Design an Automatic Water Tank Filling Tool Using NodeMCU Based on the Internet of Things

Taufan Maulana Hazbi, Alfian Ma'arif
Department of Electrical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

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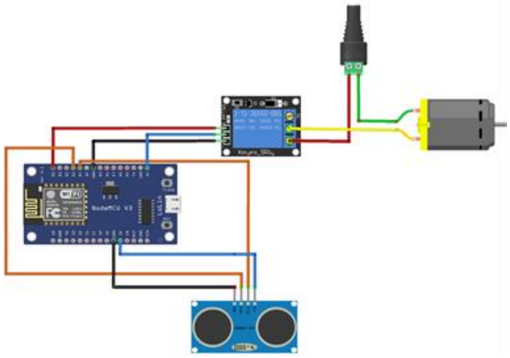
Corresponding Author:

Alfian Ma'arif,
Department of Electrical Engineering,
Universitas Ahmad Dahlan,
Yogyakarta, Indonesia
Email: alfianmaarif@ee.uad.ac.id

ABSTRACT



Drought is still common in Indonesia, especially in the prolonged dry season while the world's clean water reserves are only around 3%. Groundwater is a renewable natural resource, but overexploitation can cause problems such as sink holes, land subsidence, and seawater intrusion, therefore, the design of filling water tanks and automatic height meters is made as an effort to save water. these automatic water tank measurements use the Internet of Things method accessed through Blynk. An internet of things-based tool measurement system with a water level principle uses an ultrasonic HC-SR04 sensor to measure Blynk's integrated water level, using the Nodemcu ESP8266 microcontroller as the main control. The overall result of the design of the tool, the water topping up process is shown in units of percent, the ultrasonic sensor HC-SR04 displays the actual distance and water level to Blynk in cm.

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1. INTRODUCTION

Water is a source of life for living things, not only for daily needs, but also important in the production process. Excessive water use without restrictions can result in scarcity of clean water while the world's freshwater reserves are only around 3% [1]. The scarcity of clean water not only hampers the pace of the economy and economy but can damage ecosystems. Groundwater is a renewable natural resource, but awareness of the importance of clean water is still not considered because of the lack of public knowledge about the scarcity of clean water [2].

Cases of scarcity of clean water in Indonesia occur in the dry season when groundwater reserves continue to be used while rainfall is very low. Groundwater can be replenished when it rains, but when groundwater runs out before it can be replenished it can result in emptiness in the soil [3]. This vacancy can cause problems such as land subsidence, where the space is empty and the land height decreases resulting in the area being submerged by seawater [4].
In modern times like today, water that used to be free goods is now a commodity item (economic goods), which means that water can be traded [5]. In an industrial process such as the processing of beverages and ice cubes, water is the main ingredient, too much waste means to waste money [6]. Water use also does not escape the problem of water scarcity so supervision is needed on every use. Human labor surveillance is somewhat ineffective, because humans cannot operate continuously and are exhausted [7].

A manual control system is a control system with the subject of living beings, for example by humans. Usually this system is used in some non-critical processes. While the automatic control system is a control system where the subject is replaced by a device called a controller. Where the task of turning on and off is no longer done by the operator, but at the command of the controller [8][9].

Microcontrollers can be the basis in the performance of a system automation because they can be integrated with peripheral inputs and outputs through each path so that they can be a solution in meeting technological needs [10][11].

The design of this tool is expected to be an alternative means in an effort to save clean water and its use can be applied to related industrial processes. The working system of this tool places the sensor on the tank lid in a downward position, the pump uses a submersible type so that it can be placed outside or inside the water source, nodemcu and relay are placed in a box to protect the component [12]. Monitoring system through Blynk, displaying the water level, actual distance, and water filling process indicated in percentages, water automatically fills the tank when the percentage value is less than 20 percent [13].

2. METHODS

IoT is known as the everyday computing of objects that are connected by the internet and capable of identifying themselves to other devices. The characteristic of IoT is that it has the ability to transfer data over a network without human-to-human or human-to-electronic device interaction. IoT works by using programming where each command generates interconnected interactions without human intervention so that humans only serve as supervisors and regulators of the tools that have been designed [14]. In the design of this tool, it uses the HC-SR04 ultrasonic sensor as a height monitoring tool and a 12V DC pump as a water filling tool. This circuit works using predefined programming via the Arduino IDE. Furthermore, for media clouds on IoT, use the Blynk application to monitor water levels [15][16].

2.1. Internet of Things

IoT is the concept of internet connectivity by exchanging information with each other with existing objects can be seen in Figure 1. IoT evolved from the convergation of MEMS (micro-electromechanical system) wireless technology and the internet [17]. IoT uses physical goods that are connected to wireless modules such as nodeMCU. Then nodeMCU connected to the internet will send data from the physical item to the cloud platform for monitoring such as Blynk, Antares, or Thing Speak [18].

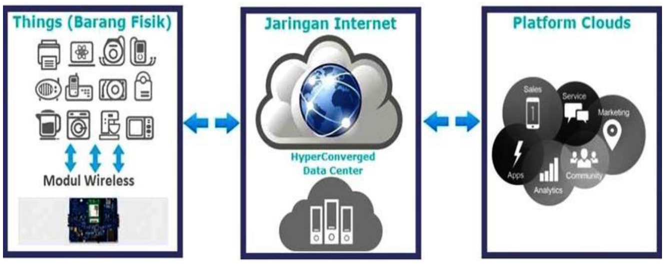

Figure 1. IoT architecture

2.2. Wiring Diagram

NodeMCU gets a 5V voltage source, then the HC-SR04 ultrasonic sensor gets a 3.3V voltage source from nodeMCU with the trigger connected to D3 and echo on D4. Furthermore, the relay gets a voltage of 3.3V from the nodeMCU with input pins on D0 next part of the relay, positive (+) pump 12VDC connected to the COM relay negative (-) connected with negative adapter and positive (+) adapter 12VDC which can be seen in Figure 2 [19] .

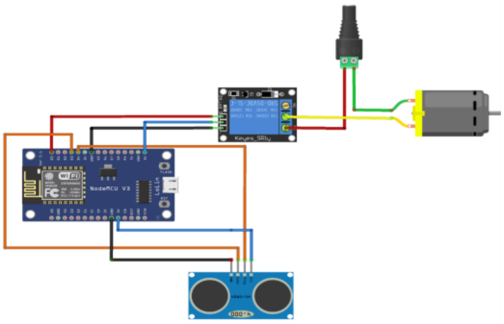

Figure 2. Wiring Diagram

2.3. Block Diagram

In this study, it used the NodeMCU ESP8266 microcontroller as its main control can be seen in the Figure 3. The design of the system uses the HC-SR04 ultrasonic sensor as a tool to measure the water level in the tank with one wire communication which is then received by the main control. NodeMCU then converts and processes the data provided by the sensor. NodeMCU gets a voltage source from a 5VDC adapter using a USB cable. If the measurement of the HC-SR04 sensor is less than set, the relay automatically works to turn on the pump to fill the tank to the specified limit [20]. The pump gets a voltage source from a 12VDCc adapter.

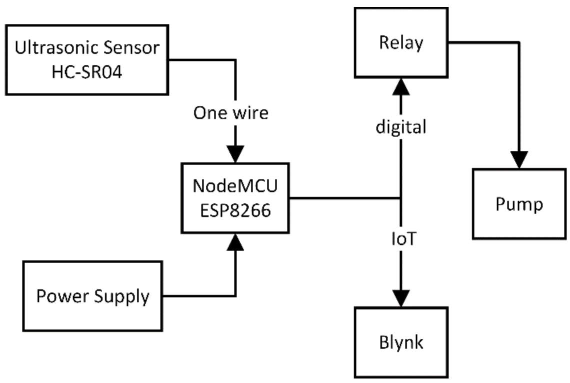

Figure 3. System Block Diagram

2.4 Accuracy and Precision

The sensor distance is relative, it is said that because the measured height will change as the water level increases or decreases. To determine the distance and the percentage of height on the sensor can use the Equation (1).

$$100 - \left(\frac{Actual\ Distance\ \times 100}{Limit}\right) \tag{1}$$

With:
The actual distance is the height of the sensor from the trigger mouth to the surface of the tube
Limit is the water level limit that has been set

To determine the value of sound waves in the air and the distance traveled by ultrasonic waves that are back and forth from the transmitter to the receiver, the Equation (2) and Equation (3) can be used

$$S = V \times T \tag{2}$$

$$S = \frac{(\mu S \times t)}{2} \tag{3}$$

With:
S is the Distance, V is the speed of sound (340m/s), T is Time (second), t (μS) 0.034 cm/μS.

Accuracy is the level of similarity of values in a number of measurements that are carried out repeatedly using the same measuring instrument. Sensor accuracy using the Equation (4) and Equation (5).

$$Accuracy = \left[1 - \frac{\delta X}{X}\right] \times 100\% \tag{4}$$

$$\delta X = \frac{\sqrt{\sum_{i=1}^{n}(\bar{X} - Xi)^2}}{n(n-1)} \tag{5}$$

With:
δX is standard deviation divided by, $\bar{X}$ is Average test data

Accuracy is a condition where the level of measurement of the sensor is comparable to the measuring instrument used, in this study a measuring instrument in the form of a ruler was used. Level of accuracy using Equation (6).

$$\%Accuracy = \left(1 - \left|\frac{H - \bar{X}}{H}\right| \times 100\%\right) \tag{6}$$

With:
H is the actual value, $\bar{X}$ is the average value of the test data

2.2. System Flow Chart

In this study, the sensor limit height and water level values were measured using the HC-SR04 sensor as the main parameters. The values displayed are Actual Distance, Water level, Pump Status and Charging Poses which are displayed in percentages displayed periodically via Blynk. When the water level value is less than 20% the relay will turn on to start the pump. If the measured altitude value is more than 20% but less than 100%, then the state is judged as not yet full, and the pump will continue to charge until the specified state. When the tank is in a state of more than 20% and has reached the set limit then the state of the tank is full and the relay works to turn off the pump. If the tank is full and then there is a shrinkage of water to below 20%, then the condition is considered not suitable so that the relay will work again to start the pump. If the temperature value has reached the specified limit, then the relay will work to turn off the pump as shown in Figure 4.

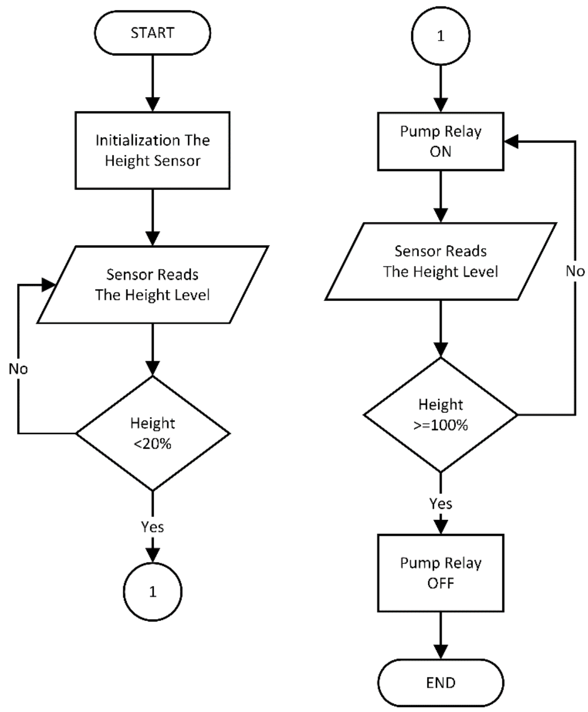

Figure 4. System flow chart

3. RESULTS AND DISCUSSIONS

3.1. HC-SR04 Sensor Calibration Value Testing

Calibration is carried out in order to get accurate and stable results, calibration is carried out at a distance of 5 cm, 10 cm, 15 cm, 20 cm, 25 cm, 30 cm with a time lag of 10 seconds for each distance. The sensor distance is a relative distance which means that it can be more or less several cm in measurements for which a measuring instrument in the form of a ruler is used as a comparison. The HC-SR04 sensor has the ability to measure distances as far as 3 – 400 cm. Tests were carried out at a distance of 4 cm, 5 cm, 10 cm, 15 cm, 20 cm, 25 cm, and 30 cm over a span of 10 seconds. The test results of the HC-SR04 sensor can be seen in table 1. Then from table 1 the tests on the sensor are made in the form of a table so that a graph is obtained. By using the Average as the X axis and the Ruler Distance as the Y-axis so that the graph from Table 1 can be noticed in Figure 5 obtained the value of Y = 1.0478 is called the calibration function where the sensor measurement results are later calibrated with Y so that a more accurate distance is obtained.

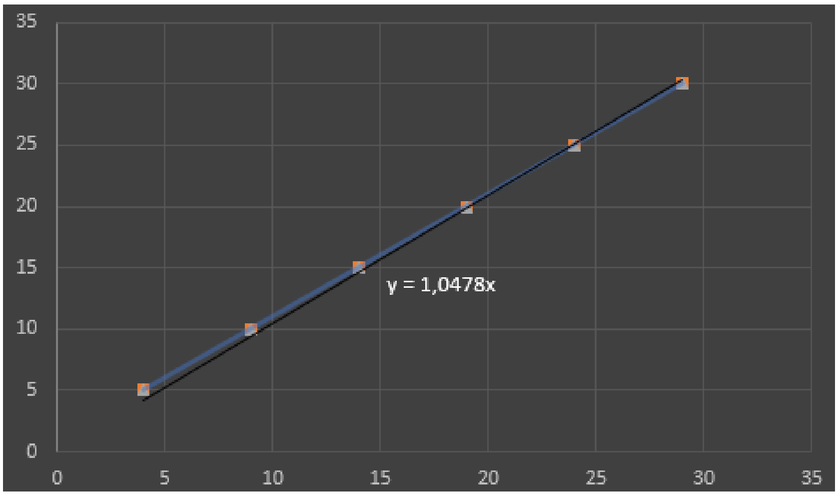

Figure 5. Sensor Calibration Test Graph

Table 1. HC-SR04 Ultrasonic Sensor Calibration Value Testing

Ruler Distance	Sensor Measurement	Average	Standard Deviation	Accuracy	Accuracy (%)
5	4	4	0	100	80.0
10	9	9	0	100	90.0
15	14	14	0	100	93.3
20	19	19	0	100	95.0
25	24	24	0	100	96.0
30	29	29	0	100	96.7

3.2. Internet of Things Testing

In this study, Blynk was used as an internet of things medium. The data presented represents the actual distance of the sensor, water level, and charging process displayed in percentages. The measurement data uses the HC-SR04 sensor, the measurement of the water level and the actual distance of the sensor is displayed in cm so that it is easy to understand by the user. The display on Blynk can be seen in Figure 6.

In the Figure 6 shows Blynk's display as an internet of things media that shows the actual distance of the sensor, water height, pump status, and the charging process displayed in percentage form. Table 2 below shows the comparison of water levels by sensors and the comparison with rulers. Table 2 shows the results of comparing HC-SR04 sensor measurements with water height compared to measuring instruments in the form of rulers. From the test, an average accuracy result of 90.5% with an error of 1.10% was obtained. The graph in Table 2 can be seen in Figure 7.

Figure 6. Internet of Things Testing

Table 2. Sensor Test on Water Volume with Comparison of Gauges on The Ruler

No	Rated Water Level (CM)	Ruler Measurement (CM)	Pump Status	Charging Percentage (%)
1	2	1.5	ON	9
2	3	2.5	ON	13
3	4	3.5	ON	18
4	5	4.5	ON	23
5	6	5.5	ON	27
6	7	6.5	ON	32
7	8	7.5	ON	36
8	9	8.5	ON	41
9	10	9.5	ON	45
10	11	10.5	ON	50
11	12	11.5	ON	54
12	13	12.5	ON	59
13	14	13.5	ON	64
14	15	14.5	ON	68
15	16	15.5	ON	73
16	17	16.5	ON	77
17	18	17.5	ON	82
18	19	18.5	ON	86
19	20	19.5	ON	91
20	21	20.5	ON	95
21	22	21.5	OFF	100

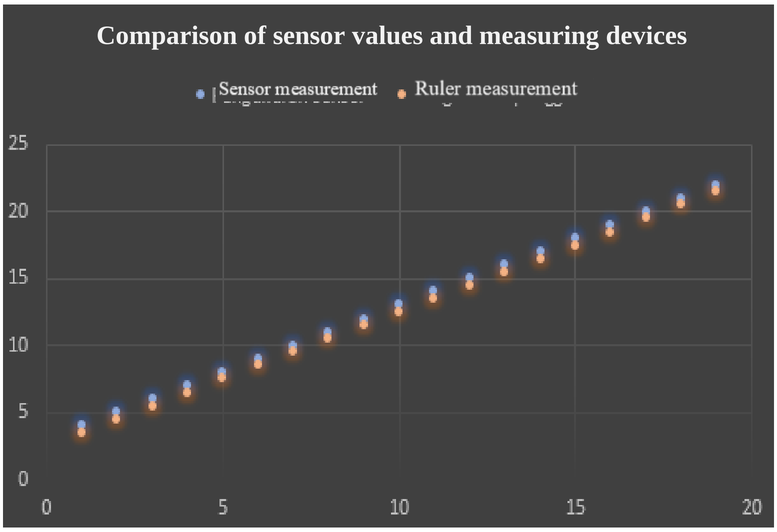

Figure 7. Water Level Testing Using Sensors with Comparison of Measuring Instruments

3.3. Actual Distance Measurement

The actual distance of the sensor is the actual distance from the trigger end of the HC-SR04 sensor to the surface of the tube used. The measurement is the opposite of the water level, the farther the water level, the farther the measurement shown, the closer the water level the closer the measurement of the actual distance of the sensor. Actual distance measurements can be seen in the following Table 3.

Table 3. Testing the Difference Between Water Volume and Actual Distance of Sensors Using a Ruler as a Comparison

No	Actual Distance of Measured Sensor (CM)	Ruler measurement (CM)	Pump status	Charging Percentage (%)
1	27	26.5	ON	9
2	26	25.5	ON	13
3	25	24.5	ON	18
4	24	23.5	ON	23
5	23	22.5	ON	27
6	22	21.5	ON	32
7	21	20.5	ON	36
8	20	19.5	ON	41
9	19	18.5	ON	45
10	18	17.5	ON	50
11	17	16.5	ON	54
12	16	15.5	ON	59
13	15	14.5	ON	64
14	14	13.5	ON	68
15	13	12.5	ON	73
16	12	11.5	ON	77
17	11	10.5	ON	82
18	10	9.5	ON	86
19	9	8.5	ON	91
20	8	7.5	ON	95
21	7	6.5	OFF	100

3.4. Whole Case Testing

At this stage, the designed tool is tested using a bucket with a height of 32 cm and a width of 15 cm with a set point of water level of 22 cm and an actual distance of 7 cm. Testing data in the form of water level values, actual distance and pump filling processes displayed in percentages on Blynk media via internet communication. The overall test results of the tool can be seen in the following Table 4.

Table 4. Overall System Testing

No	Water Level (cm)	Actual Distance (cm)	Ruler Measurement (cm)	Pump Status	Charging Percentage (%)
1	2	27	1.5	ON	9
2	3	26	2.5	ON	13
3	4	25	3.5	ON	18
4	5	24	4.5	ON	23
5	6	23	5.5	ON	27
6	7	22	6.5	ON	32
7	8	21	7.5	ON	36
8	9	20	8.5	ON	41
9	10	19	9.5	ON	45
10	11	18	10.5	ON	50
11	12	17	11.5	ON	54
12	13	16	12.5	ON	59
13	14	15	13.5	ON	64
14	15	14	14.5	ON	68
15	16	13	15.5	ON	73
16	17	12	16.5	ON	77
17	18	11	17.5	ON	82
18	19	10	18.5	ON	86
19	20	9	19.5	ON	91
20	21	8	20.5	ON	95
21	22	7	21.5	OFF	100
Accuracy					**98.46%**
Error					**1.01%**

4. CONCLUSIONS

The design of the created tool can work automatically as it should. From the test results of the entire system, sensor accuracy was obtained at 98.46% with an error of 1.01%. The set point set out in the design of this tool is full at a height of 22 cm with the indicated percentage value being 100%. In the sensor measurement, a difference of 0.5 cm is found on the ruler, this is because the height of the sensor from the surface to the tip of the trigger is 0.5 cm so that the reading starts from 0.5 cm on the ruler.

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AUTHOR BIOGRAPHY

Taufan Maulana Hazbi Born in Probolinggo on July 4, 1999. Completed his S1 Electrical Engineering at Universitas Ahmad Dahlan Yogyakarta.

Alfian Ma'arif Completed his S1 Electrical Engineering education at the Islamic University of Indonesia Yogyakarta and S2 Electrical Engineering at Gadjah Mada University Yogyakarta. His field of interest is Computer Programming & Control System. Currently he is a Lecturer the Electrical Engineering study program of Universitas Ahmad Dahlan Yogyakarta.