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## Smart Energy Meter based on Arduino and Internet of Things

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# Smart Energy Meter based on Arduino and Internet of Things

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**Abstract.** Energy meter is a measuring instrument to calculate the amount of electric energy consumed by an electrically powered device. The energy metering which measure line voltage, current, and calculating active power can be used to increase usage efficiency of electricity. This paper presets a system which provide real time energy meter reading using ACS712 as current sensor, ZMPT101B as voltage sensor, arduino and an IoT server. The energy meter can display consumed energy in kWh and electricity bills to be paid. system's user interface is in Android. the error in current measurement is less than 2 % and error for peak to peak voltage measurement is 4 %. A notification for the amount of electricity energy usage or electricity cost can be generated for user to be displayed.

## 1. Introduction

The power meters are one of important aspect in the smart grid concept [1]. They are the devices which measure electricity and also connecting different equipment over the electric grids. The concept that introduce the automation of measurements of electronic meters was called AMR (Automated Meter Reading). AMR is a concept that enables devices to be accessed remotely and collect the electronic data generated by the meter at consumer units. The data then transmitted from the meter to the electric company using radio frequency, telephone, power line or satellite communication [1].

A smart energy meter (SEM) is electronic device having energy meter chip for electric energy consumed measurement, protocols for data communication, security purposes, interface for data display and other function[2]. The difference of smart meter from traditional energy meter devices is by its communication ability. A smart meter should be able to record active power consumption and also other information of an electronic device, such as: voltage and current phasors, reactive power, maximum power demand, frequency, power factor and other information, in real time [1].

The Internet of Things (IoT) is defined by ITU and IERC as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network [3]. Following the utilization of IoT, the smart meters needs to be developed with the intention of using device and communication technology to attain consumer satisfaction. This paper present a design of a smart energy meter, which provide accurate measurement of power consumption and display it to the consumer.

## 2. Experimental

There are two basic types of electronic meters, electro-mechanical and electronic. The most common type of electricity meters are the electro-mechanical induction watt-hour meter. It works by counting

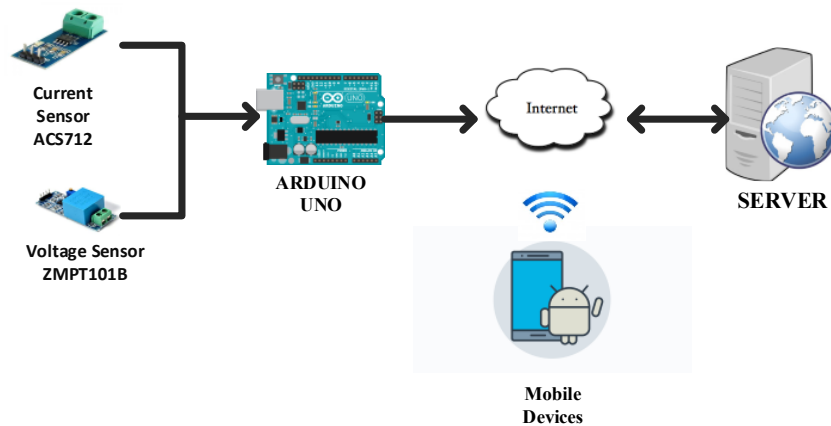


the revolutions of a non-magnetic metal disc which is made to rotate at a speed proportional to the power passing through the meter. The number of the disk revolutions is proportional to the device's energy usage[2]. The electrical power is the ratio of electric energy per unit time. In other words, it is the amount of power used or absorbed by a device within a given time. The giving unit by the International System of Units is the Watt [4]. The real power calculated from the instantaneous power signal. The instantaneous power signal is generated by a direct multiplication of the current and voltage signals [2]. Electronic power is calculate using equation (1)

$$P = V * I \quad (1)$$

where: V is the voltage (V); I is the current (A); P is the power (W)

The system's design for the smart meter using arduino and Internet of Things (IoT) is shown on Figure 1. In our system, the voltage was measured using ZMPT101B, the current was measured by ACS712, and the estimated power is calculated using the effective value of both voltage and current signal. Arduino is used to read the sensors readings and send the data via ethernet shield to the server. The server will receive the data, calculate the estimated power and display it for user. User can access the data using mobile devices.



**Figure 1.** The Design System of The Smart Meter.

ZMPT101B is a voltage sensor made from the ZMPT101B voltage transformer. It has high accuracy, good consistency for voltage and power measurement and it can measure up to 250V AC [5], [6]. ACS712 is a Hall effect-based linear current sensor Integrated Circuit (IC) with 2.1 kVRMS isolation and a low resistance current conductor. This sensor has a maximum 185 mV/A output sensitivity with extremely stable output offset voltage [7]. Both voltage and current units are isolated, very cheap, and easy to use [6]. Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board and a software or IDE (Integrated Development Environment), used to write and upload computer code to the physical board.



**Figure 2.** ZMPT101B Voltage Sensor Module.

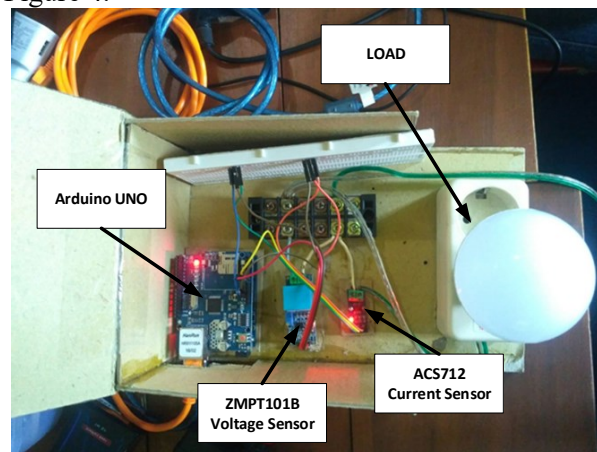


**Figure 3.** ACS712 Hall Effect Current Sensor.

After implementing the system design, sample of voltage and current were taken by connecting the sensors to electric source. Afterward, the value from the sensor is compare with data obtained from a multimeter (Heles UX866TR). A bank of 7W, 15W, 18W, 42W, and 100 W light bulb is connected as load.

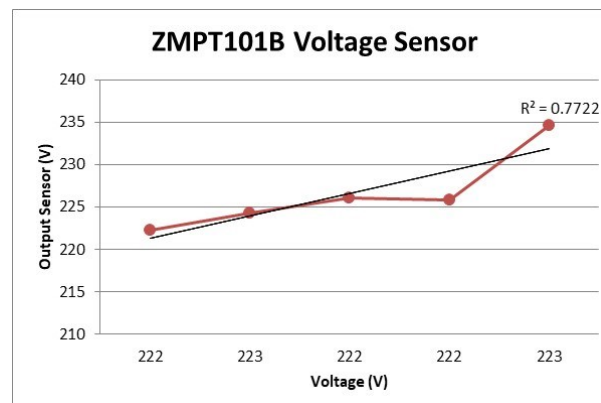
### 3. Results and Discussion

A hardware prototype had implemented according to the design. The hardware prototype for the Smart Energy Meter is shown on Figure 4.



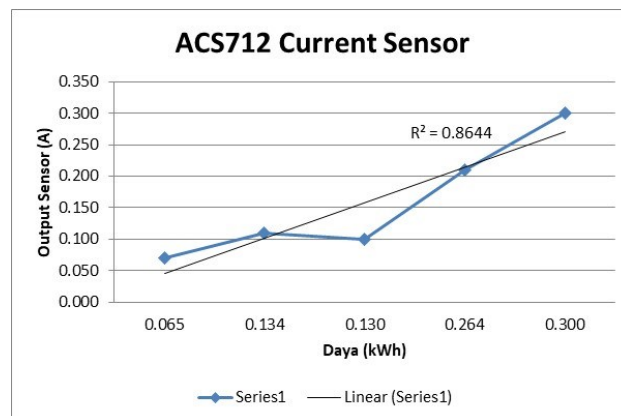
**Figure 4.** Prototype of Implemented Smart Energy Meter.

The voltage measured by the ZMPT101B voltage sensor and the multimeter were read and recorded. The values and are represented as a graph in Figure 5. The accuracy of ZMPT101B voltage sensor's reading is 77 %.



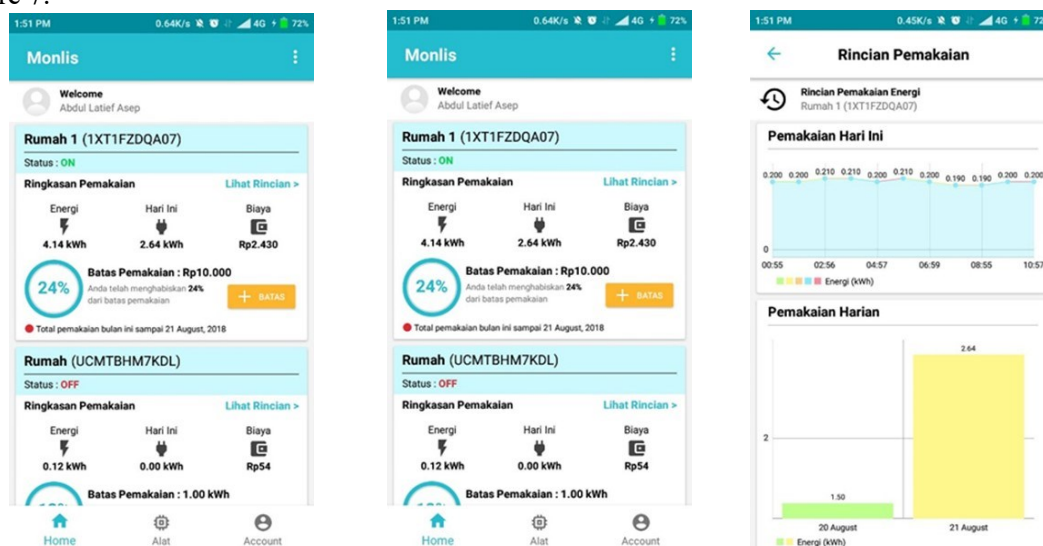
**Figure 5.** Result of Voltage Reading by the ZMPT010B Voltage Sensor.

The current measured by the ACS712 Current sensor and multimeter were read and recorded. The values and percentage errors are represented as a graph in Figure 6. The accuracy of ACS712 current sensor's reading is 86 %.



**Figure 6.** Result of ACS712 Current Sensor's reading.

User interface is design so that user can monitor usage of electricity by the equipment. The user interface also shows the cost spent for the electricity. Smart energy meter's user interface is shown on Figure 7.



**Figure 7.** User Interface of Smart Energy Meter.

#### 4. Conclusion

As conclusion, a smart energy meter using arduino and IoT has been designed and tested. The meter is design to facilitate electronic consumer to monitoring its electrical utilization. The meter consist of ZMPT101B as voltage sensor, ACS712 as current sensor and Arduino UNO with ethernet shield. The data from sensor's reading will be sent to server. Server will calculate the electrical power used by the equipment. User can monitor all of this data using mobile devices. The sensor testing shows 77 % accuracy for voltage sensor and 86 % accuracy for current sensor. The future work is to improve the sensor accuracy that the energy reading become more precise.

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