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Temperature and Humidity Monitoring System Using Node-Red Based on MQTT Protocol

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ABSTRACT

Temperature and humidity monitoring system integrated with the Internet of Things (IoT) is an innovative step in monitoring environmental conditions in real-time. This research develops a monitoring system based on the MQTT (Message Queuing Telemetry Transport) protocol integrated with the Node-RED platform. A temperature sensor is used to read temperature data, which is then sent via the MQTT protocol to the broker server. Node-RED acts as a visual interface to process, analyze, and display the temperature data in the form of an interactive dashboard. The system is designed to support easy integration, lightweight data management, and remote monitoring. Experimental data was obtained by comparing sensor readings with a variety of different environmental conditions. The test results show that this monitoring system is able to provide information related to temperature data with an accuracy above 98.4%. With this system, users can monitor temperature and humidity based on accumulated data or in real-time so that it is more accurate because it has a small average error of 0.4°C. Users can plan actions to be taken related to controlling environmental conditions.

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1. INTRODUCTION

In the era of digitalization and the industrial revolution 4.0, monitoring systems such as temperature and humidity are increasingly important for various applications, such as smart building management, industry or smart farming. Real-time monitoring of environmental conditions using the Internet of Things (IoT) has become an effective solution in developing network-based monitoring systems using the Message Queuing Telemetry Transport (MQTT) communication protocol. The communication protocol can be one of the frequently used standards due to its lightweight and efficient nature in sending data from sensor devices to monitoring platforms. Integration between sensors, microcontrollers, and IoT-based applications can facilitate real-time monitoring of environmental conditions with intuitive visual displays using Node-RED.

In this research, an Autonics THD-WD1C sensor is used which has an analog current output of 4-20 mA and which is converted to a maximum voltage of 5V. The data obtained is then processed using the Arduino IDE and sent via the MQTT protocol. Data from MQTT is then retrieved by Node-RED to be displayed in real-time in the form of a monitoring dashboard. This research aims to design a temperature and humidity monitoring system based on the MQTT protocol using the Autonics THD-WD1C sensor, integrate data from sensors through a microcontroller and an IoT platform for real-time monitoring using Node-RED, and provide environmental monitoring solutions by utilizing MQTT communication and Node-RED-based visualization.

Several previous studies have developed IoT-based environmental monitoring systems. According to [1] implements temperature monitoring using DHT22 sensors and MQTT communication, but this system is not compatible with current sensors such as Autonics THD-WD1C. Research [2] focuses on Arduino-based temperature monitoring, but only uses the HTTP protocol which has limitations compared to MQTT in terms of data communication efficiency. Based on previous studies, there is a gap in systems that can accommodate current sensors such as the Autonics THD-WD1C to be converted into digital data and sent via the MQTT protocol. This research offers a solution by utilizing resistors to convert the current output of the sensor into a voltage compatible with the microcontroller, so that data can be processed and transmitted efficiently.

The hypothesis in this research is that the monitoring system designed using Autonics THD-WD1C sensor, current-to-voltage conversion, and MQTT communication is able to provide accurate and real-time temperature and humidity data. In addition, the integration of Node-RED as a visualization platform can improve monitoring effectiveness and ease of data access by users. With this approach, this research has the potential to provide practical and efficient solutions in IoT-based environmental monitoring systems that use sensors with current output.

2. METHOD

The stages of this research are carried out in 5 (five) stages, namely the overall system circuit, system design, MQTT Broker creation, monitoring system design and display configuration.

2.1 Overall System Circuit

The system begins as shown in Figure 1 with the sensor setup process to ensure the device is connected. Once the sensor is detected, data starts to be captured and sent through the transmitter to the receiver. The received data is then forwarded to the MQTT cloud platform for publishing. From the cloud, the data is retrieved by Node-RED to be processed and displayed in the form of a dashboard. The system allows real-time monitoring of data through the Node-RED dashboard, providing easily accessible information for users.

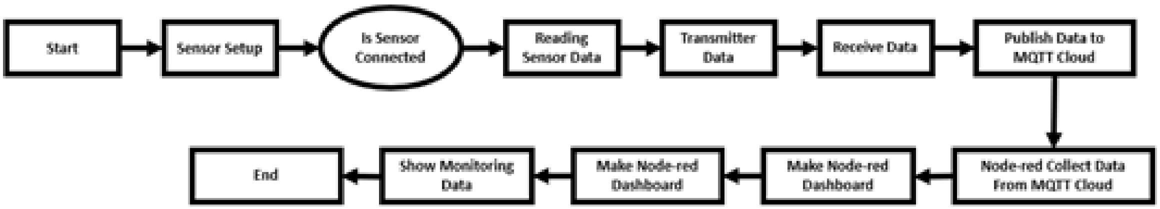


Figure 1. Overall System

2.2 System Design

This system design uses the THD-WD1-C sensor as shown in Figure 2, to read temperature and humidity data with an analog current output of 4-20 mA. The current output is converted to voltage using a shunt resistor, so that it can be processed by an ESP8266-based microcontroller module. The microcontroller sends the processed data to the Node-RED platform via the MQTT protocol for real-time visualization in the form of a dashboard. The system's power source comes from the power supply, which provides stable voltage for the sensors and microcontroller. The system enables efficient and accurate environmental monitoring, with easy integration into IoT networks.

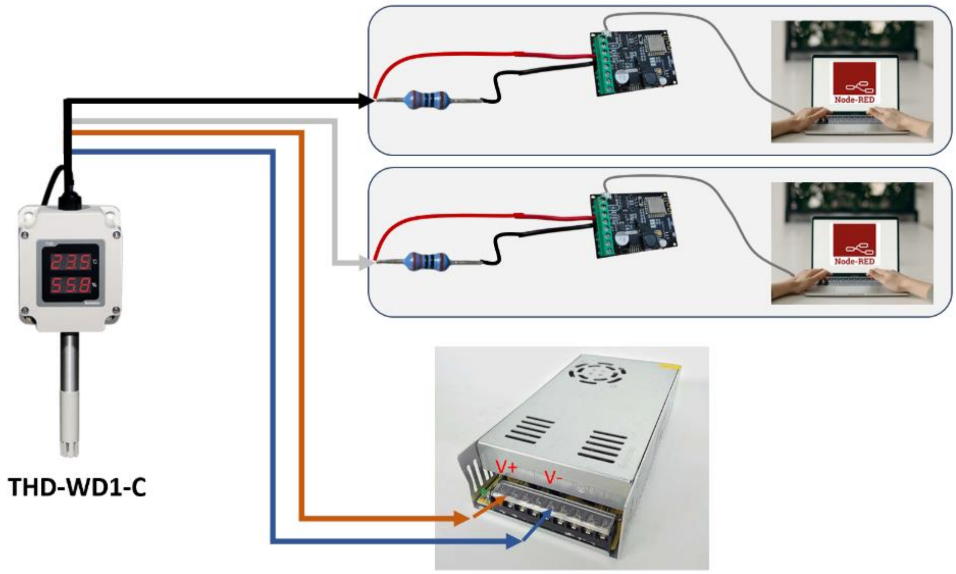


Figure 2. System Circuits

2.3 MQTT Broker Design

The MQTT protocol uses a publisher/subscriber communication model. The MQTT broker is responsible for managing the communication flow between the data sent by the publisher to the subscriber. In this research, the sensor node created acts as a publisher and the nodered application will act as a subscriber. Figure 3 shows the MQTT broker configuration.

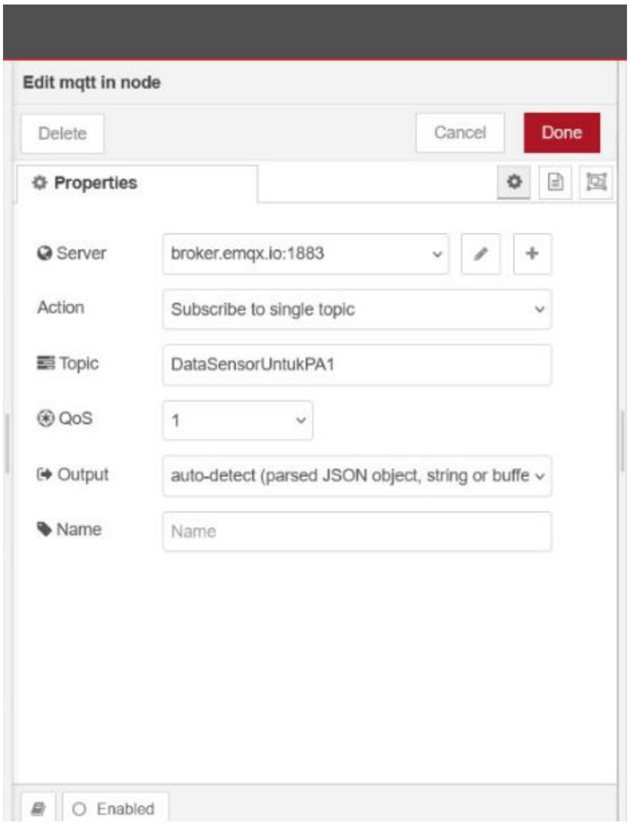


Figure 3. Setup on Node-Red

2.4 Monitoring System Design

The monitoring system is designed using the nodered application. This application provides features in the form of flow programming that can be used as an interface for web-based applications. In this study, the nodered application was installed on a raspberry pi device with the Raspbian operating system. Figure 4 shows the configuration process of the nodered application to design the appearance of the monitoring system.

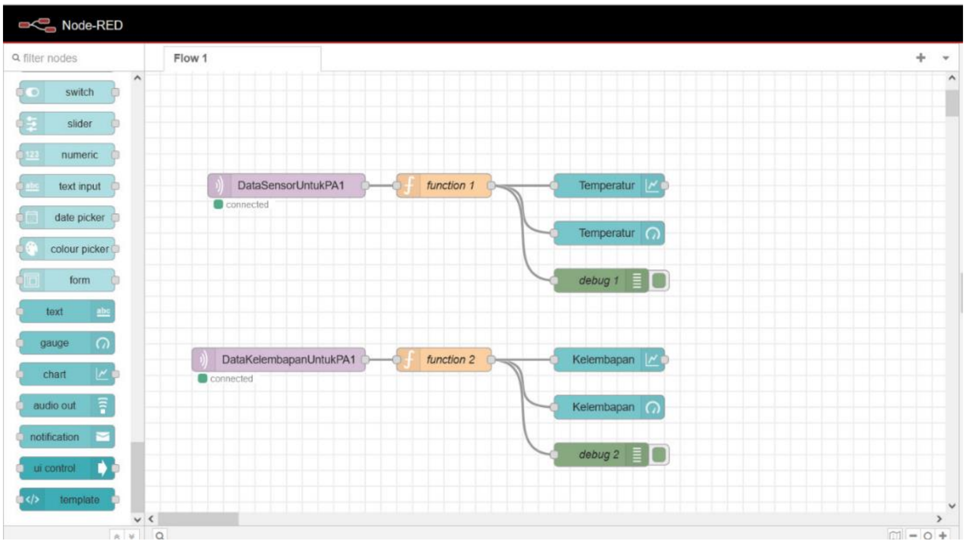
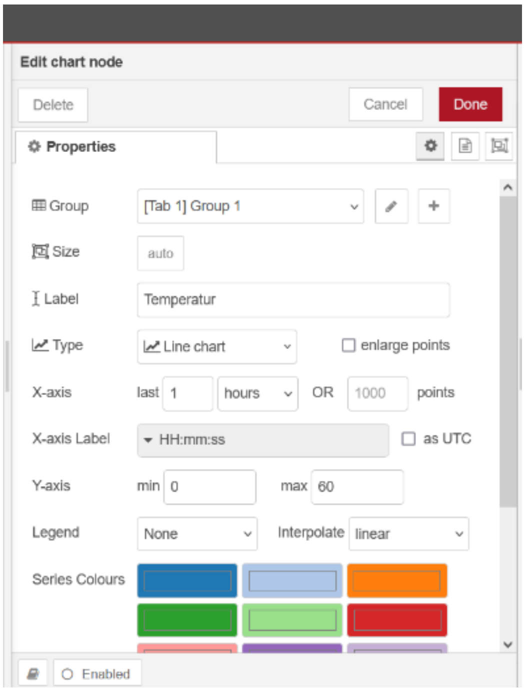


Figure 4. Dashboard view in Node-Red

2.5 Display Configuration

The Node-RED display configuration in Figure 5, sets up a chart node for visualization of temperature data. This node is in the group “[Tab 1] Group 1” with the label “Temperature.” The selected chart type is a line chart that displays data in the form of a line. The chart will show data from the last hour or up to 1000 data points, with the X-axis labeled as time in HH:mm:ss format. The Y-axis is set to display a minimum value of 0 and a maximum of 60, which most likely corresponds to the temperature data range. The color of the graph can be selected from the multiple color options provided to clarify the display. Data interpolation is set to be linear to ensure smooth data transitions between measurement points.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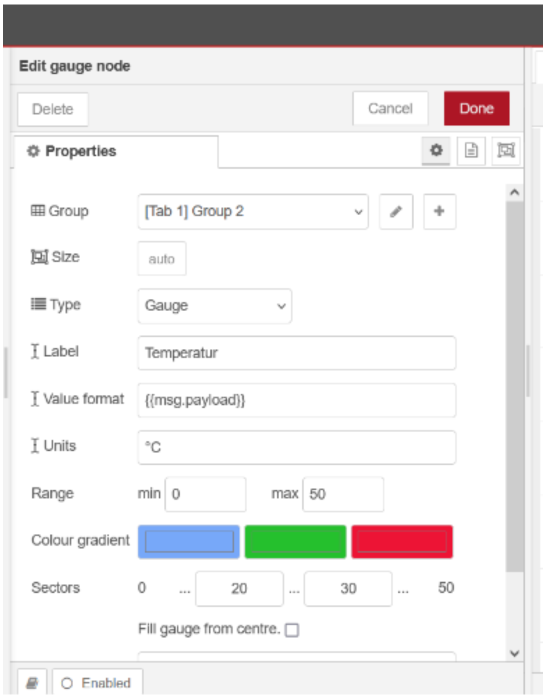
(a)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Colour gradient
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Fill gauge from centre.
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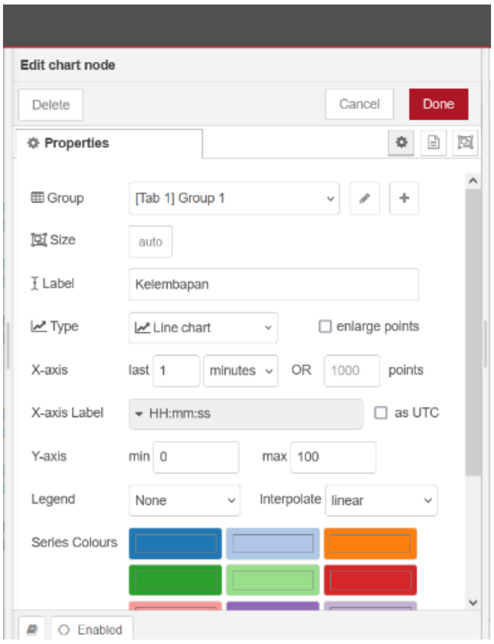
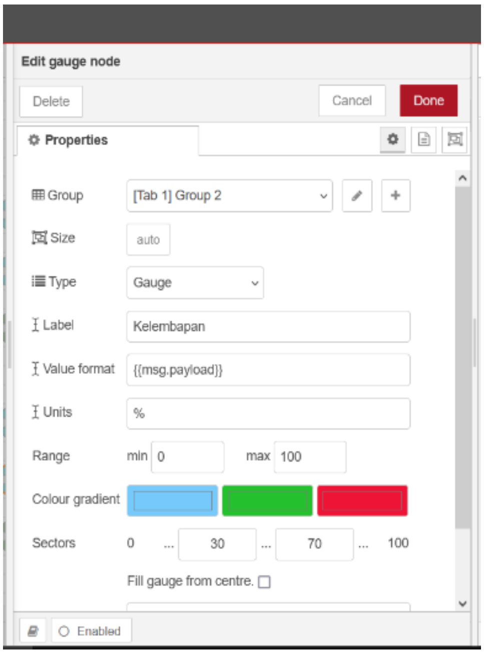
(b)



(c)



(d)

Figure 5. Configuration View on Node-Red

3. RESULTS AND DISCUSSION

Based on the test results of comparing the parameters of the temperature reading value on the THD-WD1-C sensor as shown in Figure , with the acquisition of values in the serial monitor, the average difference in temperature value that occurs is 0.4 ° C and the average difference in humidity value is 19%, these values are obtained from the display results on the sensor and reference values as in Figure 6 and Figure 7.

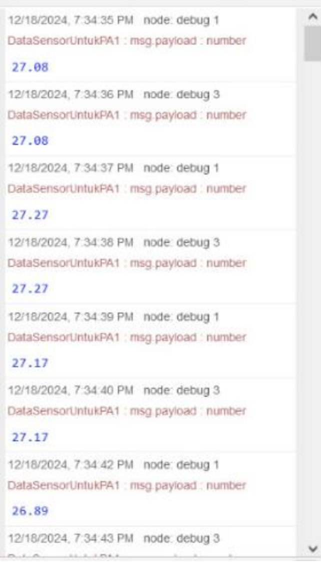


Figure 6. Serial Monitor for Temperature

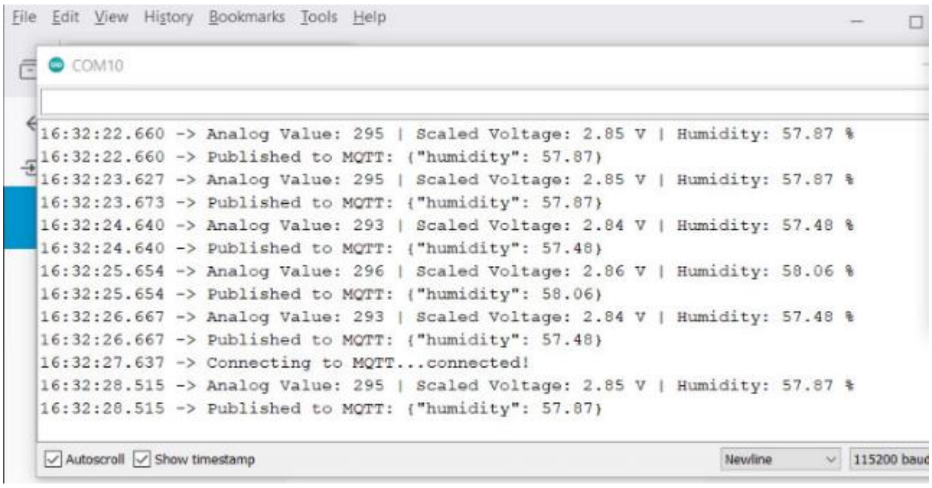


Figure 7. Serial Monitor for Kelembapan

Data testing is done by comparing the value obtained by the sensor from the serial monitor against the temperature and humidity display on the sensor. Variations of data tested include measurements in standard room conditions and air-conditioned room temperature conditions to ensure sensor performance as shown in Figure 8 and Figure 9. The results of data testing also vary depending on the weather outside the room, the number of people in the room human activity, room ventilation, or lighting conditions in the room.

Figure 8 Sensor display in an air-conditioned room

Figure 9. Sensor display at room temperature

The reference data used comes from the display on the sensor and is then compared with the data on the serial monitor, so that the comparison results can be relied upon to evaluate the level of data accuracy. For the percentage value of data accuracy, you can use the quotient formula between the average temperature on the serial monitor and the normal state or room temperature as equation (1), which is as follows:

$$\text{Error percentage} = \frac{0{,}4}{25} \times 100$$

$$= 1{,}6\% \quad (1)$$

The results of this calculation show that this method is feasible to use in temperature monitoring applications because it has a very small percentage error and almost accurate data display so that it can be applied to conditions that require high precision and real-time.

3.1. Monitoring System Testing

This test is carried out with the aim of knowing the final results of the monitoring system display that has been designed using the nodered application. Figure 10 shows the display of the monitoring system that has been made. This system has been able to display data from all sensor nodes. Data collection can be recorded in log form using a data processing system such as Node-RED which can support real-time data reading and displayed in a dashboard to facilitate monitoring. With this feature, users can monitor environmental conditions without time lag, ensuring accuracy and ease of access.

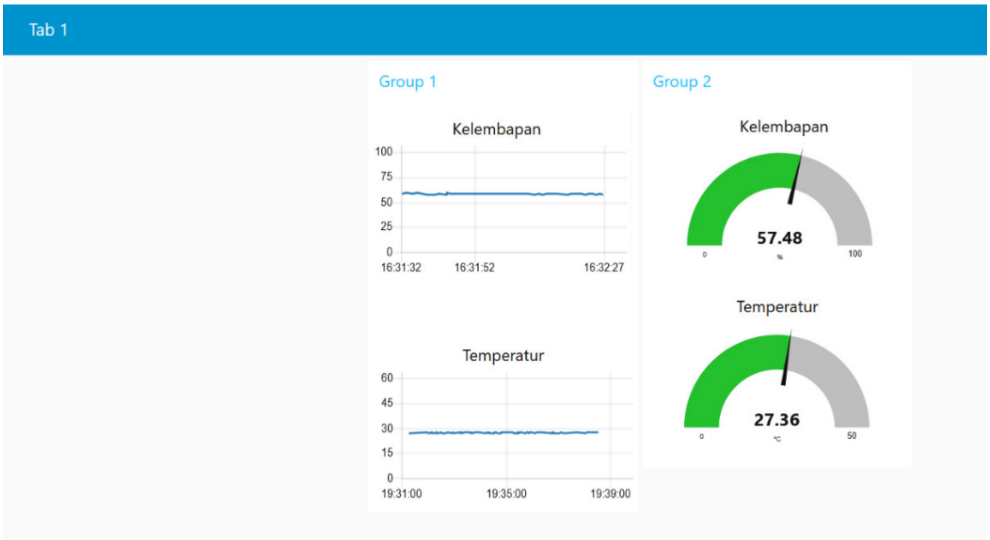


Figure 10. Display on Red Node

4. CONCLUSION

The conclusion of this research is that the Internet of Things (IoT)-based temperature monitoring system using the MQTT protocol and the Node-RED platform is able to provide solutions for real-time monitoring of environmental conditions. With the integration of temperature sensors, temperature data is successfully sent to the broker server via MQTT and visualized interactively using the Node-RED dashboard. The system demonstrates reliability in providing temperature information accurately and efficiently, even under various environmental conditions. In addition, the ease of integration, lightweight data management, and remote monitoring capabilities make this system a practical tool to support the control of environmental conditions. This research proves that IoT technology can be a significant innovation in improving the efficiency and convenience of environmental monitoring.

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