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# Development of an Internet of Things System for Lubrication Oil Level Monitoring

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## ABSTRACT

Lubricant demand is predicted to keep growing in global markets. As a result, the lubrication industry should periodically measure the quantity of lubricant stock to guarantee its safety. Both software and hardware make up the constructed lab model of the Internet of Things system. Among the specialized parts of the system are a LiDAR sensor, an Arduino Esp32 microcontroller, and a network architecture. The sensor, which is mounted on top of the tank, collects data, which is subsequently transmitted to the microcontroller for processing. The sensor's primary function is to determine the level of lubricant in the tank. The data processing and link establishment for the network infrastructure are both handled by the microcontroller. Blynk Apps, a communication platform, is integral to the development of the system that is being created. In the event of an emergency, the system may either be automated or manually operated. The software has been programmed in such a way that it is able to send commands to the sensor using Blynk Apps from any place, provided that both connections are stable. The system provides the benefits of having a low cost as well as portability. The system is able to offer reliable data on the amount of the lubricant, which makes it possible to do maintenance and restock at appropriate time.

***Abbreviations***

| | |
|---|---|
| CATIA | Computer Aided Three-Dimensional Interactive Application |
| FEA | Finite Element Analysis |
| 3D | Three Dimension |
| 2D | Two Dimension |
| IR | Infrared |
| TF | (TF) |
| ESP32 | Expressive Systems 32-bit |
| D2D | Device-to-Device Communication |
| RA | Remote Access |
| PC | Process Control |
| TOF | Time -Of-Flight |
| iTOF | Indirect TOF |
| Dtof | Direct TOF |
| IoT | Internet of Things |
| USD | United States Dollar (currency of the United States) |
| TNB | Total base number |
| N | Newton |
| SoC | System on Chip |
| MHz | Megahertz |
| Wi-Fi | Wireless Fidelity |
| MB | Mega Bite |
| DR | Data Rate |
| DT | Data Transmitter |
| PVC | Polyvinyl Chloride |

**Keywords**: Internet of Things, LiDAR Sensor, Blynk, Lubricant

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## 1.0 INTRODUCTION

The industry of lubricant plays an important role to supply good products to customers. Lubricants play a significant part in the growth of the global industrial and commercial sectors, primarily through reducing wear and friction in mechanical contacts [1]. The lubricants industry is critical to the global industrial sector due to its role in optimizing machinery operations [2]. The demand for lubricants from the automotive industry accounts for more than half of the total demand worldwide. With increasing global demand for lubricants, the global market value of lubricants is expected to reach USD182.6 billion by 2025 [3]. The forecasted growth is based on increasing demand for high-performance engines and renewable energy. In the lubricant industry, brand performance and trust are the key drivers of consumer purchase intention, as most consumers are less concerned about pricing [4]. Hence, the lubricant sector in Malaysia is now in the growth stage, with an increasing demand for automotive lubricants as a result of an increase in the number of vehicles that are being sold. This is due to the fact that the country is experiencing an increase in the overall number of vehicles in circulation. The automotive industry in Malaysia is one of the most significant consumers of lubricants which represents one of the country's main economic sectors. Because there are so many vehicles currently on the road, there is a continual demand for engine oils and lubricants. This is because these products are essential for the maintenance and repair work that are performed on vehicles on a regular basis. The automotive industry is a major consumer of lubricants in Malaysia. With a significant number of vehicles on the road, there is a continuous demand for engine oils and lubricants for regular maintenance and servicing. Lubricants play a significant part in the growth of the global industrial and commercial sectors, primarily through reducing wear and friction in mechanical contacts [5]. The industry is import driven as both the end product and raw materials are majorly imported from other countries such as Thailand, Singapore, China, Europe and USA. The prices have been continuously increasing due to increasing price of base oil and crude oil. Over the review period, Malaysia lubricants market observed a healthy growth both in terms of revenues as well as sales volume. Approximately 85 % of all lubricants used worldwide are petroleum-based [6].

The revolution from time to time has changed the technology of monitoring, from dip and dip to flow rate gauge by using the high-end tech which has improved the accuracy of data collection. The accuracy of data can be the main references for the next order of purchase. As a matter of fact, the field of monitoring technology has gone through considerable revolutions over the course of time, which has led to improvements in terms of both accuracy and efficiency. The development of monitoring technologies can be broken down into a number of stages, each of which is distinguished by advances that have improved the procedures for data collecting. In the past, one of the most popular ways of determining the amount of fluid in a tank or container was to manually use a device such as a dip stick. This technique required actual measurement and was fraught with the possibility of human mistake. Flow Measurement Instrument is the introduction of flow rate gauges which was a big step forward in terms of technological development. These devices provide data in real time on the rate at which substances are moving through a system, allowing for continuous monitoring of the flow of liquids or gasses through a system.

Meanwhile, robotics and sensing technology involves monitoring technology which is significantly aided by the use of automation. The development of sensors allows for the automatic collection of data as well as its transmission for further analysis. This improves the efficiency of data collection process and reduces the number of times when frequent manual intervention is required. Hence, the concepts of telemetry and remote monitoring meaning in the implementation of telemetry technology have made it possible to do remote monitoring on a variety of parameters. This means that data could be collected from far-flung areas and delivered to a central hub for analysis, hence decreasing the requirement for personnel to maintain a physical presence at monitoring sites. Based on Technologies of an Extremely High-End as technological development moved forward, more sophisticated options are available. These include the application of sophisticated data analytics, as well as the usage of cutting-edge sensors and IoT (Internet of Things) devices. Monitoring systems' accuracy and capacity for prediction have been further bolstered by the development of technologies such as high-resolution imagery, algorithms for machine learning, and artificial intelligence. Artificial Intelligence and Machine Learning Monitoring with data analysis have been completely transformed as a result of the combination of artificial intelligence and machine learning. These technologies have the ability to predict patterns, recognize anomalies, and improve processes based on past data, all of which contribute to more informed decision-making. By using blockchain to ensure the integrity of data means that the blockchain technology has been implemented in several applications so that monitoring data can be monitored without compromising its integrity or security. This is of utmost significance in spheres of endeavour in which even minor instances of data manipulation or illegal access could have significant repercussions. Monitoring in real time and computing via the cloud are due to the developments of cloud computing; thus, real-time monitoring capabilities are becoming more commonplace. The processing and analysis of data can take place in real time, which can provide rapid insights and enable prompt responses to changing conditions.

A good number can drive a good cost saving. From accurate data, the production shuts down or any delay in logistics may be avoided in the next phase of ordering. Thus, waiting period for customers is eliminated. Traditional lubrication monitoring typically depends on human capabilities. Not all variant measurements are accurately monitored by human capability, such as; 1) viscosity, an indicator of the overall health of a lubricant [7]; 2) water content, to evaluate the risk of losing functionality and rust development [8]; and 3) the total base number (TBN), to determine the likelihood of oxidation of the lubricant [9].

As a result on the implementation of Revolution Industry 4.0, real-time monitoring of lubricants' level capacity is very important. To ensure that the stock is sufficient for blending and ready to produce in order to supply the product at the needed production rates of high-quality goods, the process must be carried out with the most effective teamwork. Both the conventional monitoring approach and the semi-manual monitoring stock focus on bridging the communication gaps that exist between the different teams. This paper discusses on developing a system of IoT for monitoring level lubricant in lab scale. The system uses LiDAR as a sensor and Arduino EASP32 as a communication device. The system is able to monitor the level of stock lubricant inside the tank in real time data. It presents the historical evolution of Lidar and how it became one of the essential pieces of equipment in high precision measurements [10].

## 2.0 METHODOLOGY

### 2.1 Sensors

The development of an IoT based lubricant monitoring system at a lab scale size requires a combination of hardware and software components, prototyping, calibration, integration with IoT platform and testing. The specific materials and methods used depend on the project requirements and the available resources.

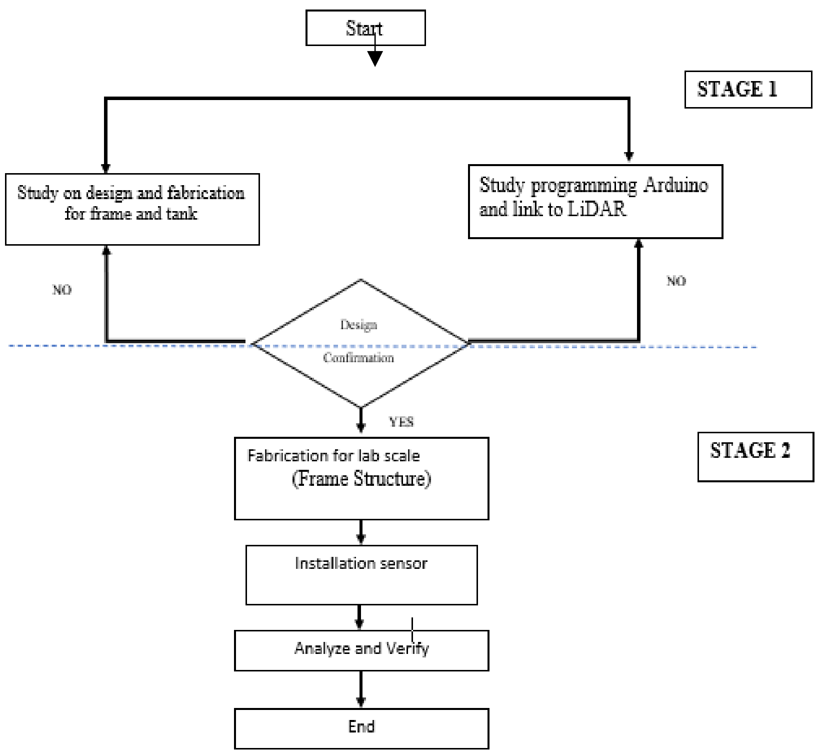


**Figure 1:** Research Flow Chart

Before going into a full comparison on the application and development tendencies of steel or aluminium materials, the material development trends in design concept consideration are firstly overviewed from the strengthen point of view. This will be done before going into a comparison on the application and development tendencies of aluminium materials. Therefore, the design has been established after a few alterations brought on by design concept considerations; the aluminium alloy profile 20 x 20 was chosen since it is able to fulfil the design's intended purpose and fulfils its intended function. Although it is well documented that aluminium alloys and products can be used for constructions in a variety of applications, the performance of these materials under conditions of impact, fatigue, and corrosion still raises some reservations in certain sectors of the engineering community. The primary reason for selecting Aluminium Alloy 20 x 20 is due to the fact that it possesses excellent mechanical and physical qualities. The structure appears to have sufficient strength to support the weight of the tank based on its overall features. The material must have a high corrosion resistance in order to guarantee that it will not sustain any damage in the event that the lubricant on the material is slit. To be able to handle the tests that are done on it, the aluminium frame's workability needs to be at a good level. Mechanical properties and general characteristics are shown in Table 1 and Table 2.

On the other hand, designing aluminium structures and components for optimal and predictable performance during service necessitates specific knowledge and experience about the structural stiffness, stability, and fatigue behaviours of structural components such as hollow sections and assembled structures, the crash behaviours (energy absorption and failure mechanisms) of structural components and modules, and the corrosion performance of aluminium alloy structures as well as evaluating the design concept in terms of its technical feasibility which is meant by "technical feasibility." Think about the limitations imposed by technology, the resources at your disposal, and everything else that could have an effect on how the design is implemented. One of the elements that should be included in the design consideration idea is "cost and budget." This refers to the monetary implications of the design concept. Consider the available funds along with the costs of materials, production, and development. Strike a balance between the design vision that is intended and the limits imposed by practicality. In comparison to other materials, turning an aluminium alloy is a very simple process. Before any fabrication can take place, the design of the structure's frame is first drawn up using CATIA, followed by an analysis of the design. The layout of the structure must be sturdy and robust enough to support the tank when it is placed in the middle of the structure. Therefore, the design of the structure has been validated, and the software that does finite element analysis (FEA) has been examined. For the first stage of the investigation, refer to the drawing in version one that is two dimensions (Figure 2). Aluminium alloys have a low specific gravity, low cost, and very good mechanical qualities, in addition to having a light weight. Hence, Aluminium alloys are found to be a suitable material in making products in some of the applications like screws, pushes, machine parts, aerospace, missiles and architectural applications [11].

**Table 1:** Mechanical properties of steel and aluminium alloy.

| Material properties | Steel (Q420) | Aluminum alloy (6061-T6) |
|---|---|---|
| Yield strength (MPa) | 420 | 240 |
| Elastic modulus (GPa) | 210 | 70 |
| Density ($kg/m^3$) | 7850 | 2700 |
| Poisson's ratio | 0.3 | 0.3 |
| Thermal expansion coefficient (/°C) | $1.2 \times 10^{-5}$ | $2.4 \times 10^{-5}$ |

**Table 2:** General Characteristics of Aluminium

| Characteristic | Appraisal |
|---|---|
| Strength | Medium |
| Corrosion Resistance | Good |
| Weldability & Brazability | Good |
| Workability | Good |
| Machinability | Fair |

The design has been validated and established, and its confirmation is based on the few aspects of the design concept that are the strongest. This is to guarantee that the structure will not topple down. Referring to Figure 2 which is a 3D drawing and Finite Element Analysis (FEA) comparison during no load (static) and loaded, it involves the use of mesh generation techniques for splitting a complex problem into small elements, as well as the use of software developed with a FEM algorithm. Figure 3 shows the Finite Element Analysis (FEA) comparison during no load (static) and loaded.

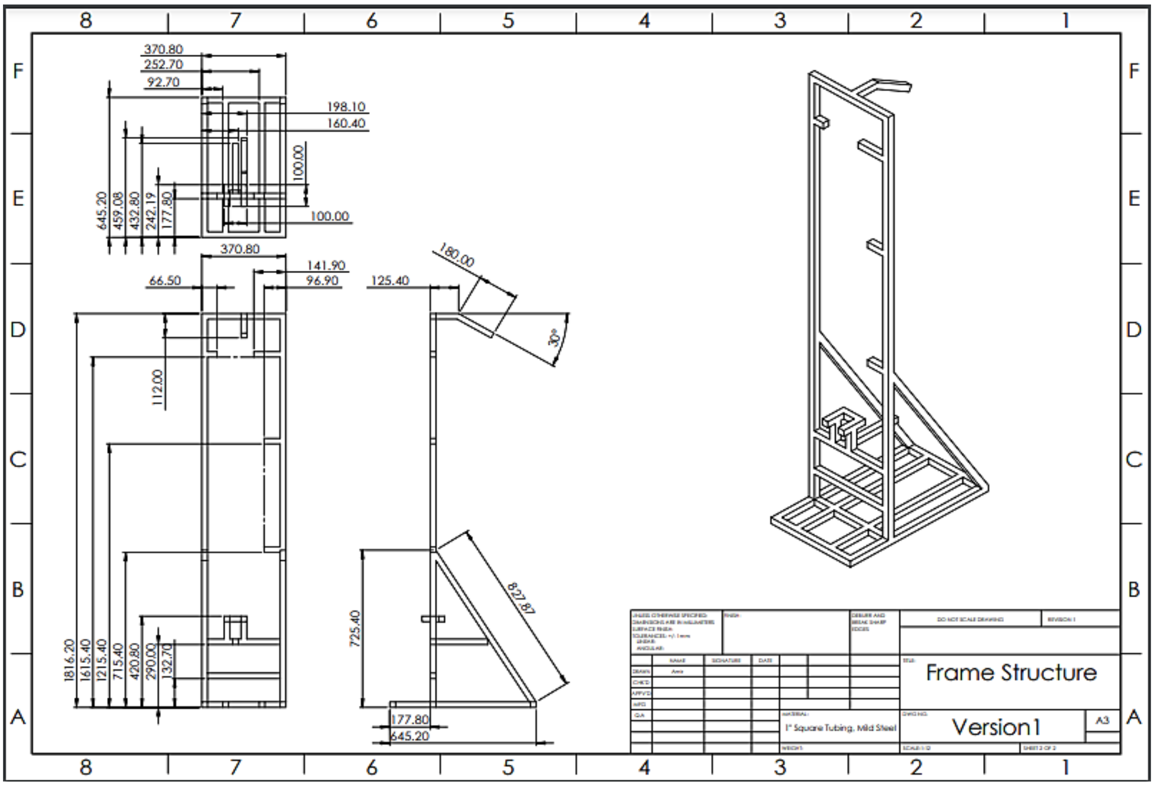


**Figure 2:** 2D Drawing Frame Structure

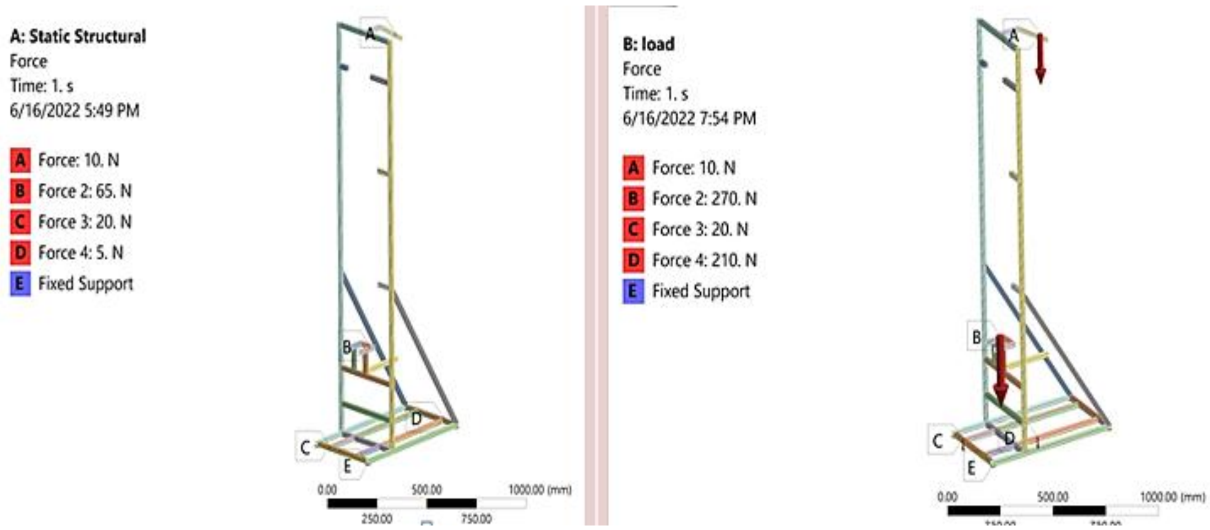


**Figure 3:** Comparison FEA for both static and loaded situation

For Finite Element Analysis, the Aluminium Profile 20 x 20 is chosen as the main structure based on the few concepts design. The mesh technique used in 3D analysis is shown in Figure 3. As constraint is placed at point E during static structural analysis, there is force at point A, B, C and D as the weight of the frame itself. However, when the load of full tank with 270N is parked at point B, the force at point D increases to 210N and the force at point A and C is the same with unloaded force. The measurement for every length of the stick of the aluminium has been cut off as it is designed with the combination of joining and connected by screw L type corner bracket fitting and corner angle bracket connector. By using aluminium profile as per Figure 4, the structure is only jointed with the screw without any welding involved. The frame has strength and light weight. Hence, this presents the lubricant monitoring level system, in which the tank's design and manufacturing are customized to the system's needs. For the data collection to be precise, the tank must be mounted to an aluminium frame that is bolted together. During laboratory testing, the pump must run continuously for the entire time period required to obtain accurate results. As a result, the source must be operational at all times such as the DC panel used in this test as well.

### 2.2 Programming

The Time-of-Flight (TOF) principle serves as the foundation for TF-Luna's design. It does this on a regular basis, and the modulation waves of near-infrared photons that are released will be reflected when they come into contact with an object. The laser detection and ranging system, also known as LiDAR, determines the time of flight by measuring the phase difference over the entire round trip, and then it uses this information to calculate the distance between itself and the item that is detected.

TF-Luna supports power saving mode for power-sensitive applications as it reduces its power consumption by adjusting both the current level and duty cycle of the light source. Table 3 lists the parameters of the TF02-Pro. With a 5V power supply, TF-Luna's power consumption on continuous ranging mode is about 350 mW as the light source switches to the highest current level and duty cycle.

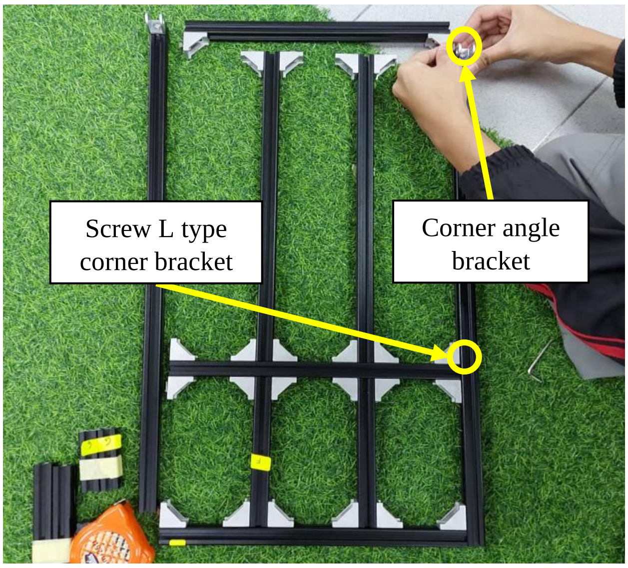


**Figure 4:** Aluminium Profile 20 x 20

**Table 3:** Major Electrical Parameters of TF02-Pro

| Description | Parameter value |
|---|---|
| **Supply voltage** | 5V~12V |
| **Average current** | ≤200mA |
| **Peak current** | 300mA |
| **Average power** | ≤1W |
| **Communication level** | LVTTL（3.3V） |

A light detection and ranging (LiDAR) system that measures the distances from objects and 2-D shapes is an essential component for object/environment detection and recognition in autonomous vehicles, robots, and drones. For measuring the distance, a LiDAR system employs time-of-flight (TOF) measurement using an infrared (IR) light source. The data transferred to the cloud are sent to the homeowner to display the accuracy and availability of their storage level system via Blynk, a mobile-compatible and user-friendly application that generates clears data visualization. There exist two types of TOF measurements: indirect TOF (iTOF) and direct TOF (dTOF). An iTOF sensor measures the phase delay of the reflected light [12].

### 2.3 Blynk App

ESP32 is a powerful SoC (System on Chip) microcontroller with integrated Wi-Fi 802.11 b/g/n, dual mode Bluetooth version 4.2 and variety of peripherals. It is an advanced successor of the 8266 chip primarily in the implementation of two cores clocked in different version up to 240 MHz. Compared to its predecessor, except these features, it also extends the number of GPIO pins from 17 to 36, the number of PWM channels per 16 and is equipped with 4MB of flash memory. The traditional IoT module needs a Wi-Fi peripheral device for establishing the wireless connectivity. However, the modern IoT modules have a wide range of facility like 4G and 5G networks for enabling their connectivity with a cloud server. Hence, the possibility of transmitting huge data from one place to another place becomes easier as the networks are moving their pockets faster [13]. IoT, smart home automation, and embedded technologies are now advancing rapidly. This is directly related to the creation of hardware modules that are now available and processors. A development board is developed that has an implemented area of communication interface and peripherals with the main processor chip.

Currently, the ESP32 chip's popularity is increasing, with both hardware variations of this chip and different software branches developments are taking place. A large number of developers as well as academics are working on using them. The generation ESP32 chip will replace the ESP8266 microcontroller. Conventional or direct D2D communication suffers from some limitations such as the long distance between the D2D transmitter (DT) and D2D receiver (DR) and/or the poor channel condition between them [14]. Therefore, the use of aiding nodes to work as relays between the DT and DR becomes crucial [15]. This serves the modern wireless communication applications that demand an extended range of communication with a high degree of reliability and flexibility [16], [17]. The relay-aided D2D communication comes with new challenges such as the RA and PC problems that have to be considered during the different transmission time slots. This should be done considering the existence of the relay besides the DT and DR [18][19].

**Figure 5:** TF-Luna ToF LiDAR Module

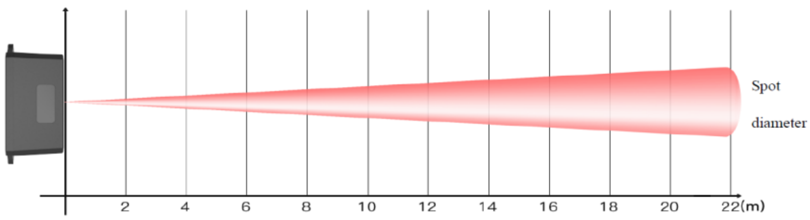


**Figure 6:** Schematic diagram of detection angle

### 2.4 System Integration

The software handles the connection to Apps Blynk and programming the Arduino, while the hardware consists of a TTGO T-Display ESP32 (as in Figure 7) and a TF-Luna ToF Lidar distance sensor as a detection and measurement to approach and create a platform for communication. Lidar is a device used to probe the regions, detect the objects in them, and map the surroundings and the distances from the different objects [20]. It works on the principle of Radar, but in this case, instead of using radio waves, it uses light-based remote sensing or lasers. Its basic form is a laser as an energy source scattered in all directions. It then records and measures the reflected signals and their characteristics to formulate the region and distance information [21]. Figure 8 shows the flowchart of the Lidar coding. The data are stored in the cloud so that it can be retrieved at any time in the future. The use of ESP32 with Wi-Fi connectivity is required for this research because the data are automatically linked to the device. The data collection can be monitored on the screen of a mobile phone as well as a computer. The data are transformed into a graph to make it easier to visualize as required. The source of the direct source (DC) is applicable for current supply.


**Figure 7:** The Espressif Systems 32-bit (TTGO-ESP32) display

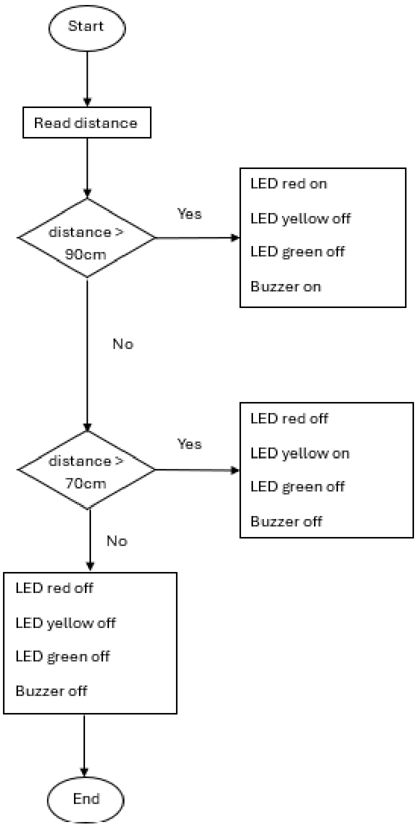


**Figure 8:** The coding flowchart

## 3.0 RESULT AND DISCUSSION

This study uses a scaled-down prototype of a real storage tank in a controlled laboratory environment. Based on technical drawings and actual plant specifications, the original 7660 cm industrial tank is reduced to a 100 cm prototype. Since the model could not stand on its own, a 120 cm-high support frame is designed to hold it securely. The system simulates the real-life process of loading lubricant from a tanker into a storage tank and then transferring it to the production line.

Using the PUGH method or Decision Matrix Method, the material and design of the prototype are evaluated and confirmed. The frame is made using aluminium profile 20 x 20 after design approval and measurement calculations to verify the data will fulfil the standards.

**Table 4:** Table PUGH for Material Frame selection

| Criteria | Baseline (Mild Steel) | Aluminum | Stainless Steel | Composite Material |
|---|---|---|---|---|
| **Strength** | 0 | - | + | - |
| **Weight** | 0 | + | - | + |
| **Cost** | 0 | + | - | - |
| **Durability** | 0 | - | + | + |
| **Ease of Manufacturing** | 0 | + | 0 | - |
| **Corrosion Resistance** | 0 | + | + | + |
| **Total Score** | - | X | Y | Z |

In the Pugh Method, the legend used in the decision matrix represents how each alternative compares to the baseline option:

"+" (Plus): The alternative is better than the baseline for that criterion.
"0" (Zero): The alternative is equal to the baseline for that criterion.
"-" (Minus): The alternative is worse than the baseline for that criterion.

Before proceeding to the next process, all assembly section work must be completed. PVC pipes for installation are cut to the required length and positioned within the frame. The system's wire installation follows as a critical phase. Connections from the power supply, ESP32, oil pump, solenoid valve, and switches are all verified for proper functionality. Aluminium alloy constructions exhibit greater susceptibility to wind forces but demonstrate lower vulnerability to node defects compared to steel structures. To further examine the applicability of aluminium alloy structures, researchers investigated the static and stability performance of structures with spans of 1600 m and 2000 m. Results demonstrated that super-long span constructions utilizing aluminium alloy can achieve exceptional mechanical performance [22]. In the test run, the functional module produced useful results. The Blynk bot interacts with the ESP32 of that specific station and displays the real-time fluid level it has just received from a Lidar sensor.

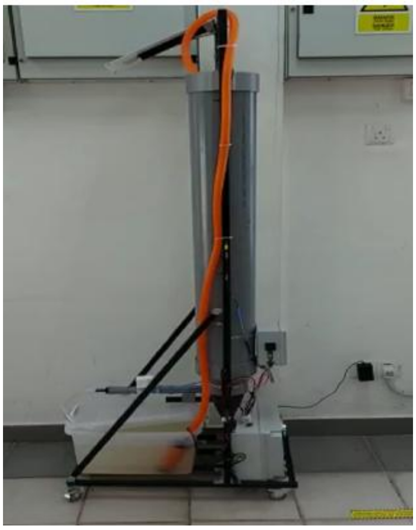

**Figure 9:** The Finished Level Monitoring Lubricant in lab scale

As illustrated in Figure 10, the block diagram depicts an automated lubricant management system with level-triggered controls. When the lubricant level in the tank decreases below a predetermined threshold, a relay activates the water pump to replenish the supply. Once the lubricant reaches the reference point, the oil pump automatically deactivates. The system enables remote operation of the supply valve via mobile phone or computer interface, allowing users to redirect water to alternative locations as needed. The relay-controlled water pump activation sequence is initiated whenever lubricant levels fall below the established reference point, and this automated cycle persists until system shutdown.

A relay will turn on the water pump and fill the tank when the amount of lubricant in the tank drops below a set level. The oil pump will be shut off when the lubricant level reaches the reference point. The user can control the supply valve using the system through phone or laptop to deliver water to another location. The water pump is automatically turned on by the relay when the amount of lubricant in the tank drops below the reference point. This cycle continues until the system is permanently shut off.

The device can operate manually as well as through an automated software as shown in Figure 11. In the event of an emergency, the pump or solenoid valve can be turned on or off manually using the Blynk Dashboard or using an emergency push button, if one is present. Once the equipment, be it a pump or a solenoid, has reached its maximum capacity, the entire system will immediately stop operating until a fresh command is issued. In addition to that, the system's calibration has been measured three times using the collected data. The recording of the system calibration has been completed.

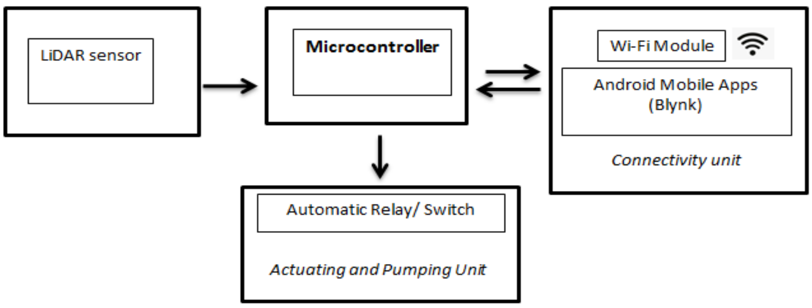


**Figure 10:** The block system diagram

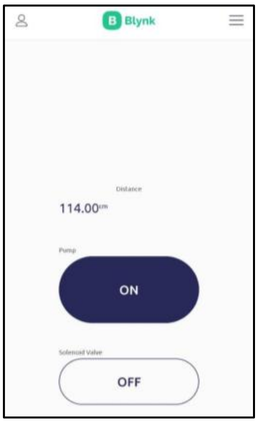


**Figure 11:** The Result displayed through Blynk Apps

The analysis of the data is essential in order to determine whether or not all of the system's components are working well. The graph of the data collected for the calibration is displayed in Figure 11. The numbers are recorded continuously beginning with the pump being turned on and the solenoid valve being turned off. Blynk allows for communication in real time to take place between the software and the physical device. Through the Blynk dashboard, Blynk applications are able to rapidly operate your Internet of Things devices, view sensor data, and receive notifications. Blynk is an Internet of Things phase that enables remote control of electronic devices by employing its iOS and android applications. It provides an efficient dashboard that clients can use to create realistic interfaces with a variety of different devices. Additionally, Blynk has the capability to save the data and display the sensor's data information. Blynk gives libraries to the vast majority of the prevalent equipment stages like Arduino, ESP8266, Raspberry pi, Spark Fun and so on.

The graph in Figure 12 depicts the sensor's calibration graph which shows network stability and evaluates the IoT device's capacity to maintain a consistent connection by cellular, Wi-Fi, or LoRa networks in a variety of operating and environmental circumstances.

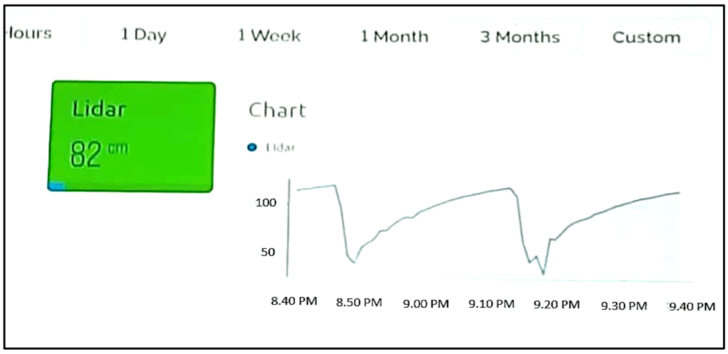


**Figure 12:** Graph calibration system

## 4.0 CONCLUSION

The development of an IoT-based lubricant oil level monitoring system at a lab scale demonstrates the feasibility of using LiDAR sensors for real-time and precise level detection. The prototype maintains reliable network connectivity and effective data transfer while accurately simulating industrial lubricant storage and transfer procedures. Utilizing LiDAR technology, the system's excellent precision and long range make it appropriate for industrial applications involving oil level monitoring. However, for large-scale deployment, considerations including cost, environmental adaptability, and power usage are necessary. Future studies may examine energy-efficient LiDAR variations, better data processing methods, and hybrid sensor integration to maximize monitoring accuracy and dependability in order to improve system performance.

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## AUTHORS CONTRIBUTION

| | |
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| Nur Shaebah Mat Hussain | Data Curation, Writing - Original Draft |
| Mohd Khairol Anuar Mohd Ariffin | Supervision, Project Administration, Review & Editing |
| Siti Azfanizam Ahmad | Writing - Review & Editing, Resources |
| Zulkifli Mohamed | Technical & Software Supervision |

## DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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