

# Design of an Internet of Things (IoT) based Main Reservoir Water Level Measuring Device at Siti Hajar Hospital Sidoarjo

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**Abstract**— *The volume of water levels in hospital water reservoirs really requires full monitoring. Where water reservoirs often run out when the water is to be used. This is very fatal and hinders activities that must be carried out immediately. If this happens, it will result in the failure of ongoing activities at the hospital. This research aims to design a prototype that is capable of monitoring water levels in IoT-based hospital reservoirs. By designing a water level monitoring system in the reservoir using the HC-SR04 ultrasonic sensor as an input that measures water level and ESP32 as a microcontroller. The application produced from MIT App Inventor is a notification output and can display monitoring results. Based on the research results, it shows that the water level monitoring system in the reservoir can work well as expected, namely when the water is at the 25% limit, the application will send a notification to the smartphone in the form of sound so that users or technicians can find out and find the cause of the decreasing water level.*

**Keyword** : MIT App Inventor, IoT, ESP32, Sensor Ultrasonic, Sistem Monitoring

## I. INTRODUCTION

Every hospital always needs water for daily activities, such as surgery, dialysis, bathing, cooking, washing, and so on. Currently, hospital construction is always equipped with water tanks to store water produced by the Regional Water Supply Company (PDAM) to conserve water usage. Additionally, the use of water tanks serves to monitor total water usage each month.[1] However, water tanks often run out of water when it is needed. This is extremely critical and hinders activities that must be carried out immediately. If this occurs, it results in the failure of ongoing activities at the hospital. To address this issue, a water level monitoring and control system is implemented using wireless technology, which sends information to a smartphone and displays the water level in the tank to anticipate water shortages.

The limitation of the water tank radar is that it operates on a pre-set automatic system. When changing the predefined limits, manual adjustment is required. Additionally, the pump may activate more than once a day because as water levels decrease, the float switch automatically activates, causing the switch to turn on. If this occurs repeatedly, it can lead to power surges .[2]

Based on the above discussion, a solution is proposed by designing a prototype for the final project titled “Water Level Monitoring System in a Water Tank Based on IoT (Internet of Things).” To monitor the water level in the water tank, a NodeMCU ESP32, ultrasonic sensor, and relay are required. By utilizing the IoT system, when the water tank is empty, the NodeMCU ESP32 will send a notification to the smartphone via an application created using MIT App Inventor to monitor the water level in the tank remotely. The purpose of this article is to design a prototype capable of monitoring the water level in a tank based on IoT.

## II. METHODS

The tools and materials required to support the research on the Internet of Things (IoT)-based Water Level Measurement Device for the Main Water Tank at Siti Hajar Hospital in Sidoarjo include:

Tools:

1. Digital Multimeter
2. Soldering Iron
3. Solder
4. Screwdriver
5. Laptop
6. Android Smartphone
7. Arduino Software

Materials:

1. NodeMCU ESP32
2. HC-SR04 Ultrasonic Sensor
3. Relay
4. Regulator Module
5. Power Supply
6. Jumper Cables
7. PCB Board

The system design currently being developed is an Internet of Things (IoT)-based Water Tank Level Measurement Device for Siti Hajar Hospital in Sidoarjo. To monitor the water level in the water tank, a NodeMCU ESP32, ultrasonic sensor, and relay are required. By utilizing the IoT system, when the water tank is empty, the NodeMCU ESP32 will send a notification to a smartphone through an application

created using MIT App Inventor to monitor the water level in the IoT-based tank.

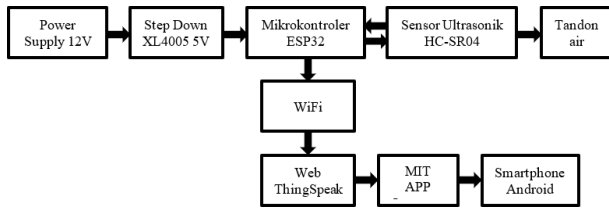


Fig. 1. System Block Diagram

The NodeMCU ESP32 circuit functions as the main controller that receives input and processes output from the entire system. The main component of this circuit is the Tensilica Xtensa LX6. The Tensilica Xtensa LX6 microcontroller IC in the ESP32 has been programmed to run the entire system. There are several pins on the ESP32 that are used in the circuit. Pins D1 (GPIO 08) - D2 (GPIO 09) are connected to the HC-SR04 ultrasonic sensor, which functions as an input.[3] The ESP32 pin circuit diagram used can be seen in Picture 2.

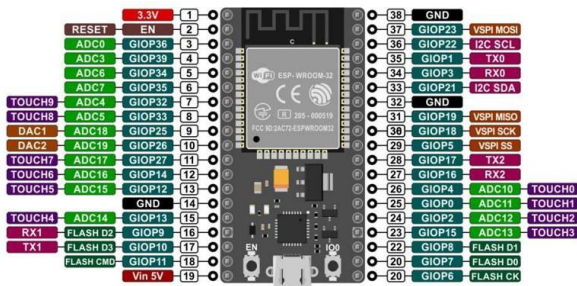


Fig. 2. ESP 32 Pin

The LM 2596 step-down module (regulator module) circuit functions to reduce the 12-volt input voltage to 5 volts. The 5-volt voltage functions to supply the entire circuit that uses 5-volt voltage, such as the photoelectric sensor circuit, stepper motor circuit, and relay circuit. The step-down module circuit diagram can be seen in Picture 3.



Fig. 3. Step-down module circuit

The software design is divided into two parts, namely the software design used to program the Arduino Uno and the flowchart. To design the program and write data to the ESP32 flash memory, the main software used is Arduino 1.8.3.

The following is the code used to create an Internet of Things (IoT)-based Water Level Measuring Device for the Main Water Tank at Siti Hajar Hospital in Sidoarjo.

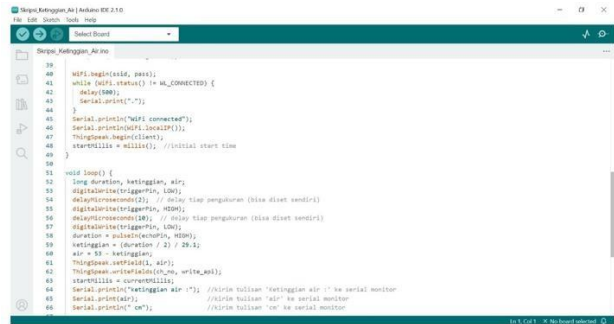


Fig. 4. Arduino IDE application display

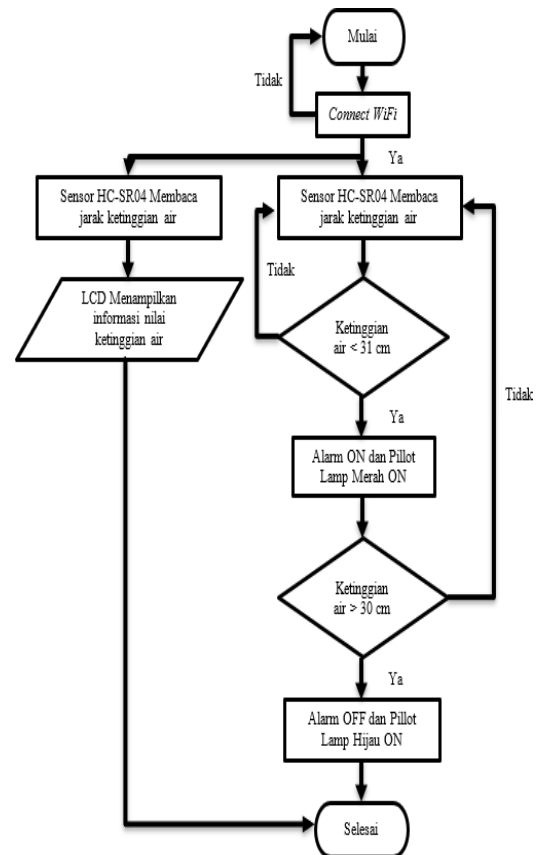


Fig. 5. Flowchart

The wiring diagram for the design of the Internet of Things (IoT)-based water level measurement system for main reservoirs can be seen in the picture below.

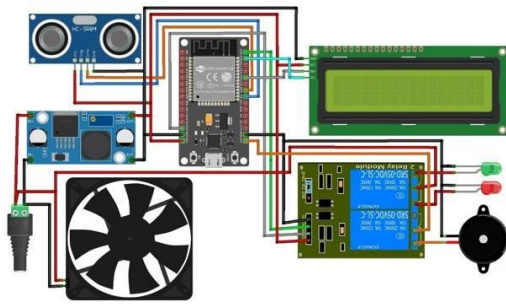


Fig. 6. Diagram wiring

III. RESULT AND DISCUSSION

1. Prototype system results

The results of the Internet of Things (IoT)-based water level measurement system prototype can be seen in the image below.

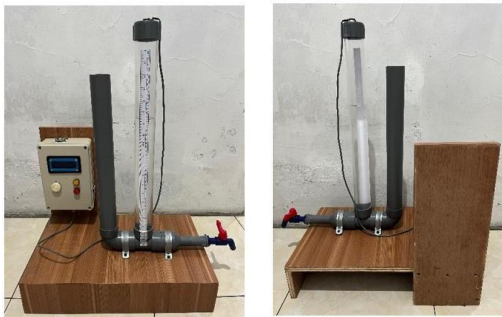


Fig. 7. Front and rear views of the prototype water level measurement system for reservoirs

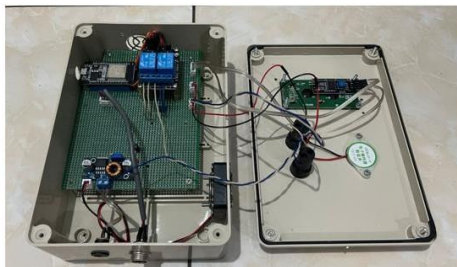


Fig. 8. View of the prototype system for measuring water levels in reservoirs

The IoT-based water level measuring device for the main water tank in Figure 12 consists of a pipe that is analogous to the main water tank with an HC-SR04 ultrasonic sensor at the top of the pipe and a box containing a 12V power supply, XL4005 5V step-down converter, and ESP32 microcontroller.

This device is capable of measuring and transmitting data and notifications to an Android smartphone, enabling technicians to monitor the water level in the hospital's main water tank without needing to physically inspect the storage location.

1. Device Calibration

Device calibration is performed prior to conducting comprehensive testing of the IoT-based water level

measurement device for the main water tank. The calibration of this device aims to minimize errors in its accuracy compared to certified measuring devices.

2. Device Testing

At this stage, device testing is conducted to determine the accuracy of the device before it is used as a water level measuring device for the main water tank in real-world conditions.

The test results of the IoT-based water level measurement device design at Siti Hajar Hospital in Sidoarjo are presented to demonstrate the effectiveness of water monitoring and the accuracy of water level measurements. Based on the data obtained, the following are the test results and measurements of the device:

Table 1. Test results of the device

NO	Water Level Height (cm)	Data Output		Control Panel Indikator		Buzzer	Data Transmission Interval
		LCD Panel Discount	Smartphone App Discount	Yellow Light	Red Light		
1	0	0	0	Off	Hidup	On	10 second
2	5	5	5	Off	Hidup	On	8 second
3	10	10	10	Off	Hidup	On	10 second
4	15	15	15	Off	Hidup	On	7 second
5	20	20	20	Off	Hidup	On	11 second
6	25	25	25	Off	Hidup	On	9 second
7	30	30	30	Off	Hidup	On	10 second
8	35	35	35	Hidup	Off	Off	10 second
9	40	40	40	Hidup	Off	Off	9 second
10	45	45	45	Hidup	Off	Off	8 second

The table above shows that the test was conducted 10 times with time measurements using a stopwatch. In the first experiment, the smartphone application read 10 seconds at a water level of 0. In the last experiment, with a water level of 45 cm, the time required to display the results on the smartphone application was 8 seconds.



Fig. 9. Test results of the device with a water level of 0 cm



Fig. 10. Test results of the device with a water level of 35 cm

- a. Average HC-SR04 sensor :

Which is:

$\mu$  = Average

$x_i$  = Measurement value

$n$  = Number of data points

$$\mu = \frac{x_1 + x_2 + x_3 + x_4 + x_5}{n}$$

$$= \frac{40+40+40+40+40}{5}$$

$$= \frac{200}{5}$$

$$= 40$$

- b. Accuracy % HC-SR04 sensor:

Which is:

$R_x$  = Measurement value data of the device

$R_a$  = Standard measurement value data of the device

$$\text{Accuracy \%} = 1 - \left[ \frac{R_a - R_x}{R_x} \right] \times 100\%$$

$$= 1 - \left[ \frac{40-40}{40} \right] \times 100\%$$

$$= 1 - \left[ \frac{0}{40} \right] \times 100\%$$

$$= 1 - 0 \times 100\%$$

$$= 1 \times 100\%$$

$$= 100\%$$

The accuracy of the HC-SR04 sensor in the experiment is 100%. Therefore, it can be concluded that the HC-SR04 sensor works and functions properly.

- c. Error MAX6675 sensor :

Which is:

$R_x$  = Measurement data from the device

$R_a$  = Standard measurement data from the device

$$\text{Error \%} = \left[ \frac{R_a - R_x}{R_x} \right] \times 100\%$$

$$= \left[ \frac{40-40}{40} \right] \times 100\%$$

$$= \left[ \frac{0}{40} \right] \times 100\%$$

$$= 0 \times 100\%$$

$$= 0\%$$

The error value in the experiment using the HC-SR04 sensor is 0%. Therefore, it can be concluded that the HC-SR04 sensor functions properly.

- d. HC-SR04 sensor deviation:

Which is:

$\mu$  = Average

$R_x$  = Instrument measurement data

$R_a$  = Standard instrument measurement data

$$\text{Deviation} = | \mu^{R_x} - \mu^{R_a} |$$

$$= | 40 - 40 |$$

$$= 0$$

The standard deviation value in the HC-SR04 sensor experiment results is 0. Therefore, it can be concluded that the HC-SR04 sensor works and functions properly.

- e. Standart deviation of HC-SR04 sensor :

Which is:

$\sigma$  = Standart deviation

$x_i$  = Measurement value

$n$  = Number of data point

$\sum X_i$  = Sum of data values

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{(n-1)}}$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (40-40)^2 + (40-40)^2 + (40-40)^2 + (40-40)^2 + (40-40)^2}{5-1}}$$

$$\sigma = \sqrt{\frac{0}{4}}$$

$$\sigma = \sqrt{0}$$

$$\sigma = 0$$

The standard deviation value in the HC-SR04 sensor experiment results is 0. Therefore, it can be concluded that the HC-SR04 sensor works and functions properly.

#### IV. CONCLUSION

This study aims to design and test an Internet of Things (IoT)-based water level measurement system for the main water tank at Siti Hajar Hospital in Sidoarjo to prevent water depletion and facilitate water level checks. Based on the test results and data analysis conducted, the following conclusions can be drawn:

1. The HC-SR04 distance sensor is effective in measuring the water level in the tank, with an average value of 40 cm and an accuracy rate of 100%. Therefore, the Hot Plate Magnetic Stirrer based on a microcontroller integrated with an Android smartphone is sufficiently effective for use.
2. Data transmission from the device to the Android smartphone takes 15 seconds because ThigSpeak only provides a minimum update interval of 15 seconds.

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