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Wireless Monitoring System for Miniature Flexible Tank Performance

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Abstract: The Internet of Things (IoT) grown faster widely through the global for its applications to the society. The implementation of IoT in the logistics industry in order to build a smart logistic system that contributes to the security and efficient monitoring system as currently, there is lack of efficient wireless monitoring system that can provide real-time data of container's surrounding in order to ease the management of goods. This thesis will present a thorough development process of the prototype of the wireless monitoring system for miniature flexible tank in reference to the real-sized tank provided by MyFlexible company that will highlight the implementation of sensors, microcontroller, and Blynk. Blynk is an example of IoT server that provides an application for user to monitor their respected system that has been programmed into the microcontroller linked to its server. The system will work with various sensors to sense any changes on the tank's surrounding and data will be transmitted to the server. The data then will be displayed over the Blynk application which allows the user to monitor the data in real-time. However, the system has a limited operational system which required a Wi-Fi connection linked to the microcontroller. This project is expected to provide an efficient monitoring system to be implemented in the real application of flexible tank. Hence, it will ease the management of supply to monitor their packages in real-time.

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Keywords: IoT, Flexitank, Wireless Technology, Blynk

1. Introduction

Mankind has been transporting goods since thousands of decades before even without a container by moving goods in the barrels, foods and even materials that no one ever seen in their own land. They literally started to ship the goods from the sea to the air and even on the land. Evolving from air transportation for passenger to transporting goods, conventional cargo generally successfully started on early 1955 when an American, Malcom P. McLean, a trucking entrepreneur bought a steamship company with an idea of transporting entire truck trailers with having the cargo attached still inside [1].

This project will be focusing on a miniature size of flexitank container, in reference to the real-size tank developed by MYFlexitank (MYF). MYF currently nominated as the second's lowest cost of a bulk tank offering two types of its tanks; econ and premier. Flexitank commonly used as it is way more economical, efficient, easy to use and easily available. Thus, flexitank has become the wiser choice for business in many industries globally.

Shipping cargos and containers had been utilizing the use of IoT that ensuring the new level of efficiency and safety in shipping the products. Jan Hoffmann, head of United Nations Conference on Trade and Development (UNCTAD) stated that the shipping containers is probably the most widely utilized in transporting goods as 80.00 % of global transportation goods carried by shipping containers [2]. Statistically, around 775 million of container travelled around the globe in past year, transporting goods here and there [3].

The risks in shipping industries then led to the manufacture of an intelligent shipping container that is intelligent enough to take a real-time insight on the containers by utilization of the IoT. Thus, we can see that the implementation of IoT really benefits the community to solve even the smallest problem that arises.

The objectives of this study are to determine the suitability of sensors used for flexible applications such as a flexible tank and to develop a monitoring system for the flexible tank that can be monitored through IoT applications.

1. Literature Review

Flexitank has been developed in early 1960s to transport water and fuels to the military base [4]. The main reason for the enormous growth of flexitank is that it is economically way affordable than ISO tanks. Bulk liquid shippers nowadays moving to the flexitank to save at most 25-30% of shipping cost. The flexitank manufacturers around the globe had developed various types of flexitank in order to fulfil the companies' demand.

Goodrich, a liquid cargo transporter company had encountered a similar flexitank leakage problem where the tank developed a leakage during export shipment. Three flexitanks carrying non-hazardous Linear Alkyl Benzene being noticed to have a leakage by the captain of the carrier vessel [5].

In previous study, Bakar, S. A. A., *et al*. proposed an underwater detection by using waterproof ultrasonic sensor [6]. The measured distance's feedback in form of sound being monitored through mobile phone. JSN-SR04T transducer had been used in the distance of an object determination based on the standard pulse echo. In addition, Macaulay, J., Buckalew, L., & Chung, G. had stated in his paper where the Dundee Precious Metals (DPM), a Canadian mining corporation that operates Europe's major goldmine is using IoT to link its end-to-end mine operation [7].

In a proposed Internet of Things based home monitoring and device control system by Pravalika, V., & Prasad, R, they had proposed a system where the system will be monitoring the temperature value, water level in the tank, gas leakage and motion detection values [8]. The significant advantage of the implementation of IoT system on our life is that we could monitor a system through the smartphone where anybody possess one of it and being kept close with us in our daily life.

2. Methodology

In this section, the crucial element of the project for instance project planning, system block diagram, project operational flow, experimental setup, hardware and software components as well as the analysis of the system will be discussed and highlighted.

3.1 Project plan

The project planning can be referred in Figure 1 where the plan generally started with the idea of implementing IoT interlinked with Wi-Fi module that will be used in the wireless monitoring system of the downscaled flexible tank.

Literature research on the previous journals regarding the components that we think will be suitable to be implemented in this project had been conducted and gone through the software and hardware development planning thoroughly. The data gained from the hardware will be conveyed through the IoT platform and then can be observed through the smart phone. The system then being tested to ensure the flow of the system is working and to observe the data accuracy gained from the system built and then be going through a precise troubleshooting to troubleshoot any errors occurs.

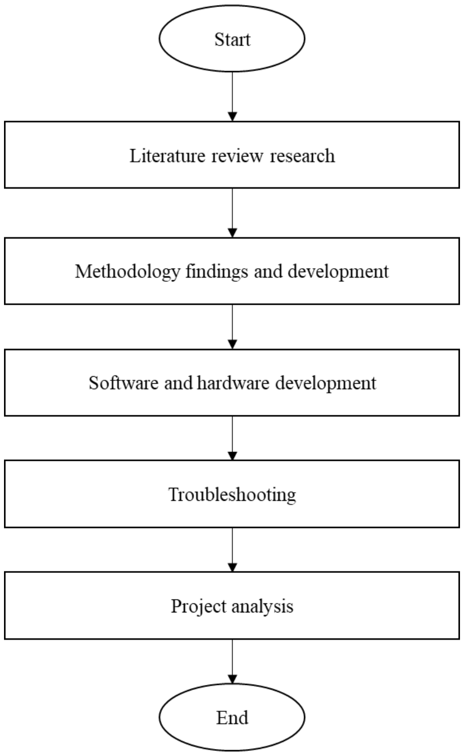


Figure 1: Project planning

3.2 Project Flow

Project flow was divided into 2 stage where the first stage of the plan was generally determining what kind of components and hardware that are suitable to be implemented in the project. These sensors and modules then being assembled together with the MCU and programmed through Arduino IDE. The sensors and modules then being run to display their respective data on the Arduino IDE serial monitor.

In the second stage, the programmed MCU of the sensors and camera module will be once again programmed by using the same earlier basic code but with the addition of certain codes from Blynk to link the MCU board with the Blynk IoT server. Both of the stage will be only going through the final testing when all the sensors and camera modules data show up in the Blynk application and work as intended.

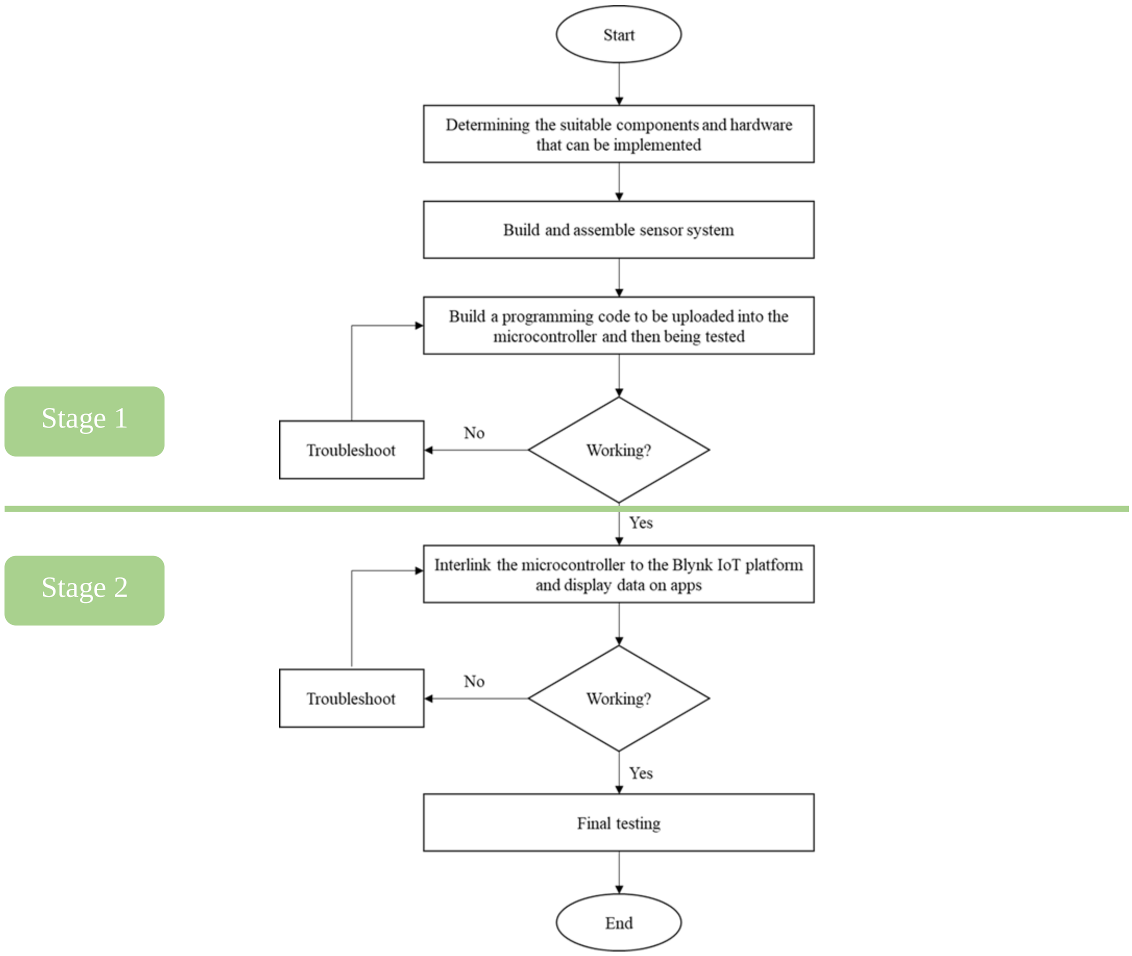


Figure 2: Flow of the wireless monitoring system

3.3 Hardware Components

Initially, all the components were assembled with each of the connections being studied and observed so that there will be no error cause by the misconnection of the components. The main hardware that had been implemented are as follows:

1. Waterproof ultrasonic sensor
2. Water sensor
3. ESP32 Wi-Fi module
4. ESP32-CAM module

The similarities between all these components are as follows:

1. Work with low power voltage supply between 3.3V to 5V.
2. Small, portable and easy to be implemented everywhere.
3. Low power consumption.

3.4 Experimental Setup

The experimental setup of the system can be referred in Figure 3. Three components which are the water sensor, ultrasonic sensor being attached on the inner part of container. The data from each of the sensors and the camera module then being conveyed to the microcontroller. The data then being sent to the Blynk IoT platform server and automatically got the insight organized and the being displayed on the application to be monitored by the user.

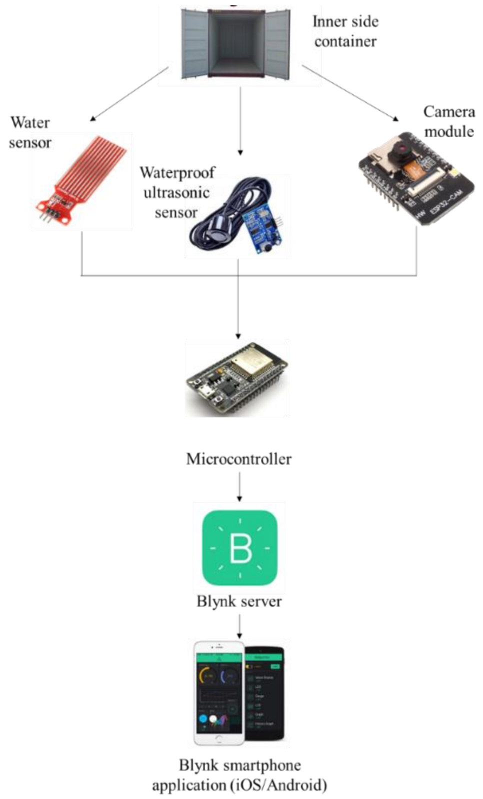


Figure 3: Experimental setup of the wireless monitoring system

3. Results and Discussion

This chapter will be presenting the results and data analysis from the software and hardware testing that has been accumulated. The results of this project have been accumulated and obtained from the Blynk smartphone application that has been linked to the microcontrollers used this project. The results were divided into three which consists live streaming, wave amplitude shift as well as leaking alarm trigger.

4.1 Live Streaming

ESP32-CAM module programmed by using ESP32 development board interlinked to Arduino IDE as shown in Figure 4 and were used to gain live streaming of the tank container. The setup of the ESP32-CAM module can be seen on Figure 5 and the camera module will show the live streaming of the surrounding that can be observed through Blynk smartphone application as shown in Figure 6 below.

Figure 4: ESP32 development board with ESP32-CAM module

Figure 5: ESP32-CAM module setup to observe the tank

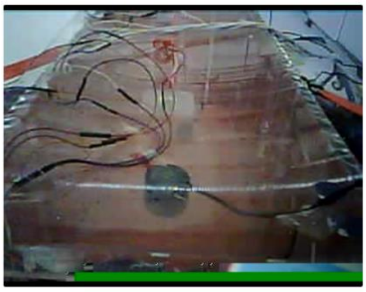


Figure 6: Live streaming of ESP32-CAM module in Blynk application

4.2 Wave Amplitude Shift

Four waterproof ultrasonic sensors have been implemented to observe amplitude of wave of liquid contained in the container. The ultrasonic sensors being setup in sequence as shown in Figure 7 whereby Figure 8 shows graph of 1-minute wave amplitude shift data gained the Blynk graph as can be seen in Table 1. The data then being focused to the early 10 seconds data to maximize the observation on amplitude shift as shown later in Figure 9.

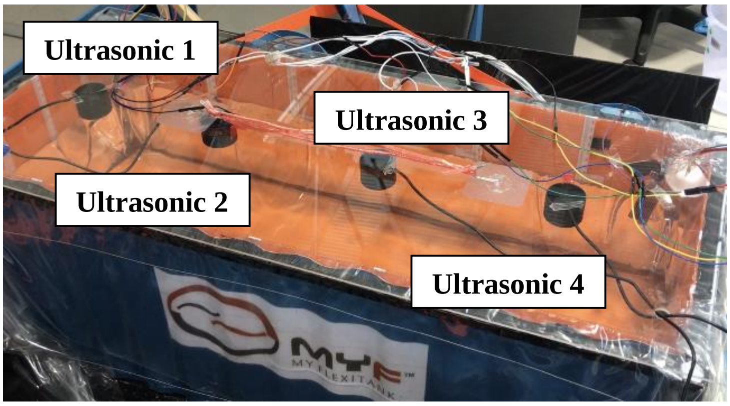


Figure 7: Ultrasonic sensors testing setup

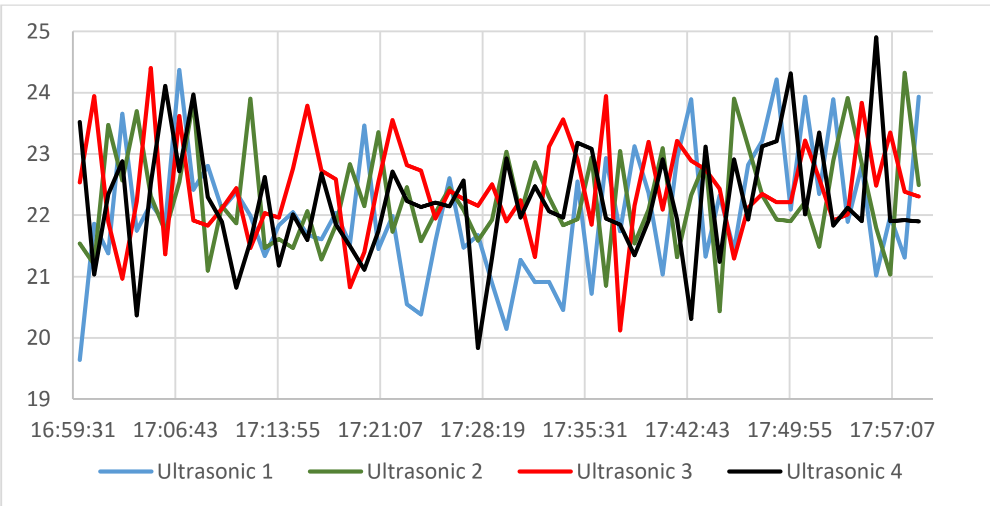


Figure 8: 1-minute wave amplitude shift data

Table 1: Water amplitude reading obtained from Blynk graph

US1	US2	US3	US4	TIME
19.64242424	21.53850932	22.53623188	23.52283465	17:00:00
21.86387435	21.19354839	23.9453125	21.032	17:01:00
21.375	23.47204969	21.89361702	22.34057971	17:02:00
23.65816327	22.56626506	20.96638655	22.87837838	17:03:00
21.74853801	23.69642857	22.22727273	20.36521739	17:04:00
22.19148936	22.31034483	24.40145985	22.51724138	17:05:00
21.86440678	21.73684211	21.36290323	24.11290323	17:06:00
24.37349398	22.54022989	23.62068966	22.71631206	17:07:00
22.41397849	23.87654321	21.91603053	23.97122302	17:08:00
22.80597015	21.09459459	21.83333333	22.29577465	17:09:00
22.10382514	22.14705882	22.10526316	21.89473684	17:10:00
22.37172775	21.86956522	22.44202899	20.81889764	17:11:00
21.99453552	23.90243902	21.46456693	21.56923077	17:12:00
21.3372093	21.46357616	22.03649635	22.625	17:13:00
21.83516484	21.61290323	21.96153846	21.18110236	17:14:00
22.04918033	21.46451613	22.75886525	22.01470588	17:15:00
21.67977528	22.06666667	23.78826173	21.59541985	17:16:00
21.6091954	21.27702703	22.72661871	22.68055556	17:17:00
22.03783784	21.83870968	22.58865248	21.84962406	17:18:00
21.53179191	22.83428571	20.82644628	21.49606299	17:19:00
23.46551724	22.14906832	21.4	21.11023622	17:20:00
21.45054945	23.35365854	22.54347826	21.7443609	17:21:00
21.98913043	21.72955975	23.55333333	22.71034483	17:22:00
20.55063291	22.45714286	22.81690141	22.23529412	17:23:00
20.38323353	21.57419355	22.72661871	22.13475177	17:24:00
21.5739402	22.04166667	21.94736842	22.20567376	17:25:00
22.60301508	22.44047619	22.4	22.14388489	17:26:00
21.47191011	22.08917197	22.26315789	22.56462585	17:27:00
21.6741573	21.5875	22.15441176	19.83453237	17:28:00
20.89265537	21.92727273	22.50364964	21.30769231	17:29:00
20.14906832	23.03508772	21.90151515	22.92666667	17:30:00
21.27325581	22.02531646	22.24460432	21.96323529	17:31:00
20.90643275	22.86390533	21.31818182	22.47222222	17:32:00
20.91071429	22.29710145	23.11702128	22.06796117	17:33:00
20.45253676	21.83870968	23.56389716	21.96323529	17:34:00
22.54830192	21.93429832	22.91238121	23.18273323	17:35:00
20.71920938	22.94023912	21.84930212	23.08202342	17:36:00
22.93010232	20.84923194	23.94129305	21.94538032	17:37:00
21.73954912	23.04820923	20.12301343	21.84538295	17:38:00
23.12398233	21.53948532	22.15434443	21.34368982	17:39:00
22.36423547	22.09381232	23.19820412	21.9124829	17:40:00
21.03409235	23.0939	22.09213922	22.91233948	17:41:00
22.93129384	21.31232892	23.21309421	21.92830423	17:42:00
23.89340212	22.32402934	22.89238914	20.31049239	17:43:00
21.32487934	22.89234892	22.74593485	23.12093823	17:44:00
22.32049823	20.43298532	22.43095822	21.2398234	17:45:00
21.42837492	23.901248	21.29378932	22.9128713	17:46:00
22.82379202	23.12387233	22.12398342	21.93274823	17:47:00
23.21389122	22.32879231	22.34872342	23.12387121	17:48:00
24.21380913	21.93238294	22.21039123	23.21038412	17:49:00
22.09314802	21.90192832	22.21098131	24.3129812	17:50:00
23.93049821	22.21930924	23.21932814	22.01293011	17:51:00
22.34823041	21.48743029	22.59830231	23.34829342	17:52:00
23.89346721	22.8912093	21.9130492	21.82938042	17:53:00
21.89234092	23.91029394	22.01293822	22.1238932	17:54:00
22.81230891	22.84329823	23.83204923	21.9034092	17:55:00
21.0192484	21.7923489	22.48193482	24.90239584	17:56:00
21.98210932	21.0324875	23.3489236	21.9042348	17:57:00
21.31092342	24.32193	22.38329412	21.92039122	17:58:00
23.9310491	22.49238022	22.30324823	21.90134892	17:59:00

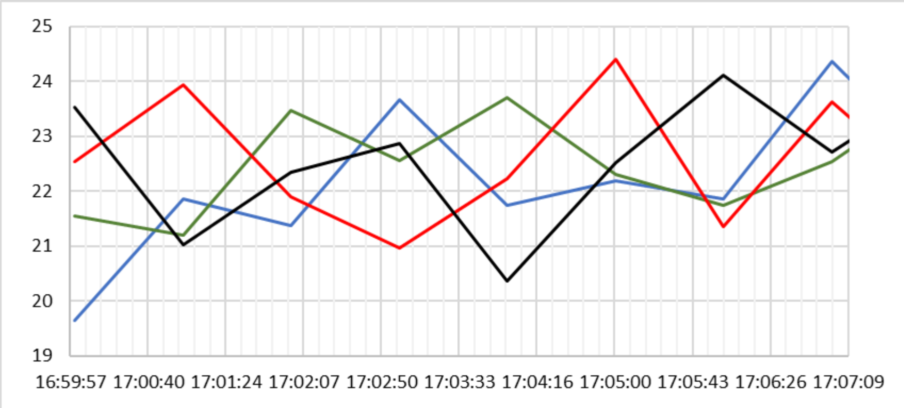


Figure 9: Initial 10 seconds data of the amplitude shift

The signal detected at 17:00:00 with the signal reflected by ultrasonic 1 followed by ultrasonic 2, 3 and 4 as the movement of water started from point 1 towards point 4. The wave then continuously moved from point 1 to 4 and vice versa. In addition, the amplitude reading started to scatter unanimously in the middle part of the graph shown in Figure 8 as the wave experienced interference: constructive and destructive interference between the wave that came from both left and side of the container.

4.3 Leaking Alarm Trigger System

The leaking alarm trigger system was initially being planned to detect any leakage at the bottom of the container of the flexitank. Leakage parameter was being set at 3 level which are at low, medium and high. The experimental test was being set up as shown in Figure 4.12 where the water sensor being placed in the beaker and being placed at the same axis with the container.

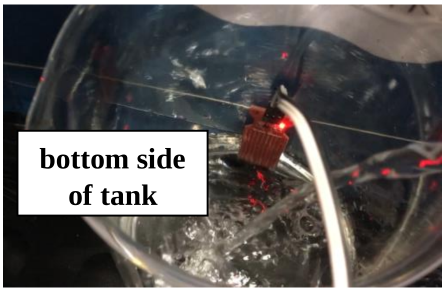
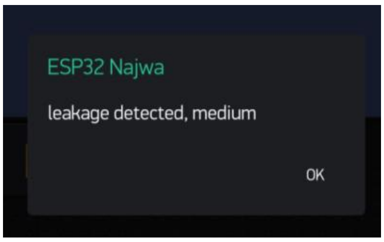


Figure 10: Water sensor setup

As the level of water at the medium parameter of the water sensor, the Blynk app has sent a pop-up notification to alert regarding the leaking at the container as shown in Figure 11 and the same pop-up notification popped when it reached the high level as shown in Figure 12. The status of the leakage also can be observed through virtual LCD panel in Blynk application as shown in Figure 13.



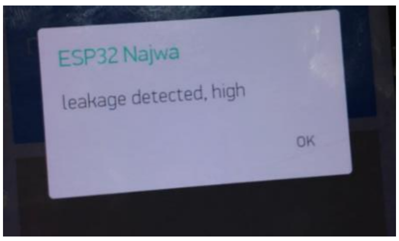


Figure 11: Pop-up notification when the leakage was at medium parameter

Figure 12: Pop-up notification when the leakage was at high parameter

Figure 13: Instant status of leakage on Blynk virtual LCD panel

The overview of the sensors and camera module in the Blynk application can be referred in Figure 14 where there are 4 virtual LCD displaying the reading of the ultrasonic sensor, 1 virtual LCD showing current state of leaking as well as the live streaming panel.

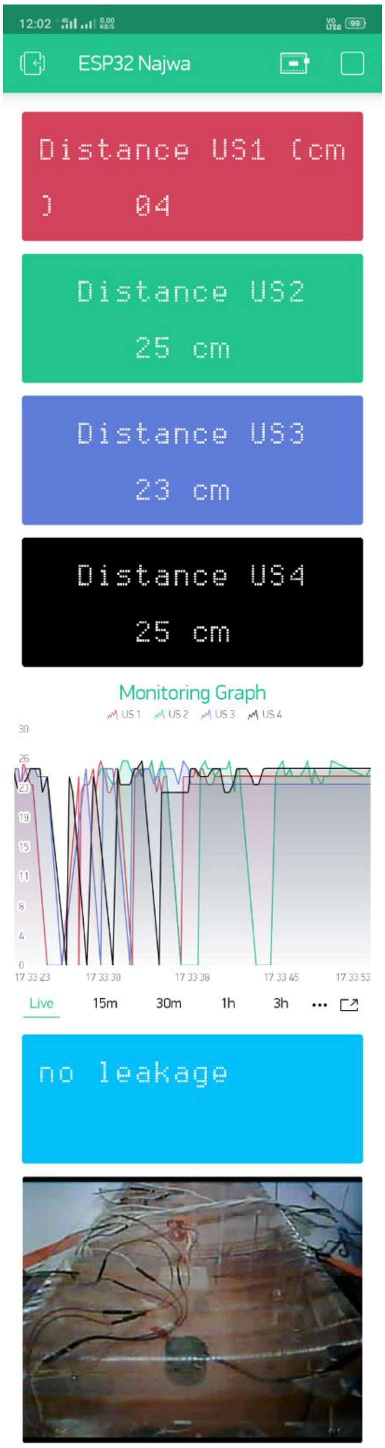


Figure 14: Overview of the sensors and camera module in Blynk application

4. Conclusion

In a nutshell, this study had achieved its objectives lined out earlier whereas the suitability of sensors used for flexible applications such as a flexible tank has been analyzed throughout the study. The monitoring system for the flexible tank that can be monitored through IoT applications was achieved where the data from the sensors accumulated through the Blynk server and displayed over the Blynk application that allows user to monitor any changes on the sensors. This monitoring system however can be improved with the use of any other sensors that might help in producing a reliable and effective monitoring system for flexible application in future.

Even though the wireless monitoring system works as intended, there are some recommendations that can be implemented in future improvement as follows:

i. Live streaming from ESP32-CAM can only be streamed through video panel on Blynk application. ESP32-CAM does come with micro-SD card storage but the streamed video yet can't be recorded and be saved into the micro-SD card. The advanced module
ii. Other type of sensor might be implemented as well to improve the monitoring system as such to monitor the shear strain on the flexible tank due to the impact of the fluid inside the tank.

Acknowledgement

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