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The Utilization of IoT in Real-time Temperature and Humidity Monitoring Using Microcontroller: A Literature Review

Fachrul Rizky Syaputra[1]
[1]Undergraduate Program in Applied of Instrumentation Meteorology, Climatology Geophysics (STMKG)

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ABSTRACT

Temperature and humidity must be considered in various fields such as weather, agriculture, technology and industry. The Internet of Things (IoT) can be applied in temperature and humidity monitoring systems so that the data obtained is real time. The research uses a literature review method that has the main goal of searching journals through Google Scholar. This study analyzes the use of IoT for temperature and humidity monitoring using various sensors such as DHT22, DHT11, and DS18B20 in various fields. Based on several journals from 2017 to 2024, it was selected to provide an understanding of the effectiveness and accuracy of different types of sensors in environmental monitoring. The results of the study show that IOT makes it easier to monitor environmental conditions efficiently and accurately, helping to make decisions quickly and automatically. The DHT22 sensor is effective for monitoring due to its low cost and good quality, while DS18B20 excels in accuracy. This research is useful in the development of IoT in various environmental monitoring needs.

Corresponden Author:

Fachrul Rizky Syaputra,
Undergraduate Program in Applied of Instrumentation Meteorology, Climatology Geophysics (STMKG)
Tangerang City, Banten, Indonesia
Email: fachrul2105@gmail.com

1. INTRODUCTION

Observation of temperature and humidity values is an important aspect in various fields, such as weather, agriculture, technology, and industry. The values on these two parameters affect quality, safety, and the environment. Consistent measurement and monitoring of these two parameters can help ensure environmental conditions are within the optimal range of the observed area. So that to improve the operational efficiency of a system, it is necessary to maintain product quality. This research aims to develop accurate temperature and humidity monitoring methods to support the stability of various aspects of life. It is hoped that with this research, problems caused by temperature and humidity conditions will not occur again so that no losses will occur.

This can be exemplified in the agricultural sector where the type of plants planted must be adjusted to the temperature conditions and also the soil in the area. Like tea plants are

better in the mountains and corn is better in the lowlands. In the field of Technology, it can be seen that electronic devices are very vulnerable to high temperatures so that they will cause wars to be damaged faster. Meanwhile, in industrial factors, it can be exemplified in the food industry for the storage of ingredients, temperature and humidity conditions must be considered so that the ingredients are not damaged.

In this modern era where technology is increasingly developing and making human life inseparable from technology. The Internet of Things (IoT) can be used in various fields, including monitoring environmental conditions. IoT can allow users to control sensor data anywhere in real-time. With IoT, devices like the Arduino UNO can collect data and transmit it through a Wi-Fi module and allow us to know and analyze data remotely [1]. Internet of Things (IoT) platforms can be used to analyze temperature and humidity data. If only using a space thermometer to monitor environmental data with a small observation area, it is not enough. This is evidenced by the statement that temperature and humidity vary greatly in various locations. Conditions that exist in different regions can be very different [2].

DHT22 sensors and similar types are mostly used in IoT temperature and humidity monitoring systems, however, there is limited information about validating the accuracy of DHT22 sensors [3]. By utilizing sensors connected to the network, the system can automatically transmit data to a monitoring platform that can be accessed remotely. IoT-based temperature and humidity monitoring systems also support tool automation, such as controlling fans, heaters, or cooling systems based on observed environmental conditions. This is useful for improving energy efficiency and reducing operational costs. Automation of this equipment is very important to do in this day and age where humans want something in an easy way.

2. RESEARCH METHOD

2.1 Data Sources and Search Strategies

This study uses a literature review method that has the main purpose of searching journals through Google Scholar. In the search process, it is focused on the title of the Journal with appropriate keywords such as the words "IoT", "temperature", and "humidity". After that, a search was carried out about the theme. The selected journal is an English-language journal published in the 2017 - 2024 times frame [4].

2.2 Inclusion Criteria

In writing this journal, certain criteria are used where the journal must use sensors to measure temperature and humidity such as DHT11, DHT22, or DS18B20 and must use IoT. Journals that only use sensors and are not integrated with IoT are not used.

2.3 Quality Assesment

This study does not use a standard that is usually used to assess the results of IoT-based research for temperature and humidity observation. Thus, the risk of bias is evaluated on two main assessments, namely the accuracy of sensor measurements and reliability in transmitting data and humidity observation. Thus, the risk of bias is evaluated on two main assessments, namely the accuracy of sensor measurements and reliability in transmitting data.

3. RESULT AND DISCUSSION

Table 1. Literature Review Result

No	Title	Year	Author	Remarks
1	Design of Monitoring System Temperature And Humidity Using DHT22 Sensor and NRF24L01 Based on Arduino	2023	Azhari Nasution, T. I. Sinaga, S. H. Sudiati	The research begins with a literature study, followed by system design based on hardware and software requirements. This system uses of a base node (Arduino Uno, nRF24L01) and a client node (Arduino-Uno, DHT22, LDR, nRF24L01). Data is collected and transmitted wirelessly, with real-time results displayed on an LCD. A buzzer alarm triggers if the temperature exceeds 32°C or humidity exceeds 65%. The power supply uses a step-down transformer to convert 220V AC to 12V DC. The NRF24L01 module provides reliable communication over 800 meters, with sensor accuracy of 1.4% for temperature and 3.8% for humidity.
2	On the Evaluation of DHT22 Temperature Sensor for IoT Application	2021	Ahmad, Yasser Asrul Surya Gunawan, Teddy Mansor, Hasmah Hamida, Belal Ahmed Fikri Hishamudin, Adam Arifin, Fatchul	The temperature monitoring system uses a DHT22 sensor and is connected to a Raspberry-Pi, MySQL database, and Grafana for real-time display. The DHT22 was chosen for its accuracy, affordability, and low power consumption. The system was compared to an industrial-grade Keithley 6517-TP thermocouple across three experiments: room temperature, ice bath, and boiling water. While the DHT22 provided accurate readings, it was slower in detecting rapid temperature changes. The system is ideal for monitoring environments with gradual temperature shifts due to its low cost and IoT capabilities.
3	IoT based Temperature and Humidity Controlling using Arduino and Raspberry Pi	2019	Barik, Lalbihari	IoT-based systems for temperature and humidity detection are an efficient way to monitor farm conditions in real time. The sensors will continuously measure these parameters, and the data is sent to a

				cloud platform via an Arduino microcontroller, and the information is then sent to the farmers' mobile phones via GSM, allowing them to track environmental conditions remotely. This system helps farmers make timely decisions to optimize crop growth and can prevent problems such as overwatering or drought. The setup is energy-efficient, cost-effective, and scalable for a wider range of agricultural applications.
4	Performance Analysis Comparison of DHT11, DHT22 and DS18B20 as Temperature Measurement	2023	Yulizar, David Soekirno, Santoso Ananda, Naufal Prabowo, Muhammad Agung Perdana, Ilham Fajar Putra Aofany, Diar	Temperature monitoring is essential in various sectors such as agriculture, food production, and healthcare, making temperature monitoring essential. Temperature sensors are commonly used in applications such as seawater desalination, hydroponics, and fermentation processes. This study compares the accuracy of three temperature sensors: DHT11, DHT22, and DS18B20. Laboratory calibration and field tests were conducted. The results showed that DS18B20 had the smallest uncertainty (0.17°C) and the highest accuracy (99.05%), followed by DHT22 (98.15%) and DHT11 (97.19%). Thus, DS18B20 is more accurate and reliable for temperature measurement.
5	The feasibility study: Accuracy and precision of DHT 22 in measuring the temperature and humidity in the greenhouse	2023	Wardani, I. K. Ichniarsyah, A. N. Telaumbanua, M. Priyonggo, B. Fil'Aini, R. Mufidah, Z. Dewangga, D. A.	This greenhouse uses hydroponic systems like the nutrient film technique and Dutch bucket to grow high-value crops like lettuce, pak choi, and melon. The study aimed to create a microclimate monitoring system for the greenhouse using affordable sensors. DHT22 sensors were used to measure temperature and humidity at different points in the greenhouse, transmitting data through a master-slave system based on Atmega2560 and ESP32. The system sends real-time data to a cloud platform, Ubidots, accessible via mobile devices. The study found that the DHT22 sensors provided accurate readings, with RMSE values of 1.48°C for temperature and 3.18% for humidity. Regression analysis showed strong correlation coefficients, indicating the system's precision in monitoring greenhouse conditions. The research contributes to affordable smart farming technologies for Indonesia.
6	Server Room Temperature & Humidity Monitoring Based on Internet of Thing (IoT)	2019	Alvan Prastoyo Utomo, Moechammad Aziz, Abdul Winarno Harjito, Bambang	An IoT-based temperature and humidity monitoring system is quite effective in monitoring and controlling conditions in the server room. The DHT22 sensor used can detect changes in temperature and humidity with good accuracy. The data collected in real-time is stored on the server and can be accessed via the web and notifications are sent to the user via the Telegram application if the temperature or humidity exceeds a pre-defined limit. This system allows users to control the temperature of the server room remotely, improving efficiency and preventing hardware damage in the event of drastic environmental changes.
7	Monitoring and Control Food Temperature and Humidity using Internet of Things Based-on Microcontroller	2021	Riadi, Imam Syaefudin, Rizal	The system is designed into two things: hardware and software for data transmission. DHT22 is used to measure temperature and humidity, and the data is sent to a server using ESP8266. If humidity exceeds 80%, a heater is activated; if temperature exceeds 30°C, a cooler is turned on. Results and Discussion The system has been tested for temperature and humidity control, with results indicating that the DHT22 provides accurate data. Temperature control tests showed fluctuations that aligned with the settings, while humidity tests indicated a decrease in humidity values as expected. Data was transmitted and visualized through the Thingspeak application, indicating

				successful data transmission. Fermentation of tempeh lasts about 2-3 days with an optimal temperature of 35°C. Data analysis was performed using standard deviations to evaluate sensor accuracy, revealing that small deviation standards show accurate and representative data.
8	Distant temperature and humidity monitoring: prediction and measurement	2021	Hafeez, Farrukh Sheikh, Usman Ullah Khidrani, Attaullah Bhayo, Muhammad Akram Abdallah Altbawi, Saleh Masoud Jumani, Touqeer Ahmed	Over the past decade, manufactured insights (AI) has significantly affected areas such as dialect preparing, healthcare, and observation. Machine learning calculations analyze designs, driving to developments like self-driving cars and progressed climate estimating. The Web of Things (IoT) is additionally progressing quickly, with applications in savvy homes and horticulture, making IoT more progressive than the mechanical transformation due to broad smartphone utilize. This paper presents a show for monitoring humidity and temperature employing a Wi-Fi-connected mechanical vehicle. It utilizes a repetitive neural organize (RNN) with a DHT22 sensor for estimations and an IP camera for route. Comes about demonstrate tall forecast precision, improving unwavering quality for future work including progressed calculations and broad information collection.
9	Monitoring Temperature, Humidity And Controlling System In Industrial Fixed Room Storage Based On Iot	2020	Seman, Mohd Tarmizi Abdullah, M. N. Ishak, M. K.	By using several techniques in its processing, it is hoped that it can compare the measured value and the expected value in one study. Data-driven machine learning algorithms aim to predict values from temperature and humidity. The experiment was conducted in both outdoor and indoor environments. The statistical results reveal that, compared to outdoor settings, indoor environments achieve higher accuracy. To further improve the accuracy of the model, more data must be collected over a longer period of time. In addition, better meteorology-related algorithms can be used to get more accurate predictions. The use of special and advanced temperature and humidity sensors will also increase the accuracy value
10	Modeling Automatic Room Temperature and Humidity Monitoring System with Fan Control on the Internet of Things	2022	Hendajani, Fivtatianti Mughni, Arif Wardhani, Ire Puspa Hakim, Abdul	This IoT-based system has two main functions: monitoring temperature and humidity using the DHT22 sensor displayed on the web page, and controlling fan speed with pulse width modulation. (PWM). The fan is operated manually, but it can be automated based on the room's temperature and humidity values. This system uses the L298N motor driver and requires an additional power supply for the fan. The website can be accessed using the server's IP address, and it is recommended to add a password for security. This prototype can be developed for various electronic devices such as fans, lights, and TVs. The use of applications like Blynk is recommended for global access and further development.
11	Development of embedded system in monitoring temperature and humidity as supporting smart farm	2020	Puspasari, Fitri Fahrurrozi, Imam Oktiawati, Unan Yusmaniar Satya, Trias Prima	NodeMCUs can be integrated with temperature and humidity sensors and their outputs can be transmitted over the web in realtime. Temperature and humidity data is sent from the NodeMCU device to a database, which is then viewed on the website. In the future, this gadget can be equipped by installing it on a fan or a locked blower. So that the microcontroller can directly instruct the blower to lower the temperature of the cage when it reaches the comfort zone. Significant advances in information and communication technology have improved traditional monitoring and mitigation methods in terms of precision and accuracy

				and faster delivery of measurement results, enabling savings in cost, time, and energy.
12	Temperature and Humidity Monitoring System in Internet of Things-based Solar Dryer Dome	2023	Tazakka Ma'arij, Dzakarasma Yudhana, Anton Ma'arij, D T Yudhana, A	The study shows that weather, temperature, and humidity are correlated. During the day, the temperature and humidity inside the SDD are higher and lower than those outside, regardless of whether it is raining or clear. The temperature error values for the DHT22 and DHT11 sensors, compared to the ThermoPro, are 1.572% and 0.721%, respectively. However, the humidity error values differ, with both DHT22 and DHT11 showing a 5% inaccuracy compared to the ThermoPro. This indicates that adjustments are needed in the program. The greatest temperature difference between the inside and outside of the SDD occurs at 9:00 AM WIB.
13	A Prototype of Monitoring Temperature and Humidity on Photovoltaic Using ESP8266	2020	Subastiyan, H. Sunanda, W. Gusa, R. F.	In the province of the Bangka Belitung Islands, the need for power has been rising yearly. According to the most recent data, the region has 77,362 kVA of connected capacity, 449,450 consumers, and an installed power capacity of 353.9 MW. Steam, diesel, biomass, and gas plants are among the power sources; their combined capacity is 306 MW, and their net output is 280 MW. As a result, solar energy is being investigated as a potential alternative energy source, especially on the island. Using sensors to gather data on temperature, humidity, sun radiation, and voltage for analysis, this study focuses on monitoring photovoltaic parameters.
14	Designing an IoT system for monitoring and controlling temperature and humidity in mushroom cultivation fields	2019	Nasution, Tigor Hamonangan Yasir, Muhammad Fahmi Soeharwinto	an IoT-based monitoring system successfully measured temperature and humidity for oyster mushroom cultivation. Temperature and humidity are sent to the cloud using ThingSpeak once every 30 minutes. The system is also able to control the temperature of around 25-29°C to support the growth of mushrooms. The results of the experiment showed that oyster mushroom cultivation with a temperature control system was more effective, because optimal environmental conditions could be maintained. This shows the potential of IoT in improving efficiency for the agricultural sector.
15	Implementation Of Monitoring and Control Temperature and HumidityBased on IoT in The Oyster Mushroom Cultivation Room	2023	Wibowo, Budi Cahyo Rozaq, Imam Abdul Pratama, Tredi Pratama	Experiments conducted by the author, it was found that the DHT22 sensor has an accuracy level of 99.44% for temperature measurement and 99.4% for humidity. The website will instruct the existing actuator with a delay of 2.8 s to heat up and 3 s to pump. This is used to maintain the temperature and humidity conditions of the kumbung chamber against the optimal temperature and humidity values that have been determined. For the average watering time is 115 s and for the heater 383 s.
16	Implementing IoT for Development of a Low-Cost Environmental Monitoring System	2018	Nascimento, Michel H.S. Moreira, Anderson L.S. Domingues, Marco A.O. Castro, Arthur L. Moura, Denis L.	The DHT22 sensor has quite good quality in temperature and humidity monitoring in systems integrated with IoT. DHT22 has a temperature range between -40°C to +80°C with quite good accuracy and a humidity range from 0 to 100% RH (Relative Humidity). In addition, this sensor also has low power consumption, making it suitable for IoT applications that operate continuously with a maximum consumption of 1.5mA. The DHT22 can provide measurement results in a digital format through data pins, making it easy to integrate into microcontrollers such as NodeMCUs used in IoT systems. Its advantage over other sensors is its ability to provide accurate data with little delay, although additional calibration may be required when used in extreme environments.

17	Development of Temperature and Humidity Control System in Internet-of-Things based Oyster Mushroom Cultivation	2020	Najmurrokhman, Asep Kusnandar Daelami, Ahmad Nurlina, Elin Komarudin, Udin Ridhatama, Hasbi	Monitoring and control of humidity and temperature are important factors for optimal oyster mushroom cultivation, where the conditions must be in the range of 18-30°C and humidity 65-85%. IoT-based systems, such as Cayenne, allow for real-time remote monitoring and maintenance, ensuring mold grows in the ideal environment. Sensors such as the DHT11 can monitor temperature and humidity data, so actuators such as fans and mistmakers can maintain conditions within the required limits. This increases efficiency by enabling continuous monitoring and automated adjustments, supporting high-quality mushroom production.
18	Development of an IoT-based Real-Time Temperature and Humidity Monitoring System for Factory Electrical Panel Rooms	2024	Medagedara, O. V. Liyanage, M. H.	The Arduino IDE's serial monitor shows the programmed algorithm and the IP address for accessing the web server online. This created IP address enables users to see a visual display of temperature and humidity readings that are refreshed every 30 seconds. Data is collected every 10 seconds using the DHT22 sensor to maintain server efficiency and guarantee smooth functioning. The configuration of the chart, such as axes, text alignment, colors, and component positioning, is set up through an HTML file that is sent to the microcontroller, guaranteeing a precise visual display of the gathered information.
19	IoT based temperature and humidity monitoring framework	2020	Rahman, Rafizah Ab Hashim, Ummi Rabaah Ahmad, Sabrina	IoT platforms can be used to analyze temperature and humidity data. If only using a space thermometer to monitor environmental data with a small observation area, it is not enough. This is evidenced by the statement that temperature and humidity vary greatly in various locations. Conditions that exist in different regions can be very different
20	Monitoring temperature and humidity of server room using Lattepanda and ThingSpeak	2019	Nasution, T. H. Muchtar, M. A. Seniman, S. Siregar, I.	IoT-based temperature and humidity monitoring systems, which use Lattepanda and ThingSpeak, can ensure optimal conditions in the server room. Monitoring is carried out in real-time every 30 seconds, allowing for more effective management of temperature and humidity to prevent potential damage that may occur. By utilizing the DHT11 sensor, temperature and humidity data can be sent in real-time and observed in the form of graphs through the ThingSpeak platform. This system can support data-driven decision-making for better infrastructure management.

Several scientific journals show that IoT technology plays a very important role in monitoring optimal agricultural environmental conditions. The DHT22 sensor, along with Arduino and NodeMCU, used for accurate temperature and humidity monitoring. The data helps farmers in managing agricultural conditions effectively to support optimal plant growth [5], [6]. By using data that can be monitored in real-time, farmers will be able to immediately find out the condition of the plants even though they are not in place. For example, a temperature and humidity monitoring system with IoT is applied in maintaining temperature and humidity for oyster mushroom cultivation rooms. Temperature and humidity are automatically controlled to ensure the ideal environment is expected to add to the value of productivity [7], [8]. It can also be applied in different types of fungi such as beetle mushrooms. The Cayenne app can also be used for real-time access options and remote monitoring [9].

Monitoring of temperature and humidity values is also important for microclimates in greenhouses. The DHT22 and DHT11-based systems used in the experiment provided results with high accuracy. The system can also be connected to a cloud platform so that it can be accessed in real-time [10], [11]. This can help greenhouse owners to know the condition of the greenhouse and can solve the problem quickly. In addition, by utilizing DHT22 sensors and RNN networks. Users can create a system to predict and measure temperature and humidity inside existing greenhouses. The system generates accurate predictions for the automatic setting of the greenhouse environment [12]. With this prediction system, if an extreme condition occurs, users can prepare preparations so that the quality of the greenhouse is maintained. To automatically maintain environmental conditions in agricultural greenhouses to match the desired conditions, fan control using PWM can be used [13].

In the industrial field, IoT systems can also be applied to monitor temperature and humidity for raw material storage rooms to be produced. The DHT22 sensor integrated with ESP8266 can be used to maintain material quality by automatically activating the temperature and humidity control device if the storage space conditions go out of the desired limits [14]. In addition to being monitored, a system can be equipped with tools that are used to restore temperature and humidity values according to the desired. If after the temperature and humidity control device is active, the user can still observe whether the condition is normal or not. And if it is still not normal within a certain period of time, users can come directly to check the condition of the room

For monitoring systems, Lattepanda and ThingSpeak can be used so that data visualized in the form of graphs[15], [16]. With graphs, the data will be easier to analyze. The use of IoT in industrial storage systems can also be used to compare environmental conditions inside and

outside industrial spaces. This aims for long-term monitoring that allows the development of algorithms for efficient environmental control of the industrial area [3]. IoT platforms can be used to analyze temperature and humidity data. If only using a space thermometer to monitor environmental data with a small observation area, it is not enough. This is evidenced by the statement that temperature and humidity vary greatly in various locations. The results of the statistics reveal that, compared to outdoor settings, indoor environments achieve higher accuracy [17].

The monitoring system can also be applied in the food industry by utilizing DHT22 to monitor temperature and humidity conditions in food fermentation chambers [13]. The IoT system developed is useful for supporting the automatic control of air conditioning and heating according to specified parameters [18]. This can improve the quality of fermented results because in making fermented food, the value of temperature and humidity in the room must be considered. This is because yeast or bacteria used for making fermented food have special conditions in order to develop properly. In addition, another acceptable advantage is the reduction of losses caused by the failure of the fermentation process on the material.

This system can also be implemented to monitor the temperature and humidity in the server room. By using DHT22 sensors and Telegram platform for real-time alerts. This system allows the adjustment of the temperature and humidity in the room to meet safe limits and avoid damage to the device [16]. Of course, this is very important because the price of existing devices is likely to have a high value. It is hoped that by using this system it is expected to be free from damage to the device due to poor room conditions. This can happen because if the temperature is too high, the device will also become hot. Then if the temperature is very cold, the humidity will be high so that the water content in the air is very high which can result in an electrical short circuit.

In solar panels, temperature, humidity, and voltage monitoring can be controlled using ESP8266. This system can be used to ensure that optimal conditions so that the energy efficiency of the panels can be well maintained, especially in areas with high solar radiation such as Bangka Belitung province [19]. This system can use DHT22 and can be set up with updates every 30 seconds to maintain operational stability in the factory [20]. This is very important to be able to utilize the power source that comes from sunlight. If the efficiency level of the tool is high, a large amount of energy will be obtained. However, if the efficiency of the equipment is low, the potential of areas with high solar radiation will not be optimal.

Sensor DS18B20 is the sensor with the highest accuracy for temperatures with an uncertainty of about 0.17°C, then for the DHT22 sensor with an accuracy of 98.15%. However, in its application, the DHT22 sensor is more often used because of its fairly good accuracy and lower cost. Although DS18B20 sensors provide the best results in applications that require highly precise measurements [21]. In this case, it can be understood that in making a tool, the economic factor of the tool to be designed must also be considered. The DHT22 sensor is of good quality for temperature and humidity monitoring with IoT systems, has a temperature range of -40°C to +80°C, humidity 0-100% RH, low power consumption, and accurate measurement capabilities, but may require additional calibration in extreme environments [22].

This can be a guide that in designing a system, you must not only pay attention to the value of accuracy. However, it must also pay attention to its economic value. If a system can have a low price and good enough accuracy, the device can be mass-made and make more existing observation locations. This is of course better because as explained earlier, each region has a different value. So that if there are more observation locations, it will be easier to make a prediction system because it is rich in a lot of data.

4. CONCLUSION

The Internet of Things (IoT) has revolutionized monitoring systems across various sectors, providing real-time data that enhances decision-making processes for faster responses. In industries such as agriculture and renewable energy, IoT applications enable the optimization of environmental conditions to ensure they are always at their most suitable levels. This real-time monitoring capability is vital for improving efficiency and productivity. In agriculture, IoT plays a significant role by improving crop productivity through effective temperature and humidity management. Similarly, in industrial settings, IoT systems are critical in preventing equipment damage by ensuring optimal environmental conditions are maintained.

Moreover, the DHT22 sensor is particularly effective in IoT applications where temperature and humidity monitoring is essential. Despite the DS18B20 sensor providing higher accuracy for temperature measurements, the DHT22 remains a popular choice due to its reasonable cost and adequate accuracy. It is well-suited for diverse environments such as greenhouses, server rooms, and storage spaces, making it a reliable and economical option for a wide range of IoT applications.

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