Design a Simple Prototype Of An IoT-Based Gas Detector System As a Safety Effort On Ships

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***Abstract*— This study examines the design of a prototype IoT-based gas detector system as part of safety procedures on tankers specializing in transporting LNG. Early detection of gas leaks is important in sensitive and high-risk LNG transportation to prevent serious accidents and negative impacts on the marine environment. This study proposes a gas detector system connected to an IoT network, which allows continuous and real-time monitoring of gas conditions on board ships. Placing the prototype device provides important advantages in a scientific context. This study proposes a gas detector system connected to an IoT network, which allows continuous and real-time monitoring of gas conditions on board ships. Placing the prototype device provides important advantages in a scientific context. Three experiments were conducted on the prototype with LED indicators. The experiment results showed that the red LED light was on as an indication of a gas leak, while the green LED light indicated a safe gas condition inside the prototype device. The system design method includes the selection of the right gas sensor, the development of reliable hardware, and the use of IoT technology for the direct transmission of gas detection data to the control center. System implementation involves hardware and software integration, system reliability testing, and performance evaluation in simulations and real-world situations. The prototype test results showed a similar response to the use of portable gas, matches, and gas stoves. When a gas leak occurs, the buzzer is active, and the LED indicator is red. The first sensor sounded at 0.74 seconds in the portable gas test, 0.55 seconds in the match test, and 1.84 seconds in the gas stove test. Thus, the system provides a consistent and reliable response in detecting gas leaks. This research contributes to developing better maritime security technology, protecting the marine environment, and maintaining the safety of LNG transportation operations.**

***Index Terms*—IoT; LNG; Arduino; Gas Sensor**

I. INTRODUCTION

Sea transportation is included in a vehicle designed to move people and goods from one place to another by sea as the main route of travel used in the process or transportation system. Sea transportation includes various related activities such as navigation, logistics, shipping, and port management. When we imagine the splendor of a ship crossing the vast ocean, we are often fascinated by the beauty and elegance of the ship. However, behind the splendor lies an invisible threat: the danger of leakage in the ship's tank. Leaks in ship tanks are not only a technical problem but also pose a significant risk to maritime security, the environment, and human life [1].

The ship's tank serves as fuel and cargo storage. Leaks in neglected tanks can potentially cause marine contamination and threats to ecosystems and human health. Significant economic losses can also occur due to the cost of cleaning, repairs, and lawsuits. Leaks in ship tanks also disrupted trade and shipping operations, hurting global supply chains[2].

According to Hasugian, leaks in ship tanks threaten human safety and can cause serious accidents such as sinking or fire—the risk of incalculable loss of life and property. Prevention and detection are necessary with advanced technology, routine maintenance, and intensive training for the crew [3].

The construction of LNG ships involves unique aspects of handling cold LNG liquids safely and reliably. The hull is made of low-temperature-resistant steel with a strong structure. LNG tanks have insulation, cooling, piping, valves, and safety equipment. The propulsion system uses a dual-fuel engine, while the cooling system maintains the LNG temperature and dissipates engine heat. There is also an automatic security and control system. All of these systems must comply with industry standards for the safety and reliability of LNG vessel operations [4].

Tankers transport LNG in special tanks with low temperatures and specific pressures. In addition to LNG, ships carry fuel, water, food, and other equipment. Cargo arrangements must pay attention to safety, efficiency, and international regulations. Filling, storing, and transporting LNG requires careful handling according to safety standards [5].

Safety systems on LNG vessels protect the ship, LNG cargo, and crew. It includes leak detection, fire extinguishing, ventilation, access control, and environmental and security monitoring. Integrating these systems forms solid protection and reduces the risk of accidents. Maintenance of this safety system is important to maintain the safety of the ship, crew, and the environment[6].

Applying IoT technology to leak detection on ships is a promising and innovative solution. IoT involves connecting and exchanging data between various devices or physical objects over a network, opening up new opportunities for real-time monitoring and detecting leaks. One of the key advantages of IoT adoption in this context is its ability to provide better visibility into the vessel's overall condition. Smart sensors connected to IoT networks can be placed at various critical points on LNG vessels, including around gas storage tanks.

These sensors can detect changes in temperature, pressure, and chemical components within the LNG storage space, providing an in-depth understanding of the environmental conditions surrounding the ship.

This implementation not only provides early detection of potential leaks but also allows for a quick response to emergencies. Vessel monitoring and management teams can receive notifications in real-time if any anomalies or leaks are detected, allowing them to take preventive measures or coordinate evacuations if needed.[7].

The data collected by IoT sensors can be thoroughly analyzed to identify patterns that can be early indicators of potential leak risk. It aids in preventive maintenance planning and improves overall operational efficiency. While IoT offers promising solutions, challenges such as data security and system integration should be of close attention. However, with the continuous development of technology, the application of IoT in leak detection on LNG vessels promises to be a big step towards higher operational safety and better environmental protection[8].

II. RESEARCH METHOD

This research was carried out in the computer laboratory and ship construction workshop of the TRKP Vocational College of Diponegoro University, Semarang City.

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This research is systematically summarized in the following flow:

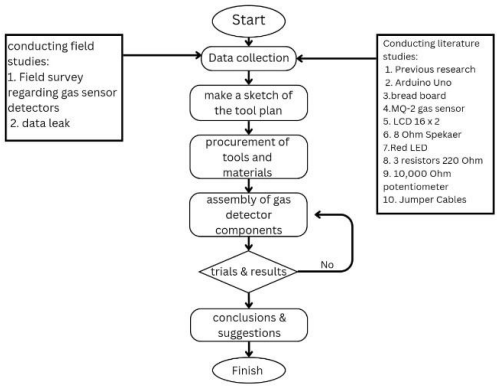

Fig. 1. Research Flow Chart

The needs of tools and materials in this study used in the manufacture and installation of prototypes in this journal can be seen in the following:

- Arduino Uno Functions to make prototyping, microcontroller programming, and creating advanced tools easier.
- The MQ-2 sensor monitors and detects the state of these easily leak gases.
- Breadboard serves to design a simple electronic network.
- Resistors to regulate the amount of current flowing by generating resistance to current flow, voltage regulators to divide the voltage at two or more points in the circuit, limiting current to protect other component components in the circuit from excessive current flow, and LED controllers to limit the current flowing through the LED to prevent damage to the LED due to excessive current.
- 16 x 2 LCD To display text and characters in a format of 16 characters per line and two lines to display text clearly and easily read and monitor data from the sensor in real-time. Where the generated data needs to be displayed, LEDs are used as visual indicators in various electronic devices to indicate on/off power status and as visual markers in security or safety applications such as emergency lights.
- Buzzers are used for notification or alarm devices to warn of a particular event or condition.
- Jumper cable is used to connect components in an electronic circuit and connect various electronic components such as microcontrollers, sensors, modules, and other devices in a circuit.

III. RESULT AND DISCUSSION

The IoT application carried out in this research startswith the assembly and testing of tools.

A. *Tool Assembly*

At the assembly stage, joining all the components into a single unit becomes key in building a working rare. This is done by using jumper cables that are Male and Female types, ensuring that all components are correctly connected, as shown in the following Figure 2.

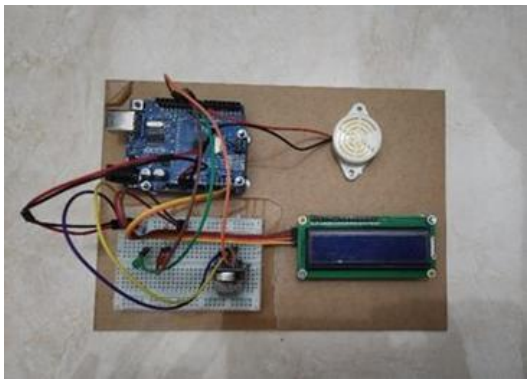

Fig. 2. Tool Assembly

Fig. 3. Sketch Display on Arduino Application

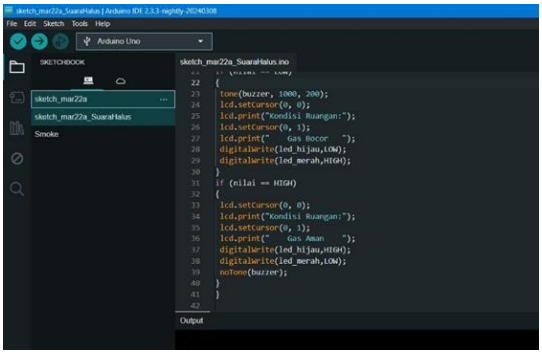

Fig. 4. View on the first Script

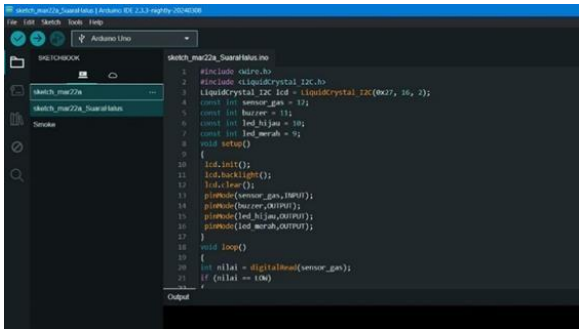

Fig. 5. Display on the second Script

After all the scripts are entered, click the "Upload" button on the Arduino IDE application for the next step. Then, wait a while to see the LED on the Arduino board flickering. If the upload is successful, a "Done Uploading" message will appear on the status bar.

B. *Prototype Testing*

The testing activities discussed the test results obtained.

- LED Testing
  The LED test aims to find out if the LED is lit properly; if the LED is appropriately lit, the green LED will turn on, which means that the gas status is safe and there is no leak; if the red LED is on, it means that a leak in the gas is detected.
- LCD Testing
  LCD testing is carried out to determine if there is a gas leak in the condition of the room. If there is no leak, then on the LCD, it is written "SAFE GAS." If there is a leak, then on the LCD, it is written "GAS LEAK."
- Buzzer Testing
  The buzzer test is carried out to determine whether the buzzer system sounds if there is a leak, and when there is no leak, the buzzer does not sound.
- Sensor Testing
  Sensor testing is carried out to determine whether the sensor works well. There are three methods for testing the sensor: a lighter, portable gas, and gas stove.

TABLE I. TOOL TEST TABLE

Validation	Test			Buzzer	LED
	1	*2*	*3*		
Portable Gas	0.74s	1.17s	1.85s	Flame	RED
Match	0.55s	0.93s	1.18s	Flame	RED
Gas Stove	1.84s	2.57s	3.71s	Flame	RED

Table 1 shows the test data of the tool. In the prototype test, when using portable gas, the buzzer lights up, the LED indicator is red, and the first test of the sensor sounds at 0.74 seconds; the second test of the sensor sounds at 1.17 seconds, and in the third test, the sensor sounds at 1.85 seconds.

In the test using a match, the buzzer was also turned on, the LED indicator was red, and in the first experiment, the sensor sounded at 0.55 seconds; in the second experiment, the sensor sounded at 0.93 seconds; and in the third experiment, the sensor sounded at 1.18 seconds.

Likewise, in the test using a gas stove, the buzzer turned on, and the LED indicator was red; in the first experiment, the sensor sounded at 1.84 seconds; in the second experiment, the sensor sounded at 2.57 seconds; and in the third experiment, the sensor sounded at 3.71 seconds.

C. Planning for The Placement of Prototype Tool

For the use of prototype tools, namely in the double hull, the placement of prototype tools in the double hull has several important advantages. First, the safety of the prototype tool is guaranteed from impact and damage. Second, the environment is protected because the double hull prevents the leakage of harmful materials to the surrounding environment. Third, the double hull provides better structural stability in the ship. Fourth, disruption to ship operations can be reduced by placing prototype equipment in the double hull. Finally, the placement inside the double hull also increases the confidentiality and intellectual security of the prototype tool.

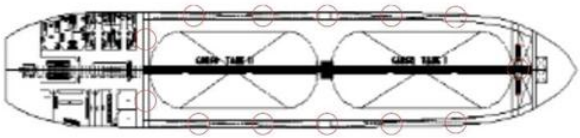

Fig. 6. Example of a figure caption

IV. CONCLUSIONS

Applying an Internet of Things (IoT) based gas detector system on LNG carriers is an innovative and practical step to improve safety. IoT technology lets sensors connected to the network detect gas leaks in real-time, enabling quick responses to emergencies and reducing the risk of accidents or incidents. Users can set up and adjust the gas detector system through a laptop or computer device connection. They can configure parameters, set sensitivity, and monitor system function. System performance testing and monitoring can also be carried out to ensure good operation without any problems detected. The use of IoT-based gas detector systems on LNG carriers provides a higher level of safety. Early detection of potential gas leaks allows for quick preventive or evacuation measures. In addition, the system aids in preventive maintenance planning and improves overall operational efficiency. Overall, designing a prototype of a ship's detector system is important in improving safety. This technology provides better visibility into the vessel's condition, quick response to emergency situations, and supports safe and efficient operations.

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