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# Design and Construction of an Automatic Chili Plants Watering System Based on the Internet of Things (IoT) Using the Blynk App

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**Abstract:** Chili is one of the vegetables cultivated by Indonesian farmers because of its high market value and many health benefits. Manual watering of plants still has weaknesses because water use is unlimited, especially for chili plants. Therefore, IoT is needed to water plants automatically and in real-time based on soil moisture and can monitor chilli plants' air temperature and pH. This research aims to replace manual watering with automatic watering. The system was tested and installed in a greenhouse using UV plastic measuring 70cm × 70cm × 70cm. The microcontroller used is ESP32. Other components are RTC DS3231, capacitive soil moisture sensor, DHT22 sensor, soil pH sensor, water pump, and blynk application. This device operates when reading input from the RTC, namely 07:00 WIB and 17:00 WIB. The watering pump will work at humidity <60% and stop at humidity >80%. At temperatures <24˚C, the lamp will be active and at temperatures >33˚C to <55˚C, condensation will be carried out using a nozzle sprayer. The soil pH sensor detects soil conditions, namely acidic, neutral or alkaline. The results of this research are quite good and follow the designed program. The average % error on the DHT22 sensor is 1.433%, and the soil pH sensor is 0.74%. Capacitive soil moisture sensors are also quite good at reading soil moisture conditions. Likewise, the RTC test has a time difference of only 6 seconds with the comparison tool.

**Keywords:** Automatic Plant Watering; Blynk; ESP32Greenhouse; Internet of Things (IoT).

## Introduction

A vital vegetable in everyday life is chili. This plant often supplements foods lacking vitamins and minerals essential for healthy growth. Earth is becoming increasingly scarce due to high consumer demand for chilies, increasing market prices and making it difficult for consumers to meet their daily needs [1]. Planting chilies requires special irrigation to keep the soil moist. Manually watering plants cause inconvenience because it does not reduce water consumption [2].

Many things need to be considered when watering plants, namely based on soil moisture, room temperature and soil acid content (pH). The ideal conditions for the growth and development of chili plants are a temperature of 24˚C to 28˚C and soil humidity of 60% to 80% [3]. Chilli plants' ideal soil acidity (pH) level is 6 to 7. If the soil humidity, pH and temperature are not good, it can cause plant growth to be disrupted and the plant to bear fruit late. This is caused by human error or lack of knowledge in measuring and controlling pH, temperature and soil moisture in chili plants [1].

Chili (Capsicum annuum L.) is one of the important vegetables with high economic value and is popular in society. Besides its delicious qualities, it has healthy nutrients such as protein, fat, carbohydrates, Ca, P, Fe, vitamins A and C, and compounds containing alkaloids such as pepper, flavonoids and essential oils [4]. Chili plants need sufficient water. Too much water will create more humidity and encourage the growth of fungus and bacteria. Soil that is too wet can cause root rot and kill the plant. Likewise, without water, chili plants will wilt and dry out. So chili plants require regular watering so that the plants do not wilt. During the dry season, chilies are usually watered 1-2 times daily. And during the rainy season, only once a day [5].

Agriculture is also a field that cannot be separated from technological developments. In this era of technological progress, the Internet of Things concept can be used in terms of innovation. Nowadays, cell phones play an important role in everything, not only in communication but also in the blynk application [6]. The Internet of Things (IoT) is defined by the IEEE (Institute of Electrical and Electronics Engineers) as a network of objects with sensors connected to an internet network. Three main components form the Internet of Things concept: physical objects embedded in sensor modules, internet connections, and data centres on servers that store application information or data [7]. The online application will collect data, which is then compiled into "big data", which will be processed, checked and utilized for the needs of relevant government agencies, the business world and other organizations [8]. This system is more efficient using the greenhouse principle and automatic watering. Implementing a planting system through greenhouses is an effective step to support agricultural development that can be implemented on urban land. This principle is not too dangerous for the environment, so that it can reduce global warming [9].

ESP32 is a microcontroller called the Espressif system, a development of the ESP8266 [10]. The ESP32 is equipped with two CPUs: an application processor and a network management processor for WiFi and Bluetooth. Other uses of this module include system monitoring and control. When not in use, the ESP32's deep sleep feature turns off the module to save power. The ESP32 is a complete

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WiFi module ideal for various IoT applications. With comprehensive features, the ESP32 is suitable for wireless connection needs [12].

Real-Time Clock (RTC) chips use little power. This chip has a two-wire array-based communications interface, 56-byte NV SRAM, clock/calendar, and binary code (BCD). RTC provides data in seconds, minutes, hours, days, dates, months, years, and programmable events [13]. Besides combining the temperature measurement unit into one module, the DS3231 RTC module is a digital timepiece and RTC (Real Time Clock). This module is also equipped with an AT24C32-type EEPROM IC, which is also functional. I2C or two cables (SDA and SCL) is the interface used to access this module [14].

The sensor for determining soil water content that can be connected to an Arduino microcontroller is a capacitive soil moisture sensor. This sensor is usually used in agriculture for automatic irrigation systems or for monitoring plant soil moisture online or offline. Today, humidity sensors can be purchased in module form, as illustrated in the image below [15]. Air temperature and humidity can be measured with the DHT22 sensor. This sensor produces a digital signal as its output. The DHT22 sensor can make very precise adjustments by considering the ambient temperature settings using values stored in the internal OTP memory [16].

Soil pH sensors measure how alkaline or acidic the soil is. This soil pH sensor measures the pH scale from 3.5 to 15. This sensor has a measurement range of 6 cm from the sensor's tip into the soil and operates on a DC voltage of 5 volts. Without requiring an amplifier module, this sensor can be connected directly to the microcontroller analog pin [17]. A relay is an electrically powered switch with two main parts: mechanical (a group of contacts for the switch) and electromagnetic (a coil). Using electrical principles, the relay shifts the switch contacts to allow a small (low) electric current to flow to a higher current [18].

The ability to control or monitor a module remotely, such as Arduino, NodeMCU, Raspberry Pi, Wemos, or other modules connected to the Internet, is provided by the Blynk platform, which is also available for use on mobile devices on the Arduino IDE the Blynk library is available making it easier to do coding [19]. The blynk application is used in this research to display data read by sensors in real-time. And can be used as a remote on-off button [20].

Based on the explanation above, the author tries to create a chili plant watering system in a greenhouse titled "Design and Build an Automatic Chili Plant Watering System Based on Internet of Things (IoT) Using the Blynk Application". This research aims to simplify the task of cultivating chili plants following the specified time and based on soil humidity, room temperature and soil pH which can be monitored via the Blynk application connected to the Internet, thereby avoiding wasted water consumption.

## Research Methods

An explanation of the tools and materials used in this research is presented below:

**Tools**

| | | |
|---|---|---|
| 1. | Laptop | : to download the Arduino IDE software |
| 2. | *Software* Arduino IDE | : to compile applications that will be received and uploaded by the microcontroller. |
| *3.* | *Smartphone* | : to install the blynk application. |
| 4. | Aplikasi blynk | : to display the output values from the sensors and control the water pump, nozzle and lights. |
| 5. | Solder | : to assemble the components used. |
| 6. | Soil meter 4 in 1 : | : a tool for measuring soil moisture and pH. |
| 7. | Hygrometer digital HTC-1 | : air temperature and humidity measuring instrument. |

**Material**

| | | |
|---|---|---|
| 1. | ESP32 | : as a microcontroller or the brain of a system. |
| 2. | Capacitive soil moisture sensor | : to monitor soil moisture. |
| 3. | Sensor DHT22 | : to measure humidity and air temperature. |
| 4. | Sensor pH Tanah | : to measure soil pH. |
| 5. | RTC DS3231 | : to schedule plant watering times. |
| 6. | Relay | : as a connector and breaker for electrical currents in water pumps, pump nozzles and lights. |
| 7. | Lampu pijar | : untuk mengatur suhu ruangan pada *greenhouse*. |
| 8. | Pompa air | : suck water from a container to water the plants. |
| 9. | Selang air | : to channel water from the container to the watering can and nozzle. |
| 10. | *Nozzle sprayer* | : to spray the greenhouse room. |
| 11. | Connecting cable | : to connect electrical current to components. |
| 12. | Socket | : as a connection between the electric current and the pump. |
| 13. | Filter | : to filter water at the pump nozzle. |
| 14. | *Step down* | : to reduce the voltage. |
| 15. | Adaptor | : to convert AC into DC. |
| 16. | Pipa | : to channel water from the hose to the plants. |
| 17. | Box komponen | : as a place for components. |
| 18. | Wadah air | : as a watering can for plants and a sprayer nozzle. |
| 19. | *Greenhouse* | : as a place to water chili plants. |

By building a system, stages are needed in building the system. The following are the steps in system design. First, prepare the tools and materials as described in the tools and materials subheading, then check the tools according to the tools and materials subheading, then assemble the automatic plant watering device, then upload the program created on the Arduino IDE as in attachment 1 to the ESP32 microcontroller and application blynk on the smartphone then connect the blynk to the ESP32. Once complete, the system can retrieve plant watering data automatically.

## Research Block Diagram

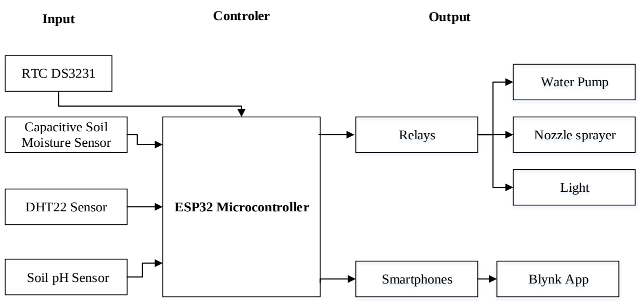


**Figure 1.** Research Block Diagram

1. The main controller of this tool is the ESP32 microcontroller.
2. RTC (Real Time Clock) functions to provide time information.
3. Soil moisture sensor functions as a soil moisture meter.
4. DHT22 sensor measures air temperature and humidity.
5. The soil pH sensor measures the acidity level of the soil.
6. The relay works by regulating high electric current at low voltage.
7. The lights function as room temperature regulators in the greenhouse.
8. Blynk on the smartphone functions to check or display soil humidity, temperature and pH values.
9. The water pump transforms water from the reservoir to the area that needs to be watered.
10. The sprayer nozzle functions as a room temperature regulator in the greenhouse.

The following are the methods used in this research:
1. A literature study process is carried out.
2. Prepare supplies and equipment for research.
3. Draw a schematic of a circuit.
4. Arrange the parts according to the designed circuit.
5. Make a program list.
6. Upload the program as in attachment 1 to the ESP32 microcontroller.
7. Connected to WiFi and Blynk.
8. Tested a prototype of an automatic chili plant waterer.

The procedure used in the program is depicted in Figure 2, starting with the initialization process. After that, the software reads input, especially the RTC clock, which shows the watering time between 07:00 and 17:00 WIB. In this system, the pump will work if the humidity is <60% and the pump will stop working if the humidity is >80%. If the temperature is <24˚C, the incandescent light will turn on, while at temperatures >33˚C to <55˚C, the light will turn off, and the sprayer nozzle will activate to neutralize the greenhouse room temperature again. The pH sensor will detect soil conditions to determine whether the soil is acidic, neutral or alkaline.

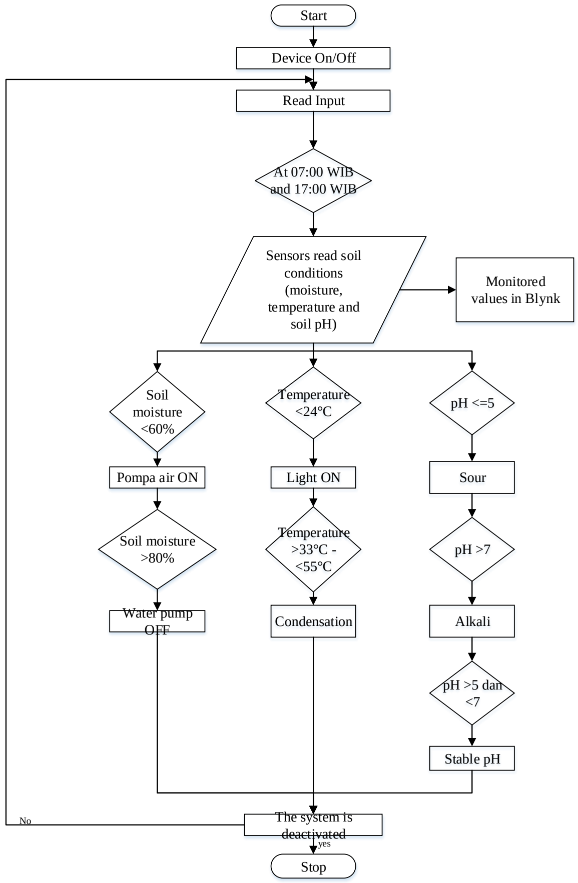


Figure 2. Flow Chart for Program Design

## Design Prototype Design

The following is a design for testing a prototype of an automatic chili plant waterer.

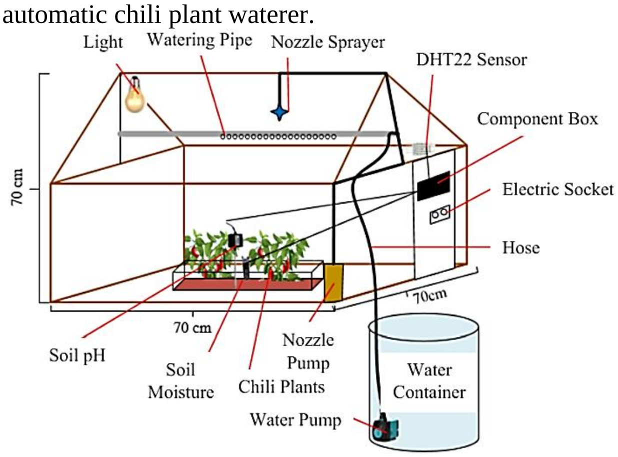


**Figure 3.** Prototype Test Design

Figure 3. is a prototype design for an automatic chili waterer in a greenhouse with 70 × 70 × 70 cm dimensions. Figure 3. shows the results of the overall tool design.

## System Testing

## Power Supply

This test is carried out using a multimeter. The multimeter consists of two probes: red (+) and black (-). Then, the red probe (+) is connected to the positive part of the adapter, and the black probe (-) is connected to the negative part of the adapter. Then, the voltage output value will appear, and the measurement process will be repeated five times.

**DHT22 Sensor**

Air temperature and humidity are measured using a DHT22 sensor. When the tool is active, the value from the sensor placed in a greenhouse will appear in the blynk application. Then the measurement results from the sensor are compared with a standard measuring instrument (Digital Hygrometer) placed in the greenhouse to see the sensor's accuracy.

**Soil pH Sensor**

This test is carried out by inserting a pH sensor and soil meter simultaneously into the soil of chili plants at a depth of ±6cm. When the tool is activated, the output from the soil pH sensor can be seen in the blynk application. The pH sensor measurement results are compared with the soil meter.

**Capacitive Soil Moisture Sensor**

This test was carried out by inserting a sensor and a soil meter as a comparison tool into the soil of the chili plants at a depth of ±6cm to see the soil moisture value. The measurement value will appear in the blynk application. The pH sensor measurement results are compared with the soil meter.

**RTC DS3231**

RTC is a sensor that regulates watering time. In this test, the watering times were set at 07.00 WIB and 17.00 WIB. When the time comes, the water pump will work according to soil moisture. The RTC test results on the blynk application will be compared with the time on the smartphone.

**Pump, Sprayer Nozzle and Lamp**

This test is used for watering plants and air conditioning in greenhouses. The watering process will be adjusted to the time programmed on the RTC, namely 07:00 and 17:00 WIB. The sprayer nozzle and lights will work according to the greenhouse room temperature conditions. If the temperature is <24˚C, the light is on, and the pump nozzle is off. However, when the temperature is >33˚C, the nozzle pump will turn on, and the light will turn off.

## Results and Discussion

This section will thoroughly explain the results of component analysis and prototype testing. Evaluation must be carried out to ensure that all system functions are connected between software and hardware components according to the procedure. The test result data collected is used to evaluate the performance of system components and the overall final results. Expected benefits and information that can be tailored to the project and its objectives.

**Power Supply Testing**

The power supply is the primary energy source that powers the designed system. 12 V and 5 V DC are the required power supply output voltage values. The 12 V voltage obtained from the adapter is then reduced to 5 V using step down as the input voltage to the microcontroller and other components. The power supply voltage test results are shown in Table 1.

**Table 1.** Power Supply Voltage Testing

| No | Vin (Volt) | Error Value Vin (%) | Vout (Volt) | Error Value Vout (%) |
|---|---|---|---|---|
| 1 | 11.88 | 1 | 5.05 | 1 |
| 2 | 11.89 | 0.91 | 5.06 | 1.2 |
| 3 | 11.88 | 1 | 5.05 | 1 |
| 4 | 11.88 | 1 | 5.05 | 1 |
| 5 | 11.88 | 1 | 5.05 | 1 |
| Average | 11.882 | 0.982 | 5.052 | 1.04 |

Based on Table 1, power supply testing on the input voltage (Vin) and output voltage (Vout) was performed five times using a multimeter to obtain stable values. In the Vin test, the first, third, fourth and fifth experiments obtained a voltage of 11.88 V, while in the second experiment, a voltage of 11.89 V was obtained. So an average value of Vin was obtained of 11.882 V. In the first experiment, the Vout test, the third, fourth and fifth voltages obtained were 5.05 V. In contrast, in the second experiment, the voltage was obtained at 5.06 V, So the average Vout value was obtained at 5.052 V. Then the values of Vin and Vout were compared with the required voltage, namely Vin 12 V and Vout 5 V to see the error value. The average error value for Vin is 0.982%, and Vout is 1.04%. The results of measurements and calculations can be seen in Appendix 2 and Appendix 4.

**DHT22 Sensor Testing**

Air temperature and humidity are measured using the DHT22 sensor test. The HTC-1 digital hygrometer is a measuring tool that will be used to compare sensor readings obtained from this test. The blynk application displays temperature and humidity readings on the sensor.

Table 2. Comparison of Testing of the DHT22 Sensor with a Digital Hygrometer

| Time | DHT22 Sensor | | Hygrometer Digital (HTC-1) | |
|---|---|---|---|---|
| | T (℃) | H (%) | T (℃) | H (%) |
| 07.01:06 WIB | 28.8 | 84.7 | 28.6 | 83 |
| 10:03:28 WIB | 28.9 | 84 | 28.6 | 82 |
| 13:26:34 WIB | 39.8 | 51.7 | 39.5 | 50 |
| 16:59:59 WIB | 30.9 | 80 | 30.1 | 80 |
| 19:20:21 WIB | 23 | 83.9 | 23.2 | 83.5 |

Information :
T: Temperature (˚C)
H: Air humidity (%)

The test results of the DHT22 sensor, which measures air temperature and humidity, produce an error value that is not too large. If averaged, it is only 1.433%. This shows that the DHT22 sensor effectively measures humidity and air temperature quickly and accurately. In research, Dipa Prakoso (2018) explains that the relationship between temperature and air humidity is inversely proportional. When the air temperature in a room rises, the air humidity will fall. Likewise, if the temperature drops, the air humidity will increase. This is because with high air temperatures there will be condensation of molecules. DHT22 sensor measurement results and error value calculations.

**Soil pH Sensor Testing**

The optimal pH range for plant growth and development is ensured by testing the soil pH sensor as a guide. Where pH <5 is acidic, pH 5-7 is neutral, and pH >7 is alkaline. A soil meter measuring instrument compares the values read on the soil pH sensor.


**Figure 4.** Soil pH Measurement

**Table 3.** Comparison of Soil pH Sensor and Soil Meter Measurements

| No | Soil pH sensor | Soil Meter | Condition | Error(%) |
|---|---|---|---|---|
| 1 | 7.049 | 7 | Neutral | 0.7 |
| 2 | 6.929 | 6.9 | Neutral | 0.42 |
| 3 | 6.736 | 6.7 | Neutral | 0.53 |
| 4 | 6.442 | 6.5 | Neutral | 0.89 |
| 5 | 6.424 | 6.5 | Neutral | 1.16 |

The error values in Table 4.3 are used to see the accuracy between the soil pH sensor and the soil meter. Based on the tests, a comparison of measurements on the soil pH sensor and soil meter shows that the measurements are not too far off, namely around 0.74%. So, it can be said that the soil pH sensor works very well in measuring soil pH. Results of soil pH measurements and error value calculations.

**Testing Capacitive Soil Moisture Sensors**

This test is carried out to determine how moist the soil is on the chili plants to control the water pump later. Soil moisture will decide whether the soil is wet, normal and dry. The soil moisture sensor measurements are compared with an analog measuring instrument, namely a soil meter.

Table 4 shows that the soil moisture value produced by the capacitive soil moisture sensor is in accordance with the information displayed by the comparison tool (soil meter). So, it can be said that the sensor is quite effective in measuring soil moisture.

**Figure 5.** Comparison of Soil Moisture Measurements and Soil Meters

**Table 4.** Tests of Capacitive Soil Moisture Sensors and Soil Meters

| No | Soil Conditions | Sensors (%) | Soil Meter |
|---|---|---|---|
| 1 | Normal | 72 | Nor |
| 2 | Normal | 67 | Nor |
| 3 | dry | 58 | Dry$^{+}$ |
| 4 | Normal | 66 | Nor |
| 5 | Normal | 61 | Nor |

**RTC Testing**

RTC is a sensor that sets the start time in seconds, minutes and hours, and can set the day, month and year. This study used RTC as a watering timer at 07:00 WIB and 17:00 WIB. Table 4.5 is the result of the RTC test displayed on the Blynk application against the time on the cellphone.

**Table 5.** Comparison of RTC Testing with the Actual Schedule

| No | RTC DS3231 | Handphone | Tool Condition |
|---|---|---|---|
| 1 | 01-02-2024<br>07:01:06 WIB | 01-02-2024<br>07:01:12 WIB | ON |
| 2 | 01-02-2024<br>10:03:28 WIB | 01-02-2024<br>10:03:35 WIB | OFF |
| 3 | 01-02-2024<br>13:26:34 WIB | 01-02-2024<br>13:26:40 WIB | OFF |
| 4 | 01-02-2024<br>16:59:59 WIB | 01-02-2024<br>17:01:05 WIB | ON |
| 5 | 01-02-2024<br>19:20:21 WIB | 01-02-2024<br>19:20:27 WIB | OFF |

Based on Table 5, it can be concluded that the RTC module has been running according to the program created in Attachment 1. The tool will be active according to the schedule given. Its accuracy is also well-tested because it has a difference of only 6 to 7 seconds. The RTC measurement results can be seen in Appendix 2.

**Testing Pumps, Sprayer Nozzles, and Lights**

Testing the pump used for watering plants and condensing the room in the greenhouse. The watering process will be adjusted to the time programmed on the RTC, while the condensation process will be adjusted to the room temperature. Based on research, the pump and relay work well as the soil moisture and temperature and air humidity sensors.

**Table 6.** Output Signal Tests for Relays and Water Pumps

| No | Relay Condition | Pump Condition |
|---|---|---|
| 1 | ON | Active |
| 2 | OFF | Not Active |
| 3 | OFF | Not Active |
| 4 | ON | Active |
| 5 | OFF | Not Active |

**Table 7.** Tests of Sprayer Nozzles and Lamps Against Room Temperature

| No | T(˚C) | Nozzle Sprayer | Light |
|---|---|---|---|
| 1 | 28.8 | OFF | OFF |
| 2 | 28.9 | OFF | OFF |
| 3 | 39.8 | ON | OFF |
| 4 | 30.9 | OF | OFF |
| 5 | 23 | OFF | ON |

Based on Table 6, the pump will turn on when the relay is on/active. Vice versa, the pump will not turn on when the relay is off/dead. Meanwhile, in Table 4.7, the pump nozzle and lights will turn on/off according to room temperature conditions. When the temperature is below 24˚C, the sprayer nozzle is off, and the light is on as a heater. However, when the temperature is above 33˚C to 55˚C, the sprayer nozzle will be on as a coolant, and the lights will be off.

### Blynk Testing

Blynk creates commands, views, and dashboards displaying data received by the ESP32. In this research, the Blynk application can display the values issued by the RTC module, soil moisture sensor, soil pH, air temperature and humidity. Apart from that, blynk can also control the condition of the water pump, nozzle pump and lights.

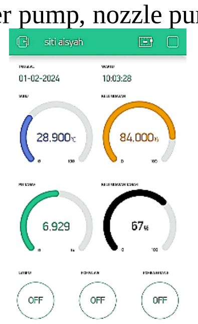


**Figure 6.** Appearances of the Blynk Application

Discussions are carried out to ensure that the system is running well. This system is designed to irrigate automatically according to schedule and soil moisture needs, including controlling soil pH and air temperature in the greenhouse. A capacitive soil moisture sensor and soil pH sensor are installed in the soil, and a DHT22 sensor, sprayer nozzle and lights are installed in the greenhouse. Pumps and blynks that display the date, time and sensor condition are system outputs [21].

Once the system is activated, the microcontroller program will start functioning, displaying the RTC clock, temperature and humidity readings from the DHT22 sensor, and pH and soil moisture content. At 07.00 and 17.00 WIB the water pump will actively water the plants according to the soil moisture value. The microcontroller will activate the heating lamp when the temperature is below 24˚C to neutralize the temperature in the greenhouse. While the temperature detected is above 33˚C to 55˚C, the sprayer nozzle is active to produce condensation in the greenhouse. The soil pH sensor will detect soil conditions that are acidic, alkaline or neutral. Based on the test results, this tool can function effectively and in line with the developed program [22].

## Conclusion

Based on the research results, it can be concluded that several sensors managed by an ESP32 microcontroller and a digital clock (RTC) are used in designing an automatic plant watering system. Real time information to determine the watering schedule set by the program. The DHT22 sensor monitors the sprayer nozzle and lights to regulate the greenhouse temperature automatically. The watering system for chili plants is based on capacitive soil moisture sensor data. To see acidic, alkaline or neutral soil conditions, a pH sensor is used to detect it. The watering date, schedule, and data produced by these sensors are also displayed in the blynk application. The blynk application also has buttons to control the lights, water pump and nozzle. Based on research that has been carried out, the tool has worked well and follows the program created. The average % error obtained by the DHT22 sensor and the comparison measuring instrument (digital hygrometer) was 1.433%. Meanwhile, the error percentage of the soil pH sensor with a comparison tool (soil meter) was 0.74%, and the test results of the soil moisture sensor with a comparison tool were also quite ideal and accurate in reading soil conditions. Likewise, the RTC test obtained a time difference of only 6 seconds with the comparison tool.

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