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Smart Relay for Controlling and Monitoring Electronic device Using Real Time Database

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Abstract
The Smart Relay using microcontroller, that equipped with relay, voltage and current sensor to monitor and control electricity usage over a website, the system can remote and scheduler the relay for switch on/off, also could monitor the voltage and current usage, the sensor data send to real time database using internet connection for displayed on a website. Test results showed the capability of the system to control the relay with an average delay on 4G network is 1.76 seconds, error of measurement voltage sensor is 1.47%, and 1.67% for current sensor, with an average delay is 6.48 seconds for voltage sensor, and 4.02 seconds for current sensor on 4G network.

Keywords; *relay, voltage, current, real time database.*

I. INTRODUCTION

Monitoring and controlling are generally carried out manually where humans must deal directly with the devices if they want to know or change the condition of the devices. This causes waste of electricity if humans forget to turn off the device or they are not at home. Other than that, in the current era of technological development, human activities are increasingly diverse and required to carry out various activities in a short time, so that monitoring and controlling manually the electronic appliances causes a decrease in human time efficiency, so it is necessary to use a device for replace this manual system.

In a previous research, to change the condition of the switch an electronic device was made by sending an SMS[1]–[3], or using android application [4]–[7], in another research that process the value data from sensor to control electric devices using microcontroller [7]–[11], then using Internet of Things (IoT) to allows user for automate all devices [6], [7], [12]–[15]. However, they not implement scheduling for control electronic devices, to obtain power consumption more efficient because users can determine the time of electronic devices usage.

In this research, we present a Smart Relay system that equipped with a voltage and current sensor, as information to user, and calculation of usage electrical power, so the user will know how many consumptions of usage electricity monthly, and schedule feature able to control relay according to the period given. This system could be a supporting tool in the use of Internet of Things technology and can be a tool that facilitates everyday human activities, because home automation is an IoT application [16].

II. SYSTEM DESIGN

A. System Block

The system consists of hardware and software, with using Node-MCU as controller board and a real time database that provided by Google Firebase as a storage data[17]–[20], as shown on Fig. 1.

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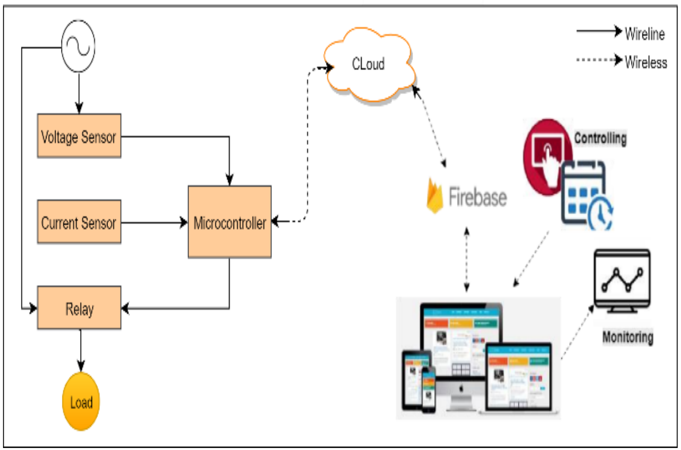

Fig. 1. Block Diagram

This system equipped with relay as a switch, ZMPT101b as the voltage sensor and ACS712 as the current sensor, and a website is capable to monitor and control the smart relay system. System can switch the relay condition, according to the input on the website or a schedule given before.

System send voltage and currents values that heading to load, then calculate the consumed of power energy that using by load devices, the data of voltage, current, and power will be displayed by the graph on a website in real time.

System could communicate with real time database using several methods, including:

1. *Get*: a command to read or retrieve data of relay condition on specified path in database

2. *Set*: a command to write or replace data on specified path in database

3. *Push*: a command to add new data on specified path in database

B. Hardware Design

The design of hardware consists several parts to integrated system consist of microcontrollers, multiplexers, relays, voltage and current sensors, to control NC (Normally Close) and NO (Normally Open) conditions on relays using the output digital pin from microcontroller, because relay works based on the presence or absence of a magnetic field on the coil in the relay and only recognizes "high" and "low" conditions.

Input multiplexer pins are analog that are used by current and voltage sensors to send data to the microcontroller, because electric current and voltage are analog signals. This system using a multiplexer to multiply analog pins because there is only one analog pin on the Node-MCU [7].

To use the multiplexer's analog pin, by modification the digital output pin on Node-MCU as a selector. The conditions of "high" and "low" on the digital pin that connected to the multiplexer will help the multiplexer to select an input pin. So the multiplexer will work alternately on each input according to the conditions given by selector pin.

Schematic and PCB layout are made in designing hardware, Fig. 2 shows the PCB layout of the system.

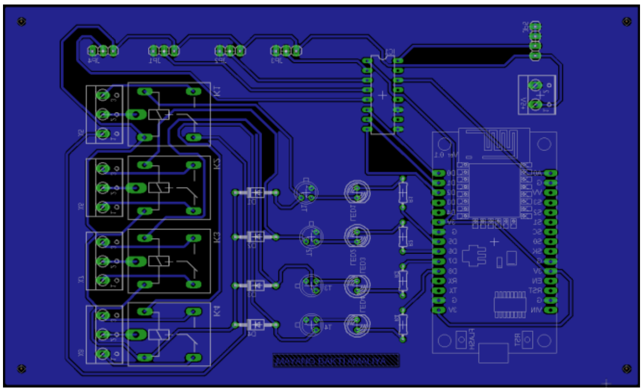

Fig. 2. PCB Layout

After designing the PCB layout, the next step is printing the PCB layout and install all part of components. In Fig. 3 shown the implanted circuit after components installation, its have 4 relay, 1 voltage sensor and 4 current sensor to monitor current usage that connected to the relay as load.

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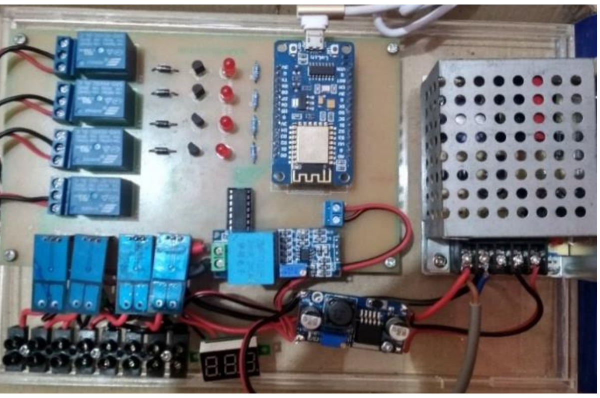

Fig. 3. Implemented Circuit

C. Website Design

When the user open that website, they will be directed to log in first to access the system (Fig. 4).

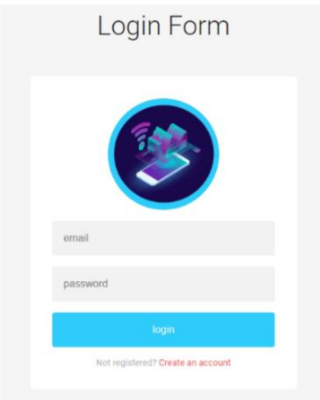

Fig. 4. Login Form

After logging in, on the dashboard, user can monitor the devices that is being used, as show on Fig. 5. User also can edit the devices name, control switch condition and monitor the voltage value that flowing to the load that displayed in a graph.

Fig. 5. Dashboard Page

User also know the amount of current and power energy that consumed by each load, as show in Fig. 6.

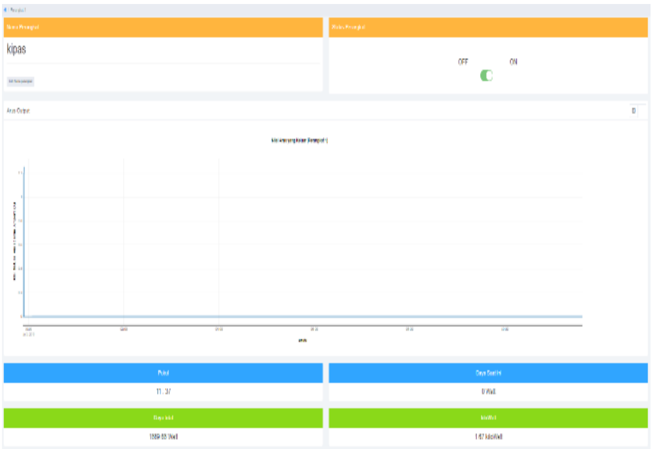

Fig. 6. Monitoring Page

In scheduling menu, user can control the switch condition of relay, when the condition must be ON or OFF by inputting the condition, hour and minute as desired, as shown on Fig 7.

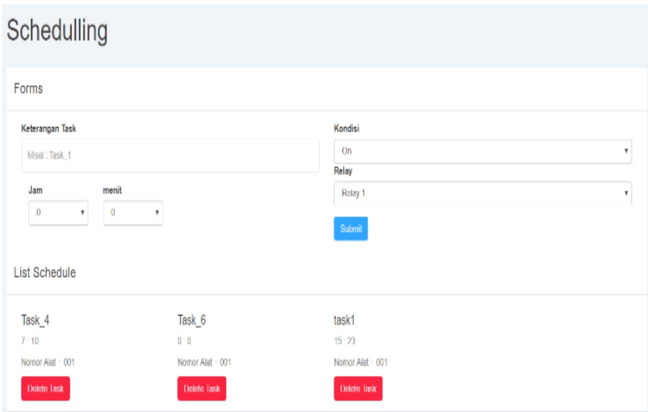

Fig. 7. Scheduling Page

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III. RESULT AND IMPLEMENTATION

Testing of the system that has been designed to divided into several parts, there are voltage and current measurement, relay control and delay testing.

To find the error data of voltage measurement, we use by comparing the result from sensor value with measurement tools as multimeter, it shown on Fig. 8,

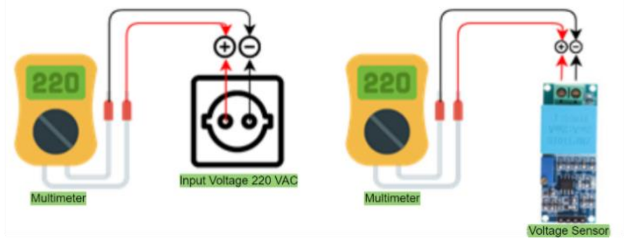

Fig. 8. Scenario of Voltage Sensor Measurement

Current measurement it compared the result of sensor reading value with measurement using clamp meter, as shown in Fig. 9. for functionality of the relay, observe by changing the value of relay on website, to obtain the average delay of sending and received data to the relay from real time database by internet with 4G connection, as show on Fig 9.

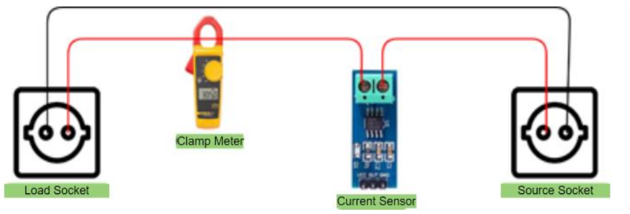

Fig. 9. Scenario of Current Sensor Measurment

A. Accuration of Relay Data

By testing the accuracy of the relay data, it can be seen that the data is still sent and received correctly even though there is a delay in the sending process.The accuracy of the data on the relay shows that the relay is worked as expected to run the Smart Relay system. Relay can adjust its conditions according to the data in database as shows in Table I.

TABLE I. The Accuracy of Relay Data

Relay No	NodeMCU Data	Firebase Data	Condition
Relay 1	"1"	"1"	ON
Relay 2	"1"	"1"	ON
Relay 3	"1"	"1"	ON
Relay 4	"1"	"1"	ON
Relay 1	"0"	"0"	OFF
Relay 2	"0"	"0"	OFF
Relay 3	"0"	"0"	OFF
Relay 4	"0"	"0"	OFF

B. Voltage Sensor Measurement

with using a dimmer to increase and decrease the input voltage, then the voltage sensor read and results by compared to the multimeter reading, the ZMPT101b sensor work with 1.47% reading error due to fluctuations or instability of the input voltage signal. The result of measurement can be seen in Fig. 10.

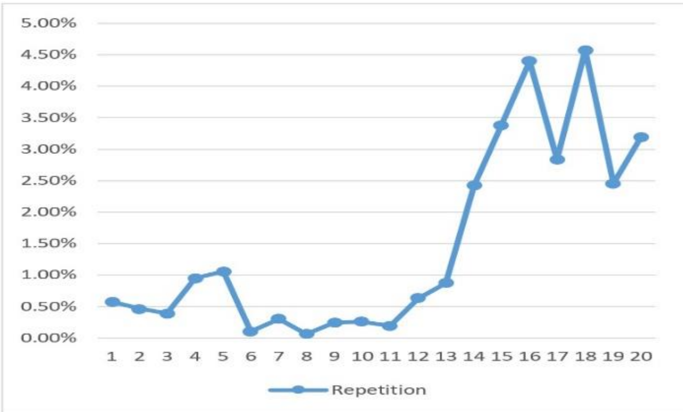

Fig. 10. Voltage Sensor Measurement Graph

C. Current Sensor Measurement

This system use a ACS712-20A and ACS712-30A as a current sensor, with 100 mV/A sensitivity level and ACS71230A have 66 mV/A sensitivity level, the measurement results are slightly different due to sensitivity differences as shown in Fig. 11.

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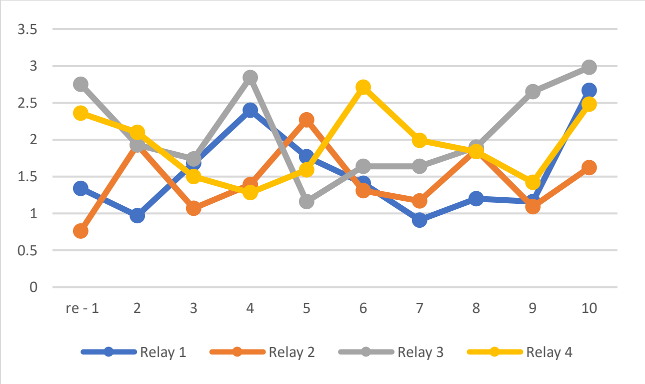

Fig. 11. Current Sensor Measurement Graph

D. Delay of Data Transmision

To obtain the average delay of sending and received data to the relay from real time database by internet with 4G connection, as show on Fig. 12 the average delay for sending relay data on 4G connection is 1.762 seconds.

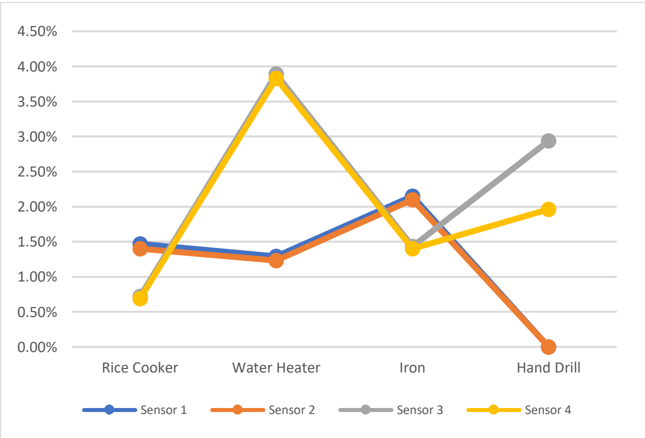

Fig. 12. Delay Graph of Sent Relay Data with 4G Connection

After 20 repetitions the average delay for sending voltage data from sensor to the database is 6.485 seconds. This significant delay is caused by the delay time that inserted into the microcontroller programming to run the system, as shown on In Fig. 13.

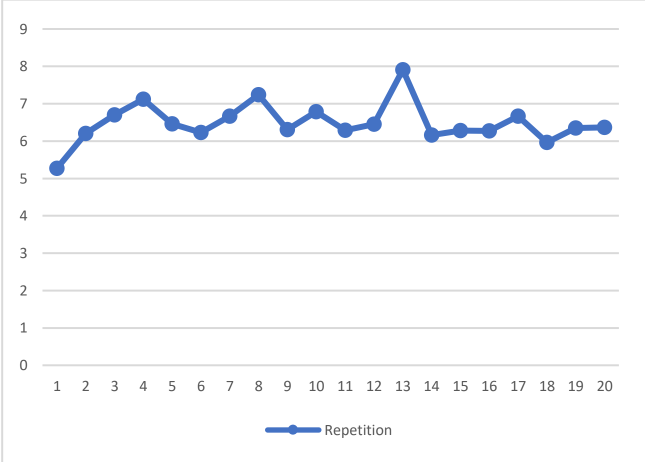

Fig. 13. Delay Graph of Sent Voltage Data with 4G Connection

In the Fig. 14 shows that in sending current data has a delay, that delay is caused by the delay time that inserted into the microcontroller programming for run the system and the sensor sends data alternately, not simultaneously.

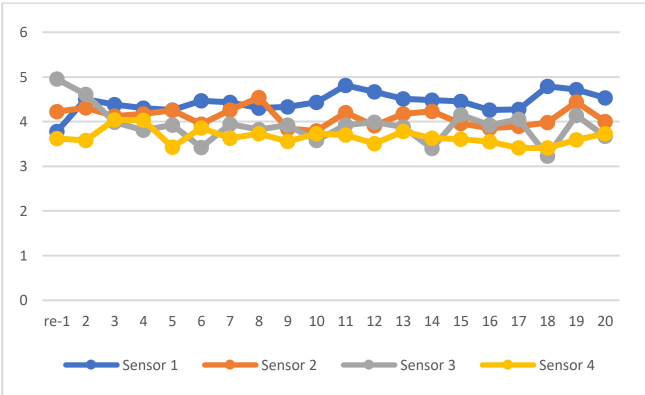

Fig. 14. Delay Graph of Sent Current Data on with 4G Connection

IV. CONCLUSION

1. Smart Relay system can be applied by using the Node-MCU as the microcontroller and use a real time database that provided by Google Firebase. System can control relay condition and monitor voltage, current and power that consumed by electrical.

2. Relay conditions can control remotely by using wireless communication with average delay to receive data from Firebase is 1.76s on 4G network

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3. Monitoring the electrical voltage value using ZMPT101b obtained an error of 1.47% with data transmission delays from Node-MCU to Firebase is 6.48s on 4G network

4. Monitoring the electrical current value using ACS712 obtained an error 1.67%. Measurements on ACS712-30A are more precise than ACS712-20A, this is influenced by the sensitivity of each sensor

5. Average delay to send electrical current data from Node-MCU to Firebase is 4.02s on 4G.

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