Performance Analysis of HC-SR04 and JSN-SRT04T Sensors for Optimization of Microcontroller-based Septic Tank Volume Monitoring Tools

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Abstract.
A septic tank is a temporary storage place for household waste, in which there are several gases that if the concentration increases, it will cause several impacts on the health and safety of people or the community around the septic tank. Previous research related to monitoring and neutralizing gas sewers in septic tanks has been successfully made, but the tool has shortcomings in terms of the use of the HC-SR04 sensor, where if the sensor is in humid conditions for a long time, then its performance cannot be optimal, due to the influence of humid space, therefore it is necessary to optimize the tool in terms of detecting the level of fulfillment of septic tank volume. As a result of optimizing the septic tank volume detection sensor which was replaced with the JSN-SR04T sensor, the volume detection results are more accurate and more stable, this is because the JSN sensor is waterproof, so that intervention from a humid environment is minimized. Testing from the two sensors found that the accuracy level of HC-SR04 in measuring distances between 20 to 200 cm, with 12 tests, the accuracy level of JSN-SR04T was 100%, and HC-SR04 was 90.1%.

Keywords: *Performance Analysis; HC-SR04; JSN-SR04T and Septic Tank.*

1. INTRODUCTION

Cleanliness is an aspect that must be a top priority in life, and this usually starts from the family environment. Various activities such as bathing, washing clothes, and cleaning household utensils are part of efforts to maintain cleanliness in the household. However, it should be remembered that these activities produce waste that should not be disposed of directly into the drainage system, as this can cause environmental pollution. In particular, waste that contains residual detergent and human waste needs to be properly and correctly managed to prevent environmental pollution. Therefore, every household must have a waste containment facility, commonly known as a septic tank. This septic tank is a temporary place to dispose of waste that can pollute the environment.

Several accidents have occurred due to excessively high concentrations of exhaust gases in septic tanks, leading to explosions strong enough to cause the tank cover to collapse. Such incidents have been recorded in Cakung, East Jakarta [1][2]. The explosion was caused by high concentrations of exhaust gases, including methane (CH_4), hydrogen sulfide (H_2S), ammonia (NH_3), carbon dioxide (CO), sulfur dioxide (SO_2), and nitrous oxide (N_2O) [3].

Susilawati and Sitohang, in their research, developed a prototype to monitor the volume and gas concentration in septic tanks. Notifications from this prototype are sent via SMS to the user's phone. However, this prototype does not include a device or component aimed at reducing gas concentration in the septic tank. The prototype uses an Arduino UNO as the main board, an HC-SR04 ultrasonic sensor to detect liquid distance in the septic tank, an MQ2 sensor to detect gas concentration in the septic tank, and a SIM800L module to send SMS notifications to the user [4].

Rusdiyono et al. conducted a study by creating a device to measure methane gas concentration from an anaerobic baffled reactor (ABR) using spoiled milk as a substrate. The device developed was a prototype that measures the concentration of methane gas in spoiled milk. This prototype consists of an Arduino UNO as the main platform, equipped with an MQ4 sensor, which functions as a detector

and measurer of methane concentration in the spoiled milk. In testing, the prototype showed an error rate of 6%, with a precision level of 95% and an accuracy of 94% [5].

Khakim et al. found that while the system built was technically in line with the intended benefits and functions, the HC-SR04 sensor used had weaknesses in detecting the volume of septic tank waste, especially under humid conditions, which reduced the sensor's performance, resulting in suboptimal system functionality. Therefore, a sensor is needed that works similarly to the HC-SR04 but is more resistant to changing environmental conditions [6].

In this study, several characteristics differentiate it from previous research, namely the optimization of the tool's function in detecting septic tank volume. An analysis will be carried out on the performance of both the HC-SR04 and JSN-SR04T sensors, which are both distance sensors, to determine which sensor is more optimal in detecting septic tank volume and is more reliable under all weather conditions.

II. METHODS

The research method used in this study adopts the Agile method [7][8], as it is considered more suitable for addressing issues related to system development due to its more flexible process. This method is illustrated in **Fig. 1.**

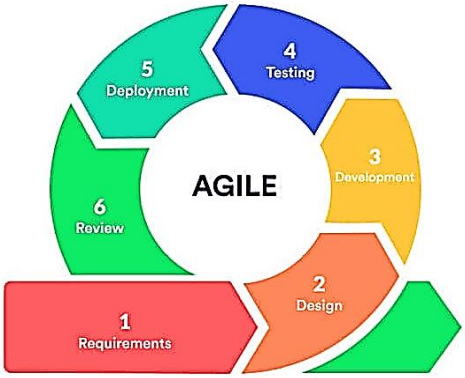

Fig. 1. Agile Method [9]

In the method used for development, an approach using the Agile method is applied, where the workflow of the method is as follows:

1) Requirements

This stage is the primary procedure in developing a system, where all necessary requirements to build the system are identified. Generally, this stage is carried out by observing either directly or indirectly the research site or object.

2) Design

At this stage, the system is designed to address or solve the identified problems. The system design should be appealing and not too complicated to use. The resulting project must be user-friendly, as tools or projects are more effective when their functionality is useful and does not burden the user during operation.

3) Development

This stage begins after the installation of the prepared components and sensors. Programming is then carried out according to the functions planned for the project. Programming is done using the Arduino IDE, which compiles C++ code.

4) Testing

After completing the assembly or installation, and programming stages, the next step is testing the project. Initial testing includes evaluating the sensitivity of the MQ2 gas sensor and the ultrasonic sensors HC-SR04 and JSN-SR04T. The results of HC-SR04 and JSN-SR04T are compared and

analyzed for performance. Once the more optimal ultrasonic sensor is identified, it is installed into the septic tank volume warning tool to be used.

5) Deployment

This stage is essentially the implementation phase, where all sensors and actuators are confirmed to function as planned. This phase also marks the readiness of the project for production and application.

6) Review

In this stage, the system undergoes regular maintenance aimed at analyzing the performance of the developed device. Maintenance focuses on two crucial components, the sensors and the actuators, and the sensor component is checked to assess its sensitivity to waste gases and liquid volume, while the actuator component is checked, particularly the fan, which serves to neutralize the concentration of sewer gases.

Block Diagram

The block diagram is a schematic of a series depicted with blocks representing a part or component that makes it easier to assemble components so that it becomes an integrated system [10], where the block diagram in the series of optimization of septic tank monitoring equipment is shown in Fig. 2.

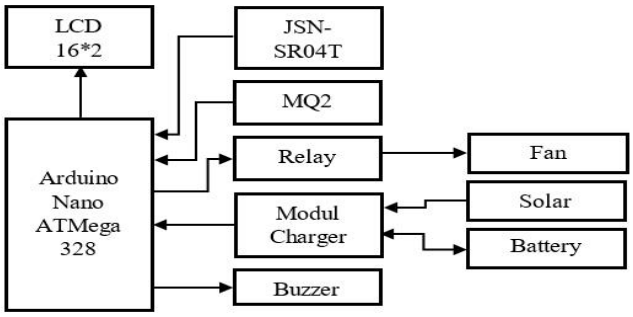

Fig. 2. Septic Tank Volume Warning Tool Block Diagram with JSN-SR04 Optimization

System Workflow

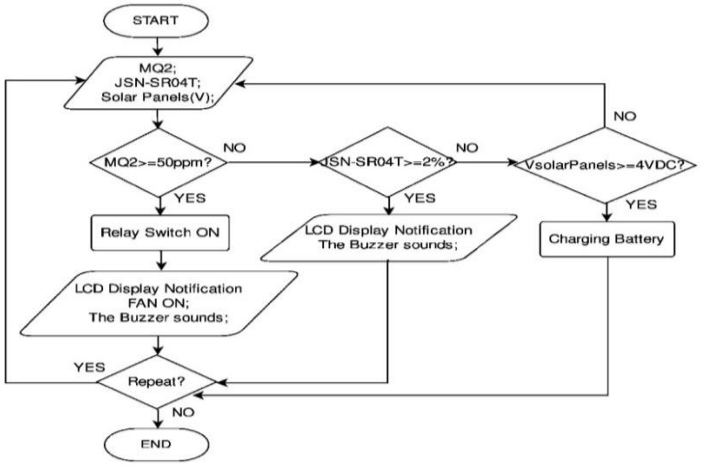

Fig. 3. Optimized septic tank volume warning tool system workflow with sensor JSN-SR04T

The system flow of the optimization of the septic tank volume warning device is intended as a medium to facilitate the reading of the workflow of the tool [11][12], where the workflow is shown in Fig. 3.

Schematic Diagram

The schematic diagram is made to facilitate the assembly stage between the components so that there is an integration between the functions of one component and another so as to form a new system [10][12], the schematic sequence of which can be shown in Fig. 4.

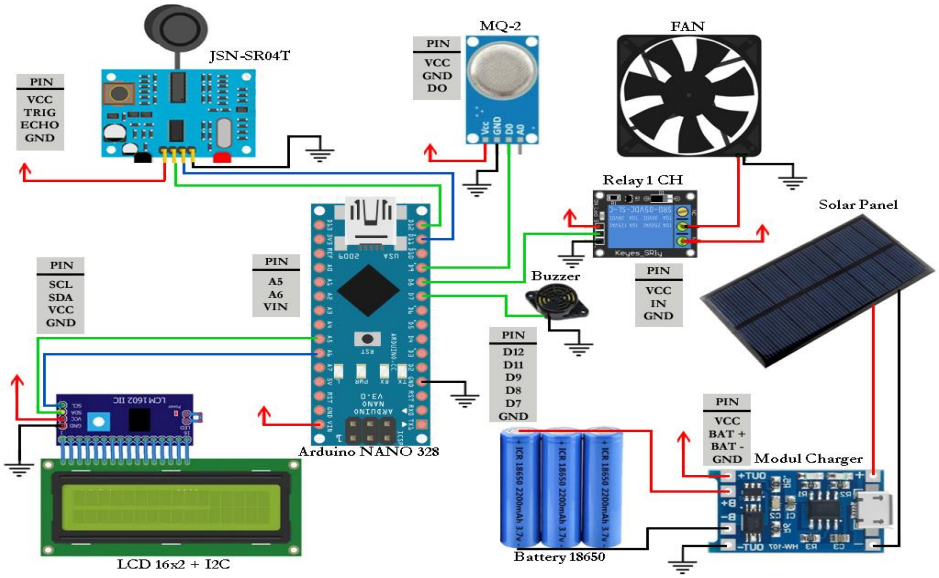

Fig. 4. Schematic of the circuit of the septic tank volume warning system optimized with sensor JSN-SR04T

Tools and Materials

In this study, there are several main components and sensors used as supporting materials, where the components and tools are as follows:

1) Arduino Nano Atmega 328, this tool is the main component (microcontroller) in which the data processing process produced by the sensor occurs, so that the data is used as input to control other tools or actuators [13][14].

2) JSN-SR04T, is an ultrasonic sensor that can detect and measure the distance of objects between the sensor and the object, this sensor is a waterproof sensor, with a detection distance between 20cm to 400cm, with more stable object detection compared to the HC-SR04 sensor [15][16].

III. RESULT AND DISCUSSION

In this section, each step by step in analyzing the performance of the HC-SR04 and JSN-SR04T sensors is explained, as follows:

System Installation

At this stage, it is the installation process or the integration of components and sensors used for the analysis process, where the analysis here is to compare the performance of the JSN-SR04T sensor with the HC-SR04, after the analysis process, a sensor that has higher accuracy will be obtained, and then the sensor will be installed on the septic tank volume warning device as an effort to optimize the performance of the tool. The results of the assembly of the test system are presented in **Fig. 5.**

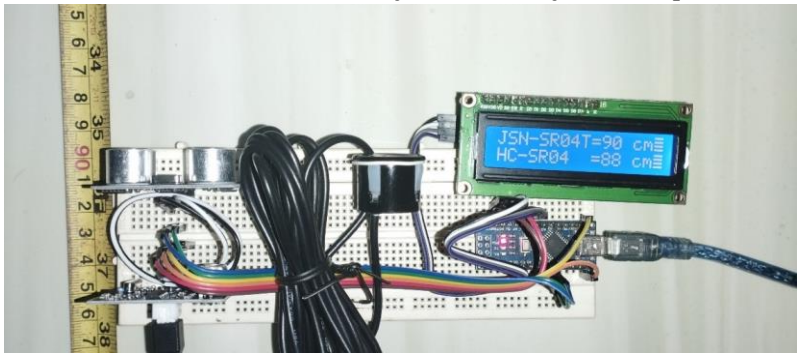

Fig. 5. JSN-SR04T and HC-SR04 sensor performance comparison system assembly

System Testing

The system test was carried out to analyze the performance results of the HC-SR04 and JSN-SR04T sensors, where the test results of each sensor were compared, and the performance results between the HC-SR04 and JSN-SR04T sensors were obtained, which were more optimal in measuring volume. The test is carried out with two schemes, where the tests are as follows:

1) Accuracy level testing of HC-SR04 and JSN-SR04T in Aquarium

Fig. 6 shows the test carried out in obtaining performance results between the HC-SR04 and JSN-SR04T sensors, where from the two sensors the measurement results are compared with the ruler measuring instrument, then the comparison results will be entered into the formula to get the volume of each test carried out, the equation used in the test is shown in Equation (1).

$$v=p*l*t \quad (1)$$

where:

v = volume

p = length

l = width

t = height

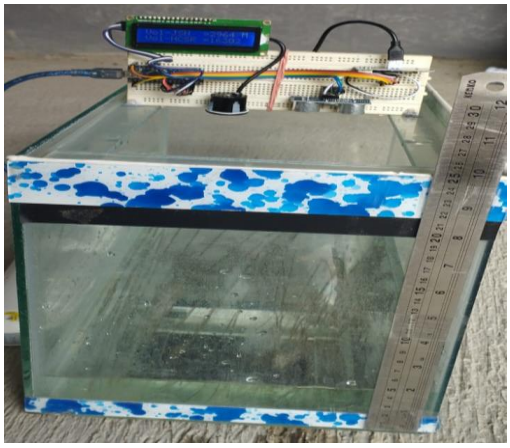

Fig. 6. Testing of the accuracy level of HC-SR04 and JSN-SR04T in calculating water volume with aquarium media

The test was carried out on an aquarium with a length of 39cm, a width of 19cm, and a height, using the measurement results from the HC-SR04 and JSN-SR04T sensors. The test technique is carried out by calibrating the sensors, where it is done by placing the two sensors in positions that show the measurement results before the aquarium is filled with water is 0cm, then after the calibration process is completed, the next step is to pour water into the aquarium with varying doses, where the test results are shown in **Table 1.**

Table 1. Accuracy test results of HCSR-04 and JSN-SR04T sensors with an aquarium

No	Testing	Water Height (CM)	Amount of Water (CC)	Volume Detection Result (CM^3)		Volume (CM^3) (p*l*t) (39*19*Water Height)	Volume Difference	
				JSN	HCSR		JSN	HCSR
1	1	0,2	300	741	741	148,2	592,8	592,8
2	2	0,3	500	741	741	222,3	518,7	518,7
3	3	0,4	800	741	11115	296,4	444,6	10818,6
4	4	2	1300	1482	11115	1482	0	9633
5	5	2,5	1800	1482	1482	1852,5	-370,5	-370,5
6	6	3	2300	2223	2223	2223	0	0
7	7	3,7	2800	2964	2964	2741,7	222,3	222,3
8	8	4,3	3300	2964	16302	3186,3	-222,3	13115,7
9	9	5	3800	2964	3705	3705	-741	0
10	10	6,3	4300	2964	4446	4668,3	-1704,3	-222,3
11	11	6,7	4800	2964	4446	4964,7	-2000,7	-518,7
12	12	7	5300	2964	5187	5187	-2223	0
13	13	7,5	5800	2964	5928	5557,5	-2593,5	370,5
14	14	8,2	6300	2964	5928	6076,2	-3112,2	-148,2
15	15	9	6800	2964	6669	6669	-3705	0

No	Testing	Water Height (CM)	Amount of Water (CC)	Volume Detection Result (CM^3)		Volume (CM^3) (p*l*t)	Volume Difference	
16	16	9,6	7300	2964	7410	7113,6	-4149,6	296,4
17	17	10,4	7900	2964	8151	7706,4	-4742,4	444,6
18	18	11,2	8500	2964	8151	8299,2	-5335,2	-148,2
19	19	11,9	9000	0	8892	8817,9	-8817,9	74,1
20	20	13,2	10000	0	10374	9781,2	-9781,2	592,8
Average of Accuracy (%)							10	20

From the test results shown in **Table 1**, it can be concluded that the accuracy level test carried out on the HC-SR04 and JSN-SR04T sensors with several tests as many as 20 times, 2 times (10%) tests were successfully carried out with JSN-SR04T, and 18 times (90%) tests failed to detect volume accurately, then the test results with HC-SR04 were obtained 4 times (20%) tests were successfully carried out, and 16 times (80%) of the tests failed to accurately detect volume.

2) Accuracy level testing of HC-SR04 and JSN-SR04T with Wall objects

The next test was carried out by measuring the distance of the two sensors from the wall object, and comparing the test results with the meter as the basis for the distance, where the test picture is shown in **Fig. 7.**

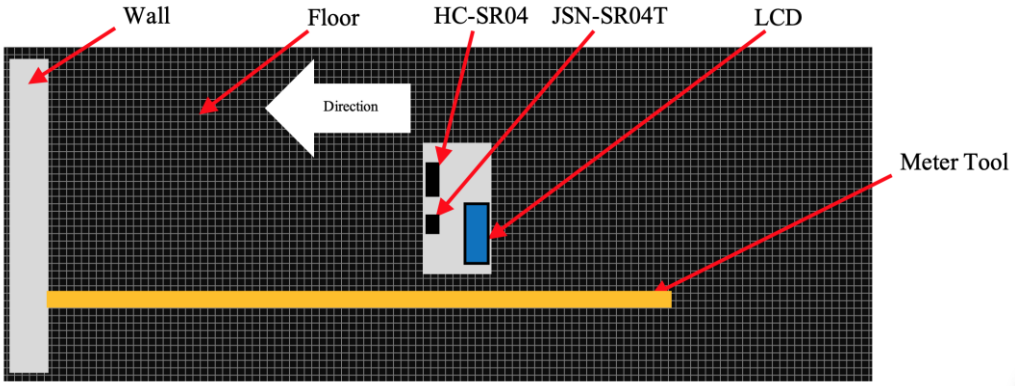

Fig. 7. Accuracy level testing of HC-SR04 and JSN-SR04T with wall objects compared with metering tools

Table 2. Accuracy level test results of HC-SR04 and JSN-SR04T with the object wall

No	Testing	Object Distance (CM)	Detection Result (CM)		Difference (CM)		Accuracy (%)	
			S1	S2	S1	S2	S1	S2
1	1	20	19	20	-1	0	99	100
2	2	40	39	40	-1	0	99	100
3	3	50	49	50	-1	0	99	100
4	4	60	58	60	-2	0	98	100
5	5	80	78	80	-2	0	98	100
6	6	110	57	110	-53	0	47	100
7	7	130	76	130	-54	0	46	100
8	8	150	149	150	-1	0	99	100
9	9	160	159	160	-1	0	99	100
10	10	180	179	180	-1	0	99	100
11	11	190	189	190	-1	0	99	100
12	12	200	199	200	-1	0	99	100
Average of Accuracy (%)							**90,1**	**100**

Notes:

S1 : Sensor 1 (HC-SR04)

S2 : Sensor 2 (JSN-SR04T)

From the test results shown in Table 2, where the test was carried out by measuring the distance between the HC-SR04 and JSN-SR04T sensors and the object (wall), then the distance between the sensor and the object was measured by referring to a meter (tool), where the test results can be concluded that from the 12 tests carried out, with distances ranging from 20cm to 200cm, the average

accuracy value of the HC-SR04 sensor was 90.1%, and the average accuracy value of the JSN-SR04T sensor is 100%.

Conclusion of Test Results

The test results that have been presented in Table 1, it can be concluded that in the implementation of the HC-SR04 sensor it is more optimal to detect objects with a distance starting from 3cm, according to the HC-SR04 sensor dataset, that at least the sensor can detect objects with a distance of at least 2cm and a maximum of 400cm [19], then from the test results it is more optimal to use HC-SR04 to detect objects with a range starting from 3cm, Although out of 20 tests, only 4 tests were accurate, but it was no better than JSN-SR04T which only 2 tests were accurate.

In the test results presented in Table 2, where the test is carried out with a distance starting from 20 cm, it can be concluded that JSN-SR04T is more accurate in measuring objects, with an average accuracy rate of 100%, and the test results of HC-SR04 with an average accuracy level of 90.1%, thus JSN-SR04T is more optimal in measuring objects with distances starting from 20cm. The JSN-SR04T sensor dataset shows that the sensor can measure distances from 20cm to 600cm [15].

From the test results of Table 1 and Table 2 that have been presented, it can be concluded that the HC-SR04 sensor is more optimal in measuring distances starting from 3cm, while JSN-SR04 starts optimally at a distance of 20cm, but in terms of accuracy produced from the two sensors, it is found that JSN-SR04T is higher in measuring distances compared to HC-SR04T, further in terms of durability in the working environment of the two sensors, JSN-SR04T is more resistant to humid conditions and is waterproof, as the sensor is classified as a waterproof sensor [15].

IV. CONCLUSION

From the results of the research that have been presented and presented in the previous discussion, it can be concluded that the results of the research on the level of accuracy between HC-SR04 and JSN-SR04T show that JSN-SR04T is more accurate in measuring the distance of objects with an optimal range between 20cm to 200cm, but if to measure the distance of objects with a range of less than 20cm, then HC-SR04 is more recommended. Furthermore, in the septic tank volume warning device, which is seen in terms of the environment used for the implementation of the tool, it is recommended to use the JSN-SR04T as a volume counter, considering that the sensor is superior to humid environments compared to the HC-SR04.

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