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Design of a NodeMCU-Based Real-Time Air Quality Monitoring System Using the Blynk Application

Elvan Satria Wirawan[1], Asni Tafrikhatin[2], Instianti Elyana[3]
[1,2]Department of Electronics Engineering, Politeknik Piksi Ganesha Indonesia, Indonesia, 54311
[3]Department of Management, Universitas Nusa Mandiri, Indonesia, 10450

elvansatria11@gmail.com

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Abstract

Currently, air quality monitoring is only through satellites, so this monitor is only general; even though sometimes we need an air quality monitor to measure air quality in the room or gas emissions in motor vehicles and factories, this research uses an MQ135 sensor to measure CO2 gas emissions, a DHT11 sensor to measure humidity and a NodeMCU ESP8266 microcontroller as the central brain. The system is designed to provide accurate and efficient air quality monitoring through the Internet of Things (IoT). They are integrating Blynk as a mobile device monitoring application that offers easy access to real-time air quality data. The Blynk interface allows users to monitor air conditions easily, receive notifications, and access data history. Based on the experimental results and the accuracy of the integrated temperature measurement, the system provides a reliable solution for comprehensive air quality monitoring in various environments.

Keywords*:* MQ-135 Sensor, DHT-11 Sensor, Nodemcu ESP8266

Abstrak

Saat ini pemantauan kualitas udara hanya melalui satelit, sehingga pemantau ini hanya bersifat umum, padahal terkadang kita membutuhkan pemantau kualitas udara untuk mengukur kualitas udara di dalam ruangan atau emisi gas pada kendaraan bermotor dan pabrik, penelitian ini menggunakan sensor MQ135 untuk mengukur emisi gas CO2, sensor DHT11 untuk mengukur kelembapan dan mikrokontroler NodeMCU ESP8266 sebagai otak pusatnya. Sistem ini dirancang untuk menyediakan pemantauan kualitas udara yang akurat dan efisien melalui Internet of Things (IoT). Mereka mengintegrasikan Blynk sebagai aplikasi pemantauan perangkat seluler yang menawarkan akses mudah ke data kualitas udara secara real-time. Antarmuka Blynk memungkinkan pengguna untuk memantau kondisi udara dengan mudah, menerima pemberitahuan, dan mengakses riwayat data. Berdasarkan hasil percobaan dan keakuratan pengukuran suhu yang terintegrasi, sistem ini memberikan solusi yang dapat diandalkan untuk pemantauan kualitas udara yang komprehensif di berbagai lingkungan.

Kata-kata kunci*: Sensor MQ-135, Sensor DHT-11, Nodemcu ESP8266*

1. Introduction

The issue of air quality has become an increasingly urgent global issue to be resolved. Poor air quality due to high levels of air pollution, greenhouse gas emissions, and various hazardous substances released into the atmosphere threatens human health and the environment **[1]**. Air pollution leads to worsening climate change. Severe climate change results in extreme weather events, increased global temperatures, and other changes that cause ecological damage, such as ecosystem quality degradation, biodiversity loss, and natural habitat destruction **[2]**. Therefore, more significant air pollution monitoring and mitigation efforts are urgently needed to protect our environment and the earth's future.

Every city should have air quality monitors to warn the public **[3]**. Existing monitoring stations tend to be limited in their geographical coverage, and the information generated is often static and limited. This makes it difficult for the public to access real-time air quality data and take appropriate precautions to keep themselves and the surrounding environment safe. In addition to threats to human health, current air quality issues also significantly impact the environment **[4]**.

The government should create an integrated air quality monitoring system that allows data generated by various sensors to be scattered in multiple locations across cities, regions, and areas **[5]**. This system should be able to provide information that is easily accessible to the public so that concrete measures can be taken to reduce pollution and minimize its negative impacts. In addition, the system should include real-time monitoring, which enables rapid response to emergencies, such as forest fires, industrial explosions, or other events that could threaten air quality **[6]**. The system should also provide valuable historical data for long-term planning to create a cleaner, healthier, and more sustainable environment.

These conditions should also enable air quality monitoring on a real-time scale, allowing the public to access air quality data in an instant, timely, and continuous manner **[7]**. The system will enable users to track changes in air quality around them, receive alerts if there is a threat to health, and provide a more robust basis for ongoing decision-making to maintain good air quality **[8]**.

Research on air quality monitoring involves developing monitoring systems that measure, record, and analyze various parameters affecting air quality **[9]**. Air quality monitoring systems generally involve sensor technology and hardware to measure parameters such as particulates (PM2.5 and PM10), pollutant gases such as SO_2, CO, NO_2, O_3, VOCs (Volatile Organic

Compounds), and air temperature and humidity [10]. These systems can measure data in real-time or at specific intervals.

Based on the description above, researchers made an air quality monitoring system using an Arduino Uno-based MQ135 sensor that can measure air quality monitoring results using an Android application, besides adding a DHT 11 sensor as an air humidity meter [11] [12]. The combination of IoT technology, MQ135, and DHT 11 sensors is expected to help humans know the condition of their environment. Better system access to air quality data can make people make efforts to reduce air quality pollution, such as reducing the use of oil-fueled motorbikes, reducing waste burning, and other activities that cause air pollution [10]. The existence of this product is expected to reduce greenhouse gas emissions and protect the natural environment.

2. Method

2.1 Air Quality Monitoring System Block Diagram

This research focuses on creating and producing a device to measure the level of fresh air quality and air humidity. This device utilizes the MQ-135 air quality sensor and the DHT-11 humidity sensor, which are integrated into a system consisting of software and hardware. The designed hardware involves the MQ-135 sensor, DHT-11 sensor, I2C LCD, and ESP8266 nodemcu . Meanwhile, the software is developed through Arduino IDE. By integrating both, this tool can provide accurate air quality and humidity data, with the hope of supporting further understanding of the surrounding environment. The block diagram used can be seen in Figure 1.

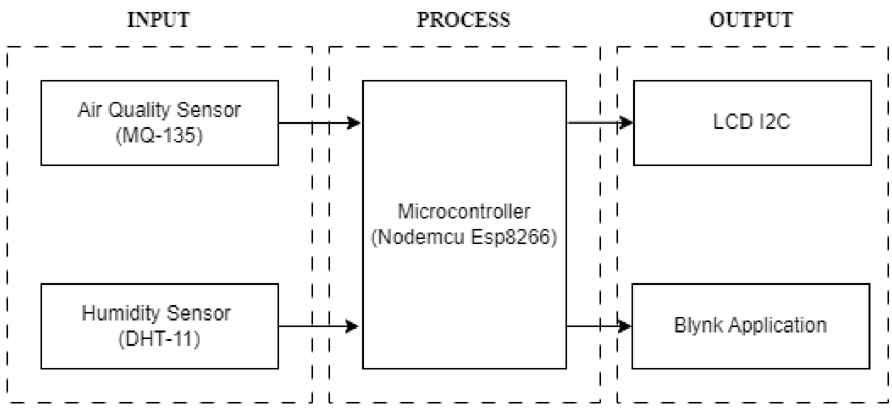

Figure 1. System Block Diagram

Figure 1 observes several parts consisting of one nodemcu ESP8266 microcontroller, divided into input, process, and output. The information of this system includes an air quality sensor (MQ-135) and a humidity sensor (DHT-11). Nodemcu ESP8266 is the processing part of the system, which is used as the system's central controller. The Blynk application shows temperature and humidity data information on the monitoring device. LCD is the output to display the fresh air quality value and air humidity.

2.2 Hardware and Cable design

The hardware design uses air quality and humidity sensors as input to receive measurements of air quality and humidity; these sensors provide information to the microcontroller to read and process data. The microcontroller used is Nodemcu ESP8266. The Nodemcu ESP8266 microcontroller sends data to the LCD to display the air quality and humidity sensor measurement results. Circuit schematic is presented on **Figure 2**.

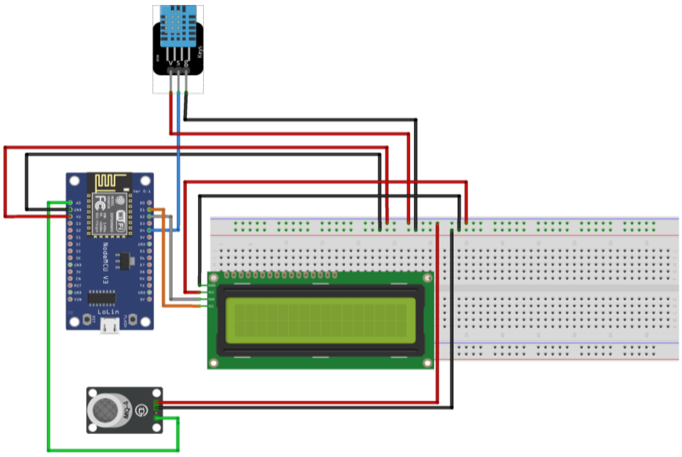

Figure 2. Circuit Schematic

2.3 Software Design

This research used Arduino IDE software to create a program that can be combined with the Blynk application to monitor temperature and humidity. Display in the Blynk application program. Monitoring design in the blynk application is presented on **Figure 3**.

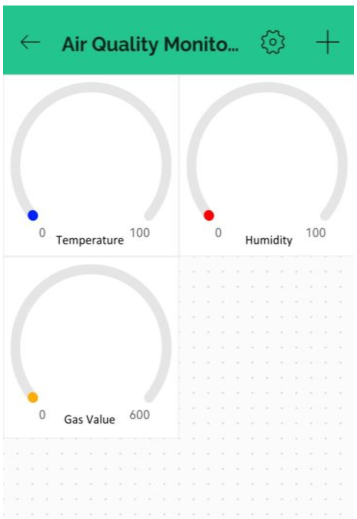

Figure 3. Monitoring Design in the Blynk Application

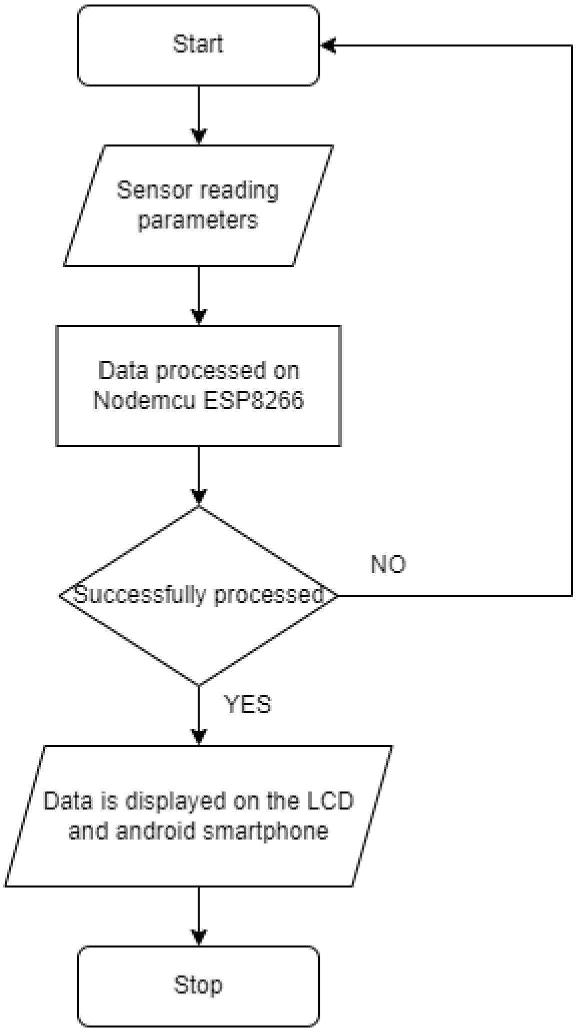

Figure 4. Tool Work Flowchart

Based on **Figure 4**, this software obtains the sensor reading system through the nodemcu ESP8266 connected to the Android device. The temperature data information is displayed on the Blynk application monitoring device, as well as air humidity. Arduino IDE software is used; the reason for using Arduino IDE is because it supports every requirement for Nodemcu ESP8266 design.

3. Results and Discussion

Working on the system uses an MQ-135 sensor, a DHT-11 sensor as input, Nodemcu ESP8266 as a microcontroller, LCD, and Blynk application as output. Design the connection scheme between Nodemcu ESP8266, MQ-135 sensor, DHT-11 sensor, and LCD. Ensure the cable placement and connections are appropriate to avoid connection problems and interference. Create an Arduino program to read data from the MQ135 and DHT11 sensors. The program should also be able to send the data to the Blynk app via a WiFi connection. Be sure to add code to control the LCD output to display information locally. Download and install the Blynk app on the mobile device. Create a new Blynk project and define the widgets to display the air quality, temperature, and humidity data. Specify the virtual pins that correspond to the Arduino code. Connect the Nodemcu to the computer and upload the Arduino program to the microcontroller. Ensure there are no errors and monitor the serial output to ensure the WiFi connection and sensor data capture are working correctly. Open the Blynk app on the mobile device and view the data displayed. Ensure that the air quality, temperature, and humidity data is sent in real-time from the NodeMCU to the Blynk app. Perform a test run to ensure that all components are functioning as expected. Identify and troubleshoot any errors or lags in data transmission. Hardware deployment results can be seen in **Figure 5**.

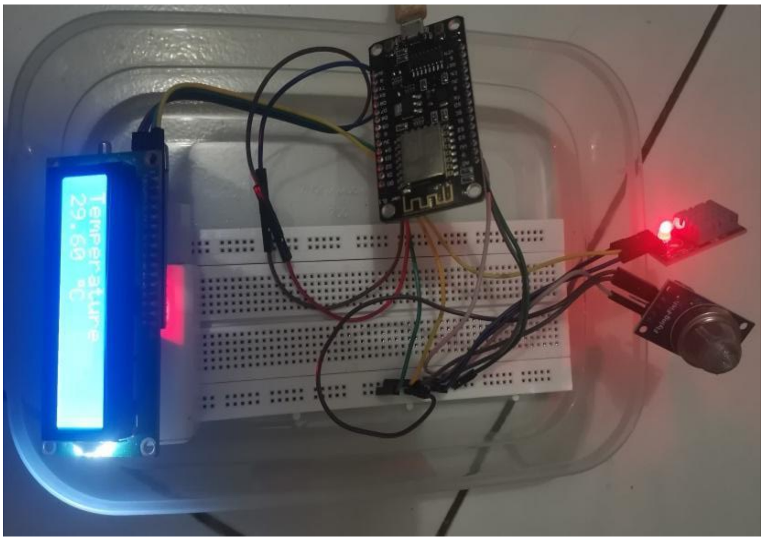

Figure 5. Hardware Deployment Results

The display on the Blynk application is presented in Figure 6.

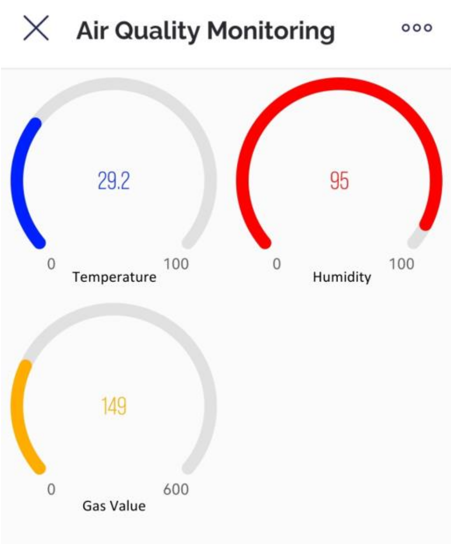

Figure 6. Monitoring View on the Blynk App

3.1 Sensor Testing

Sensors play an essential role in collecting air quality and humidity data in the tested environment. The sensor test results are shown in **Table 1**.

Table 1. Results of Sensor Testing on Products and Monitoring on BMKG

Testing	Sensor Testing		Testing	Monitoring BMKG	
	DHT-11	MQ-135		DHT-11	MQ-135
1	T: 31 H: 95	51	1	T: 29 H: 62	-
2	T: 31,20 H: 95	58	2	T: 30 H: 70	-
3	T: 31,30 H: 95	49	3	T: 31 H: 78	-
4	T: 31,40 H: 95	46	4	T: 31 H: 80	-
5	T: 31,60 H: 95	55	5	T: 31 H: 85	-

Description T : Temperature

H : Humidity

Table 1 shows the test results of the two sensors, namely the MQ-135 sensor and the DHT-1 sensor, with data taken from direct testing and BMKG monitoring. Testing was carried out five times within 5 minutes. We can use the comparison method or relative error calculation based on the data above. We can use the relative error percentage as an accuracy metric in this case. The formula is:

$$Accurace = \left(1 - \frac{Error\ Relatif}{Real\ Value}\right) \times 100\%$$

We can calculate the relative error for temperature and humidity separately and then take the average for overall accuracy.

$$Error\ Relatif\ = \left|\frac{measured\ value - real\ value}{real\ value}\right| \times 100\%$$

From the formula, we get the relative error results of an average temperature of 2.35% and an average humidity of 28.65%. So, the accuracy rate from the first to the second data is about 84.55%.

3.2 Testing Air Quality and Humidity Monitoring Equipment

Testing is done by observing and comparing data from the MQ-135 sensor and DHT-11 sensor on the LCD screen and the Blynk application. For both sensors, calibration has been carried out indoors for 24 hours. Data comparison is taken from two different conditions: outdoor conditions and conditions where the air is contaminated by harmful gases such as motor exhaust. Comparison of sensor monitoring results against motorcycle exhaust and outdoors can be seen on **Table 2**.

Table 2. Comparison of Sensor Monitoring Results Against Motorcycle Exhaust and Outdoors

No	Knalpot Motor		No	Luar Ruangan	
	DHT-11	MQ-135		DHT-11	MQ-135
1	T : 29 H : 95	90	1	T : 32 H : 95	70
2	T : 31 H : 95	100	2	T : 34,80 H : 95	77
3	T : 32 H : 95	135	3	T : 35 H : 95	81
4	T : 33 H : 95	148	4	T : 35,10 H : 95	88
5	T : 35 H : 95	223	5	T : 36 H : 95	92

Description T : Temperature
H : Humidity

Based on Table 2 data, it can be seen that there is a comparison of gas value and temperature. Based on the WHO bulletin, the CO2 threshold for clean air in Indonesia is 310-330 ppm, while for polluted air, it is 350-700 ppm. Testing was carried out five times, and different results were obtained. Sensor testing of motorcycle exhaust is carried out to test the entire system's function, especially the MQ-135 sensor. When the gas value exceeds the CO2 threshold value, the air quality category on the system will show Bad Air.

4. Conclusion

Based on the data that has been generated, the accuracy of the data obtained is close to the actual data from BMKG. With the accuracy of the sensors, especially in measuring temperature and humidity, this tool is a reliable solution for monitoring changes in air conditions. This conclusion emphasizes the importance of air quality monitoring to support appropriate decision-making and action. It highlights the role of this tool in providing accurate and continuous information on the condition of the surrounding environment. As such, it positively contributes to our understanding of air quality and maintaining a healthy and comfortable environment.

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