

## **MONITORING TEMPERATURE, HUMIDITY AND CONTROLLING SYSTEM IN INDUSTRIAL FIXED ROOM STORAGE BASED ON IOT**

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### **Abstract**

Humidity and temperature monitors have wide industrial applications in many areas such as automobile industry, food processing and evaluation of plastic encapsulations in IC packaging. However, most of these monitors had limited functionality. Hence, this paper was proposed new features that can detect, notify, record and control the humidity and temperature instantaneously in order to have stable, controllable atmospheric conditions. This research was used of temperature humidity sensor DHT-11 to detect level of humidity and temperature changes inside the room. The data and information from DHT-11 sensor will be analysed graphically on Blynk platform using NodeMCU. Humidifier will be attached at this monitor to stabilize back the atmospheric conditions when a specific humidity level must be maintained to prevent static electricity build up, preserve material properties, and ensure a comfortable and healthy environment for workers or residents in industries. In this paper, the value of temperature and humidity changes can be seen through graph and gauge in Blynk software application. The relative humidity level will be decrease as the temperature increase. Humidifier triggered when the reading of temperature and humidity is less than 20% and more than 80%. Through the mobile application, it can review and read the previous readings and histories from the temperature and humidity sensor.

Keywords: Blynk application, Humidifier, Humidity and temperature, Monitoring and controlling, NodeMCU.

## 1. Introduction

Wireless communication had significant impact on daily life especially in aspect of industry. The benefits of wireless communication technology are apparently with low cost, convenience, ease of installation and high portability. One of the important applications is to monitor the temperature and humidity of surroundings without restricting the movement of user [1].

The proposed design focuses on the development of wireless temperature and humidity monitoring prototype system with the initial emphasis on measuring the temperature and humidity of surroundings. In many industries, parts of the production and fabrication room will take place in adjustable air-conditioned clean rooms. In food industry, the storage monitoring is to preserving the raw food in certain period for sustainable the food safety and good well of quality [2]. Legal requirements mean that specially prepared, air-conditioned rooms are essential for processes such as semiconductor manufacturing, components fabricating and electronics assembly to constantly regulate air humidity.

For comparable, consistent and functional results, those working in fabrication room, production line and clean rooms require stable, controllable atmospheric conditions. The temperature and humidity is particulars sense to influence the viscosity and properties of materials, as well performed of chemical reactions. Humidity is a primary initiator and booster of devastating effects on electronics and a constant threat to production efficiency and product qualities. The necessity of this system is to minimize manpower on controlling air temperature and humidity of surroundings in industries as the effect of decrease the devastating effects on electronic components. The system will send an alarm on Blynk platform through NodeMCU and activate humidifier automatically when temperature and humidity of certain atmosphere is out of the safety range even the user is out of that certain atmosphere area [3]. Humidity and temperature of the room could be control and designed microcontroller by using a DHT-11 sensor, Arduino and microcontroller board [4-6]. However, DHT-22 sensor is accuracy and adequate for temperatures between -40°C to 80°C with an accuracy of approximately 2°C [7-9].

Undeniably, IoT based temperature and humidity monitoring effectively decrease man power on controlling temperature and humidity and lend help in time wasting of user [10]. In indirect way, it decreases cost of industries in fabricating new electronic components as it guarantees a stable and controllable atmospheric condition which slow down the devastating effects of electronic components.

Humidity and temperature have been a problem for many engineers in industries especially to grasp because of temperature. Some electronic components should be tested and kept under certain temperature to make sure the testing result will be accurate and ensure its lifespan. In reality life, the coldness and the heat can be felt by humans but the ideal temperature for the certain electronic components cannot be determined as it was made with different materials. The second problem is because of humidity. The moisture of the air may speed up the decasting effect of the pins of electronic components. Therefore, it will affect the functionality of the electronic components and brings losses in terms of money and manpower [11].

The moisture present in the air along with temperature has a long term and decasting effect on man, machine and material. Every industry of the mechanised world is affected by humidity and temperature both in terms of material and money.

Although the portable digital temperature and humidity meter is already existed, there is some limitation for the handheld device which is distance. The data through the device can only be obtained whenever humans are there. It means that every time the temperature and the humidity of a certain environment are needed, it requires the presence of humans to handle [12]. Hence, it is unable to encounter any problem happened to the electronic components and gadget and take any action immediately to prevent further damage. Besides, the data obtained through the meter cannot be reviewed back graphically.

As conclusion, this research able to implement the IoT technology in monitoring and controlling the humidity and temperature for industrial fixed room storage. Any person may access the system and monitor with an apps which has been created. Thus, it enables the users to notice about the level of humidity and temperature from anywhere anytime they want. Hence, the data can also be recorded in a database where they are collected in every hour.

## **2. Methodology**

### **2.1. Project development flow**

Figure 1 shows the research development flow of the proposed temperature, humidity monitoring and controlling system. The idea is to implement a complete temperature, humidity monitoring and controlling system. The IoT technology was proposed based on a problem statement to improve the lifespan of plastic encapsulations in IC packaging. The required hardware components were purchased after the identification of the hardware based on the functional requirements of the system. Then, the temperature, humidity monitoring and controlling system was implemented using the purchased hardware, and the required software will be developed at the same time. Both hardware and software components were tested to ensure the requirements of the system were met. If the system did not meet the requirements, troubleshooting process will be carried out to find out the problems and possible solutions to solve it. Otherwise, the temperature, humidity monitoring and controlling system cannot be developed successfully.

### **2.2. Design specification**

The temperature, humidity monitoring and controlling system must be sustainable in terms of economic, social and industrial needs. In order to improve the efficiency of the system as well as to meet the requirements of proposed solution, the design specifications of this project are set as follows:

- Measure the temperature and humidity of the environment all the time.
- Able to display the readings on the LCD.
- Implement IoT to the system.
- Acquired data can be uploaded to or retrieved from an online database.
- Display on the phone apps and record the previous history.

The temperature and humidity of the surrounding were measured using DHT11 which is specifically designed for these two measurements. Once the temperature and humidity are measured, the readings are displayed on the LCD for monitoring purpose.

To implement the Internet of Things (IoT) in the system, NodeMCU is used. The NodeMCU is an open source IoT platform comprises of a firmware which runs on the ESP8266 Wi-Fi SoC from Espress if system and a hardware which is based on the ESP-12 module. This Wi-Fi function allows the wireless transmission between the device and the online database. The acquired data from the temperature and humidity sensor will be able to be uploaded to the online database.

Using any mobile applications available, the data from the online database can be acquired and displayed. All the previous history also could be retrieved and displayed graphically on the mobile application.

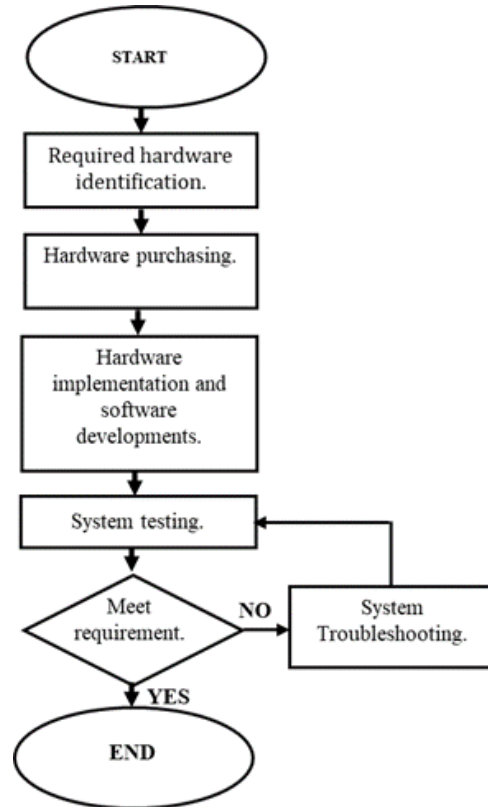


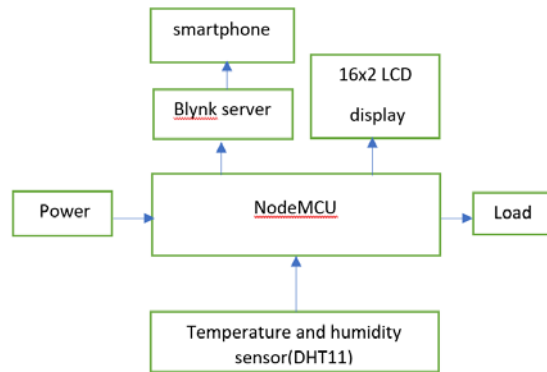
Fig. 1. Research flow.

### 2.3. System block diagram

Figure 2 shows the block diagram of temperature, humidity monitoring and controlling system based on IoT technology. The temperature and humidity sensor is the input used to get the surrounding temperature and humidity inside the room. The NodeMCU works as the brain of the system that receives data from DHT11 sensor and upload them to the database.

The DHT11 comes with built-in temperature and humidity sensor, comprises of 16-bit resolution output and the output is sent as serial data [13]. The sensor is a NTC (Negative Temperature Coefficient) type, which means that the resistance decreases with increasing temperature. It is factory calibrated and easy to interface with

NodeMCU microcontroller. It uses low operating voltage from 3.5V to 5.5V with also lower operating current not more than 0.3mA. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of  $\pm 1^\circ\text{C}$  and  $\pm 1\%$  [14].



**Fig. 2. Block diagram of temperature, humidity monitoring and controlling system.**

The NodeMCU also acts as a Wi-Fi module which creates the wireless communication between the hardware and the database. The obtained data are stored in the online database and can be monitored by any mobile applications. The  $16 \times 2$  LCD display is a unit used to display the data in real time.

### 3. Design Methodology

The main tasks of this research are shown as follows:

- Design a user interface using the LCD.
- Acquire data using the temperature and humidity sensor.
- Upload data to the online database using NodeMCU.
- Develop a database application for user to monitor the temperature and humidity.
- Design a complete prototype of the system.

In measuring the surrounding temperature and humidity inside the room, the temperature and humidity sensor is chosen because of its price. The sensing method is to take data for every two seconds and send them to the NodeMCU. The NodeMCU code is based on standard C programming language and it is written as below.

```

#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include "DHT.h"
#define DHTPIN 22
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);
char auth[] = "XXXXXXXX";
char ssid[] = "XXXXXXXX";
char pass[] = "XXXXXXXXXXXX";
void setup()
{
  Serial.begin(9600);

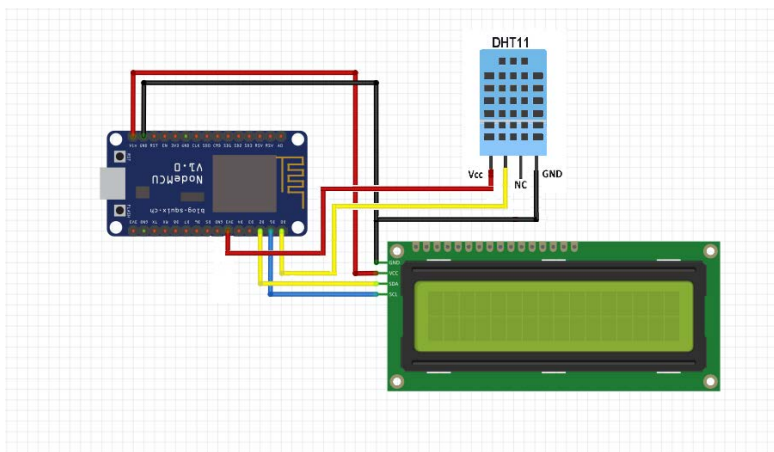
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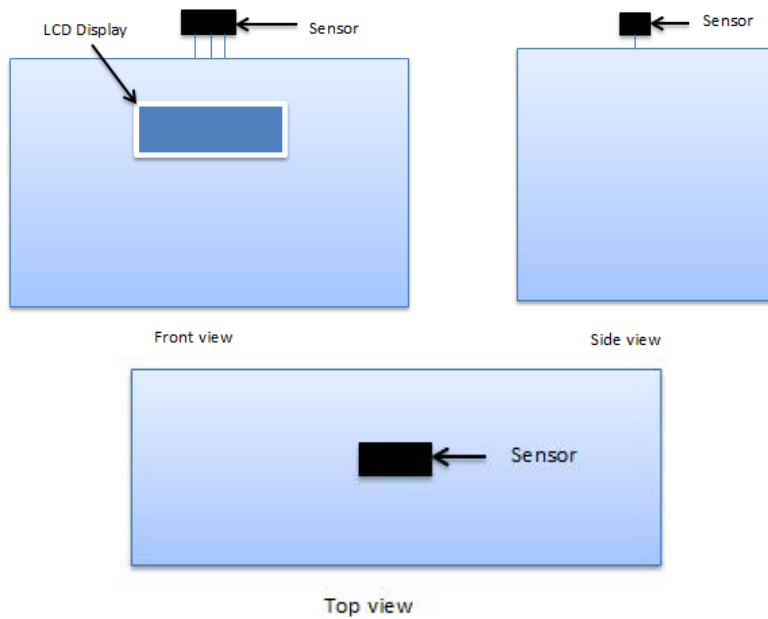
Blynk.begin(auth, ssid, pass);
dht.begin();
Serial.println("DHT11 test!");
}
void loop()
{
  Blynk.run();
  delay(2000);
  float h = dht.readHumidity();
  float t = dht.readTemperature();
  if (isnan(h) || isnan(t) || isnan(f))
  {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }
  Serial.print("Humidity: ");
  Serial.print(h);
  Serial.print(" %\t");
  Serial.print("Temperature: ");
  Serial.print(t);
  Serial.println(" *C ");
  Blynk.virtualWrite(temp, t);
  Blynk.virtualWrite(humid, h);
}

```

The schematic circuit and the microcontroller board are shown in Fig. 3. To increase the efficiency and the effectiveness of the sensor, instead of using Perspex as the main body frame, an eco-friendly cardboard is chosen. The size is minimized to reduce the space used to place the prototype as well as reducing the manufacturing cost while considering the quality and the rigidity of the prototype. Several types of prototype have been tested to fulfil the customers' need. The finalized prototype is shown in Fig. 4.



**Fig. 3. The schematic circuit.**



**Fig. 4. Finalized design of prototype.**

### System operational flow

Figure 5 shows the system operational flow chart. To get started with Blynk app, the user needs to create a new Blynk server account, create a new project with author's name, ID and password. During start up, the system will request the server and the NodeMCU microcontroller to establish connection with the Blynk app. After that, the microcontroller system waits for the serial data received from the DHT11. When the system receives the serial data from DHT11, it will send the data wirelessly to the Blynk server and display it on LCD. It will display the real time of temperature and humidity.

## 4. Results and Discussion

### 4.1. Software test

The language used to build up the coding is C language. C language is a common language used in coding, computer programming, structured programming, and recursion.

The system is first programmed to read the readings from the temperature and humidity sensor. Once it gets the reading from the sensor, it will start to evaluate the temperature value and the humidity level either the temperature or the humidity level are in the standard level. The expected result is shown in Table 1.

All the temperature and humidity values are sent to the online database through the Blynk platform, so that all the data can be recorded and reviewed. The database used is on firebase which is a mobile and a web application development platform.

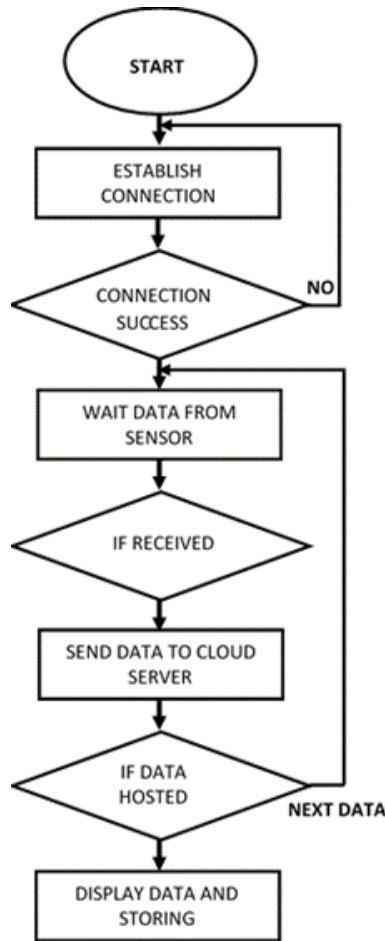


Fig. 5. System operational flow chart.

Table 1. Stimulation result of coding.

Temperature (°C)	Humidity (%)	Condition
$10 < T < 40$	$35 < H < 90$	Safe range
$> 40$	$> 90$	Alert (Both are HIGH)
$> 40$	$< 35$	Alert (Temp is HIGH & Humidity is LOW)
$< 10$	$> 90$	Alert (Temp is LOW & Humidity is HIGH)
$< 10$	$< 35$	Alert (Both are LOW)

#### 4.2. Hardware test

Figure 6 shows the LCD display with the temperature and humidity values displayed. The microcontroller interfaces the temperature and humidity sensor (DHT 11) and a relay which is used to control the load (humidifier). Table 2 shows the LCD display which corresponds to the system operations.

From Fig. 7, as we know, the relative humidity level will decrease as the temperature increase. Therefore, when the temperature is higher than 40°C, the humidity level is lower than 35%, the relay will be set to HIGH in order to trigger the humidifier to increase the humidity of the environment. Meanwhile, when the temperature and the relative humidity level return back to standard range, the humidifier will be turned off.

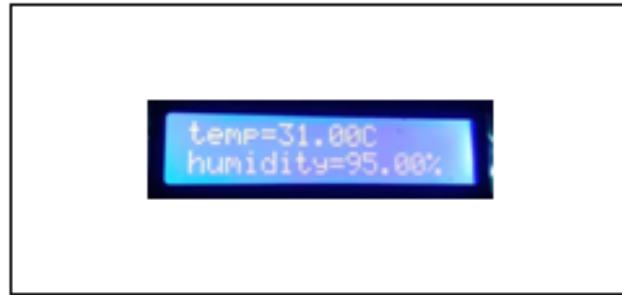


Fig. 6. LCD readings.

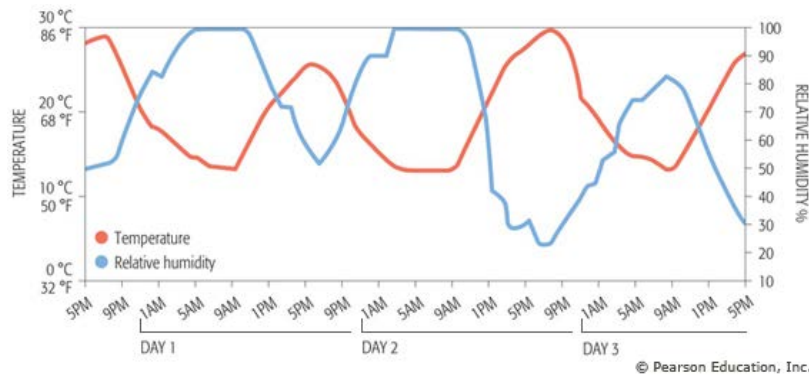


Fig. 7. Graph of temperature against relative humidity.

Table 2. LCD display which corresponds to operations.

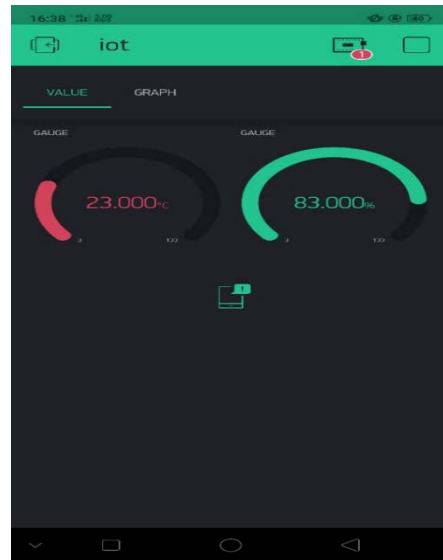
Temperature (°C)	Humidity (%)	Condition
$10 < T < 40$	$35 < H < 90$	Current temperature and humidity value
$> 40$	$> 90$	Temperature over 40°C and humidity over 90%
$> 40$	$< 35$	Temperature over 40°C and humidity below 35%
$< 10$	$> 90$	Temperature below 10°C and humidity over 90%
$< 10$	$< 35$	Temperature below 10°C and humidity below 35%

### 4.3. Mobile application test

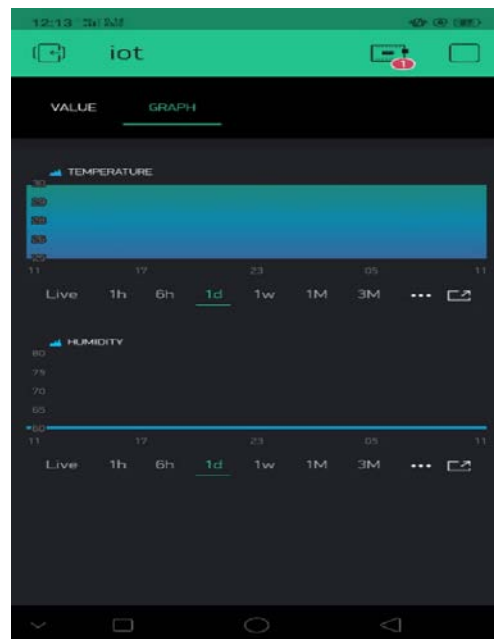
The data from database is taken through the Blynk platform and displayed on the mobile application. This IoT function allows us to get the temperature and humidity level

through wireless communication no matter where we are. Figure 8 shows the real-time database update of the application. The application will refresh itself every 3s.

Figure 9 shows that through the mobile application, reviewing and reading the previous data and histories from the temperature and humidity sensor can be done. This is another good function for the user to analyse and control the temperature and the relative humidity of the warehouse smartly.



**Fig. 8. Mobile application displays real-time value.**



**Fig. 9. Mobile application display the previous history.**

#### 4.4. Comparison and performance analysis of sensors

The selected sensors to detect temperature and humidity are types of DHT11 and DH22. Both of units are use in capacitive humidity sensor and a thermistor to measure the surrounding air, and display a digital signal on the data pin for easily sense by a microcontroller. This is good for small scale projects that just require a basic data logging.

The DHT11 has a much cheaper, but at the cost of range and accuracy. The DHT11 and DHT22 feature has the same pin out and power output. Both sensors are easier to hook up, but in collecting the data, it can require some careful timing. The DHT22 has a much expensive, and temperature measuring range is from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  with  $\pm 0.5^{\circ}\text{C}$  accuracy. However, the DHT11 temperature range is from  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$  with  $\pm 2^{\circ}\text{C}$  accuracy.

There are two specifications reason where the DHT11 is better than the DHT22. First, the sampling rate which for the DHT11 is  $1\text{Hz}/1\text{s}$ , while the DHT22 sampling rate is  $0.5\text{Hz}/2\text{s}$ . Second, the DHT11 has smaller body size. The operating voltage of both sensors is from  $3\text{V}$  to  $5\text{V}$ , while the max current used when measuring is  $2.5\text{mA}$ .

Focusing on the temperature range, the sampling rate (speed of data sent to the microcontroller), the unit pricing and sizing of making the DHT11 a good selected to be used as the sensor.

#### 5. Conclusions

The temperature, humidity monitoring and controlling system will serve as an optimal solution for all the concerned parties such as electrical component storage facilities, automobile manufacturers and food storage departments to improve their efficiency in monitoring, controlling as well as managing the environmental parameters such as temperature and humidity where these factors play an important role in their productivity and finance. The system is capable of obtaining the temperature and humidity of a space, thus providing a real time temperature and humidity monitoring either using an application in a smartphone via WIFI over IoT, a LCD display embedded in the system or a computer interface.

The application mentioned above keeps track of the temperature and humidity readings as well, which helps the user to monitor these parameters in a graph. Besides that, our system is also able to send an alert to the application if either one or both of these parameters fall in the critical region; as well as making the necessary step to bring back the particular parameter to safe region such as turning on the humidifier if the humidity falls below the assigned value.

This research was built upon basic components. Further improvements can be made to this project to increase its capability and efficiency such as temperature control. With our system in place, it can eliminate the necessity of workers to manually obtain the reading of these parameters and maintaining them frequently. Many industries especially those require the controlled storages in which the temperature and humidity plays an important role to ensure the lifespan and efficiency of their products. The system will be a great help in boosting the efficiency and reducing the cost.

**Abbreviations**

DHT-11	Temperature and Humidity Sensors
DHT-22	Temperature and Humidity Sensors
ESP-12	Miniature Wi-Fi Module
Blynk	Platform with IOS and Android Apps
NodeMCU	Internet of Thing Platform
IoT	Internet of Thing
LCD	Liquid Crystal Display
NTC	Negative Temperature Coefficient

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