Design and Development of a Ship Fuel Tank Volume Height Monitoring System Using the JSN-SR04T Sensor Based on IoT Telegram Bots with Solar Panel Energy

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Abstract. Design and Development of a Ship Fuel Tank Volume Height Monitoring System Using the JSN-SR04T Sensor Based on IoT Telegram Bots with Solar Panel Energy. Technological developments are getting faster and more advanced in this genera-tion. This can be utilized to create technology that is very widely used, namely technology in the field of electronics, by making tools for monitoring the height of fuel oil volume in ship tanks. Seafarers and the shipping industry in modern times like this can be said to need a LoT sounding meter monitoring tool because many ships in the shipping industry still use manual sounding meters, which can be detrimental to companies due to a lack of this problem. The author wants to create a tool that can provide monitoring information on ship fuel levels directly and can be controlled remotely for efficiency in working time. Sounding is an ac-tivity to measure the depth of large tanks that are difficult to reach. From this problem, the author wants to create a tool that can provide ultrasonic sensors on ship fuel levels directly and can be controlled remotely. The design of this tool is to use an underwater distance sensor with an ultrasonic sensor, which is used to determine the condition of oil parameters in the ship's fuel tank. This sensor is a sensor that functions to detect the oil level at a certain point for the output comod-ule, namely using the LCD as the output display. For data processing, a micro-controller component is used, namely the Node MCU board or ESP 8266 mod-ule. This design utilizes Internet of Things technology via the Telegram applica-tion on a smartphone, making it easier for users to find out the condition of the oil level in the ship's tank remotely via an Internet connection. In the process of providing complete information, namely when the oil level increases or decreases, the sensor will detect the distance or height of the oil parameters in the tank and send a notification via telegram that the oil or fuel is at a certain level. This tool will reset to the initial settings if the power input turns off.

Keywords: Sensor JSN – SR04T, Node MCU, Internet Of Things, LCD, Sounding Meter.

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1 Introduction

A sounding meter is used to calculate the volume of oil in a ship's bunker tank, determining the amount of fuel reserves using height as an indicator. However, some fraud occurs in sounding activities, where fuel from the bunker tank is diverted to meet other fuel needs and is depleted before reaching its destination, often due to illegal buying and selling (Putar et al., 2013).

Additionally, there is currently no monitoring system that allows ship management and crew to directly access fuel usage data. As a result, operators must routinely and manually monitor tank supplies (Saddam et al., n.d.). Errors in reading measurements often occur due to visual limitations, particularly during night measurements when lighting around the fuel tank is insufficient, leading to inaccurate results (Mahfud et al., 2019).

Advances in science and technology, especially in electronics and instrumentation, now make it possible to design measurement tools equipped with electronic sensors, signal conditioners, processors, and display systems (Sorongan et al., 2018). To address these issues, a tool is needed to measure fuel levels in the ship's bunker tank based on the Internet of Things (IoT), allowing ship management and crew to directly access total fuel consumption data without needing to be physically present at the equipment location.

2 Overview

2.1 Review of Previous Research

In this chapter, the researcher will explain the Review of Previous Research and the theoretical basis of "Design and Development of a Ship Fuel Tank Volume Height Monitoring System Using the JSN-SR04T Sensor Based on IoT Telegram Bots with Solar Panel Energy".

1. In the journal Design and Development of Realtime Sounding in a Storage Tank Simulator Based on the AVR ATMEGA 8535 Microcontroller (Citra Widya Edukasi Journal, Vol The sensor is processed using the capabilities of the AVR ATMEGA 8535 microcontroller (Mahfud et al., 2019).
2. In the second journal with the title Prototype of IoT-Based PLTGU Grati HSD Tank Monitoring and Controlling System (Jambura Journal of Electrical and Electronics Engineering, Vol. 4, 2 (2022), In this research, the researcher used several sensors that aim to be input, including the HCSR Sensor -04, gas sensor type MQ-7, fire sensor type SEN-0004, and the last one uses a DS18B20 temperature sensor. The data generated by the sensor will then be entered into the Arduino Uno, and then the data will be sent to the NodeMCU ESP8266 in the process of sending data using WiFi so that the data can be connected to the internet. Furthermore, the I-Could data obtained from the NodeMCU ESP8266 will be monitored and controlled using a smartphone using the Blynk application (Saddam et al., n.d.)

3. In previous research with the title HCSR04 Ultrasonic Sensor Based on Arduino Due for Altitude Monitoring Systems (Journal of Physics and Applications, Vol 15, 2 (2019)) The input circuit consists of the HCSR04 sensor which is connected to the Arduino Due and then the process from the Arduino is connected to the ESP 8266 so that can connect to a computer using the internet (Puspasari, et al., 2019).

In the first journal, the researchers did not use the Node MCU module. In contrast, this research incorporates the Node MCU module, allowing the monitoring system I developed to be Internet of Things (IoT)-based. In the second journal, the researchers used the HC-SR04 sensor to detect fuel levels on the ship. In this study, however, I used the JSN-SR04T sensor, which is oil-resistant and offers greater accuracy than the HC-SR04. In the third journal, previous researchers relied on computer input voltage as a power supply for the equipment. In this research, I aim to use solar cells as a renewable energy source and utilize the waterproof JSN-SR04 sensor.

3 Research Methods

This study uses a descriptive qualitative research methodology combined with experimental methods, as the researcher will conduct multiple experiments to achieve a successful design. The design incorporates solar panels, lithium-ion batteries, DC buck converter modules, DC jacks, Node MCU, JSN-SR04T ultrasonic sensors, and a 16x2 LCD for the control system to allow operation and monitoring. The research was conducted over 12 months on the MT Tanker ship Transko Arafura by PT Pertamina International Shipping.

3.1 Research Study

In the process of this research, the researcher needs a reference or literature to find a solution, the right way and method to solve a problem raised in this research about how to build a sounding meter by conducting a library study of several literary sources through books, journals, and internet.

3.2 Designing Software

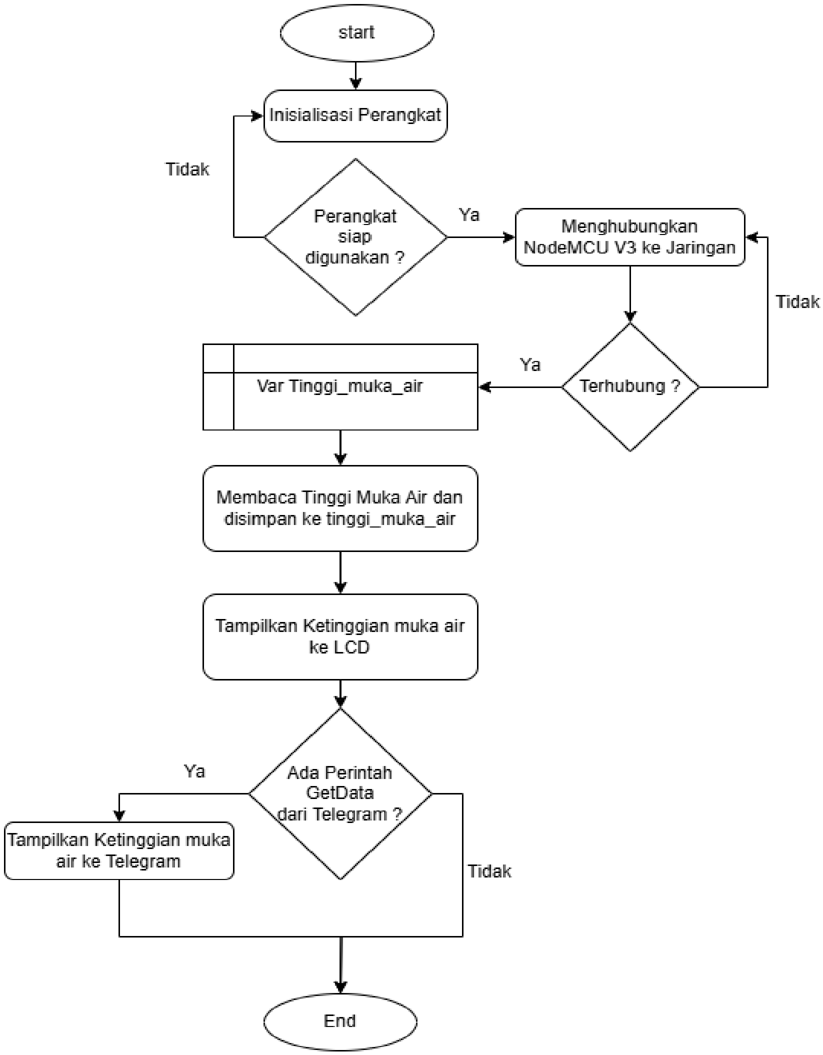

Fig. 1. Flowchart. Source : Personal Documentation

Press the ON switch first to activate the circuit. Then the MCU Node will be active to manage data from the JSN-SR04T sensor that will be used. When the sensor has read the oil level in the ship's tank, several output indicators will provide information about the ship's fuel level parameters. Then it will display the fuel level on the LCD and via smartphone with the Telegram application according to the data obtained in centimeter height units.

3.3 Designing Hardware

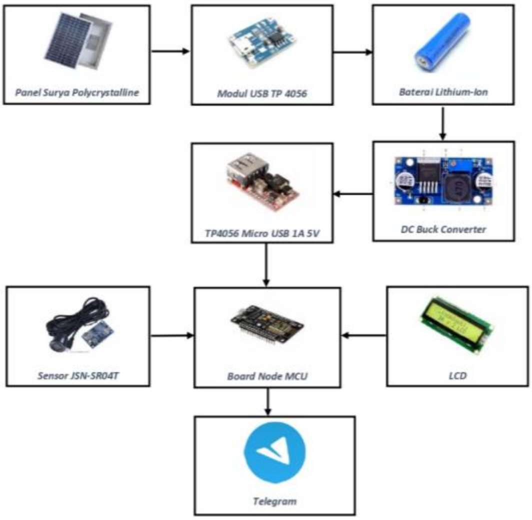

Fig. 2. Block Diagram. Source: Personal Documentation

Information:

1. The solar panel will convert sunlight energy into electrical energy which will then be stored in a lithium-ion battery using the help of the TP 4056 USB Charging.
2. The power from the lithium battery will then be stepped up with a DC Buck converter and connected to the NodeMCU V3 board using the TP4056 Micro USB 1A 5V Module because it only requires an input voltage of 3.3 – 5 volts to be able to turn on the NodeMCU V3.
3. Data input resulting from JSN-SR04T sensor monitoring information will then be sent to the MCU Node
4. The MCU node will send the fuel level results to the LCD and send the data to Telegram if there is a get data command to Telegram.

3.4 Tool Design

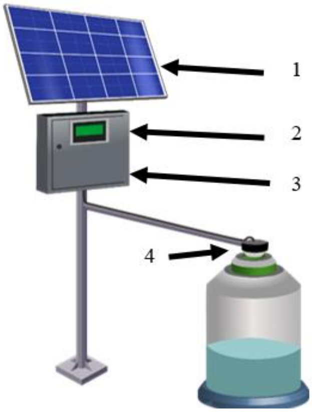

Fig. 3. Tool Model Design. Source: Personal Documentation

Information:

1. The solar panel functions as a power source to charge the Lithium Battery.
2. The LCD functions to display the JSN-SR04T Sensor measurement results
3. This panel box contains several main components such as the MCU node, Lithium-ion battery, 5V USB Boost module, and charging module.
4. JSN – SR04T sensor which functions to measure fuel level.

3.5 Electronic Design of Device Circuits

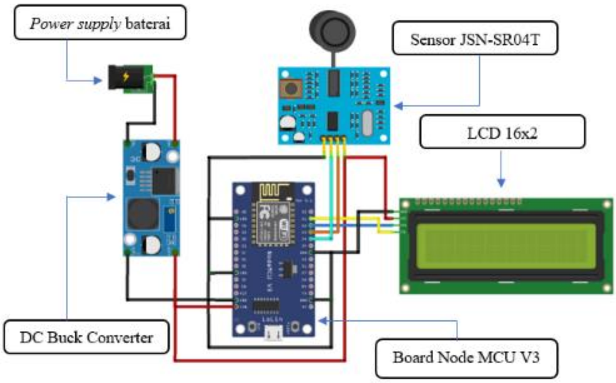

Fig. 4. Equipment Circuit Schematic. Source: Personal Documentation

The power supply comes from a battery connected to a DC buck converter, which functions to stabilize the electrical voltage within the circuit. Additionally, this component boosts the voltage from 3.7V to 5V, which is then supplied to the Node MCU board. In this research, the Node MCU ESP8266 was selected for its advantages, including a built-in WiFi module that enables activation of the JSN-SR04T sensor and the LCD within the circuit. This Node MCU can send and receive sensor reading data through a Telegram Bot.

3.6 Solar Panel Design

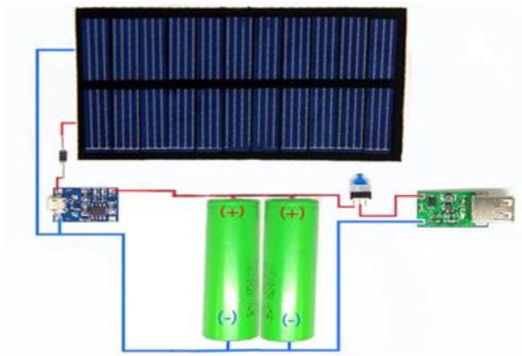

Fig. 5. Solar Panel Design. Source: Personal Documentation

This design requires four lithium batteries connected in parallel and can store power with a capacity of 10,000 mAh, a voltage of 3.7 volts, and a current of 0.38 mA so that it can be used at night or in cloudy weather. This solar cell circuit is connected to a micro USB charger module, battery, switch, and 5-volt USB boost module.

3.7 Tool Testing

Panel Power Test. The solar panel testing process involves connecting the solar panel board to four lithium batteries in parallel using the USB TP4056 charging module. To check if the solar panel is charging, observe the TP4056 USB module, which has two LED indicators in different colors. A red LED indicates that the battery is charging, while an unlit red LED shows that the battery is not charging. A blue LED indicates that the battery is fully charged.

Overall Tool Testing. In this overall test, all components—including the Node MCU V3 board, JSN-SR04T sensor, LCD, and other components—have been assembled into a complete tool. Begin by pressing the switch button on the Box Panel to power on the device. Then, position the JSN-SR04T sensor at the center of the well or tank diameter to take measurements. The Node MCU processes the sensor readings and sends a notification with the measurement results to the Telegram bot. For manual verification, you can view the readings directly on the LCD located on the Junction Box Panel on the tool pole. Results and Discussion.

4 Results

4.1 Tool Design Result

Fig. 6. Tool Design Result. Source: Personal Documentation

At the top, a solar panel supplies voltage to the lithium battery. At the front, a junction box measuring 20 cm (L) x 30 cm (H) x 12 cm (W) serves as the electrical and control unit. An LCD screen on the door of the junction box provides water level information. Additionally, a supporting iron pole approximately 60 cm tall holds the JSN-SR04T sensor in place.

Testing the NodeMCU V Internet Connection. This process involves a smartphone that has a WiFi analyzer application installed and a Node MCU V3 board with a WiFi network. This test is carried out to find out how far the node MCU module is from getting an inter-net connection and measuring the WiFi strength waves.

Fig. 7. NodeMCU V3 internet connection distance testing. Source: Personal Documentation

Power Testing on Solar Panels. This test uses an AVO Meter as a current and voltage meter. The condition of the panel itself can be seen on the charging module, where on the module there is an LED as an indicator of charging or not charging.

Fig. 8. Power Testing on Solar Panels. Source : Personal Documentation.

Testing Battery Power. This test aims to determine the durability of a battery that has a capacity of 10,000 mAh, a voltage of 3.7 volts, and a current of 0.38 mA using an AVO meter, with the device active without being connected to a solar panel.

Fig. 9. Testing battery power. Source : Personal Documentation

Testing the JSN-SR04T sensor. Testing of the JSN-SR04T sensor was conducted by comparing its readings with those from a ruler, observing any differences between the two out-puts. The author tested the JSN-SR04T sensor with two different liquid media: water and Diesel B30.

Fig. 10. JSN-SR04T Sensor Testing on Water and Diesel B30. Source: Personal Documentation

Overall Tool Testing. In the first testing stage, the solar panel was evaluated to determine the in-put voltage and electric current produced, using an AVO meter. Next, the JSN-SR04T sensor readings were tested to ensure that the sensors and out-put indicators functioned correctly in real-time according to the water level. This test was also necessary to verify that the notification messages received on Telegram matched the readings displayed on the LCD in the junction box.

4.2 Presentation of Data

In presenting this data the author will display and process data which will make it easier to determine the level of success of the tool that has been created following the design of the previous tool. This data is taken based on the tool that the author has created.

Retrieving Internet Connection Data on NodeMCU V3.

Table 1. Testing internet connection distance on NodeMCU V3.

Distance (m)	dBM	Connection NodeMCU V3		Display dBM
		yes	no	
2	-55	✓		
4	-60	✓		
6	-65	✓		
8	-75	✓		
10	-82	✓		
12	-87	✓		
15	-127		✓	

Based on the data obtained, Node MCU V3 is still connected to an internet connection with a max range of 12 meters, whereas when Node MCU V3 is above 12 meters from the WiFi range, Node MCU V3 is disconnected from the internet connection.

Solar Panel Data Collection

Table 2. Solar panel power testing

Time	Voltage (V)	Current (mA)	Condition of solar panels
08.00	4.55	0.34	charging
09.00	5.06	0.42	charging
10.00	4.22	0.31	charging
11.00	4.82	0.38	charging
12.00	5.33	0.43	charging
13.00	4.65	0.36	charging
14.00	4.31	0.32	charging
15.00	5.10	0.42	charging
16.00	5.05	0.42	charging

The solar panel power data collection was carried out 9 times at one-hour intervals. It can be seen that the condition of the solar panel at a current of 0.31mA is that the solar panel is still charging.

Data collection on battery power resistance. Data collection on battery power resistance was carried out for two days 12 times until the maximum battery power limit could not turn on the Node MCU V3 relay board. The test was carried out when the device was not connected to a solar panel.

Table 3. Battery resistance testing

Day - 1		
Time	***Voltage (V)***	***Current (mA)***
06.00	*4.20*	*0,91*
09.00	*4.11*	*0,90*
12.00	*4.02*	*0,90*
15.00	*3.93*	*0,90*
18.00	*3.84*	*0,90*
21.00	*3.75*	*0,90*
24.00	*3.66*	*0,90*
03.00	*3.55*	*0,90*
06.00	*3.46*	*0,90*

Day - 2		
Time	***Voltage (V)***	***Current (mA)***
09.00	*3.27*	*0.89*
12.00	*3.28*	*0.89*
13.00	*3.24*	*0.89*

From the test results recorded on the first and second days, the voltage of the battery decreased as it supplied power to the Node MCU. On the second day, at noon, the device was unable to turn on due to a voltage drop of 3.24V. By 13:00, the battery no longer provided sufficient voltage, despite being supported by a 5V USB module to activate the relay on the Node MCU board. The data indicate that the battery lasted only up to 32 hours.

Data Retrieval of Sensor JSN-SR04T. The researcher conducted several test trials using two different liquid media with varying properties and densities. By employing these different media, the aim was to assess the reliability of the sensor in measuring distances in various liquid forms.

Table 4. JSN-SR04T sensor testing on water and B-30 solar

Water Height(cm)	*JSN-SR04T Sensor (cm)*	*Ruler (cm)*
0	*0.00*	*0*
4	*4.00*	*4*
12	*12.00*	*12*
13	*13.00*	*13*
24	*24.00*	*24*

Solar height (cm)	*JSN-SR04T Sensor (cm)*	*Ruler (cm)*
3	*3.00*	*3*
5	*4.00*	*5*
8	*8.00*	*8*
11	*11.00*	*11*
13	*13.00*	*13*

Testing the sensor by comparing the data readings produced by the sensor with a ruler, the data obtained by the sensor is quite accurate with a fairly small percent error value, even up to 0% in 5 trials at different heights.

Overall Tool Data Retrieval. The author will verify that the solar panel can effectively convert sunlight into electrical energy and ensure that the lithium-ion battery can store power efficiently, providing a reliable power supply that lasts a long time. This data collection will be conducted simultaneously by comparing the sensor readings displayed on the LCD screen with those shown on the Telegram bot application.

Table 5. Overall tool testing

Time	**Solar Panels**		**LCD (cm)**	**Get data Bot Telegram**
	V	**mA**		
09.00	4.82	0.38	9.00	
11.00	5.05	0.41	15.00	
13.00	5.30	0.43	3.00	
15.00	5.10	0.42	22.00	

Overall tool testing is performed at different times to evaluate the tool's performance within the specified time frame. Test results indicated that in the morning, the output voltage decreased slightly due to cloudy weather, which reduced sunlight exposure. Sensor performance was also assessed about the solar panel test times to confirm that the device functions properly when turned on for at least half a day. This is because the tool does not require a significant amount of voltage, and the solar panel's charging process to the battery remains stable even under slightly cloudy conditions.

4.3 Data Analysis

Based on the experimental results measuring the height of the water and B30 diesel, it was found that the JSN-SR04T ultrasonic sensor could accurately detect the height of both substances. This accuracy is attributed to the relatively high density of diesel and water, which allows these substances to effectively reflect sonar waves from the sensor, enabling precise distance readings. Below is a table showing the density of the objects measured.

Table 6. Object Density Tables

Liquid	Density (kg/m^3)
Water	1.00 x 10^3
Sea water	1.03 x 10^3
Gasoline	0.68 x 10^3
Mercury	13.6 x 10^3
Diesel B30	0.88 x 10^3
LSFO	0.99 x 10^3

From the table it can be concluded that the JSN-SR04T sensor can still read the results of ECHO reflections with the ship's fuel (Solar B30) very well, thus this tool can be applied on ships to measure the level of the ship's fuel.

5 Closing

5.1 Conclusion

The design of the sounding meter tool utilizes the JSN-SR04T sensor to monitor water levels, with the sensor readings displayed on an LCD screen located on the panel box and accessible via a smartphone Telegram bot. The solar panel is designed to serve as a renewable energy source for the tool. The author concludes that the system func-tions effectively, successfully charging lithium batteries using the USB TP4056 charg-ing module. The power stored in the lithium battery is then used to operate the sound-ing meter.

The sounding meter reading information system, which utilizes the Telegram applica-tion, simplifies monitoring the fuel level in the ship's bunker tanks over long distances. Testing shows that data transmission is quite fast, with only a few seconds of delay. Therefore, the use of the Telegram application in this tool is deemed suitable for op-eration aboard ships.

5.2 Suggestion

Based on the results of the final assignment that has been carried out, there are sug-gestions for making further tools that can be used more optimally, here are some suggestions for research that can be carried out further

1. The charger module in the battery circuit currently lacks a voltage or ampere indicator to show how much power remains in the battery. To enhance user experience, it would be beneficial to add a charger module that can display the remaining power in the battery, either in numeric form or through other indicating devices.

2. The internet connection that can be connected to this tool is still limited. So you can add a component, namely a transmitter so that it can be connected over a long distance.
3. The software used on the device still uses telegram where data can only be sent in the form of notifications, so special software can be used as a monitoring medium.

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