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## Monitoring electrical energy in electronic energy audits through internet of things technology

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**Abstract.** Energy conservation, especially electricity, can be done by conducting an energy audit. Energy audit activities can analyse and find energy-saving opportunities from energy use. This study developed a prototype of a wireless electrical energy monitoring system on a laboratory scale to monitor the use of electrical energy from both electrical equipment using a microcontroller as a sensor node. These nodes have installed several sensors, namely the current sensor, humidity sensor, temperature sensor and light sensor. The protocol used in communication between nodes and servers is the HTTP protocol in the Internet of Things design that can communicate using internet network intermediaries. Data on the server can be monitored in real time using the application on the client side.

### 1. Introduction

Energy conservation is an integrated, planned and integrated effort to reduce energy costs incurred (saving energy saving costs) or general definition means that activities in energy use efficiently and rationally which is really needed thus it will reduce energy costs [1]. One of ways to realize energy savings is to conduct energy audit activities [2]. According to problems of conducting energy surveys, the location of rooms and electrical equipment's is far from each other that will make the monitoring process not easy [3], therefore the solution is by using wireless sensor combined with Internet of Things [4] and integrated in energy audit information systems [5,6]. Internet of Things has been used in wide area, from monitoring [7], controlling [8] until automation [9]. The use of electrical energy in Indonesia is still classified as wasteful of energy [10], thus affecting electricity supply, especially on the Java and Bali islands. Examples of energy waste in activities in buildings are the use of air conditioning and lighting that remain turned on when there are not people inside building.

In this paper, proposed way to conduct electronic energy audit is performed. The previous researches were only focus in preliminary energy audit [5] and manual energy audit [11–13]. Real-time energy usage data will be taken by current sensor node built in esp8266 that can be connected to internet through Wi-Fi access.

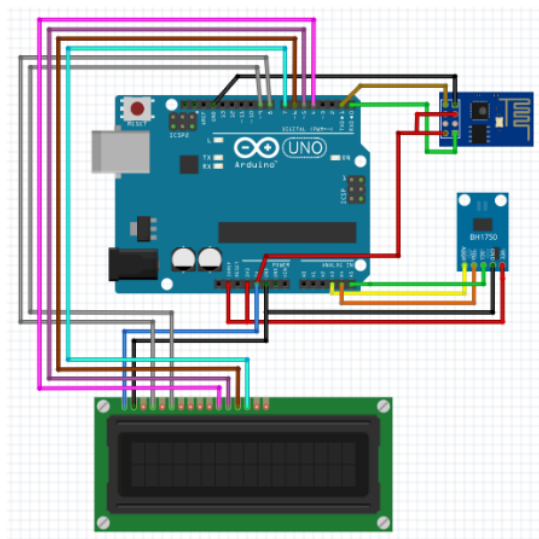


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## 2. Methods

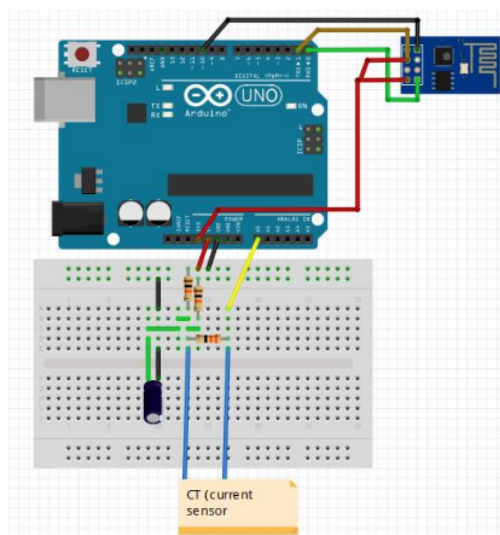
This research is focused in making prototype of electrical energy monitoring that their data collected by sensor nodes sent to server through internet. These sensor nodes have ability to communicate to server by esp8266 Wi-Fi module. It has two type sensor nodes in this prototype. First type sensor node collects light luminosity from lamp that can be seen in Figure 1. Luminosity value is collected by BH1750 light sensor module. HTTP protocol is used to make request and respond mechanism between sensor node and server. The connection between sensor node and server are through a web service. Because the limitation of the Arduino does not possibly make an SSL connection and it need unique (API key) for more secure connection. The authorized device by server is sensor node that sent the correct API key.



**Figure 1.** Sensor node for measuring lux energy.

Respond from server is in JSON format that can be seen in Figure 1. JSON format is chosen because it is lightweight data format compare to the others [14], JSON has advantages for data exchange in web service.

Second type sensor node is for electrical current monitoring that consist of Arduino UNO board and current sensor (see Figure 2). This Arduino is also attached with esp8266 module for wireless connection. Electricity current is sensed by current transformer sensor that used electromagnetic mechanism. Alternating current is measured by current sensor in particular ratio for example 100:0.05 means maximum 100A current in primary coil will be 50mA in secondary coil.

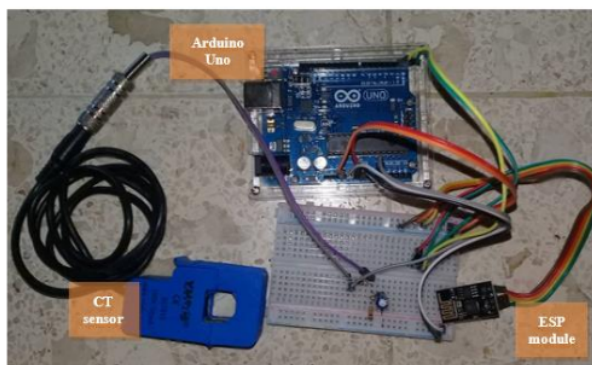


**Figure 2.** Current monitoring using CT sensor in Arduino Uno with 8266 module built in.

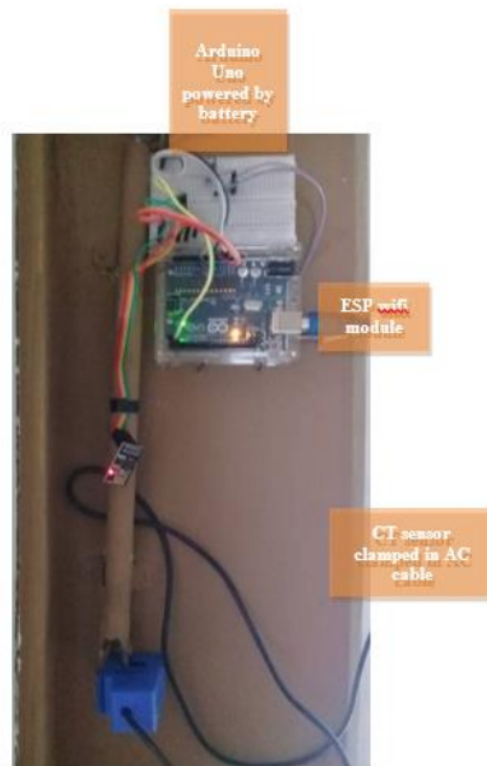
### 3. Results and discussion

The implementation for sensor node to measure electricity current is shown in Figure 3. This sensor node prototype uses project board to make easy connection between electronics components and Arduino Uno. Figure 5 shows the instalment of sensor node in home electricity. The Arduino Uno is powered by battery that supply constant voltage into circuit. The CT sensor has split core that can be separated and clamped to single core AC (alternating current) cable.

Measurement data from Arduino is sent to server using HTTP protocol combined API keys for making secure connection and can be observed in real time using browser application that can be seen in Figure 6. This sensor node has Wi-Fi module that can send data directly to server through internet. The current monitoring shows current ripples because noise from not good grounding of measurement cable and Arduino itself.



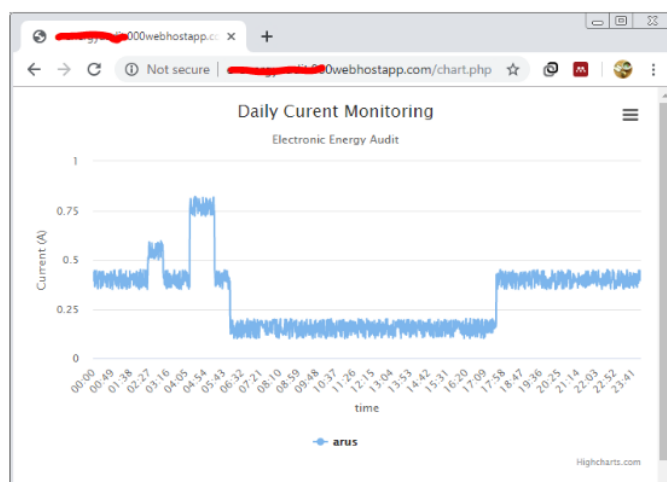
**Figure 3.** Sensor node connected to CT and ESP8266 components.



**Figure 4.** Sensor node instalment in home near KWH-meter.

The sampling data collection is a day measurement. To calculate yearly energy consumption, monthly current measurement is multiplied by voltage (230V) and time (in a year). Then it can calculate energy use index by divided total building area. This value of energy use index can be compared to standard index [15]. Energy consumption of building can be indicated to be wasteful if calculation value is higher than standard value.





**Figure 5.** Electricity monitoring in a day.

Data of humidity, temperature and lux of room are also collected by sensor node that illustrated in Figure 1. This data actually is for comfort manner for human in room. Comfort situation needs to take into account for saving energy, for example the room using a 100-watt incident lamp for lighting can be categorized to energy wasteful. This lamp should be replaced other energy save lamp (e.g. TL (tube luminescent) lamp or LED lamp).

#### 4. Conclusion

Based on previous experiment, it can be concluded that this system of electrical energy has been able to conduct as initial systems design. This system is only prototype that only work on laboratory scale; therefore, it needs to be enhanced in future experiment.

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