

(Research/Review Article)

Design and Development of an ESP8266-Based Digital Thermometer Using a DHT22 Sensor with OLED Display Output

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Abstract: The advancement of microcontroller technology enables the development of accurate and practical temperature measurement devices. This study aims to design and build a digital thermometer based on ESP8266 using a DHT22 sensor to measure air temperature and humidity in real time, with the measurement results displayed on an OLED screen. The research methodology includes circuit design, microcontroller programming, sensor calibration, and system testing by comparing the measurement results with reference instruments. The test results indicate that the system operates stably and responsively. The average temperature measurement deviation compared to the reference thermometer is **6.26 °C**, while the average humidity measurement deviation compared to the digital hygrometer is **4.56 %RH**. These results indicate that the DHT22 sensor provides acceptable accuracy and remains within tolerable limits for environmental monitoring applications

Keywords: Digital thermometer, ESP8266, DHT22, OLED, Temperature and humidity measurement.

1. Introduction

Monitoring air temperature and humidity plays a crucial role in various aspects of human life. In agriculture, for example, the growth and development of almost all plant species are significantly influenced by temperature and humidity. This is also true in the healthcare sector, particularly in the maintenance of medical equipment and in baby incubators. In animal husbandry, automated egg hatching chambers are essential. Similar practices can be found in fisheries and the military, as well as in research. *Gap analysis* is a field of study, and has even been widely developed for smart homes, smart offices, smart villages, and more.[2][8][10]

With so many fields requiring temperature and humidity monitoring, improvements in monitoring methods and devices are also needed. As time goes by, human life is inseparable from network technology. The use of network technology serves to obtain information from monitoring and observation results. The use of network technology can be implemented using a microcontroller integrated with a wireless-fidelity (Wi-Fi) module. [1], [5], [15]

2. Literature Review

Temperature and humidity measurements are important parameters in monitoring environmental conditions because they affect the comfort and stability of the system. The development of embedded system technology allows these measurements to be carried out digitally using electronic sensors integrated with microcontrollers. One of the widely used sensors is the DHT22, which is capable of measuring temperature and humidity simultaneously with a good level of accuracy.[3] This sensor uses a thermistor element for temperature measurement and a capacitor element for humidity measurement, and produces data in the form of digital signals so that they are easily processed by microcontrollers[3][6][12][14].

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The ESP8266 is a microcontroller equipped with an integrated Wi-Fi module and is widely used in embedded system-based monitoring applications. This microcontroller has the ability to read sensor data, process information, and transmit data wirelessly over the internet. With programming support using the Arduino IDE, the ESP8266 can be efficiently integrated with various sensors and output devices, including the DHT22 sensor and OLED display[2]. The Wi-Fi connectivity capability of the ESP8266 makes the measurement system more flexible and has the potential to be developed towards *the Internet of Things (IoT)*. [2][4][8][11][13]

OLED (Organic Light Emitting Diode) displays are a display medium that offers high contrast, wide viewing angles, and low power consumption. These characteristics make OLEDs suitable for use as display outputs in small embedded systems. In digital thermometer systems, OLEDs function to directly display temperature and humidity measurements so that users can monitor environmental conditions in real time without the need for additional devices.[7][9]

The integration of the DHT22 sensor, ESP8266 microcontroller, and OLED display forms a digital measurement system capable of reading, processing, and displaying environmental data in real-time. The sensor functions as input, the microcontroller as the data processing and communication center, and the OLED as a visual interface for the user. This theoretical basis serves as the main foundation in the design and implementation of the digital thermometer in this study. [4][7][10]

3. Method

Figure 1 is a picture of the component circuit used to create a Digital Thermometer Design Based on ESP8266 with a DHT22 Sensor and OLED Display Output. The Hardware Components used are the DHT22 Sensor, ESP8266, OLED LCD. The Software used is Arduino IDE. Pin 1 on the DHT22 sensor which is VCC is connected to pin 3V3 of the ESP8266. Pin 2 on the DHT22 sensor which is data is connected to pin D4 of the ESP8266. Pin 3 on the DHT22 is connected to GND of the ESP8266. [2]

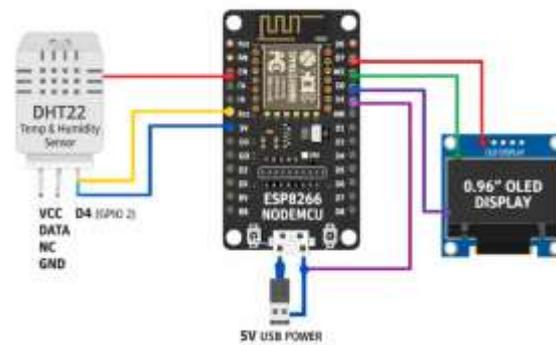


Figure 1. Circuit Schematic

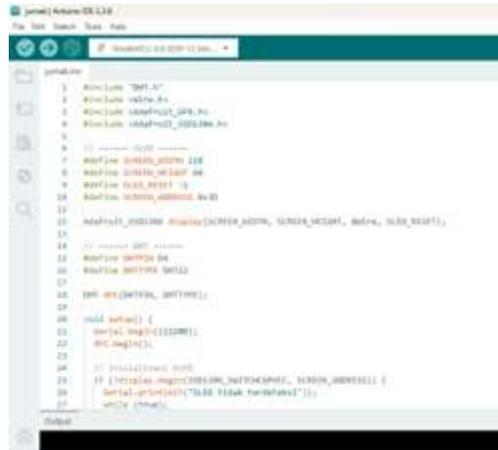


Figure 2. Programming on the Arduino IDE

Figure 2 shows the ESP8266 programming using the Arduino IDE. The programming is done to enable the ESP8266 to read and send data from the sensor to the OLED LCD. The DHT22 sensor library is entered and uploaded to the ESP8266.

Sensor calibration is performed by comparing the temperature on the DHT22 sensor with the thermometer and humidity data on the DHT22. Data collection is carried out with 3 trials, each trial repeated twice to obtain a standard deviation value. The accuracy of the instrument's measurements can be determined by comparing the DHT22 values for humidity. [4]

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n X_i$$

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

The description of equations 1 and 2 is x is the average, s is the standard deviation, x is the value of the i-th sample and n is the number of data.

$$\%Akurasi = 100\% \cdot \left| \frac{\text{sensor-alat kalibrator}}{\text{alat kalibrator}} \right| \times 100\%$$

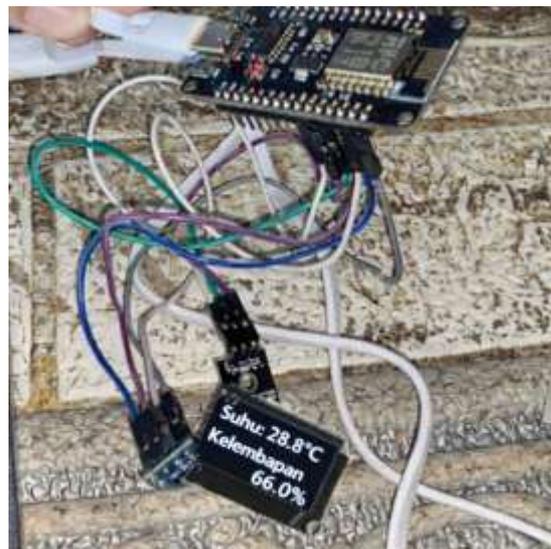


Figure 3. Tool Implementation

Figure 3 is a picture of the tools used to conduct this research, ESP8266, DHT22 Sensor, OLED LCD, Jumper Cable, and USB Cable.

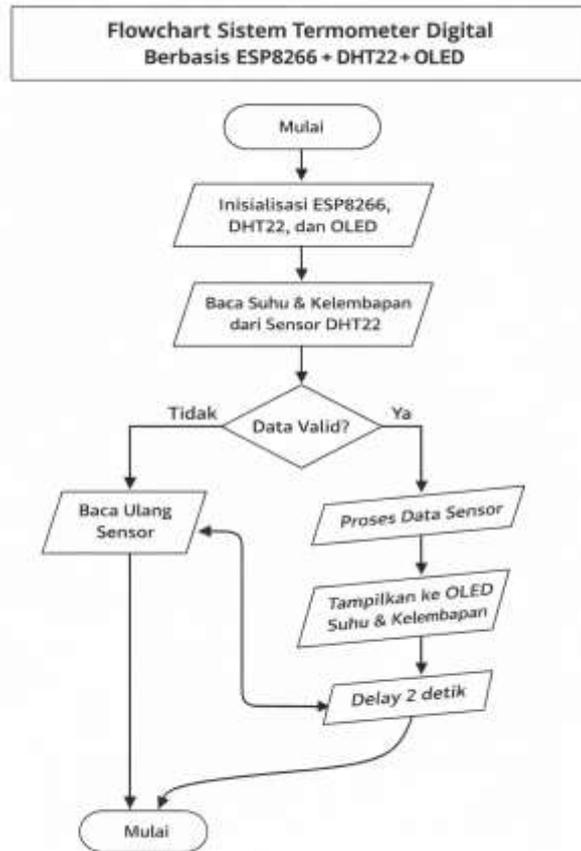


Figure 4. Flowchart

This flowchart illustrates the program workflow on the ESP8266, so it is most appropriate for research methods, not introductions or results.

4. Results and Discussion

Testing of an ESP8266-based digital thermometer system with a DHT22 sensor and an OLED display output was conducted to determine the device's performance in measuring air temperature and humidity. This testing was conducted by comparing the DHT22 sensor measurements with reference devices, namely a standard digital thermometer and hygrometer. Each measurement was performed three times, and each experiment was repeated twice to obtain an average value and reduce errors.

4.1 . Temperature Test Results

Table 1 shows the results of temperature measurements between the DHT22 sensor and the reference thermometer.

No	Reference Temperature (°C)	DHT22 Temperature (°C)	Calibrated Temperature (°C)	Difference (°C)
1	28.5 °C	33.5 °C	33.7 °C	5.20 °C
2	28.5 °C	34.6 °C	34.8 °C	6.3 °C

3	28.5 °C	34.7 °C	34.9 °C	6.4 °C
4	28.5 °C	34.8 °C	35.0 °C	6.5 °C
5	28.5 °C	35.2 °C	35.4 °C	6.9 °C

Table 1. Temperature Measurement Results

4.2 . Humidity Test Results (Rh)

Humidity testing is carried out by comparing the relative humidity (RH) value measured by the DHT22 sensor with a digital hygrometer as a reference tool.

No	Reference RH (%)	RH DHT22 (%)	Calibrated RH (%)	Difference (%)
1	70.0%	71.9%	72.9%	2.9%
2	70.0%	72.0%	73.0%	3.0%
3	70.0%	73.4%	74.4%	4.4%
4	70.0%	74.6%	75.6%	5.6%
5	70.0%	75.9%	76.9%	6.9%

Table 2. Humidity Measurement Results

4.3 . Discussion of Results

Based on the test results in Table 1, an average temperature measurement difference of 6.26 °C was obtained between the DHT22 sensor and the reference thermometer. This difference indicates a difference in temperature readings, where the DHT22 sensor produces a relatively higher value than the reference device. However, the resulting difference value tends to be consistent in each test, thus indicating the stability of the sensor readings. After the calibration process, the temperature measurement results are closer to the reference value, thereby increasing the level of system reliability.

In the air humidity test as shown in Table 2, an average difference in humidity measurements was obtained of 4.56%RH between the DHT22 sensor and the reference hygrometer. Based on the datasheet, the DHT22 sensor has a humidity measurement accuracy tolerance of around $\pm 2-5\%$ RH. Thus, the difference obtained in this test is still within the tolerance limits allowed by the sensor specifications. This difference in measurement values can be influenced by environmental conditions, sensor response time, and differences in the characteristics of the reference measuring instrument.[3][6][10]

Overall, the test results show that the DHT22 sensor integrated with the ESP8266 is capable of providing stable and fairly accurate temperature and humidity measurements. The obtained difference values are still within the sensor's tolerance limits, so the designed system is suitable for use in environmental monitoring applications that do not require a high level of precision.[14]

5. Conclusion

This research successfully designed and built an ESP8266-based Digital Thermometer that is able to measure temperature and humidity using the DHT22 Sensor and display the measurement results in real-time on an OLED Display. Based on the test results, the system is able to work stably and responsively, where temperature and humidity data can be read and displayed well by the ESP8266 and OLED. The results of the measurement comparison show that the DHT22 sensor has a difference in value to the reference tool, but after the calibration process, the measurement value becomes closer to the reference value and is still within the acceptable tolerance limit for environmental monitoring applications. [7][10][15]

In addition, the use of OLED displays provides a clear display, high contrast, and low power consumption, making it suitable for embedded system applications. The drawback of this system lies in the accuracy of the DHT22 sensor, which is still affected by environmental conditions and the sensor's limitations in high-precision measurements. Therefore, periodic calibration is required to maintain data accuracy.

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Reference

- [1] R. Buyya and AV Dastjerdi, *Internet of Things: Principles and Paradigms* . Boston, MA, USA: Morgan Kaufmann, 2016.
- [2] A. Yuhana, S. Hidayat, and D. Permana, “Design and Construction of a NodeMCU ESP8266-Based Temperature and Humidity Monitoring System,” *Journal of Computer Technology and Systems*, vol. 8, no. 2, pp. 85-92, 2020.
- [3] M. Hudhoifah and DI Mulyana, “Implementation of Environmental Temperature and Humidity Monitoring Using IoT-Based DHT22 Sensor,” *MALCOM: Indonesian Journal of Machine Learning and Computer Science*, vol. 4, no. 2, pp. 210–218, 2024.
- [4] R. Saputra, H. Putra, and A. Andre, “Design of an Environmental Monitoring System Based on ESP8266 and DHT22 Sensor,” *ELECTRON Scientific Journal of Electrical Engineering*, vol. 3, no. 1, pp. 1–9, 2022.
- [5] A. Kurniawan and I. Maulana, “Room Temperature and Humidity Monitoring System Using Web-Based ESP8266,” *Jurnal RESTI*, vol. 5, no. 3, pp. 456–463, 2021.
- [6] SR Ramadhan, FA Nugroho, and L. Sari, “Implementation of the DHT22 Sensor in a Sensor-Based Environmental Monitoring System Microcontroller,” *Journal of Information Technology and Computer Science*, vol. 7, no. 4, pp. 721–728, 2020.
- [7] MF Hakim and A. Nugraha, “Design of an ESP8266-Based Digital Thermometer with OLED Output,” *Journal of Electrical Engineering and Informatics*, vol. 9, no. 2, pp. 101–108, 2023.
- [8] N. Hidayati, R. Kurniawan, and S. Wibowo, “Internet of Things-Based Temperature and Humidity Monitoring Using NodeMCU,” *Mulawarman Informatics Journal*, vol. 15, no. 1, pp. 12–19, 2020.
- [9] A. Prasetyo and Y. Firmansyah, “Implementation of OLED as a Display Media in Embedded Systems,” *Journal of Microcontrollers and Embedded Systems*, vol. 6, no. 2, pp. 55–62, 2019.
- [10] AS Putra and R. Amelia, “Design and Construction of an IoT-Based Temperature and Humidity Monitoring Tool,” *Budidarma Informatics Media Journal*, vol. 6, no. 1, pp. 230–237, 2022.
- [11] Espressif Systems, ESP8266EX Datasheet, Shanghai, China, 2020.

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- [12] Aosong Electronics, DHT22 (AM2302) Digital Temperature and Humidity Sensor Datasheet, 2019.
- [13] S. Monk, Programming Arduino: Getting Started with Sketches, 2nd ed. New York, NY, USA: McGraw-Hill, 2020.
- [14] A. Zainuddin and B. Pratama, "Accuracy Analysis of DHT22 Sensor for Temperature and Humidity Measurement," Jurnal Instrumentasi, vol. 4, no. 2, pp. 88–95, 2021.
- [15] K. Ashton, "That 'Internet of Things' Thing," RFID Journal, pp. 97–114, 2019.