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MONITORING OF ELECTRICAL SYSTEM USING INTERNET OF THINGS WITH SMART CURRENT ELECTRIC SENSORS

Muhammad Hafizd Ibnu Hajar, Akhmad Wahyu Dani, Satriyo Miharno
Electrical Engineering, Faculty of Engineering, Universitas Mercu Buana
Jl. Meruya Selatan, Kembangan, Jakarta Barat 11650
Email: muhammadhafizd@mercubuana.ac.id wahyu.dani@mercubuana.ac.id
s.miharno@mercubuana.ac.id

Abstract -- *Electricity is one of the most important human needs. In the presence of electricity it can facilitate human work. But it should be noted that too large and uncontrolled electricity use will be wasteful and get high costs. The problem is that electricity is not monitored accurately, easily and efficiently. This study aims to design an electric current monitoring device with an IoT system. IoT is a concept with the ability to transfer data by network, no need humans to humans or humans to PCs. In this concept, the SCT 013-000 electric current sensor is connected to the load, it will be show electric current value in the LCD, if the electric current which is determined exceeds the capacity, Wemos D1 including Wifi ESP 8266 will be sending a notification to the telegram. The system has been implemented with ironing load for 3.29%, the dispenser load is 0.20% and Magicom's get load for 1.07%. The delay time also has been implemented in the relay for 1.50 second when relay is on and 0.78 second when relay is off. When the notification send to the telegram also have a delay for 6.2 second. So, monitoring of electrical system using internet of things with smart current electric sensors has been done.*

Keywords: *Monitoring System; Internet of Things; Wemos Module; Current Electric SCT-013 000.*

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INTRODUCTION

Electricity is a very useful energy in human life in this era, where energy can be integrated into light energy, heat energy, motion energy and others (Donose et al., 2017). Humans really need energy to help their daily needs, where electricity has been used in house, schools, offices, industrial trade and others even though electricity needs increase every year (Rebolini, 2017).

In the beginning, the main function of the kWh meter was to calculate electricity consumption. Along with the development of technology, the kWh meter develops into an automatic measuring device that can send the measurement results to the electricity company. The development of kWh meters is supported because of the extraordinary development in the world of information technology, especially the internet, which is now able to send data easily and quickly (Badaruddin & Hutabarat, 2016; Fitriandi, Komalasari & Gusmedi, 2016). Unfortunately, electric power companies in Indonesia still cannot provide digital kWh meters that can show the electricity that has been used.

Some related studies that are used as references and comparisons is: Some related studies that are used as references and comparisons is: Designing a microcontroller-based current and voltage monitoring device with an SMS gateway. Monitor the electric current using the ACS712 sensor while the voltage uses the ZMPT101 sensor. The amount of current and voltage is then processed by the microcontroller to be sent using GSM Shield. This paper presents the development of a monitoring system for electrical energy consumption and power quality analysis, also known as power quality analysis (PQA). This paper also describes software developed for Raspberry Pi, which receives processing information from ARM processors and presents them in real-time using an easy-to-use touchscreen interface. System for Monitoring Electricity Loads Based on Arduino Microcontrollers. Monitoring electrical power using SCT 013-000 sensor and for voltage using transformer a step-down voltage. The power monitoring system is sent to the PLQ DAQ database and displayed using an LCD (Silva and Afonso, 2017; Vo, 2017; Yumang et al., 2016; Zhang et al., 2016; Ihsanto & Bukhori, 2017; Riswandi, 2015; Sitorus et al., 2011).

Therefore, this paper aims to monitoring of electrical system using internet of things with smart current electric sensors. The electric current will be measured with a current sensor SCT 013-000, showing in the LCD and send the notification to the telegram, this measurement directly from the power meter. If the electric current will exceed the maximum capacity of the breaker, the notification will be informed to the user via telegram and users can also turn off the power by telegram. will be informed to the user via telegram and users can also turn off the power by telegram.

METHOD

This section will be describing a design of a Wemos-based control current monitoring tool via telegram. This device is used to process data received from SCT 013 sensor. So the data will be process by Wemos and then displayed to the LCD 20x4 and informed via telegram to the user when exceeding the limit specified by Wemos program. Block diagram of the system designed is shown in Fig. 1.

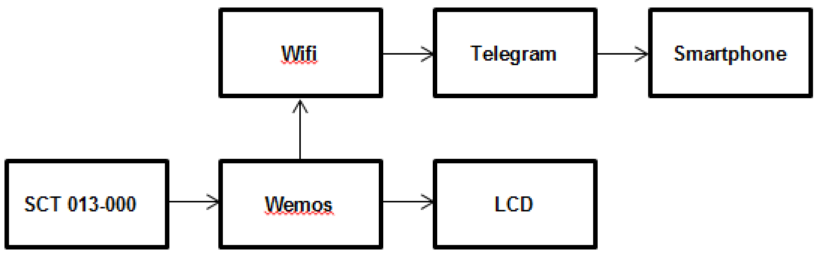


Figure 1.Block Diagram System

The system is proposed to implement an Internet of Things, or Io. IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Several inspirations of another IoT application is depicted in Fig. 2

Figure 2.IoT Inspiration

Then, the system also applies a Wemos. Wemos is a microcontroller-based development with a Wi-Fi module ESP8266. Microcontroller Wemos is created as a solution for expensive microcontroller-based wireless systems. For the Microcontroller Wemos the cost incurred to build a cheap microcontroller-based Wi-Fi system, only one-tenth of the cost incurred when building a Wi-Fi system using Arduino Uno Microcontroller and Wi-Fi Shield. Block diagram of Wemos is shown in Fig. 3.

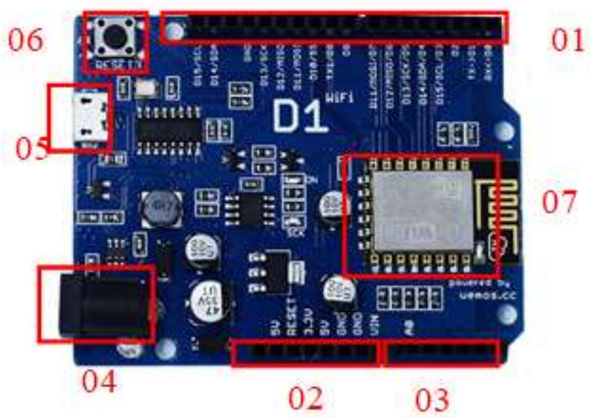


Figure 3.Wemos Block Diagram

Besides that, the system used a CT sensor that can measure electric current. CT is an intermediate current measurement where the limitations of the ability to read the meter. Such as on high voltage channels systems. CT is generally used in addition to reading media also used in electric power protection systems. SCT 013-000 is one of CT type that is shown in Fig. 4.

Characteristics of current sensors SCT013 has size: 13mm x 13mm and with 1 m cable length. The material core is built with by Ferrite with fire resistance property is in accordance with UL 94-V0 and has resistance of dielectric with 100V AC / 1MIN 5 mA.

Figure 4.Current Sensors SCT013

A relay is an electronic switch that is operated electromagnetically by an electrical signal with a small current to move the connecting switch or breaker switch for a large load current. The switch on the relay will be change the position of opening or closing the switch contacts in the relay when given electromagnetic energy.

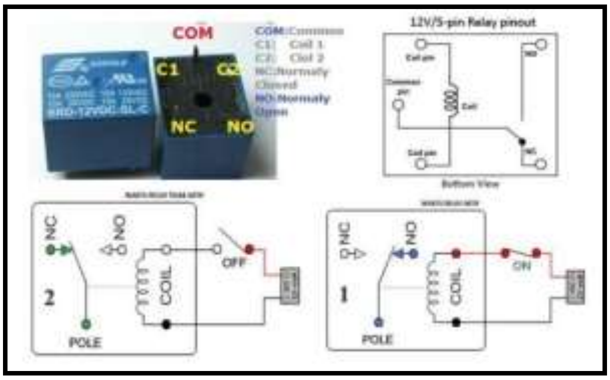


Figure 5.Form, Pin Configuration, and SPDT Relay Scheme

A telecommunication system used to control and monitor the system here is based on Telegram Messenger. Telegram Messenger is a messaging app for smartphones with basic similar to WhatsApp messenger. Telegram messenger is a cross-platform messaging application that allows us to exchange messages without the cost of SMS because telegram messenger uses the same internet data package for email, web browsing, and others. By using Telegram, we can chat online, share files, exchange photos and more.

Based on Fig. 5, the block diagram shows where the sensor is the current status detector. Then the inrush into Wemos to convert to digital and in the further process then the data is displayed on 20x4 LCD interface and sent by Wi-Fi ESP8266 to Telegram Network to inform the electrical status. Flow chart of the system is depicted in Fig. 6.

SCT current sensor 031-000 detects current input then converted to the analog value. Wemos microcontroller system receives and processes input data sensor input as primary data then microcontroller calculates the value of the value. ESP8266 Wi-Fi system that has been programmed and synchronized with BotTelegram can monitor and control current through telegram. A relay that has been installed can command from telegram can disconnect or connect the flow of electricity. The result of the microcontroller calculation is then sent on I2C LCD 20x4 to display. LCD 20x4 then display current value and then read the user.

The simulation of hardware is tested using a designing tool with the Proteus Software as shown in Fig. 7.

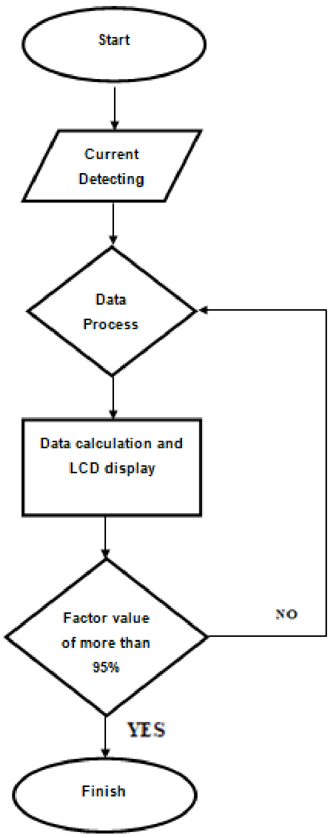


Figure 6.Flowchart of the system

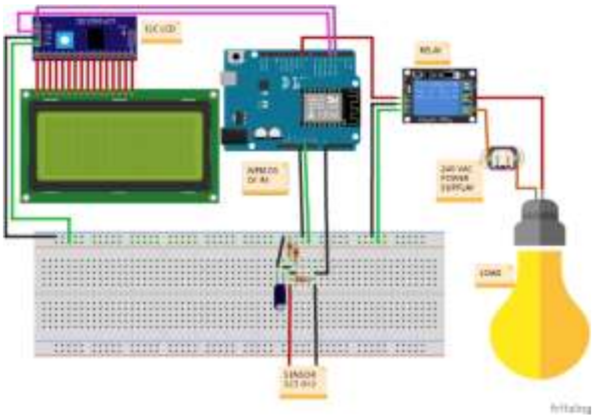


Figure 7.Designing Tools

The circuit uses a voltage or DC power supply (Direct Current) of 12V obtained from the adapter or external power. Wemos D1 ESP8266 is a component that processes input data from current sensors. Then the microcontroller processes the data received in accordance with the program that has been made before and the microcontroller outputs in accordance with the program that has been implanted. Then calculate the value of analog values that can then be displayed interface to LCD20x4 and can be viewed in BotTelegram with the appropriate command has been made.

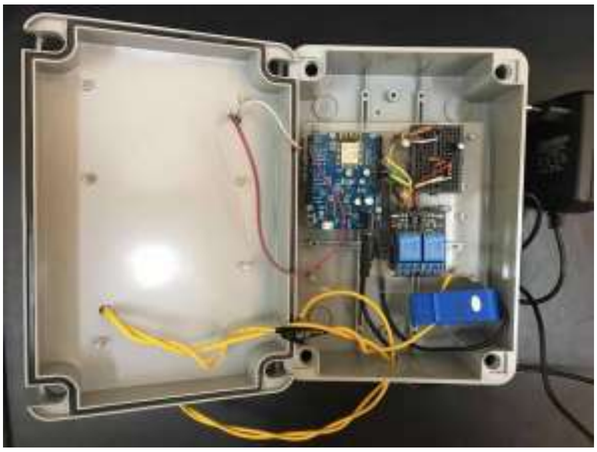
RESULT AND DISCUSSION

A device has been made and then testing to compared between current sensors with digital ampere pliers. This measuring has been trying until 5 times with the 3 seconds for interval and the data will be averaging calculated and compared with the result from digital ampere meters. The testing will be doing from several loaded such as dispenser, magic com and iron. Figure 8 shows the tool in the box

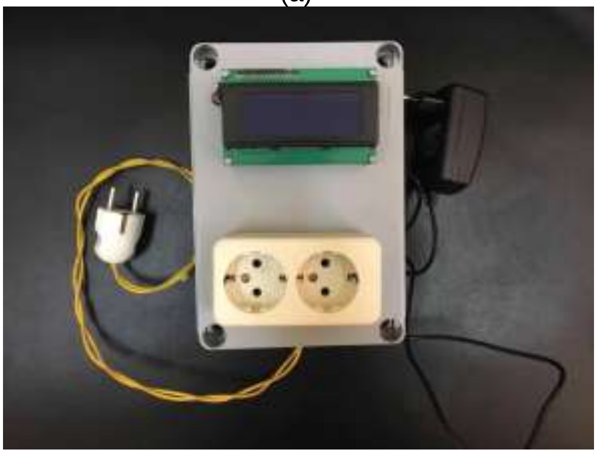
Wemos Module Testing

The testing of circuit has been done to find out whether the microcontroller Wemos has been working as expected. To find out about this, a measurement has been done using the Arduino IDE Serial Monitor. In the picture below shows how to test the Wemos microcontroller. The testing procedure is as follows:

1. Wemos microcontroller is connected to a computer via a USB cable.
2. Arduino IDE Serial Monitor is used for monitoring on serial ports..



(a)



(b)

Figure 8.Electrical Monitoring Device
(a).Inside and (b).Front side

Table 1. Module Wemos Testing

Test	Command Arduino IDE	Pin Wemos Testing	Delay (second)
1	GPIO 2	Pin 9	1,34
2	GPIO 14	Pin 5	1,65
3	GPIO 0	Pin 8	1,26

In the Table 1, Arduino IDE command testing for the Wemos pin has been obtained that the Arduino IDE GPIO 2 command is found on pin 9 of Wemos D1 with a response delay of about 1.34 seconds, GPIO 14 is on pin 5 of Wemos D1 with a response delay of 1.65 seconds and the Arduino IDE GPIO 0 command is located at Pin 8 Wemos D1 with a response delay of 1.26 seconds. Then it can be concluded from the Arduino IDE Software command that the Wemos pin is not all the same

LCD Testing

Tests are carried out to find out wheres LCD 20x4 circuit working is done properly, the input voltage of 5VDC and the connecting pins are already soldered with I2C to the SDA and SCL pins. Fig. 9 shows the picture of a 20x4 LCD test image.

Figure 9.LCD Testing

Based on testing in Fig. 9, it can be concluded that the LCD runs well. Table 2 is the result of the LCD test trial.

Table 2. LCD Testing

Test	Text Testing	Status	Delay (second)
1	Hello Word!	Good	1,76
2	Running Text	Good	1,90
3	Tes LCD	Good	1,67

Wemos testing for LCDs by testing the first text, it is "Hello Word" runs well and the delay 1.76 seconds, the second test is "Running Text", the condition is good and functioning properly. There is have a delay for 1.90 seconds and the last text is "Test LCD" text conditions well and delay 1.67 seconds.

2 Channel Relays Testing

Relay testing is intended to test whether a relay can be process commands that have been given through Wemos. If indeed the relay has received a connection from Wemos, it can see the indicator light on the relay will light up as shown below. Input from Relay in the form of VCC connected with 5 Volt from Wemos. In 1 which is connected with Pin 9 Wemos there are have pin is blink on Wemos microcontroller and the last ground is connected with Wemos ground pin.

Figure 10.Testing of 2 Channel Relays

Based on Fig. 10, the relay light is on. It means the relay is functioning properly. The relay test results can be seen in the Table 3.

Table 3.Relay Response

Test	Initial Conditions	Relay Conditions	Response (second)
1	On	Off	1,34
2	On	Off	1,65
3	Off	On	0,67
4	Off	On	0,89

Current Sensor with the Iron Load Testing

The test of the current sensor compared to the Extech Pliers Ampere uses an Iron load as listed in Table 4.

Table 4.Testing Current Sensor with the Iron Load

Test	Current Sensor	Ampere Pliers	Error (%)
1	1.77	1.81	2,26%
2	1.75	1.82	4,00%
3	1.76	1.83	3,98%
4	1.76	1.82	3,41%
5	1.78	1.83	2,81%
Average	1,76	1,82	3,29%

The first test with the current sensor get 1.77 A, whereas in Ampere Pliers obtained 1.81. It can be concluded error at 2.26% electric current. The second test is 1.75 and ampere pliers 1.82, then error 4.00%. The third test at 1.76, while the ampere pliers 1.83, then error 3.98%. The fourth test is 1.76 and the ampere Pliers is 1.82, then the error is 3.41%. The last test of the current sensor is 1.78 and the ampere pliers 1.83, and then the error is 2.81%. From the five tests with the iron load, there is an average is on the current sensor of 1.76A and in the Ampere Pliers is 1.82A and the average error is 3.29%.

Current Sensor with the Dispenser Load Testing

The next test is the current sensor compared to the Extech Pliers amperage uses a Dispenser load. Table 5 shows the results.

Table 5.Current Sensor with the Dispenser Load Testing

Test	Current Sensor	Ampere Pliers	Error (%)
1	1.21	1.25	3,31%
2	1.29	1.25	3,10%
3	1.28	1.27	0,78%
4	1.26	1.27	0,79%
5	1.24	1.25	0,81%
Average	1,25	1,25	0,20%

The first test with the current sensor is 1.21 A, whereas in Ampere Pliers is 1.25. It can be concluded error at 3.31% current. The second test of the sensor current is 1.29 and Ampere Pliers 1.25, then error 3.10%. The third test is 1.28 for current sensor and 1.27 for the ampere pliers, then error 0.78%. The fourth currents sensors test is 1.26 and the ampere pliers are 1.27, then the error is 0.79%. The last test is 1.24 and for the ampere pliers 1.25, and then the error is 0.81%. From the five tests with the Dispenser load, there is an average is on the current sensor of 1.25 A and in the Ampere Fliers is 1.25A then the average error is 0.20%.

Current Sensor with the MagiCom Load Testing

The current sensor compared to the Extech Pliers Amperage uses a Magic com load.

Table 6. Current Sensor with the Magic com Load Testing

Test	Current Sensor	Ampere Pliers	Error (%)
1	1.30	1.33	2,31%
2	1.37	1.35	1,46%
3	1.32	1.35	2,27%
4	1.34	1.35	0,75%
5	1.33	1.35	1,50%
Average	1,33	1,34	1,07%

Test with the current sensor is 1.30 A and Ampere Pliers there is 1.33 it can be concluded error at 2.31% current. The second test of the Sensor is current is 1.37 and Ampere Pliers 1.35, then error 1.46%. The third test is 1.32 for current sensor and 1.35 for the Ampere Pliers, then error 2.27%. The fourth test of currents sensors is 1.34 and the ampere pliers are 1.35, then the error is 0.75%. The last test of the current sensor is 1.33 and the ampere pliers are 1.35, and then the error is 1.50%. From the five tests with the Dispenser load, there is an average is on the current sensor of 1.33A and in the Ampere Pliers is 1.34A than the average error of 1.07%.

Testing of ESP8266

ESP8266 device testing is done by connecting Wemos D1 including ESP8266 with Wifi that has been listed in the program. Connection testing is done by ping test from PC to IP that has been installed on ESP8266. The result of this test is shown in Fig. 11.

The test results of the ESP8266 connection are connected to the wifi that has been registered into the Arduino IDE program. The author also tests that can be viewed from the serial monitor available on the Arduino IDE program, this is done to find out the IP that is obtained by ESP8266 as depicted in Fig. 12.

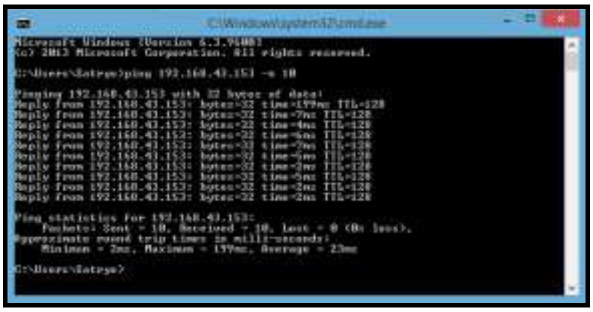


Figure 11.ESP Connection Testing

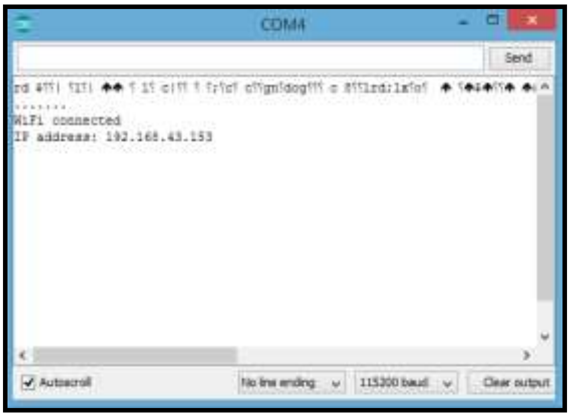


Figure 12.IP Display

Based on Fig. 12, it can be known that Wemos D1 is connected to Wifi and gets an IP of 192.168.43.153. Table 7 listed an internet speed experiment that is connected to the tool.

Table 7. Internet Speed

Test	Download	Upload	Delay (second)
1	23,51Mbps	13,11Mbps	1,13
2	8,55Mbps	16,20Mbps	1,82
3	8,67Mbps	13,70Mbps	1,93
4	28,54Mbps	6,81Mbps	1,54
Average	17,32Mbps	12,46Mbps	1,61

There is the first test to download 23.52 Mbps and upload 13.11 Mbps with a delay of 1.13 seconds. The second test was 8.55 Mbps and Uploaded 16.20 Mbps with a delay of 1.82 seconds. The third test is 8.67Mbps and uploads 13.70Mbps with a delay of 1.93 seconds. The fourth test is 28.54Mbps and Uploads is 6.81Mbps with a delay of 1.54 seconds. Of the four tests, the average download value was 17.32 Mbps and Upload 12.46 Mbps with an average delay of 1.61 seconds.

Testing of Telegram Connection

This test to find out how fast the time needed to respond to the telegram used to send message, Table 8 is the results of the test.

Table 8. TelegramBot Response

Test	Response (second)
1	5
2	5
3	5
4	8
5	8
Average	6.2

Based on the test results data in the Table 8, average response time from sending TelegramBot messages using the internet wifi accest that has been connected to ESP8266 with the average time is 6.2s.

CONCLUSION

This research about monitoring of electrical system using internet of things with smart current electric sensors has been done. The implemented electrical current using SCT 013-000 sensor with Extech brand ampere got a percentage with iron load 3,29%, while with Dispenser loading equal to 0,20%, and MagiCom load equal to 1,07%. From iron load testing, MagicCom, and Dispenser there is 6.81% and also about the delay time of relay with an average ignition time is 1.50 seconds and when turning off 0.78 seconds and then the delay time in the telegram application with an average of 6.2 seconds

The design of the tool should be developed, so that others who see it are interested in implementing this tool and are easy to learn. Need to add RTC so it can see the clock in real time and microSD to store RTC data.

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