ATLANTIS PRESS

Advances in Engineering Research, volume 208

Proceedings of the International Conference on Innovation in Science and Technology (ICIST 2020)

Monitoring Room Temperature and the Use of Cooling Power Based on IoT

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***Abstract*—Air conditioning is a device used to stabilize the temperature and humidity of the air in a room. Air conditioning uses volatile refrigerants and absorbs a lot of heat around it so that the surrounding temperature drops. The use of air conditioning requires a large amount of electrical power, resulting in a waste of power. To overcome this problem, a device designed to monitor the use of air conditioning power. The IoT-based Room Temperature Monitoring and Cooling Power Usage have the objective of monitoring the power consumed by the air conditioner as well as monitoring the temperature in the room through an application installed on a smartphone. This tool uses the ESP8266 to send data readings, DHT22 to read room temperature and humidity, Sonoff PowR2 to read air conditioning current and power, and uses a communication protocol in the form of MQTT with CloudMQTT as a server. The result of this tool is a monitor of the power consumed by the air conditioner. This monitor can display power consumption wherever the user is when the smartphone connected to the internet.**

Keywords—air conditioner, room temperature, ESP8266, DHT22, power monitor

I. Preliminary

A. Background

Air control is the process of conditioning the air of a room by regulating temperature, humidity, flow, and cleanliness in order to obtain the desired air condition. The air control system is an application of the cooling system. The basic principle of this air conditioning system is to transfer heat from one room to another. The air from the conditioned room is circulated through the evaporator, because the temperature of the fluid (refrigerant) in the evaporator is lower than the room air temperature, so the heat from the air is absorbed by the refrigerant. Furthermore, the refrigerant circulating in this refrigerant dissipates heat from the evaporator in the condenser to another room [1].

Air conditioning is a secondary requirement because in addition to its relatively expensive price and requires a large amount of electrical energy, it is also expensive to maintain. Meanwhile, the use of air conditioning is used in all campus rooms, such as in the Semarang State Polytechnic. In its use in the Control Laboratory, Electronics Workshop, Semarang State Polytechnic, there is often waste in the use of air conditioning. This waste occurs due to the location of the laboratory which is located at the end of the workshop, as well as the frequent loss of the remote air conditioner. This problem can be overcome by using a room temperature monitoring system and the use of air conditioning power that can be monitored via a smartphone. This system can display the power consumption of the air conditioner, indoor air temperature, and air conditioner on-off setting. Therefore, a final project entitled Room Temperature Monitoring and IoT-Based Cooling Power Usage was made. This tool uses input in the form of a DHT22 temperature sensor, a processor in the form of an ESP8266 and a data processor in the form of an MQTT Server, and an output in the form of an air conditioner and a viewer application that can be installed on a smartphone.

B. Literature Review

1) Air conditioner: Room pending is the process of conditioning the air of a room by adjusting its temperature, humidity, flow, and cleanliness in order to obtain the desired air condition. The air conditioning system is an application of the refrigeration system. The basic principle of this room cooling system is to transfer heat from one room to another. The air from the conditioned room is circulated through the evaporator. Because the temperature of the fluid (refrigerant) in the evaporator is lower than the room air temperature, the heat from the air is absorbed by the refrigerant. Furthermore, the refrigerant circulating in this refrigerant dissipates heat from the evaporator to another room (Figure 1).

Fig. 1. Air conditioner.

2) ESP8266: ESP8266 is a WiFi module that has the function of connecting devices to the internet network and making TCP / IP connections. Inside the ESP8266 there is already a processor, access to GPIO and memory so that the ESP8266 can replace the Arduino (Figure 2).

The ESP-12F WiFi module is one type of the ESP8266 microcontroller developed by Ai-Thinker Technology. The ESP-12F supports the IEEE 802.11b / g / n standard protocol, which is the WiFi technology used in wireless devices. Users can use the ESP-12F to add networking capabilities to existing devices or build separate network controllers. The dimensions of the ESP-12F are 24x16x3 mm. The frequency range is between 2412 - 2484MHz. The ESP-12F is equipped with 16 pins by 9 pins GPIO. The power supply voltage used is 3.3 Volt with a current> 500mA.

Fig. 2. ESP8266.

3) Temperature and humidity sensor: The component for detecting air temperature and humidity is the DHT22 sensor (Figure 3). DHT22 is a temperature and relative humidity measuring sensor with a digital signal output. The DHT22 sensor has 4 pins consisting of power supply, data signal, null and ground. DHT22 has better accuracy than DHT11 with a relative error of 4% temperature and 18% humidity measurement.

Fig. 3. DHT22 sensor.

4) Current and power sensors: The current and power sensor module used is Sonoff PowR2 (Figure 4). The current and power sensor module Sonoff PowR2 works at a voltage of 100 - 240V AC with a maximum current of 15A. Data from the readings of this tool can be displayed on a smartphone using the eWelink application. The input is a voltage from the output device in the form of AC and the output is a value of current, voltage, and power [2].

Fig. 4. Sonoff PowR2 sensor module.

Sonoff PowR2 uses the CSE7759B IC as a component for measuring current, voltage, and power, which does not require calibration. The CSE7759B IC is a multifunctional measuring chip which can support high frequency pulses to measure electrical quantities and read relevant parameters of current, voltage and power via UART. The serial port baudrate is 4800bps (± 2%) 8 data bits with 1 parity check and 1 stop bit. The characteristics of the CSE7759B IC are that it has a tolerance of ± 2%, requires a 5V power supply voltage and has a reference voltage of 2.43V, and enters a reset state when the power supply voltage is <4V.

5) MQTT server: Message Queuing Telemetry Transport is a lightweight publish / subscribe based communication protocol specifically designed for low power communication between devices (Figure 5). MQTT runs on top of the internet protocol TCP / IP. The communication system with the publish / subscribe paradigm requires some sort of distribution agent or in MQTT it is called a broker (server). All users must have a connection with a broker. Users who send messages to the broker are known as publishers. The broker then filters the incoming messages and distributes them to users who are interested in receiving them. Users who are interested in receiving these messages, have previously registered with the broker, they are called subscribers.

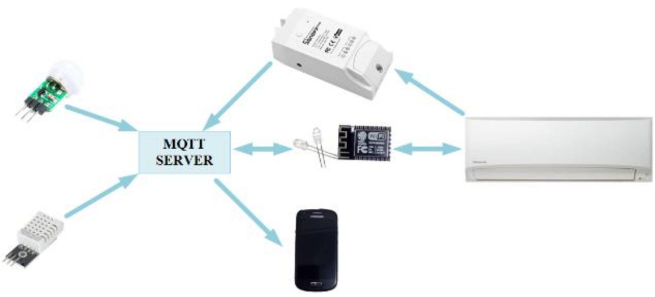


Fig. 5. Paradigms publish / subscribe on MQTT server.

In this final project, there is a design in the form of a temperature and humidity sensor as well as a current and power sensor that acts as a publisher. All publishers are connected to an online server, namely CloudMQTT. A device that acts as a subscriber is an application installed on a smartphone.

6) Smartphones (Smartphones): Smartphone is a mobile phone or smartphone equipped with modern features and high capabilities like a computer (Figure 6). Smartphone can also be interpreted as a mobile phone that works using an operating system (OS) software that provides a standard and basic relationship for application developers.

Fig. 6. Smart mobile.

7) 5 Volt Power supply: Power supplies are equipment that provides a voltage or power source for electronic equipment with the principle of converting Alternating Current (AC) voltages to Direct Current (DC) voltages that can be used as a power source for electronic equipment. The power supply used as a voltage source is the 5V2A Adapter.

II. Research Methods

A. System Design Stage

The process of making the final project of Room Temperature Monitoring and IoT-based Room Cooling Power Usage is divided into three stages, namely the design stage, the manufacturing stage, and the testing phase (Figure 7).

The final project design of room temperature monitoring and the use of IoT-based cooling power is divided into several different parts. These sections are input, processing, and output. The components in the input section are the Sonoff PowR2 sensor as a current and power reader for AC, and 2 DHT22 sensors as an indoor temperature reader. The processing section uses the ESP8266 microcontroller as a data reader from each sensor and sends the readings to the data processing center, and the MQTT Server as a data processing center and gives instructions or commands on input and output devices. The external part consists of a remote in which there is an infrared sensor to control the air conditioner, as well as an application on a smartphone that functions as a data viewer.

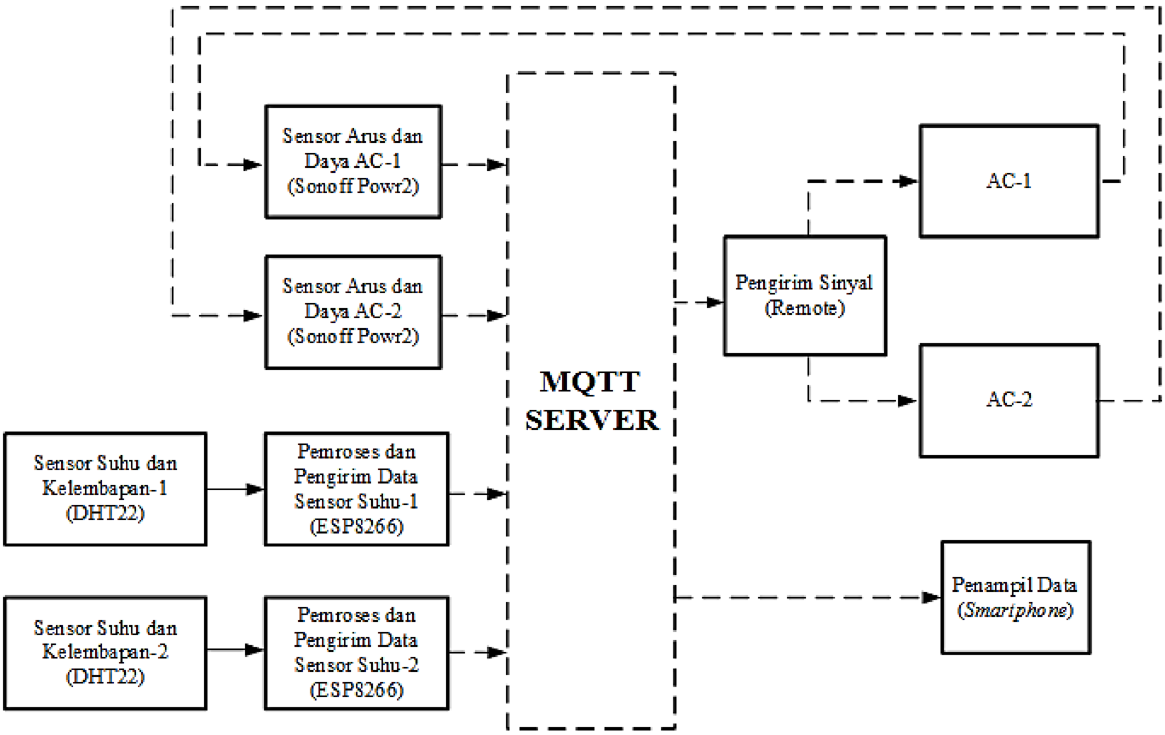


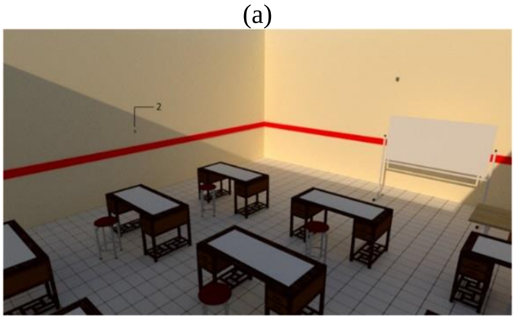
Fig. 7. Block diagram.

B. *Making stage*

In the stage of making a final project entitled Monitoring Room Temperature and Using IoT-Based Cooling Power, it consists of two processes. This process is the process of making software and the process of making hardware.

1) Hardware manufacturing: Hardware is installed in the Control Laboratory located at the Electronics Workshop, Semarang State Polytechnic (Figure 8).

(a)



(b)

Fig. 8. (a) Right side wall view, (b) view of the left side wall.

Information:
1 = The first DHT22 temperature sensor
2 = Second DHT22 temperature sensor
3 = Remote
4 = Current and power sensors Sonoff PowR2 first air conditioner
5 = Current and power sensors Sonoff PowR2 second air conditioner

The hardware manufacturing consists of two black boxes for two sets of temperature sensors. Each box has a size of 10x7.5x3.5 cm with a plastic material. In each box there are several components, namely the ESP8266, LM1117T regulator, and sensors (Figure 9).

Fig. 9. Black box construction temperature sensor circuit.

2) Software development: The software development in this final project uses the Tasmota firmware that is inserted into the ESP8266 to set the device address and connect to the server. MQTT server creation is done using CloudMQTT. This server functions as a data processor for each sensor reading sent by the ESP8266. To create an application that can be installed on a smartphone, a web application called MIT App Inventor is used. With this application, room temperature and air conditioning power usage can be monitored. Flow chart image can be seen in Figure 10.

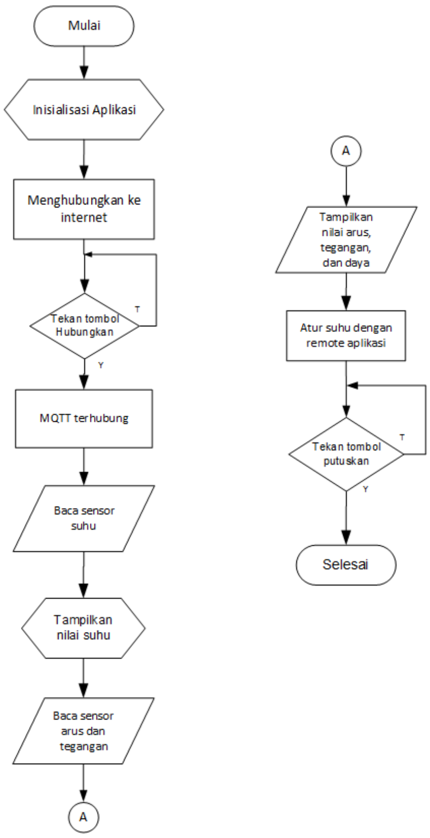


Fig. 10. Flow diagram.

3) Measurement and testing stage: The measurement stage is carried out to determine the performance of the tool. The measurement stage produces data which is then analyzed to determine whether the tool can work properly or not. The process of measuring temperature is done by reading the temperature value displayed on the application and using a thermometer as a comparison, while measuring the voltage using a multimeter. Measurements taken are measuring the sensor power supply voltage, measuring temperature, and measuring power.

- Measurement of the sensor power supply voltage serves to find out what voltage value each sensor requires while working. Measurements are made using a digital multimeter at certain points as in Figure 11.

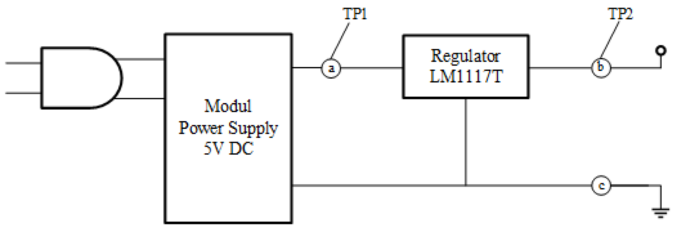


Fig. 11. Sensor power supply voltage measurement point.

- Temperature measurement has a function to determine the temperature value in the room. Temperature measurement uses two ways as a comparison, namely using a digital room thermometer and reading the readings in the application.
- Power measurement is done as a comparison between measuring power using an application and measuring using a measuring instrument. The measuring instrument used is a digital multimeter to measure voltage and digital ampere pliers or a clamp meter to measure current.

III. Results and Discussion

A. *Measurement* Results of Sensor Power Supply Voltage

Measurement of the sensor power supply is carried out at the points shown in Figure 11. The measurement results are shown in Table 1.

TABLE I. MEASUREMENT OF THE POWER SUPPLY FOR EACH SENSOR

Device	Measure Point	Measurement Result (V)
DHT22 temperature sensor (1)	TP1 (a - c)	5.2V DC
	TP2 (b - c)	3.22V DC
DHT22 temperature sensor (2)	TP1 (a - c)	5.23V DC
	TP2 (b - c)	3.25V DC

Based on 1, the results show that the voltage range at Measurement Point 1 is 5.2V DC to 5.23V DC. The measurement results at Measurement Point 2 are 3.22V DC to 3.25V DC.

B. *DHT22 Temperature Sensor Measurement Results*

The DHT22 temperature sensor measurement results are compared with the readings on the Tasmota firmware. Temperature measurement was carried out on November 5, 2020 at the Control Laboratory, Electronics Workshop, Semarang State Polytechnic. Table 2 and Table 3 display the results of temperature measurements.

TABLE II. THE FIRST TEMPERATURE SENSOR MEASUREMENT

Hour	Temperature-1		
	Tasmota	*Thermometer*	*%error*
13.38	29.1° C	28.1° C	3.56%
14.18	27.9° C	27.8° C	0.36%
14.58	27.1° C	27.1° C	0.00%
15.38	26.8° C	27.2° C	1.47%

TABLE III. SECOND TEMPERATURE SENSOR MEASUREMENT

Hour	Temperature-2		
	Tasmota	*Thermometer*	*%error*
13.38	28.6° C	29.3° C	2.39%
14.18	28° C	27.9° C	0.36%
14.58	27.4° C	26.9° C	1.86%
15.38	26.9° C	26.4° C	1.89%

Based on Table 2, at 13:38 WIB the reading of the temperature sensor-1 in the application was 29.1 ° C, while on the thermometer it was 28.1 ° C. The reading at temperature-2 is shown in Table 3 which shows 28.6 ° C on the application and 29.3 ° C on the thermometer. The temperature continued to decrease until at 15.38 WIB the temperature-1 showed 26 ° C on the application and 27 ° C on the thermometer, and the temperature-2 showed 26.9 ° C on the application and 26.4 ° C on the thermometer. The difference between the% error from the smallest to the largest is 0.00% to 3.56%

C. *Power Measurement Results*

The measurement of the power consumed by the air conditioner is carried out in two ways, namely reading the power value displayed on the Tasmota firmware and using a multimeter. The measurement was carried out on November 5, 2020 at the Control Laboratory, Electronics Workshop, Semarang State Polytechnic. The results of the power reading using the Tasmota firmware are listed in Table 4.

TABLE IV. POWER READING

Hour	Tasmota		
	Voltage (V)	*Current (A)*	*Power (W)*
13.38	222	6.1	1310
14.18	222	6.08	1307
14.58	226	6,139	1331
15.38	226	6.29	1364

Based on Table 4, the power readings on the current and power sensors are displayed in the Tasmota firmware. The reading of the power does not require recalculation because the values for current, voltage, and power are displayed automatically. In contrast to readings using the Tasmota software, measurements using a multimeter can only find out the value of voltage and current and must calculate the power value based on the measured voltage and current. The results of measurements using a multimeter are shown in Table 5.

TABLE V. POWER MEASUREMENT.

Hour	**Multimeter**		
	Voltage (V)	***Current (A)***	***Voltage (V)***
13.38	222	13.38	222
14.18	222	14.18	222
14.58	226	14.58	226
15.38	226	15.38	226

The parameters measured are voltage and current. To find the power value using the following power calculation formula.

$$P = V.I \tag{1}$$

Based on Table 5, the power reading using the firmware at 13:38 shows 1310 watts, while the measurement using a multimeter produces a power of 1291.66 watts. This shows that there is a difference between measuring power using applications and calculations based on measurements using a multimeter.

D. Discussion

Based on the results of measurement, testing, and data analysis, the final project of Room Temperature Monitoring and IoT-based Air Conditioning Power Usage can work well. Based on the results of temperature measurements using an application and a thermometer, it can be seen that there is a difference in values that is not too large. Likewise, the measurement of current, power, and voltage using an application using a multimeter measuring instrument. There is a difference in reading values that is not too big. The application can continue to display the value of room temperature as well as the current, voltage and power of the air conditioner as long as the smartphone is connected to the internet.

The reading results displayed on the application also show that the MQTT Server can quickly receive data from the publisher, then processes the data into information sent to the subscriber in the form of an application installed on a smartphone.

IV. CONCLUSION

From the implementation of the final project entitled Room Temperature Monitoring and IoT-based Room Cooling Power Usage, it can be concluded as follows.

- This final project has not succeeded in making a monitoring system that displays at what temperature is regulated by the air conditioner.
- The room temperature and power usage readings are shown successfully in the applications installed on the smartphone.

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