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Smart Solar Ventilation System for Home Using Internet of Things (IOT)

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Abstract: Industrial revolution 4.0 or IR4.0 has been widely applied at the current industrial level. By using today's technological facilities, users can monitor and control devices or equipment more efficiently and effectively. Related to this project, this exhaust fan is widely applied at home or around commercial buildings. So, the IoT system has been installed on this exhaust fan to make it easier for users to control and monitor the state of the device's open and close switch. Furthermore, with the use of renewable energy such as solar power, electricity can be supplied continuously without affecting the earth's ecosystem itself. In accordance with Malaysia's climate which is mostly hot, energy supply can be channeled continuously and efficiently. Therefore, this project is designed to make it easier for users to automatically monitor and control the condition of opening and closing the exhaust fan switch, especially in residential areas. In application, the temperature sensor will detect high temperature to automatically open the exhaust fan switch and close the switch when the temperature returns to normal. So, this can achieve the goal of IR4.0 to be applied in our daily life in order to keep up with the flow of technology today.

Keywords: Industrial Revolution 4.0, Renewable Energy, Monitor, Control

1. Introduction

In today's technological age, most buildings, offices and homes have good and effective ventilation systems to cool the home. This can be detailed with the use of an exhaust fan. If examine at home, exhaust fans are usually located in rooms and kitchens to reduce the heat trapped in the home environment. Good ventilation in the environment affects the quality of the air that breathe oxygen every day. Every human being deserves to receive clean air every day to live a good life. Specifically, exhaust fans draw out excess humidity, smoke, and other airborne impurities. Mold growth is facilitated by high humidity and steam. By venting the steam outside, exhaust fans can be used to reduce the spread of mould inside the home. Furthermore, exhaust fans aid in the preservation of your home's furnishings. If air is not allowed to circulate correctly around furniture, it might deform or decay. The exhaust fan

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can stabilize a good environmental temperature by releasing hot heat in the house [1]. By installing and applying this exhaust fan system at home, people at home can breathe clean air without any harmful smoke at home. In addition, houses located close to factories or mining centers are obliged to install this system to reduce this dirty ventilation. Air quality is very important in human life. When people breathe in contaminated air, the poisons that are present in the air go into our lungs, where they have the potential to enter our bloodstream and be transported to our internal organs, including our brain. This affects the health of a person with various dangerous diseases such as asthma, cancer and will also shorten the lifespan of a person [2].

Browse about this project, this exhaust fan is powered by a solar system that can supply enough electricity for the exhaust fan. Malaysia has an equatorial climate, which means that it gets sunlight all year long. Solar power can guarantee sustainable energy. There are important things to think about when talking about the long-term use of energy. One of the most important things has to do with energy sources, and the goal is to use less energy from fossil fuels and more energy from renewable sources. It is to make sure that consumers always have a steady supply. As a result, it is possible to lessen the amount of pollutants in the environment, to produce less carbon, and to save life from the potentially disastrous effects of global weather and climate change. It also contributes to maintaining a clean and safe atmosphere for us to live in.

In addition, this project is powered by the Internet of Things (IOT) system. The Internet of Things (IoT) is a network of interconnected computing devices, networks, and services that enable embedded systems like processors, sensors, and communication gear to gather, transmit, and act on data from their physical surroundings. With this IOT system, the exhaust fan can monitor and control the state of the exhaust fan. By using only, the phone, the exhaust fan can control the open and close switch automatically when temperature reach a limit by a set of temperature. This also can control manually by our phone. So, this can control the exhaust fan with a long distances rate. Using temperature sensor, Blynk application can display a current temperature and humidity rate for monitor it. This can be aligned with the latest advanced technology which is in line with Industrial Revolution 4.0.

1.1 Air Ventilation System

A ventilation system is a mechanical structure made up of interconnected equipment that regulates the flow of air in enclosed areas, such as private residences and commercial buildings. Its primary purpose is to bring in a steady supply of clean air, which comes in most cases from the outside air, while simultaneously directing stale air away from the building. Fans and pumps are typical components of these systems, as are vent grates and air flow tunnels; but, in the majority of instances, the principal operational components are all constructed within the walls and ducts of the respective structures. People that use the place often are not privy to any of the operational components that are present [3].

1.2 Solar Energy System

Simply put, solar power comes from the sun. It may be transformed from solar radiation into either electrical or thermal energy, making it the most widely available kind of energy on Earth. In addition to daylight illumination, the sun's rays offer the energy needed to keep Earth spinning. Each photon of sunlight that reaches Earth's surface includes this energy. All of Earth's weather systems and energy sources can be traced back to the sun, and every hour, enough solar radiation reaches Earth's surface could theoretically provide global energy demands for nearly a full year. Here on Earth, we transform the sun's energy into useable form using photovoltaics and solar thermal collectors. As the price of solar panels continues to drop, more and more people in more and more locations are able to take advantage of this renewable energy source. Solar energy, being renewable and environmentally friendly, will be crucial to the world's ability to meet its future energy needs [4].

2. Materials and Methods

2.1 Block Diagram

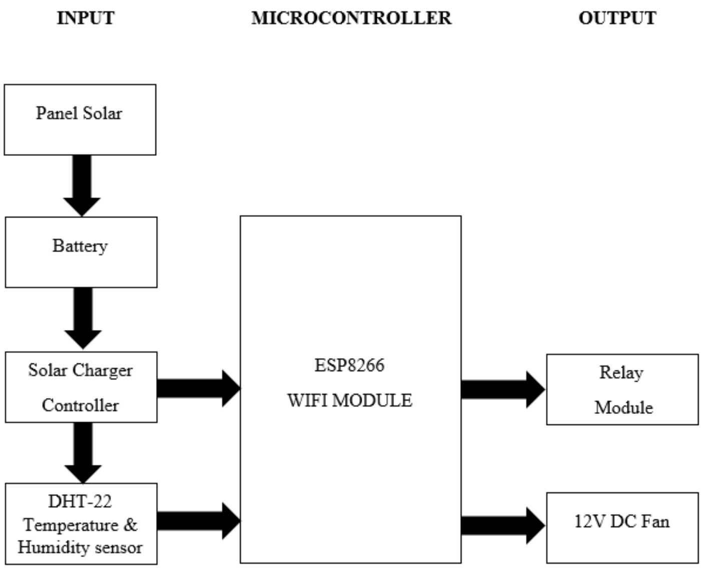

Figure 1: Block Diagram of system

Figure 1 shows Smart Solar Ventilation System for Home using IoT entails a number of processes. For this Block Diagram, ESP8266 will become as a microcontroller. Specifically, solar energy from the solar panel will channel 12 V energy to the solar charger controller. The purpose of a solar charger controller is to regulate the solar charging of a battery or battery bank. It serves as an intermediary between the solar panels and the batteries to ensure safe and efficient charging. For sure, battery will get a supply from the solar charger controller. The 12 V energy as a whole will contribute energy to the Vdc fan. Because the maximum voltage of the ESP8266 is only 5 V, ESP8266 LUA expansion shield will be use to lower the voltage value from the 12 V to 5 V. This component has its own converter to decrease the voltage. When the ESP8266 has worked, the temperature sensor will identify and detect the temperature and humidity rate of our home environment. The temperature data will be sent to the Blynk application on our phone via ESP8266. From there, the system can monitor the temperature of the room only through the phone application. When the temperature can be detected, the on and off switch on the application can work. Electricity supply from the solar system is able to turn on the exhaust fan at a stable rate.

2.2 Flowchart

A flowchart in Figure 2 below is a graphical representation of the order in which a series of steps and decisions must be carried out in order to complete a process. There is a notation for each stage of the process contained within a corresponding diagram shape. Connecting lines and arrows point in the appropriate directions between each step. This makes it possible for anyone to view the flowchart and follow the process in a logical manner from the beginning to the end.

In a more detailed explanation for the flow chart, it starts with load libraries of sensors. The system will identify the sensor component used. After that, each coded pin will be identified by the system. The system will verify the network and check the Wifi connection to be connected to the Blynk application through the ESP8266 Wifi module. Once the connection is complete, the temperature and humidity will be detected and measured by the DHT-22 sensor. If there is any error, this process will be repeated until successful. The LCD will display the temperature reading as well as the reading on the Blynk application on the mobile phone.

After that, the exhaust fan will be turned on automatically when the temperature is measured over 34°C using the IoT concept. When the temperature has been in a stable state and the specific temperature is below 34°C, the exhaust fan will be turned off automatically. This process repeats itself according to the current temperature conditions. The exhaust fan can also be controlled manually using the Blynk application on the phone. Just click the open and close button on the application.

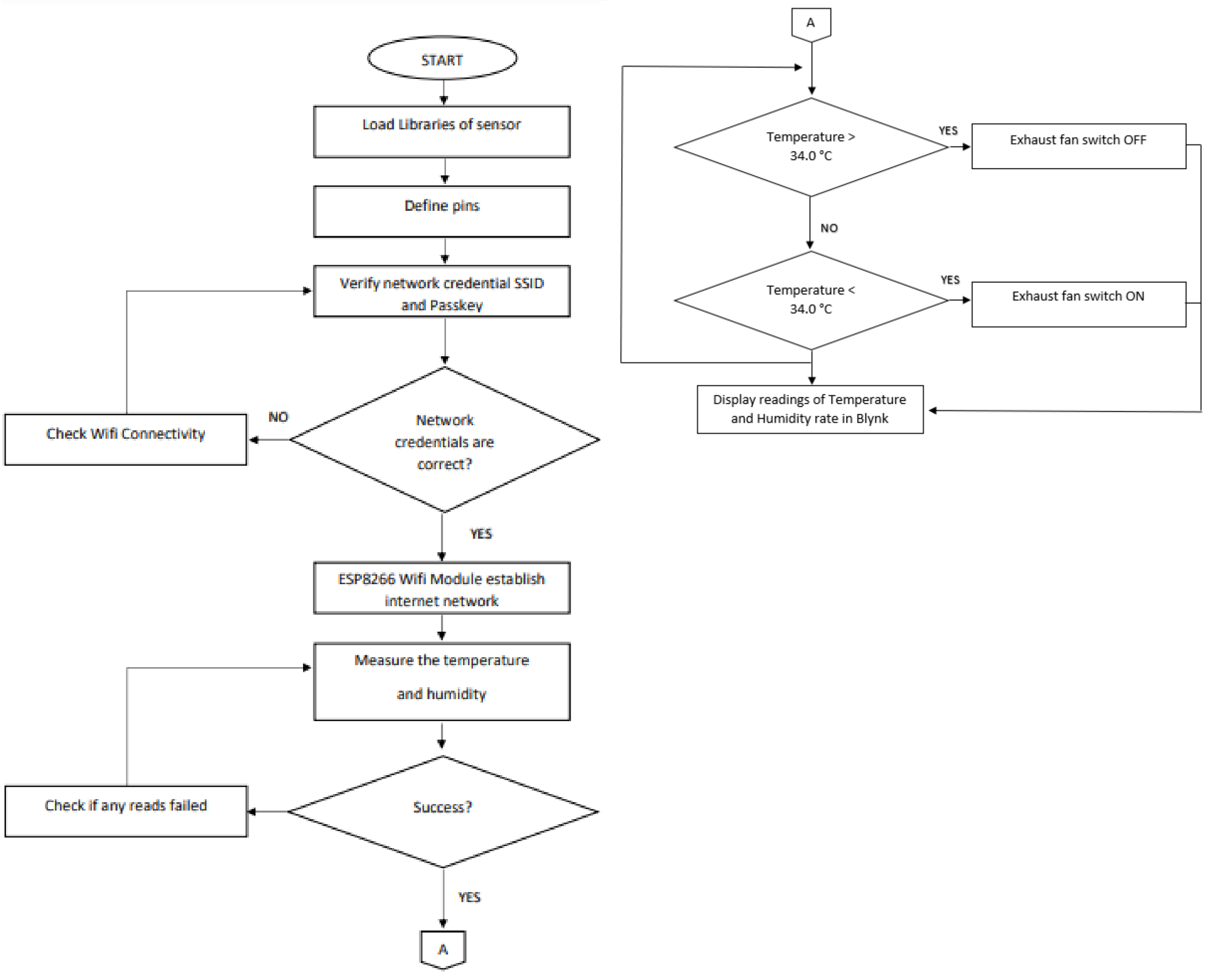

Figure 2: Flowchart of system

2.3 Schematic diagram

The circuit is implemented by using ESP8266 Wifi Module, Solar Charger Controller, 12 Vdc Fan, Solar Panel, DHT-22, Relay Module, Battery Storage 12 V and ESP8266 LUA Expansion Shield. Circuit works entirely by using energy from solar energy. The maximum solar energy absorbed into the solar panel is 12 V. The energy absorbed to this panel will be stored in the storage battery. The solar charger controller becomes the middle agent between the solar panel and the battery to store energy for the battery and as protection for the load. So, the total voltage of 12 V will be fed directly to the exhaust fan. Because the maximum voltage of the ESP8266 is only 5 V, a ESP8266 LUA Expansion Shield is needed to lower the 12 V to 5 V to be fed to the ESP8266. DHT-22 temperature sensor is needed here to detect the ambient temperature and humidity rate at home. The ESP8266 Wifi Module is become microcontroller and as a communication between the system and our phone through the Blynk application. Relay plays a dominant role as a normally open states to control the 12 Vdc fan switch.

It also serves to isolate the control circuit from the device or system being controlled. When the connection is complete, the Blynk application can fully function to control the 12v vdc fan automatically and manually. The value of temperature and humidity rate will display in a Blynk application to monitor it.

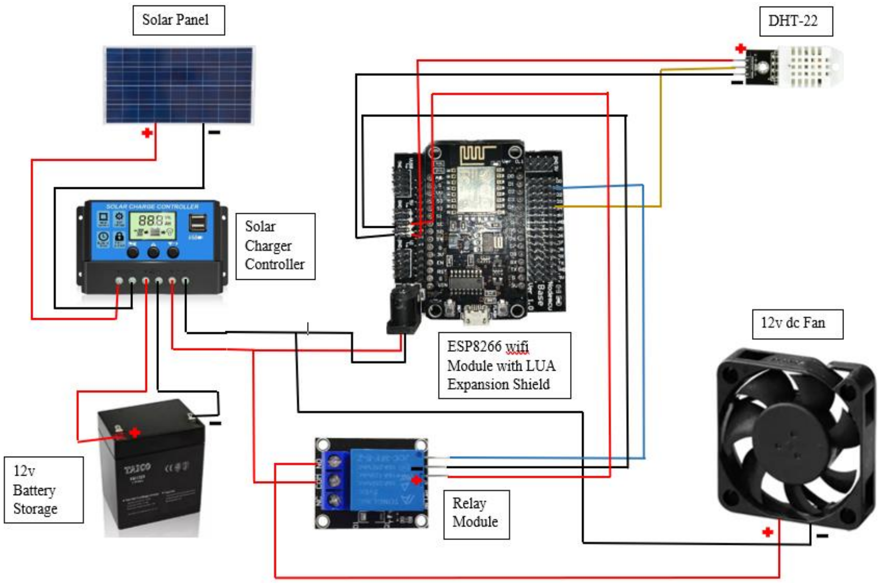

Figure 3: Schematic diagram

3. Results and Discussion

This chapter discusses the outcome of the project where analysis and experiments are being conducted in order to test the functionality and performance of the solar exhaust fan Internet of Things (IoT) with using DHT-22 which is temperature and humidity sensor.

3.1 Rate of increase voltage due to solar system aspect

Table 1: Rate of increase voltage

Time	Tilt Angle	Irradiance (W/m^2)	Ambient Temperature (˚C)	Voltage (V)
8 AM – 10AM	3˚	113	28.5	8.46
10 AM – 12 AM	3˚	507	34.8	9.84
12 PM – 2 PM	3˚	151	36.0	10.37
2 PM – 4 PM	3˚	831	51.7	11.68
4 PM – 6 PM	3˚	194	35.8	11.88

From the table above, the time every 2 hours from 8 am to 6 pm has been recorded to get the value of the voltage increase on the 12 V battery storage. Some of the main factors that play a role in this voltage increase are tilt angle, irradiance and ambient temperature. The same tilt angle is used in this testing. The battery will automatically stop saving energy when the voltage value has exceeded 12 V.

The quantity of sunlight or solar energy that reaches the surface of a solar panel is referred to as its irradiance. Typically, it is measured in wattage per square meter (W/m2). The level of irradiance determines the intensity of sunlight available to be converted into electricity by the solar panel. Higher irradiance levels generally result in greater power output from solar panels, whereas lower irradiance levels diminish their ability to generate electricity. When designing and installing solar panels, it is crucial to take into account the irradiance levels at a particular location.

Irradiance levels are affected by the angle and orientation of the solar panels, atmospheric conditions (such as cloud cover), and the time of day or season. Understanding local irradiance patterns optimize the placement and orientation of solar panels to capture the maximum amount of sunlight throughout the year. The temperature of solar panels is also a crucial factor in determining their efficiency. Solar panels generate electricity via the photovoltaic (PV) effect, in which sunlight excites electrons in PV cells to produce an electric current. However, as the temperature of solar cells increases, their efficiency tends to decrease.

Solar panels absorb heat as they absorb sunlight. The temperature coefficient is a measure of how much a solar panel's efficacy degrades when exposed to excessive heat. Typically, the efficacy decreases by a certain percentage for every degree Celsius above the panel's rated temperature. High temperatures can increase resistive losses, reduce voltage output, and negatively impact the solar panel's overall power output. Therefore, it is essential to control the operational temperature of solar panels in order to maximize their efficiency and power output.

3.2 Actual and virtual temperature comparison test

Table 2: Actual and virtual temperature

Actual Temperature (˚C)	Virtual in Blynk Temperature (˚C)	Fan Condition	Accuracy Percentage (%)
30.6	30.0	OFF	98.02
32.5	33.0	OFF	98.48
37.3	37.0	ON	99.20
42.5	42.0	ON	98.82
49.0	50.0	ON	98.00
54.9	57.0	ON	96.32

Based on the table above, there are a slight difference in terms of the decimal point at the recorded temperature. This can be attributed to several main factors:

1. Measurement location

The DHT-22 sensor measures the temperature of its encompassing environment, whereas the infrared thermometer measures the temperature of a specific object or surface. Due to factors such as heat dissipation, air circulation, or proximity to other heat sources, the temperature of an object and the ambient temperature can be different.

2. Response time and refresh rate

Response times and refresh rates could be different for the DHT-22 sensor and the infrared thermometer, respectively. Since the DHT-22 sensor normally has a slower reaction time, the temperature values that are displayed in the Blynk application might be updated at a different pace in comparison to the readings that are taken in real time by the infrared thermometer.

3.3 Minimum voltage rate to operate 12 Vdc fan

Table 3: Minimum voltage rate

Voltage (V)	Fan Condition
9.60	OFF
10.00	OFF
10.40	OFF
10.80	ON
11.20	ON
11.60	ON
12.00	ON
12.40	ON
12.80	ON
13.20	ON
13.60	OFF (over voltage)
14.00	OFF (over voltage)

Based on the table above, shown the voltage required to turn on the 12 Vdc fan. The voltage at which a 12 Vdc fan is designed to operate is typically 12 V. To ensure reliable operation, a tolerance voltage range is specified due to factors such as voltage fluctuations in the power supply or minor variations in the internal components of the fan. Typically, the voltage tolerance range is expressed as a percentage of the rated voltage. The tolerance for the majority of 12 Vdc fans is around 10 V±. This indicates that the fan can operate between approximately 10.8 V and 13.2 V. If the voltage supplied to the fan falls below the tolerance range's lower limit, the fan may operate at a reduced speed or fail to commence. Insufficient voltage can prevent the fan motor from rotating at the required speed to produce airflow.

Alternatively, if the voltage exceeds the upper limit of the tolerance range, the fan may operate at higher than intended velocities. This may appear advantageous for enhanced airflow, but it can also have disadvantages. Running the fan faster than intended can place additional strain on the motor and bearings, potentially diminishing the fan's lifespan and increasing the likelihood of failure. To assure optimal performance and longevity of a 12 Vdc fan, a stable power supply within the specified voltage range is required. This can be accomplished by employing a dependable and suitably rated power source or voltage regulation mechanisms such as voltage regulators or power supplies with excellent voltage regulation characteristics.

3.4 Automatic operation 12 Vdc fan by Blynk

Table 4: Temperature requirement to operate fan

Temperature (˚C)	Fan Condition
30	OFF
31	OFF
32	OFF
33	OFF
34	OFF

35	ON
36	ON
37	ON
38	ON
39	ON
40	ON

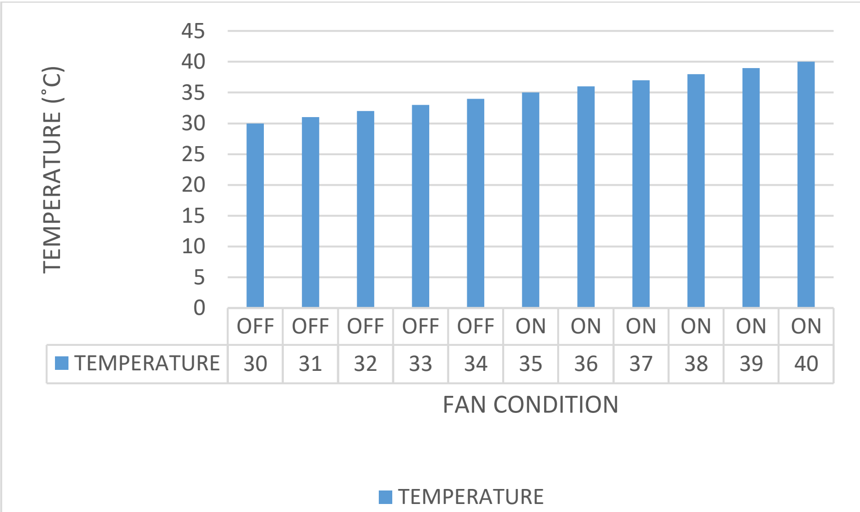

Figure 3: Temperature vs fan condition chart

The 12V DC fan with automatic temperature control is an intelligent ventilation solution designed to maintain a comfortable environment by activating when the temperature exceeds 34˚ Celsius and deactivating when it falls below 35˚ Celsius. This system employs a DHT-22 sensor, a prevalent digital temperature and humidity sensor.

The DHT-22 sensor precisely gauges the ambient temperature and provides the control circuit with real-time temperature data. When the temperature reading exceeds 34˚ Celsius, the control circuit is activated to turn on the 12 Vdc fan. Once activated, the fan operates at its specified speed to provide effective cooling. As the fan circulates air within the space, it aids in the dissipation of excess heat, ensuring a safe and agreeable temperature.

This cooling procedure continues until the DHT-22 sensor detects a temperature below 35˚ Celsius. Upon reaching this lower threshold, the control circuit autonomously turns off the 12 Vdc fan after receiving temperature data. This intelligent temperature control mechanism eliminates the need for manual intervention and maximizes energy efficiency by activating the fan only when required. The 12 Vdc fan system with automatic temperature control using the DHT-22 sensor is suitable for applications in which maintaining a precise temperature range is essential.

3.5 Blynk interface

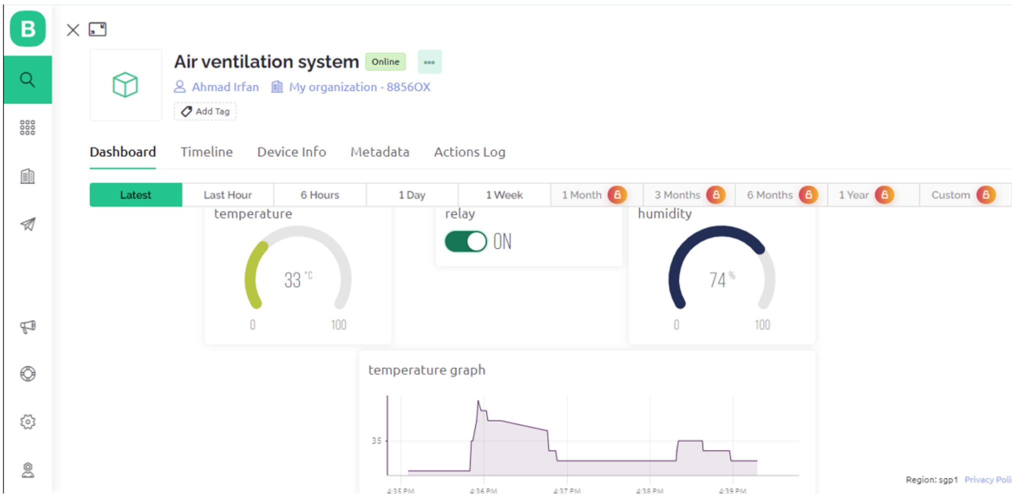

Figure 4: Blynk interface

The Blynk interface provides a comprehensive visualization of temperature and humidity data, as well as a temperature graph for observing temperature trends over time. The interface is intended to provide real-time data and command over the environment monitored by the DHT-22 sensor. The interface's temperature gauge displays the present temperature in degrees Celsius. This gauge provides an instantaneous visual representation of the ambient temperature, allowing for a rapid assessment of the current circumstances. The gauge will increment or decrement as the temperature rises or declines, providing a dynamic and intuitive display. Similarly, the interface's humidity gauge displays the present relative humidity level. It indicates the quantity of moisture in the air and helps user assess the environment's comfort level. Similar to the temperature gauge, the humidity gauge increments or decrements in response to variations in humidity.

The temperature graph is an important component of Blynk interface. This graph depicts a historical perspective of the temperature measurements for a given time period. The graph is updated in real time, allowing to observe fluctuations and patterns in the temperature. Depending on the selected time scale, it is possible to monitor the temperature's evolution over hours, days, or even longer periods. The temperature graph can be modified to suit individual preferences. User can modify the time scale to focus on specific time intervals or obtain a broader perspective by zooming in or out. This feature allows to analyze temperature trends, recognize patterns, and make informed decisions based on past data.

4. Conclusion

In conclusion, the development of an intelligent photovoltaic exhaust fan with Internet of Things capabilities has numerous advantages. By harnessing solar energy and incorporating IoT technology, the system becomes energy-efficient, automated, and easy to control. Components of the project, such as the ESP8266 WiFi module, solar charger controller, DC fan, DHT-22 sensor, battery storage, and relay module, collaborate to monitor room temperature and humidity, activate the fan when necessary, and provide real-time data monitoring via the Blink application. Through this project, users will be able to experience a comfortable and well-ventilated environment while reducing their energy consumption and dependence on nonrenewable energy sources. The incorporation of IoT capabilities enables control and monitoring, giving users the option to manually control the fan or have it activated automatically when the temperature exceeds 34˚ Celsius. The accessibility of temperature and humidity data within the Blynk application enables users to make informed decisions and optimize ventilation strategies.

In addition, the project provides the groundwork for future enhancements and integration with other IoT devices and home automation systems by incorporating scalability, safety measures, and efficient energy management techniques. This enhances adaptability and expands the potential for establishing a comprehensive smart home ecosystem. Overall, the smart solar exhaust fan project with Internet of Things (IoT) capabilities demonstrates the potential of integrating renewable energy sources, sensor technology, and internet connectivity to develop sustainable, user-friendly, and energy-efficient solutions for enhancing indoor air quality and comfort.

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