10.	Submission of Project Dissertation (Hard Bound)															

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

Chapter 4 will show the results obtain throughout the project. It is divided to 5 section starting with prototype design, selected microcontroller and sensor with its specification, ultrasonic measurement testing, testing embedded ESP 8266 in Arduino and the results from the overall prototype after integrating all the devices. Based from the results all the data are able to upload to the website and be monitor as real time monitoring. The calculation for each 0.01 cm increment for the tank were calculated and tabulated in Appendix A. Appendix A and a ruler are used to verify the volume obtain from the ultrasonic.

4.1 Prototype Design

All the item needed to build the prototype was able to obtain and assemble. The type of material chosen for the frame of the tank are PVC pipe with a diameter of 22 cm. Next, the microcontroller use for testing are Arduino Uno, it is obtain by online purchasing. For the purpose of testing in program the code, Arduino Uno is sufficient to use. Hence, for the IOT application, a compatible microcontroller are needed to achieve the online monitoring. Lastly the sensor, ultrasonic sensor was purchase in the local electronic store. All the items was assemble and tested accordingly, together with the calculation of the tank. There are few step in the calculation in order to obtain the right volume.

As for the calculation of volume, the controller are able to compute the volume with respect to the height of the oil level. The project progress is according to the project activity for FYP I and FYP II. The early stage of designing the prototype is by sketching the overall connection from the tank to the microcontroller and lastly to the monitor to display the results as shown in Figure 4.1.The sketch shows the side of the tank is visible to observe the fuel oil level in the tank. Next, the design was draw into 2 dimension (2D) with side, top and front view as shown in sthe Figure 4.2, 4.3, and 4.4. Lastly, the 3D Modelling of the tank are as shown in Figure 4.5

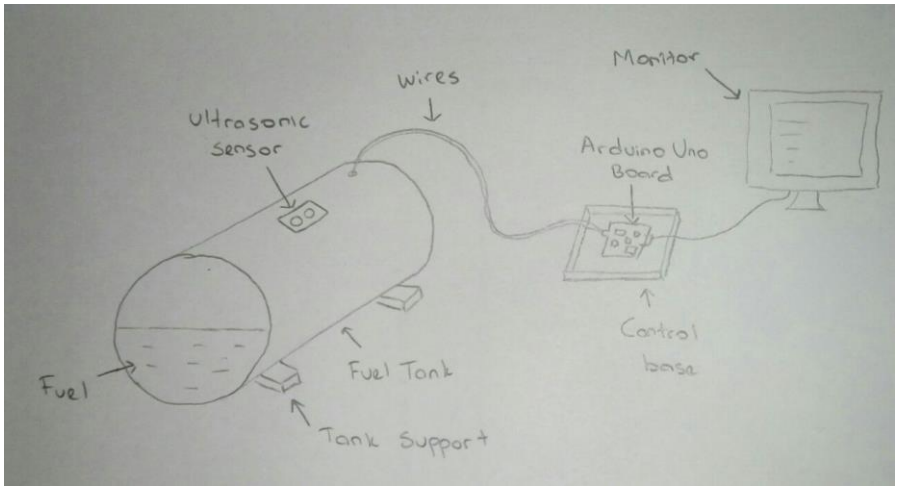


Figure 4.1: Sketching of Prototype

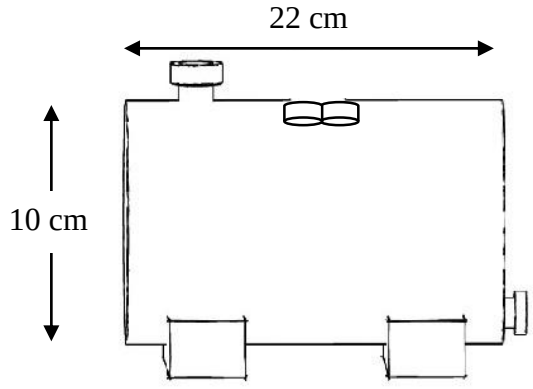


Figure 4.2: Side View of the Tank with Ultrasonic in the middle of the Tank

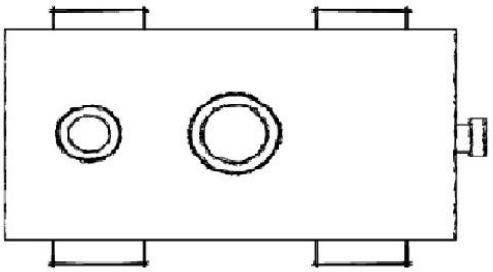


Figure 4.3 Top View of the Tank

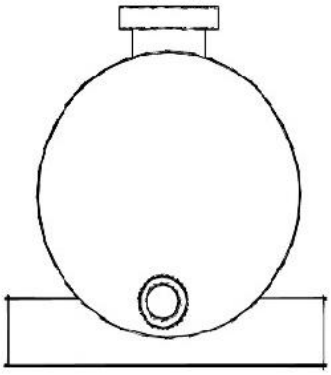


Figure 4.4: Front View of the Tank

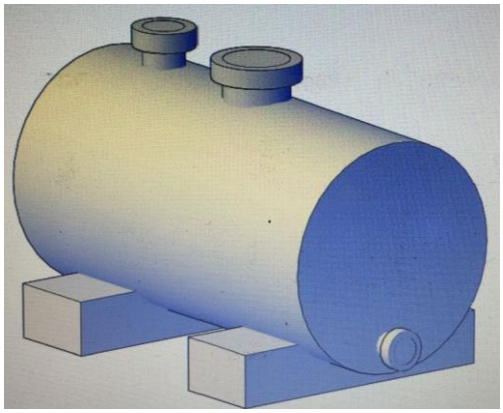


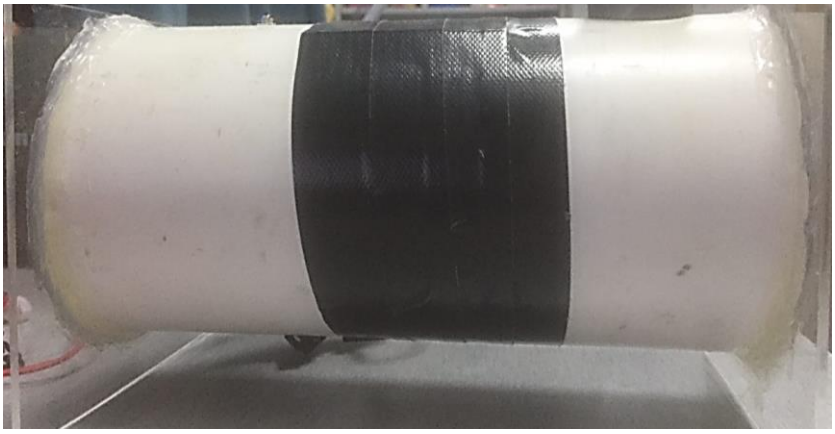
Figure 4.5: 3D Modelling

4.1.1 Polyvinyl Chloride

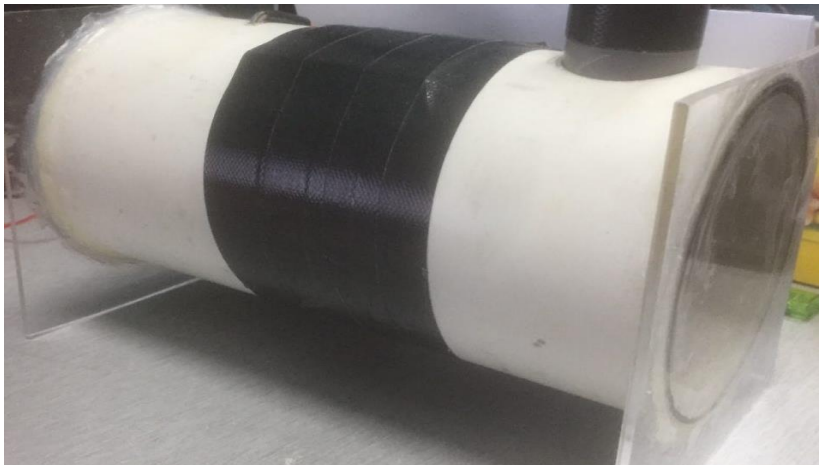
The Polyvinyl Chloride, PCV is lightweight and easy to obtain, it also durable and will not be affected by the fuel. It is cheaper to compare with a custom made or any metal material. Thus, it is suitable with the budget allocated. The hollow ends enable to customs any type of material for the ends of PVC tube. Holes were made with appropriate size for fuel inlet, ultrasonic placement and for wires passageway. All holes that were made were sealed using tapes and silicone glue to ensure there no leakage. Dimension of the tank is 10cm x 22cm x 0.1cm for its diameter, length, and thickness as shown in Figure 4.6.

4.1.2 Perspex

The Perspex seals the end to end of the PVC tube. The advantage of the perspex is the transparency and durability similar to glass. It is cheaper and easier to handle and obtain in the lab. The reason of using perpex at the ends of PVC tube is to observe the actual fuel level height for verification and compare with the height obtain from ultrasonic sensor. Perspex size is a square which is 13.5cm x 13.5cm. Therefore, the prototype of the tank is a flat head horizontal tank as shown in Figure 4.6.



(a)



(b)

Figure 4.6: (a) Side View (b) Prototype of the tank

4.2 Microcontroller and Sensor Specification

The ultrasonic sensor are connected to the pins of the Wemos microcontroller and the microcontroller are powered by the monitor or laptop. The sensor were inserted in the tank before sealing the tank. An extension of wires was used from the sensor to the microcontroller. It allows the microcontroller to be place outside of the tank and not inside the tank. The dimension and type of microcontroller and sensor as shown in Figure 4.7.

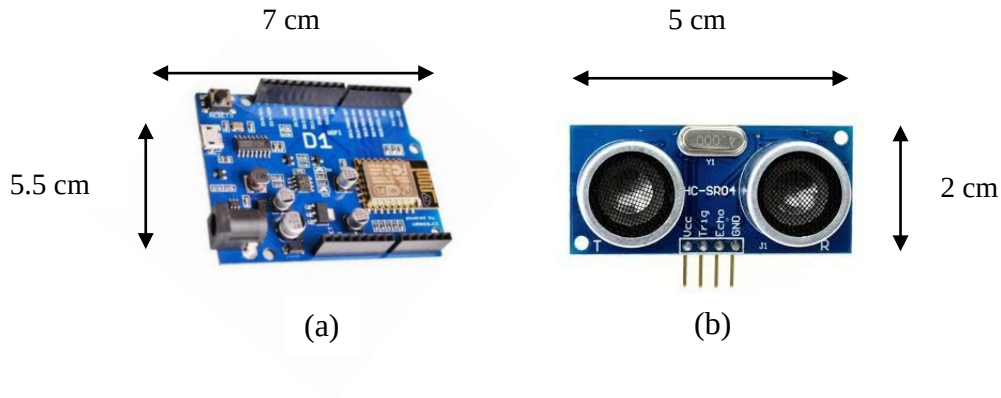


Figure 4.7: (a)Wemos Microcontroller (b) Ultrasonic Sensor

4.3 ULTRASONIC MEASUREMENT TESTING

The testing of ultrasonic take place inside the tank and result of the height was tabulated in Table 4.1. A ruler is place to verify the height obtain from the ultrasonic. Based on the results obtain in the Serial Monitor, there are only 1% to 3% difference of the actual measurement and the measurement obtain from the ultrasonic. Thus, these slight percentage difference are negligible for the next volume calculation.

Table 4.1: Results from Ultrasonic Testing

NO	MEASUREMENT WITH RULER [CM]	ULTRASONIC SENSOR [CM]
1	1.00	1.03
2	2.00	1.98
3	3.00	2.97
4	4.00	4.00
5	5.00	4.99

4.4 FUEL OIL CALCULATION

The variables that was taken into consideration are the setting of the full level height, and the calculation that need to be included. The trig pin of sensor was set to output as it will transmit the signal. Next the echo pin was set to input as it will receive back the reflected signal from the surface of the fuel oil as shown in Figure 4.8. The sound wave transmitted will took microseconds, hence in order to translate to distance, the travel duration of the sound wave need to be multiply with 0.034 and divide by 2 as shown in Figure 4.9 by using equation 2.2. Thus, we can obtain the height from the sensor to the surface of fuel. But to calculate the volume, the total height need to subtract the distance obtain previously. Therefore, we can calculate the volume of fuel oil as shown in Figure 4.10 by using equation 2.6.

```
void setup()
{
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  Serial.begin(9600); // Starts the serial communication
}
```

Figure 4.8: TrigPin and EchoPin Setting

```
  // Reads the echoPin, returns the sound wave travel time in microseconds
  duration = pulseIn(echoPin, HIGH);

// Calculating the distance
distance= duration*0.034/2;
```

Figure 4.9: Obtain the Distance between Ultrasonic and Surface of Fuel

```
//calculate the actual oil height, respect to container's height excluding sensor height
 h= full - distance;

 volume= l*(sq(r)*acos((r-h)/r)-(r-h)*sqrt(2*r*h-sq(h)));
```

Figure 4.10: Actual Height and Volume of Fuel

4.5 Testing Embedded ESP 8266 in WEMOS Microcontroller

WeMos brand has the embedded Arduino and Wifi Module ESP8266. It is the most suitable for the project application. For this section, the testing was done to check the strength of WiFi signal and testing IOT application by uploading some data to the Website.

4.5.1 Wifi Strength Connection Testing

WeMos module was able to scan the Wifi around it with its signal strength which is the number in the bracket. It also detect whether it is a free access or required password which was remarks as encrypted. Based on [14], the signal strength is nonlinear in terms of gaining or loss of signal. If the signal is in the range of -65 dBm to -70 dBm, the application will operate smoothly. The scanning are able to detect the surrounding WiFi and remark any WiFi that requires password. The remark are written "ENCRYPTED" as shown in Figure 4.11. The best signal that can be obtain is WiFi number 4 due to its range from -68 to -72.

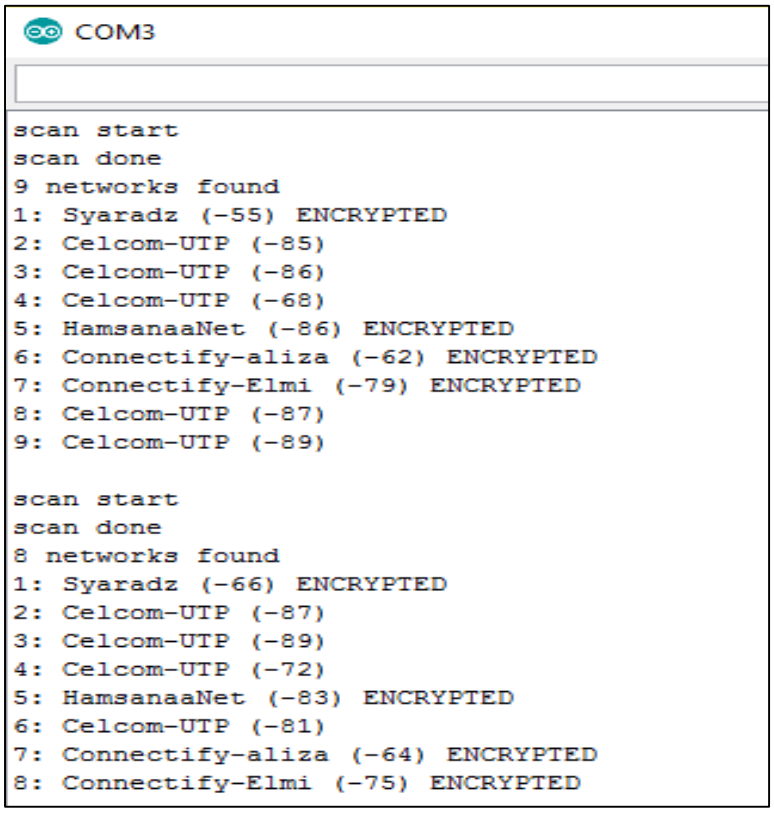


Figure 4.11: Wifi Scanning

4.5.2 Testing IOT Application

After the Wifi Scanning, the Web was created using ThingSpeak.com which is a free website. Thing Speak, TS can receive data, upload data, collect data and generate a graph correspond to the data received. For this testing, the manipulated variable used was a simple potentiometer circuit as shown in Figure 4.12. This circuit was chosen in the testing instead of the actual oil in the tank is that it is easier to manipulate and control the value for the testing. Potentiometer signal pin is connected to A0 of the Arduino. The circuit and module was place about 17 meter away from the monitor (PC). The value are able to increase and decrease by using the potentiometer knob.

Based on the following results, it can be conclude that the percentage difference from all the results is less than 10% and mostly with minimal difference as shown in Figure 4.13. Result obtain by arduino is 416 ohm and the data uploaded is 414ohm making a 0.4% difference as shown in Figure 4.13 (a).The second results have a difference of 8.5% with a slight higher value in the website as shown in Figure 4.13 (b). The third results in Figure 4.13 (c) have a 0.53% difference with a slight higher value uploaded compare to the serial monitor. The last result as shown in Figure 4.13 (d) the result obtain from the serial monitor and the value in the website is the same with zero percentage difference. Thus from these results it shows that the data uploaded to the website have a minimal percentage error of 0.53% to 8.5%. The IOT application was also able to accomplish by uploading the data from microcontroller to the website through an establish WiFi connection. Thus, after completing the testing, next is to integrate the ultrasonic sensor with WeMos microcontroller.

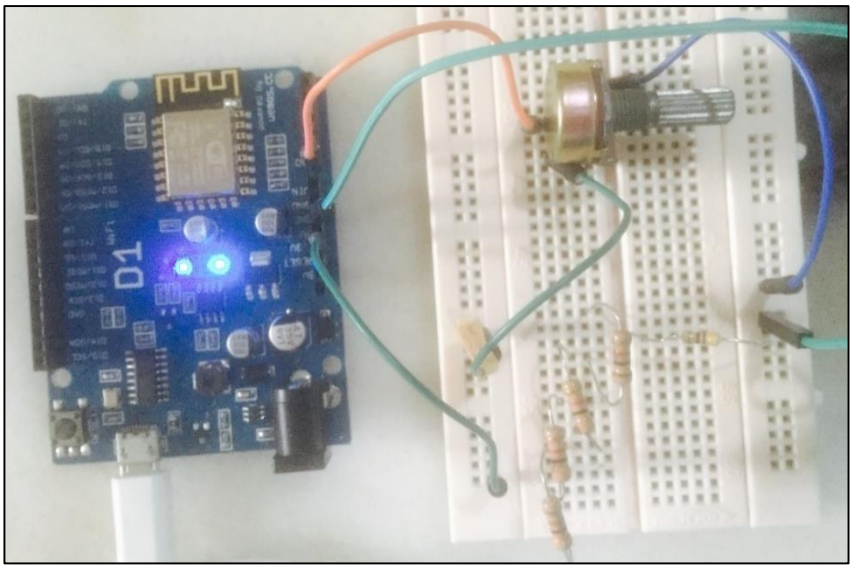
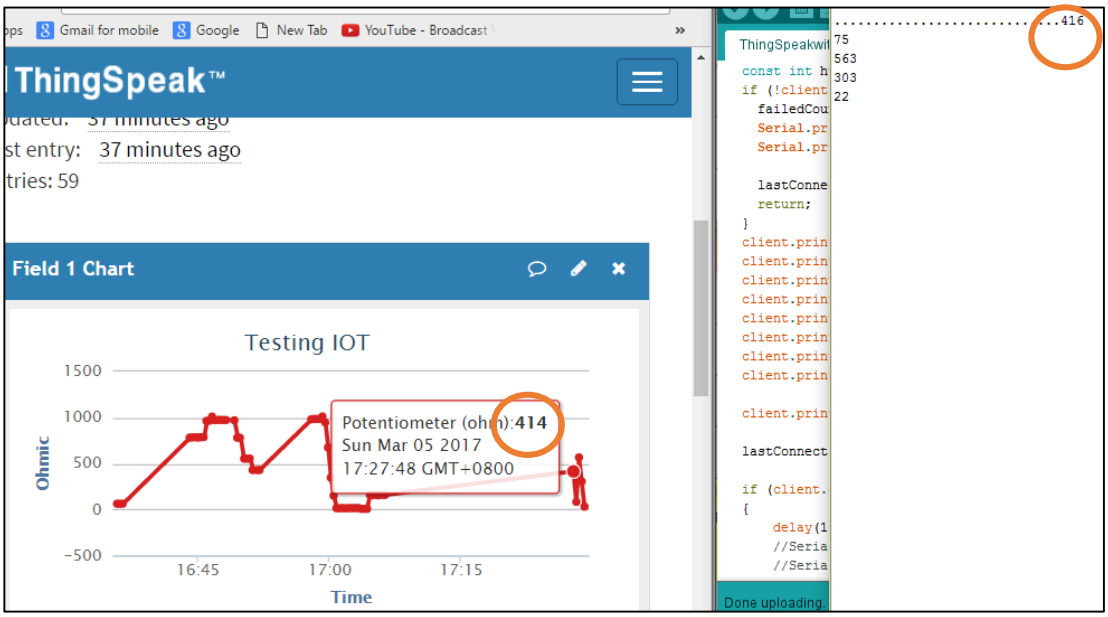
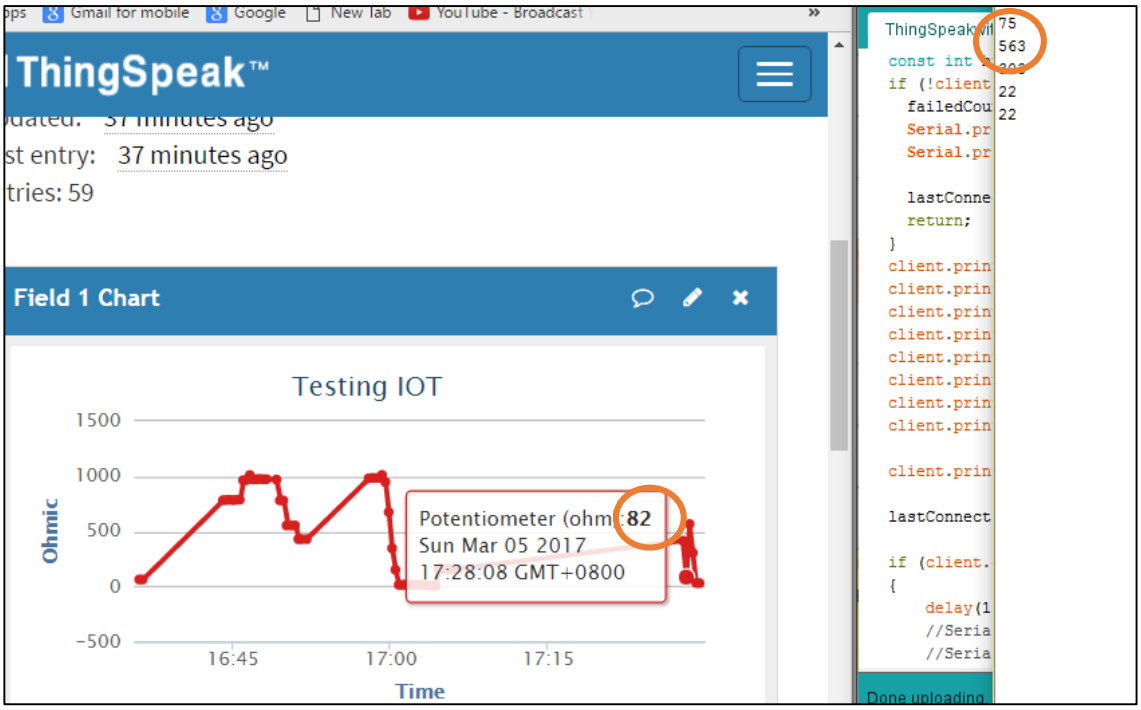


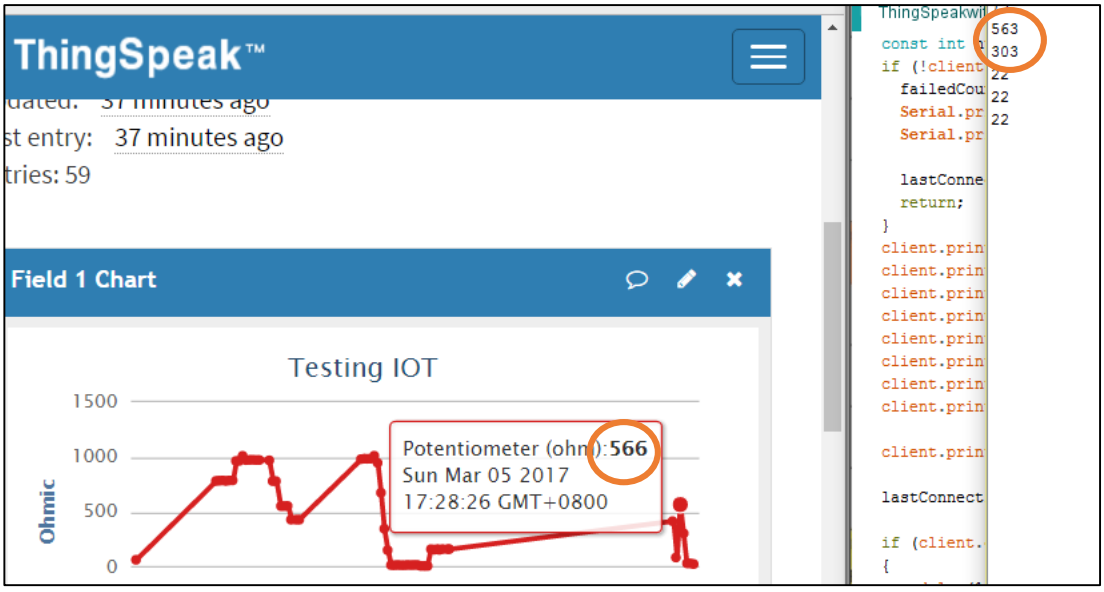
Figure 4.12: Potentiometer Circuit



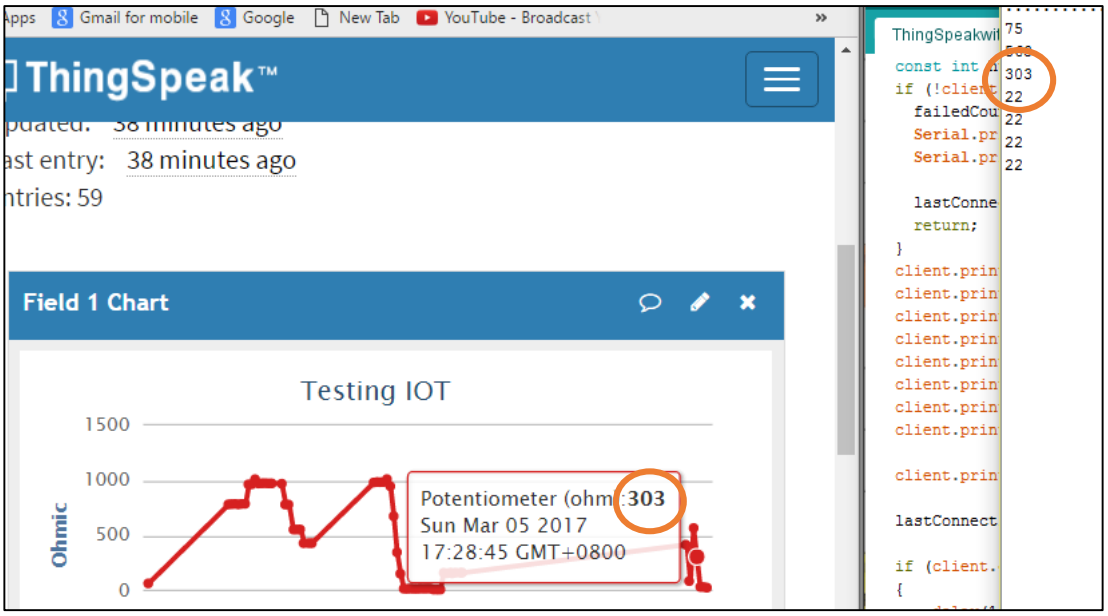
(a) Results at 416 Ohm



(b) Results at 75 Ohm



(c) Results at 563 Ohm



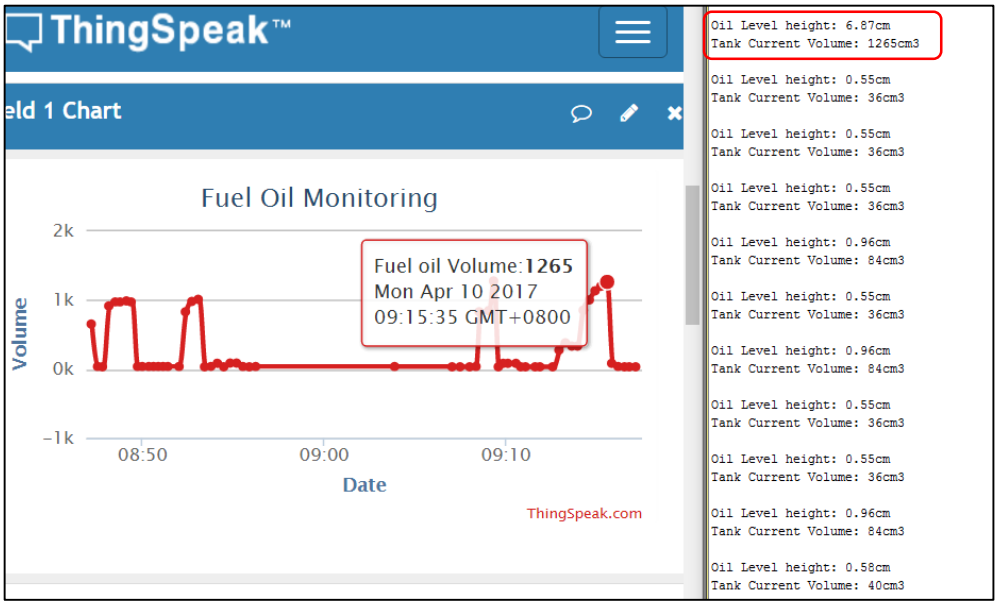
(d) Results at 303 Ohm

Figure 4.13: (a),(b),(c), (d) Comparing Result from Serial Monitor with TS

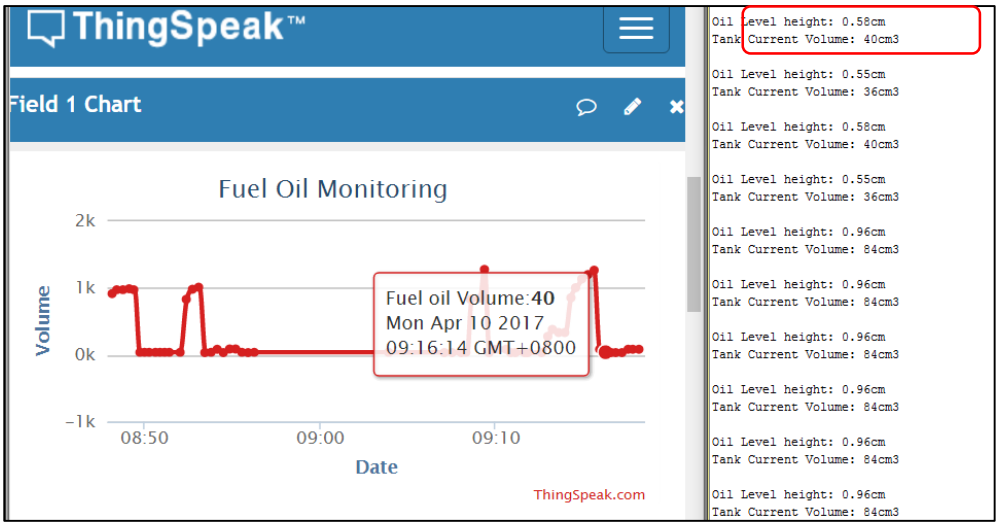
4.6 Integrating Device in the Tank

To ensure the measurements of the ultrasonic are correct, an early calculation of the prototype volume was tabulated. The calculation started from 0 cm to 10 cm of height using the formula in equation 2.6. The volume of horizontal tank can be refer in Appendix A. The finalized programme code can be refer in Appendix B. The programme code was compiled and run to WEMOS microcontroller and the results are obtain as shown in Figure 4.14. In Figure 4.14 (a) to (e) the volume obtain is 1265 cm3, 40 cm3, 84 cm3, 489 cm3 and 1013 cm3 respectively. Thus, from the measurement obtain, it is found that the measurement of volume that is obtain in the serial monitor is accurate with the data uploaded in the website. The interval of the data uploaded is 1 minute thus there will be 3 to 4 data obtain from the serial monitor before the next data uploaded to the website .

The following step is to verify the volume obtain, therefore volume obtain is compared with the calculated data in Appendix A. the results as shown in Figure 4.15. Figure 4.15 (a) the height of oil is 0.55cm, 0.58cm and 0.96 cm3 and the volume obtain are 36cm3, 40 cm3 and 84 respectively. Referring to the Appendix A the volume are mostly accurate with a percentage difference of 0.6% to 2.7% .The second results shows the height of 3.26cm, 5.62 cm, 5.68cm, and 5.70 cm. The volume obtain are 489 cm3, 998 cm3, 1013 cm3 and 1017 cm3. The percentage difference for these value are 0.02% to 0.07% which are less than 1%. Thus the value obtain are mostly accurate with the actual calculated volume.

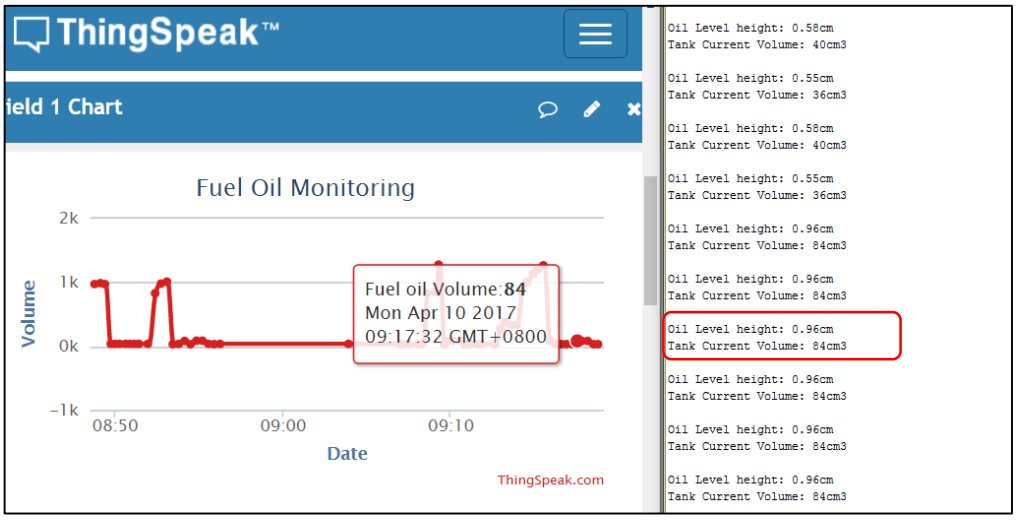


(a) Fuel Oil Volume at 6.87cm

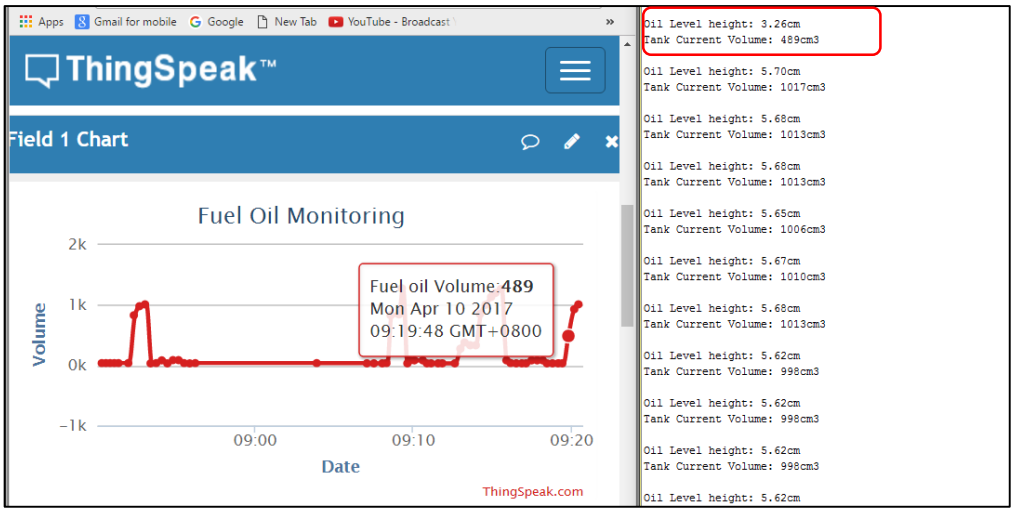


.

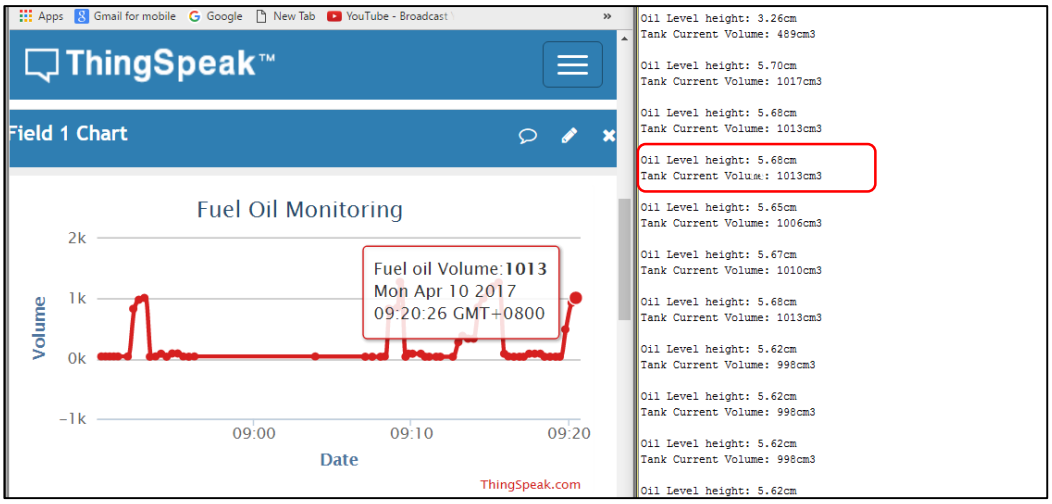
(b) Fuel Oil Volume at 0.56cm



(c) Fuel Oil Volume at 0.96cm

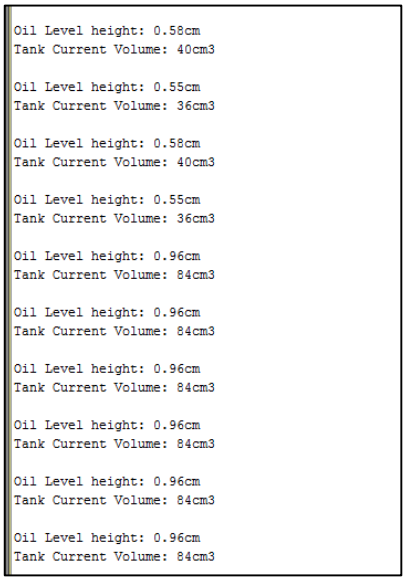


(d) Fuel Oil Volume at 3.26cm



(e) Fuel Oil Volume at 5.68cm

Figure 4.14: (a),(b),(c),(d) and (e) Tank Volume from Serial Monitor to TS



5	22	0.55	11.84	10.14512167	37.2054597
5	22	0.56	11.95	10.20852463	38.21285172
5	22	0.57	12.05	10.27062802	39.22874072
5	22	0.58	12.16	10.33146045	40.25303734

5	22	0.96	15.75	11.90148619	84.69298365
5	22	0.97	15.84	11.92709802	85.99219503
5	22	0.98	15.92	11.95204886	87.29739786

(a) Volume from 0.55cm to 0.58cm and 0.96cm of Height

5	22	3.25	30.33	8.196559873	486.9495555
5	22	3.26	30.38	8.15620244	489.0112251
5	22	5.61	42.33	-3.027216806	997.804327
5	22	5.62	42.38	-3.076074876	999.9876213
5	22	5.63	42.43	-3.124895261	1002.170366
5	22	5.64	42.48	-3.173677337	1004.352551
5	22	5.65	42.53	-3.22242048	1006.534169
5	22	5.66	42.58	-3.271124064	1008.71521
5	22	5.67	42.63	-3.319787462	1010.895665
5	22	5.68	42.68	-3.368410046	1013.075525
5	22	5.69	42.73	-3.41699119	1015.254781
5	22	5.70	42.78	-3.465530262	1017.433424

(b) Volume from 3.26cm to 5.70cm of Height

Figure 4.15: (a) and (b) Comparing Measured Volume with Calculated Data

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The objective of this project is to improve the oil level monitoring specifically in petrol station. The current method used are normally the manual technique, which allows the person undertaking the job to be exposed to hazard. Besides that, the current digitize method are using a more expensive type of measuring device, which is the combination of mechanical movement and electrical circuit. By substituting the current method with ultrasonic, it is hope to be better and cheaper measuring method. It is proven that ultrasonic to be accurate measuring device and also less expensive. This project is able to expand, especially in the monitoring side. It is viable for development with the use of more advance and compatible microcontroller for this matter. It allows the data to be uploaded in the internet and captures the current fuel oil level. The expected results is to have more convenience monitoring method by using cheaper measuring device like ultrasonic. Thus, the value of measured volume are considered accurate with the absence of decimal places. This is proven by comparing the measured volume with the calculated volume using the horizontal tank calculation. Besides that, real time monitoring are able to accomplish and thus improving the monitoring method.

For recommendation, it is also require further study on building a suitable interface in order to make it user friendly product. Besides that, a private website to upload the data for a better security. Thus, this requires an additional research on the type of controller and programming knowledge which fit the criterion.

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APPENDICES

APPENDIX A: Calculated Volume

Horizontal Tank Volume			
Radius (cm)	Length (cm)	Fuel Height (	Volume (cm3)
5	22	0.00	0
5	22	0.01	0.092732312
5	22	0.02	0.262207834
5	22	0.03	0.481561822
5	22	0.04	0.741190023
5	22	0.05	1.035532919
5	22	0.06	1.36083358
5	22	0.07	1.714329721
5	22	0.08	2.093877842
5	22	0.09	2.497750786
5	22	0.10	2.924517558
5	22	0.11	3.372966803
5	22	0.12	3.842055439
5	22	0.13	4.330872701
5	22	0.14	4.83861412
5	22	0.15	5.364562149
5	22	0.16	5.908071417
5	22	0.17	6.468557261
5	22	0.18	7.045486666
5	22	0.19	7.638370993
5	22	0.20	8.246760065
5	22	0.21	8.870237307
5	22	0.22	9.508415704
5	22	0.23	10.16093441
5	22	0.24	10.82745587
5	22	0.25	11.5076634
5	22	0.26	12.20125905

5	22	0.27	12.90796182
5	22	0.28	13.62750607
5	22	0.29	14.35964012
5	22	0.30	15.10412509
5	22	0.31	15.86073379
5	22	0.32	16.62924977
5	22	0.33	17.40946652
5	22	0.34	18.20118666
5	22	0.35	19.00422131
5	22	0.36	19.81838946
5	22	0.37	20.64351744
5	22	0.38	21.47943838
5	22	0.39	22.32599183
5	22	0.40	23.18302329
5	22	0.41	24.05038388
5	22	0.42	24.92792994
5	22	0.43	25.81552281
5	22	0.44	26.71302843
5	22	0.45	27.62031718
5	22	0.46	28.53726356
5	22	0.47	29.46374602
5	22	0.48	30.3996467
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5	22	5.87	1054.367741
5	22	5.88	1056.533791
5	22	5.89	1058.699055
5	22	5.90	1060.863522
5	22	5.91	1063.027185
5	22	5.92	1065.190033
5	22	5.93	1067.352057
5	22	5.94	1069.513249
5	22	5.95	1071.673598
5	22	5.96	1073.833095
5	22	5.97	1075.991732
5	22	5.98	1078.149499
5	22	5.99	1080.306386
5	22	6.00	1082.462385
5	22	6.01	1084.617485
5	22	6.02	1086.771678

5	22	6.03	1088.924954
5	22	6.04	1091.077304
5	22	6.05	1093.228718
5	22	6.06	1095.379187
5	22	6.07	1097.528701
5	22	6.08	1099.677252
5	22	6.09	1101.824829
5	22	6.10	1103.971423
5	22	6.11	1106.117025
5	22	6.12	1108.261625
5	22	6.13	1110.405214
5	22	6.14	1112.547782
5	22	6.15	1114.68932
5	22	6.16	1116.829818
5	22	6.17	1118.969266
5	22	6.18	1121.107656
5	22	6.19	1123.244976
5	22	6.20	1125.381219
5	22	6.21	1127.516374
5	22	6.22	1129.650431
5	22	6.23	1131.783382
5	22	6.24	1133.915215
5	22	6.25	1136.045923
5	22	6.26	1138.175494
5	22	6.27	1140.303919
5	22	6.28	1142.431189
5	22	6.29	1144.557294
5	22	6.30	1146.682223
5	22	6.31	1148.805968
5	22	6.32	1150.928519
5	22	6.33	1153.049865
5	22	6.34	1155.169997

5	22	6.35	1157.288905
5	22	6.36	1159.406579
5	22	6.37	1161.52301
5	22	6.38	1163.638186
5	22	6.39	1165.7521
5	22	6.40	1167.86474
5	22	6.41	1169.976096
5	22	6.42	1172.08616
5	22	6.43	1174.19492
5	22	6.44	1176.302367
5	22	6.45	1178.40849
5	22	6.46	1180.513281
5	22	6.47	1182.616728
5	22	6.48	1184.718821
5	22	6.49	1186.819551
5	22	6.50	1188.918908
5	22	6.51	1191.01688
5	22	6.52	1193.113459
5	22	6.53	1195.208634
5	22	6.54	1197.302394
5	22	6.55	1199.39473
5	22	6.56	1201.485632
5	22	6.57	1203.575088
5	22	6.58	1205.66309
5	22	6.59	1207.749625
5	22	6.60	1209.834685
5	22	6.61	1211.918259
5	22	6.62	1214.000336
5	22	6.63	1216.080907
5	22	6.64	1218.15996
5	22	6.65	1220.237485
5	22	6.66	1222.313472

5	22	6.67	1224.387911
5	22	6.68	1226.46079
5	22	6.69	1228.5321
5	22	6.70	1230.60183
5	22	6.71	1232.669969
5	22	6.72	1234.736506
5	22	6.73	1236.801432
5	22	6.74	1238.864734
5	22	6.75	1240.926404
5	22	6.76	1242.98643
5	22	6.77	1245.0448
5	22	6.78	1247.101506
5	22	6.79	1249.156535
5	22	6.80	1251.209877
5	22	6.81	1253.261521
5	22	6.82	1255.311457
5	22	6.83	1257.359673
5	22	6.84	1259.406159
5	22	6.85	1261.450903
5	22	6.86	1263.493895
5	22	6.87	1265.535123
5	22	6.88	1267.574578
5	22	6.89	1269.612246
5	22	6.90	1271.648118
5	22	6.91	1273.682183
5	22	6.92	1275.714429
5	22	6.93	1277.744845
5	22	6.94	1279.77342
5	22	6.95	1281.800142
5	22	6.96	1283.825001
5	22	6.97	1285.847986
5	22	6.98	1287.869084

5	22	6.99	1289.888284
5	22	7.00	1291.905576
5	22	7.01	1293.920947
5	22	7.02	1295.934386
5	22	7.03	1297.945883
5	22	7.04	1299.955424
5	22	7.05	1301.962999
5	22	7.06	1303.968596
5	22	7.07	1305.972204
5	22	7.08	1307.973811
5	22	7.09	1309.973405
5	22	7.10	1311.970974
5	22	7.11	1313.966507
5	22	7.12	1315.959992
5	22	7.13	1317.951416
5	22	7.14	1319.94077
5	22	7.15	1321.928039
5	22	7.16	1323.913213
5	22	7.17	1325.896279
5	22	7.18	1327.877225
5	22	7.19	1329.85604
5	22	7.20	1331.832711
5	22	7.21	1333.807226
5	22	7.22	1335.779573
5	22	7.23	1337.74974
5	22	7.24	1339.717714
5	22	7.25	1341.683484
5	22	7.26	1343.647036
5	22	7.27	1345.608358
5	22	7.28	1347.567439
5	22	7.29	1349.524265
5	22	7.30	1351.478824

5	22	7.31	1353.431104
5	22	7.32	1355.381092
5	22	7.33	1357.328775
5	22	7.34	1359.27414
5	22	7.35	1361.217176
5	22	7.36	1363.157868
5	22	7.37	1365.096205
5	22	7.38	1367.032173
5	22	7.39	1368.96576
5	22	7.40	1370.896952
5	22	7.41	1372.825737
5	22	7.42	1374.752101
5	22	7.43	1376.676032
5	22	7.44	1378.597516
5	22	7.45	1380.51654
5	22	7.46	1382.43309
5	22	7.47	1384.347154
5	22	7.48	1386.258718
5	22	7.49	1388.167769
5	22	7.50	1390.074292
5	22	7.51	1391.978276
5	22	7.52	1393.879705
5	22	7.53	1395.778567
5	22	7.54	1397.674848
5	22	7.55	1399.568534
5	22	7.56	1401.459611
5	22	7.57	1403.348065
5	22	7.58	1405.233883
5	22	7.59	1407.11705
5	22	7.60	1408.997553
5	22	7.61	1410.875377
5	22	7.62	1412.750508

5	22	7.63	1414.622933
5	22	7.64	1416.492636
5	22	7.65	1418.359603
5	22	7.66	1420.223821
5	22	7.67	1422.085273
5	22	7.68	1423.943947
5	22	7.69	1425.799828
5	22	7.70	1427.6529
5	22	7.71	1429.503149
5	22	7.72	1431.35056
5	22	7.73	1433.195119
5	22	7.74	1435.03681
5	22	7.75	1436.875619
5	22	7.76	1438.711529
5	22	7.77	1440.544528
5	22	7.78	1442.374598
5	22	7.79	1444.201725
5	22	7.80	1446.025893
5	22	7.81	1447.847087
5	22	7.82	1449.665291
5	22	7.83	1451.480491
5	22	7.84	1453.292669
5	22	7.85	1455.101811
5	22	7.86	1456.907901
5	22	7.87	1458.710922
5	22	7.88	1460.510859
5	22	7.89	1462.307695
5	22	7.90	1464.101415
5	22	7.91	1465.892002
5	22	7.92	1467.67944
5	22	7.93	1469.463713
5	22	7.94	1471.244803

5	22	7.95	1473.022695
5	22	7.96	1474.797372
5	22	7.97	1476.568817
5	22	7.98	1478.337012
5	22	7.99	1480.101942
5	22	8.00	1481.86359
5	22	8.01	1483.621937
5	22	8.02	1485.376967
5	22	8.03	1487.128662
5	22	8.04	1488.877005
5	22	8.05	1490.621979
5	22	8.06	1492.363566
5	22	8.07	1494.101747
5	22	8.08	1495.836506
5	22	8.09	1497.567824
5	22	8.10	1499.295684
5	22	8.11	1501.020066
5	22	8.12	1502.740953
5	22	8.13	1504.458327
5	22	8.14	1506.172169
5	22	8.15	1507.88246
5	22	8.16	1509.589181
5	22	8.17	1511.292314
5	22	8.18	1512.99184
5	22	8.19	1514.68774
5	22	8.20	1516.379994
5	22	8.21	1518.068583
5	22	8.22	1519.753488
5	22	8.23	1521.434688
5	22	8.24	1523.112166
5	22	8.25	1524.785899
5	22	8.26	1526.455869

5	22	8.27	1528.122056
5	22	8.28	1529.784439
5	22	8.29	1531.442997
5	22	8.30	1533.097711
5	22	8.31	1534.748559
5	22	8.32	1536.395521
5	22	8.33	1538.038575
5	22	8.34	1539.677701
5	22	8.35	1541.312877
5	22	8.36	1542.944083
5	22	8.37	1544.571295
5	22	8.38	1546.194493
5	22	8.39	1547.813655
5	22	8.40	1549.428758
5	22	8.41	1551.039781
5	22	8.42	1552.6467
5	22	8.43	1554.249494
5	22	8.44	1555.84814
5	22	8.45	1557.442614
5	22	8.46	1559.032893
5	22	8.47	1560.618955
5	22	8.48	1562.200775
5	22	8.49	1563.778331
5	22	8.50	1565.351597
5	22	8.51	1566.920551
5	22	8.52	1568.485168
5	22	8.53	1570.045423
5	22	8.54	1571.601292
5	22	8.55	1573.152749
5	22	8.56	1574.699771
5	22	8.57	1576.24233
5	22	8.58	1577.780403

5	22	8.59	1579.313963
5	22	8.60	1580.842984
5	22	8.61	1582.36744
5	22	8.62	1583.887305
5	22	8.63	1585.402551
5	22	8.64	1586.913152
5	22	8.65	1588.419081
5	22	8.66	1589.920311
5	22	8.67	1591.416812
5	22	8.68	1592.908559
5	22	8.69	1594.395522
5	22	8.70	1595.877672
5	22	8.71	1597.354982
5	22	8.72	1598.827422
5	22	8.73	1600.294963
5	22	8.74	1601.757574
5	22	8.75	1603.215227
5	22	8.76	1604.667891
5	22	8.77	1606.115535
5	22	8.78	1607.558128
5	22	8.79	1608.995639
5	22	8.80	1610.428037
5	22	8.81	1611.85529
5	22	8.82	1613.277365
5	22	8.83	1614.694231
5	22	8.84	1616.105853
5	22	8.85	1617.512199
5	22	8.86	1618.913235
5	22	8.87	1620.308926
5	22	8.88	1621.69924
5	22	8.89	1623.08414
5	22	8.90	1624.463591

5	22	8.91	1625.837557
5	22	8.92	1627.206004
5	22	8.93	1628.568893
5	22	8.94	1629.926188
5	22	8.95	1631.277851
5	22	8.96	1632.623845
5	22	8.97	1633.964131
5	22	8.98	1635.29867
5	22	8.99	1636.627423
5	22	9.00	1637.95035
5	22	9.01	1639.267409
5	22	9.02	1640.578562
5	22	9.03	1641.883764
5	22	9.04	1643.182976
5	22	9.05	1644.476153
5	22	9.06	1645.763253
5	22	9.07	1647.044231
5	22	9.08	1648.319043
5	22	9.09	1649.587644
5	22	9.10	1650.849988
5	22	9.11	1652.106028
5	22	9.12	1653.355717
5	22	9.13	1654.599007
5	22	9.14	1655.835849
5	22	9.15	1657.066194
5	22	9.16	1658.289991
5	22	9.17	1659.50719
5	22	9.18	1660.717737
5	22	9.19	1661.921581
5	22	9.20	1663.118668
5	22	9.21	1664.308943
5	22	9.22	1665.492351

5	22	9.23	1666.668834
5	22	9.24	1667.838336
5	22	9.25	1669.000798
5	22	9.26	1670.15616
5	22	9.27	1671.304361
5	22	9.28	1672.44534
5	22	9.29	1673.579034
5	22	9.30	1674.705377
5	22	9.31	1675.824305
5	22	9.32	1676.935751
5	22	9.33	1678.039646
5	22	9.34	1679.135921
5	22	9.35	1680.224505
5	22	9.36	1681.305324
5	22	9.37	1682.378306
5	22	9.38	1683.443373
5	22	9.39	1684.500448
5	22	9.40	1685.549453
5	22	9.41	1686.590305
5	22	9.42	1687.622922
5	22	9.43	1688.647219
5	22	9.44	1689.663108
5	22	9.45	1690.6705
5	22	9.46	1691.669303
5	22	9.47	1692.659424
5	22	9.48	1693.640765
5	22	9.49	1694.613228
5	22	9.50	1695.576711
5	22	9.51	1696.531108
5	22	9.52	1697.476313
5	22	9.53	1698.412213
5	22	9.54	1699.338696

5	22	9.55	1700.255642
5	22	9.56	1701.162931
5	22	9.57	1702.060437
5	22	9.58	1702.94803
5	22	9.59	1703.825576
5	22	9.60	1704.692936
5	22	9.61	1705.549968
5	22	9.62	1706.396521
5	22	9.63	1707.232442
5	22	9.64	1708.05757
5	22	9.65	1708.871738
5	22	9.66	1709.674773
5	22	9.67	1710.466493
5	22	9.68	1711.24671
5	22	9.69	1712.015226
5	22	9.70	1712.771834
5	22	9.71	1713.516319
5	22	9.72	1714.248453
5	22	9.73	1714.967998
5	22	9.74	1715.6747
5	22	9.75	1716.368296
5	22	9.76	1717.048504
5	22	9.77	1717.715025
5	22	9.78	1718.367544
5	22	9.79	1719.005722
5	22	9.80	1719.629199
5	22	9.81	1720.237588
5	22	9.82	1720.830473
5	22	9.83	1721.407402
5	22	9.84	1721.967888
5	22	9.85	1722.511397
5	22	9.86	1723.037345

5	22	9.87	1723.545087
5	22	9.88	1724.033904
5	22	9.89	1724.502993
5	22	9.90	1724.951442
5	22	9.91	1725.378209
5	22	9.92	1725.782082
5	22	9.93	1726.16163
5	22	9.94	1726.515126
5	22	9.95	1726.840427
5	22	9.96	1727.134769
5	22	9.97	1727.394398
5	22	9.98	1727.613752
5	22	9.99	1727.783227
5	22	10.00	1727.875959

APPENDIX B: Overall Program Code

```
  // We start by connecting to a WiFi network
  Serial.print("\n\nConnecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(10);
    Serial.print(".");


  }
  Serial.println("WiFi connected. IP address: "+WiFi.localIP());
}


void loop() {
    float h;
  long volume = 0.0;

  // Clears the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin on HIGH state for 10 micro seconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);// Reads the echoPin, returns the sound wave travel time in microseconds


//calculate the actual oil height, respect to container's height excluding sensor height
  distance = duration/58.2;
  h= (diameter - distance)-1;
  volume= 1*((sq(r)*acos((r-h)/r))-((r-h)*sqrt((2*r*h)-sq(h))));

    String tank = String(volume);
    //String height = String(h);

  if ((WiFi.status() == WL_CONNECTED) &&
      (millis() - lastConnectionTime > updateThingSpeakInterval))

  {
    updateThingSpeak("field1="+tank);
     }
  Serial.println("");
  Serial.print("Oil Level height: ");
  Serial.print(h);
  Serial.print("cm");
  Serial.println();
  Serial.print("Tank Current Volume: ");
  Serial.print(volume);
  Serial.println("cm3");
  delay(10);

}



void updateThingSpeak(String tsData)
{
  WiFiClient client;
  const int httpPort = 80;
  if (!client.connect(thingSpeakAddress, httpPort)) {
    failedCounter++;
    Serial.println("Connection to ThingSpeak Failed ("+String(failedCounter, DEC)+")");
    Serial.println();

    lastConnectionTime = millis();
    return;
  }
  client.print("POST /update HTTP/1.1\n");
  client.print("Host: api.thingspeak.com\n");
  client.print("Connection: close\n");
  client.print("X-THINGSPEAKAPIKEY: "+writeAPIKey+"\n");
  client.print("Content-Type: application/x-www-form-urlencoded\n");
  client.print("Content-Length: ");
  client.print(tsData.length());
  client.print("\n\n");

  client.print(tsData);

  lastConnectionTime = millis();
```

```
  client.print(tsData);

  lastConnectionTime = millis();

  if (client.connected())
  {
      delay(10);
      Serial.println("Connecting to ThingSpeak...");
      Serial.println();

      failedCounter = 0;
      while(client.available()){
        String line = client.readStringUntil('\r');
        Serial.print(line);
      }

      Serial.println();
      Serial.println("closing connection");
  }
  else
  {
      failedCounter++;

      Serial.println("Connection to ThingSpeak failed ("+String(failedCounter, DEC)+")");
      Serial.println();
  }
}
```