Application of the IoT Concept for Monitoring Electric Energy Consumption in Air Conditioning Equipment

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ABSTRACT
The operation of air conditioning equipment for the process of cooling the room can result in the waste of electrical energy, which can be caused by the absence of information that can inform the amount of electrical energy consumption of the equipment.

This study aims to create a system that can monitor the amount of electrical energy consumption from the operation of air conditioning equipment based on the Internet of Things (IoT), where the monitoring process can be carried out anywhere, so users can make savings on the operation of the equipment. In addition, the system created can inform the amount of the price paid in rupiah (Rp) in accordance with the amount of electricity consumption detected.

The results showed that the system created can monitor and inform the amount of electricity consumption and the price paid for the operation of air conditioning equipment, where monitoring can be done through an Android Smartphone device or through a web server.

Keywords
Monitoring, Electric Energy, Air Conditioning, IoT, NodeMCU.

1. INTRODUCTION
One of the causes of electrical energy wastage in the operation of air conditioning equipment, is in terms of electrical energy consumption of the equipment, where users do not know how much electricity energy consumption of the air conditioning equipment they use, so users can make savings on the operation of the equipment. In addition, routine maintenance of the air conditioning equipment must be considered, in order to get optimal work.[1][2][3][4].

To produce a monitoring system for electricity consumption of IoT-based air conditioning equipment, the method used is the prototyping method, where the stages are preceded by a literature study that aims to obtain references in accordance with this research, such as references on current sensors, where current sensors are used is the acs712 current sensor, where this sensor is usually used to control the motor, detect electrical loads, switched-mode power supplies and overload protection. This sensor has a high accuracy reading, because in it there is a series of low-offset linear Hall with a path made of copper. The way this sensor works is the current that is read flows through the copper wires contained in it which produce a magnetic field that is captured by the integrated Hall IC and converted into proportional voltage. Accuracy in sensor reading is optimized by installing components inside it between the conductor that produces a magnetic field and the transducer hall close together. Exactly, a low proportional voltage will stabilize the Bi CMOS Hall IC that has been made for high accuracy by the factory, where the center of the sensor output is (> VCC / 2) when the current increases in the current conductor used for detection. The resistance in the conductor of the sensor is 1.5mΩ with a low power, To determine the magnitude of the voltage at the output leg using the equation:

$$V_{Output} = 2.5 \pm (0.185 \text{ x } I) \quad (1)$$

Where I is the current detected in amperes [5][6][7].
Android, where Android is a Linux-based operating system designed for touch screen mobile devices such as smartphones and tablet computers. In this research, Android is used to create an application program for monitoring electricity consumption of air conditioning equipment [8][9].

Arduino IDE is a software written using Java. In this study Arduino IDE software is used as a media in making programs for monitoring the needs of the electrical energy consumption of air conditioning equipment [10].

NodeMCU is an open source IoT platform and development kit that uses the Lua programming language to assist in making prototypes of IoT products or can be sketched with an adruino IDE. The development of this kit is based on the ESP8266 module, which integrates GPIO, PWM (Pulse Width Modulation), IIC, 1-Wire and ADC (Analog to Digital Converter) all on one board. In this study, NodeMCU ESP8266 is used as a data processor in the electrical energy monitoring system for air conditioning equipment consumption [11].

The next stage is the stage of system design and manufacturing, in which at this stage the process of designing and making hardware is in the form of block diagram systems and software in the form of system work algorithms. To get data in connection with the work of the system created, the system testing process is carried out.

The studies related to this research are as follows:

1. Implementation of the Internet of Things (IoT) in Learning at UNISNU Jepara, conducted by Dias Prihatmoko, 2016, where the research conducted produced an LED Light Control System that can be used to control LED lights automatically using the web [12].
2. Cloud-Computing Internet of Things (IoT) System in Campus Area Network, conducted by Oris Krianto Sulaiman et al. 2017. Results In campus network or known as campus area network is very good to be applied for handling the network within the campus because there is already redundancy in every link that is connected, by using the Internet of Things system that is integrated with cloud

computing, the use of the campus network in education can be better [13]

3. The Master Plan for the Management of the Distribution of Disaster Assistance with the Concept of the Internet of Things (IoT) in North Maluku Province, conducted by Mohamad Jamil et al. 2017. Results, Can help the community and local government in monitoring the process of distributing disasters, that is, in the event of a disaster or post-disaster, The process of distributing aid will be more easily channeled to disaster victims and right on target, resulting in a process of good governance in disaster management, because the system is created using information technology media [14].

4. Ali Ramschie et al (2016) published in the International Journal of Computer Applications entitled Algorithms Air Conditioning Air Filter Detection System for Electric Energy Savings, research conducted related to making a control system algorithm that can detect when air filters from AC equipment have been dirty . When the AC air filter is dirty, the system will deactivate the air conditioner and inform it through the sound of the alarm and through the LCD display that the AC needs to be treated in connection with the air filter is dirty, so that waste of electrical energy can be avoided [15].

2. METHODOLOGI

In the process of designing and manufacturing systems according to the method used, namely the prototyping method, the stages include: system design and manufacturing; designing and manufacturing software, both software for operating systems that are embedded into the controller and software for monitoring needs (android applications and web servers).

2.1 System Design

The design of the system is made in the form of block diagrams that illustrate the relationship between input / output and controller, as well as represent the work of the monitoring system of electricity consumption of air conditioning equipment based on Internet of Things (IoT). The hardware design in the form of a block diagram is shown in Figure 1.

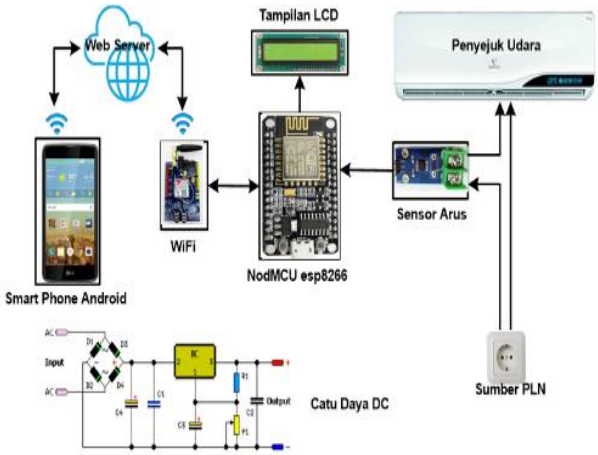

Fig 1: Block diagram system

Image Caption 1:

1. Android smartphone, functions as a medium for monitoring electrical energy consumption and the price paid for operating air conditioning equipment.
2. WiFi Module, functions as a communication medium between smartphone and nodeMCU controller via a web server, for the need to monitor electricity consumption and the price of air conditioning equipment.
3. The NodeMCU controller functions as a data processing center for the process of monitoring electricity consumption and the price of air conditioning equipment.
4. Web server functions as a data storage media monitoring the results of electricity consumption of air conditioning equipment, besides that the web server is also a medium of communication between smartphone devices and controllers for the process of monitoring the electrical energy consumption of air conditioning equipment.
5. LCD display, is a display media, to display information in connection with the amount of electrical energy intake and the price of air conditioning equipment.
6. Current sensor, serves as a detector of the amount of current consumed by air conditioning equipment, where the sensor output is inputted to the controller for data processing, then sent via WiFi communication to a web server and forwarded to a smartphone as information on electrical energy consumption and the price paid.

2.2 Software Design and Manufacture

In running and monitoring electricity consumption based on air conditioning equipment (IoT) software is needed, both software for the needs of the system work in the process of monitoring, processing data monitoring results and the process of sending data in the form of a flow chart (flow chart), software for applications android for the needs of monitoring the electricity consumption of air conditioning equipment, as well as web server applications as data storage media for monitoring the electricity consumption of air conditioning equipment.

2.2.1 Sistem Flow Chart For Controller Needs

Flow chart for the needs of the controller aims to describe the order and work functions of the monitoring system for electricity consumption of air conditioning equipment in terms of the process of monitoring and sending data to the web server. The system flow diagram is shown in Figure 2.

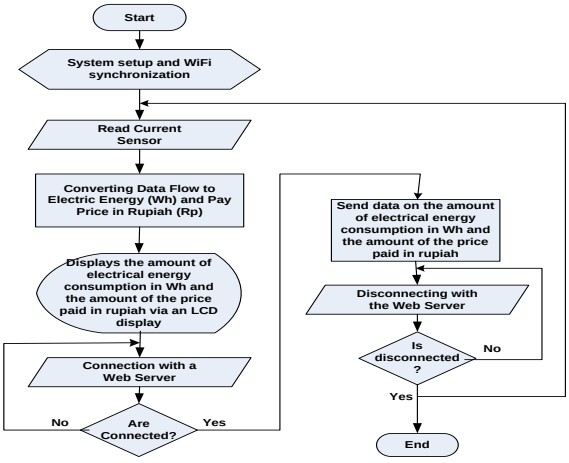

Fig 2: Flow Chart system

2.2.2 Web Server

Establishment of a web server is done using PHP my Admin, where the web server functions as data storage and information monitoring results of electricity consumption of air conditioning equipment, besides that it also functions as an intermediary for communication between an android smartphone installed with the smartIoT application and nodeMCU controller, for monitoring consumption consumption electrical energy and the price paid for air conditioning equipment. The web server display is shown in Figure 3.

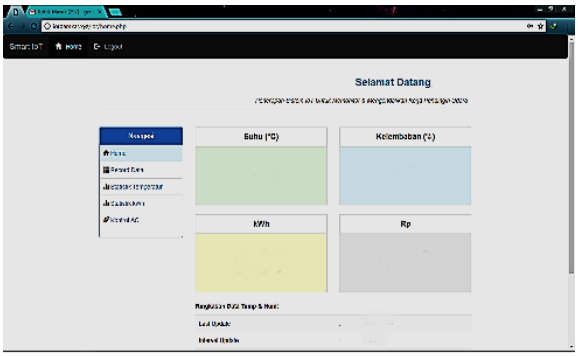

Fig 3: Web Server

2.2.3 Android Application SmartIoT

Making software for Android applications is done using the MIT Inventor app. Making software for android applications includes: making a display for the login page, making a display for the Home page, making a display for monitoring the page electricity consumption and the price of air conditioning equipment. The Android application display is shown in Figure 4.

Fig 4: Display for the Android SmartIoT application

2.2.4 Hardware Manufacturing

Hardware manufacturing is done by referring to the hardware design results in the form of block diagrams. Hardware manufacturing is done by combining modules such as: current sensor module, LCD display module, GSM sim 800 module with nodeMCU controller, so that they are integrated with one PCB board. The hardware system for monitoring electricity consumption of IoT-based air conditioning equipment is shown in Figure 5.

Fig 5: Hardware Manufacturing

3. RESULT AND DISCUSSION

The system testing process is carried out using the Black Box testing method by performing functional testing of the system created.

3.1 Testing Process Monitoring Via Smart Phone

After the SmartIoT application on a smartphone opens, the first thing to do is to authenticate the user through the login form. After the authentication process is valid, the system will enter the Home view as part of the main view of the SmartIoT application. The initial appearance of the SmartIoT application is shown in Figure 6.

Fig 6: Initial display of the SmartIoT application

From the results of tests carried out, after the user data authentication process is successful, the system will enter the main page section, where the main page section contains navigation buttons, including the kWh statistical button, where the kWh statistical button functions to view the results data monitoring the electrical energy consumption of air conditioning equipment as shown in Figure 7.

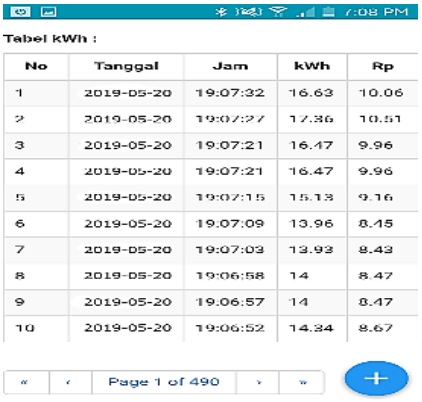

Fig 7: KWh statistics

From the kWh statistical data as shown in Figure 7, it can be seen that the data records in the form of a table stored on a web server will automatically be displayed also on the SmartIoT application on a smart phone when the kWh statistics are selected. Besides displaying kWh statistical data,

this application can also display graphs of the amount of costs in Rupiah against the consumption of electrical energy from the operation of air conditioning equipment as shown in Figure 8.

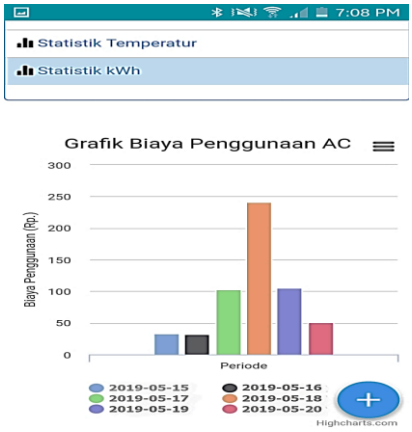

Fig 8: Graph of the costs in Rupiah against the consumption of electrical energy from the operation of air conditioning equipment

The kWh statistical data record stored on the web server contains monitoring data on electrical energy consumption in kWh and the price paid for electricity consumption from the operation of air conditioning equipment, so users can find out how much electricity energy consumption is consumed by the air conditioning equipment along with the price paid, so that users can streamline the work of the air conditioning equipment in order to minimize the occurrence of electricity waste.

The part of the program that the system runs to send data to the web server includes:

a. Open a connection with the web server

The initial step taken by the system is to open a connection with the web server, where the part of the program being run is as follows:

```
void setup () {
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
delay(1000);
Serial.println("Connecting..");
 lcd.setCursor(0, 0);
lcd.print("Connecting...");
}
Serial.print("Use this URL to connect: ");
Serial.print("http://");
Serial.print(WiFi.localIP());
Serial.println("/");
lcd.clear();
lcd.setCursor(3, 0);
lcd.print("Connected");
lcd.setCursor(0, 1);
lcd.print(WiFi.localIP());
server.begin();
SPI.begin();
delay(1500);
lcd.clear();
}
```

b. Reading current sensor data

When the monitoring system and web server are connected, then the system will then enter the program section to read the current sensor data, where the program part is run as follows:

```
void read_adc() {
dataADC = analogRead(current_sensor);
input_voltage = ((dataADC * 3.07) / 1024);
current = ((input_voltage - 2.5) / 0.185);
count_Rp_Wh();
}
```

In this part of the program, the system will convert the Analog To Digital Converter reading results into voltage and current values. After the process of reading the current sensor data is finished, the system will then run a part of the program to calculate the amount of electrical energy consumed by the air conditioning equipment and the price to be paid against the electrical energy consumption of the equipment. The part of the program is run as follows:

```
void count_Rp_Wh()
{
p = (220 * current);
i = i + p;
Wh = ((7.0 / 3600) * i);
Rp = ((Wh / 1000) * 1049);
lcd.setCursor(11, 0);
lcd.print("Rp");
lcd.setCursor(10, 1);
String rupiah = String (Rp);
lcd.print(rupiah);
lcd.print(" ");
lcd.setCursor(1, 0);
lcd.print("Wh");
lcd.setCursor(0, 1);
String daya = String (Wh);
lcd.print(daya);
lcd.print(" ");
Serial.print("Wh = ");
Serial.println(Wh);
Serial.print("Rp = ");
Serial.println(Rp);
}
```

c. Sending Wh and Rp data to the web server

After the process of reading the value of the current sensor and the process of converting the current value into the amount of electric energy (Wh) and the amount of price (Rp), then the system will then run a program for sending data to the web server. After the data transmission process is finished, the system will disconnect with the web server. The part of the program is carried out as follows:

```
HTTPClient http;
if (currentMillis - previousMillis > interval) {

previousMillis = currentMillis;

count += 1;

Serial.println("Kirim Data KWH");

http.begin("http://iotdamkar.xyz/iot/save_kwh.php?kwh="
+String(Wh) + "&rupiah=" + String(Rp) );

int httpCode = http.GET();

if (httpCode > 0) {

String payload = http.getString();

Serial.println(payload);

} else {

Serial.println("Failed to send");

}

http.end();
```

3.2 Testing Of Electric Energy Consumption Monitoring Systems Based On IoT

System testing for the process of monitoring electrical energy consumption of the operation of air conditioning equipment is carried out by implementing a system made to air conditioning equipment, where the air conditioner used is air conditioner with the LG brand capacity of ½ PK. This test is carried out to get the results of the process of monitoring and sending data from the system, which is related to the response time of the SmartIoT application on the smartphone. Testing the monitoring process and the process of sending data is shown in Figure 9.

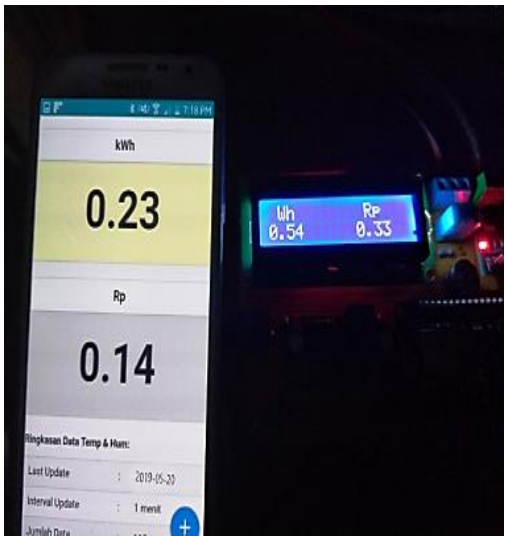

Fig 9: Testing the monitoring process and the process of sending data

From the results of tests conducted as shown in Figure 9, it appears that there are differences in the results of monitoring between electrical energy consumption data displayed on the LCD and data received and displayed on the SmartIoT application on a smartphone. This is influenced by the process of updating data from the system to the web server to the smartphone, where the time interval for the data update process is 1 minute, so the data displayed on the smartphone is delayed for 1 minute.

4. CONCLUSIONS

From the results of the research conducted, it can be concluded that the system created can monitor and inform the amount of electrical energy consumption and the price paid for the operation of air conditioning equipment, where monitoring can be done via a Smartphone device or through a web server, with a data update interval of 1 minute .

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