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Smart Meter and Electrical Energy Monitoring Devices

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Abstract: Nowadays, electricity bills are increasing from time to time with the increasingly sophisticated technology that uses a lot of electricity at home. With the use of standard meters, consumers cannot predict the use of electricity at home and cannot control electricity use prudently. By using smart meters, consumers can manage their electricity bills from continuing to increase. This project focuses on developing a Smart meter and Electrical Energy Monitoring Device that can monitor the electrical consumption at home and control electricity production by switching off the load. The project used the Arduino UNO to read the information from the AC sensor and send the notification to the consumer through a mobile phone. The project works to monitor electrical appliances and send the notification through Blynk application on the mobile phone.

Keywords: Arduino UNO, Current Sensor, Smart Meter, Power Consumption

1.0 INTRODUCTION

Human life will be difficult without electrical energy. It is also a source of socio-economic progress and agricultural development in-country and is primarily a basic need for human life. Furthermore, the provision of electricity is not only the necessities of life, but it becomes very important to shape the general public's lives. Again, to bridge the gap between the demand for electricity consumption in Malaysia and electricity suppliers, non-technical losses can be overcome with advanced technology to solve this problem.

In this project, the Smart Meter and Electrical Energy Monitoring Devices are proposed to reduce the electricity consumption in homes by having it monitored using the mobile phone and controlling the electrical load to avoid rising electricity bills. This project will send the data of electrical uses in the home and send the information to the consumer by informing the data through mobile phone. In this project, the smart meter will be upgraded from using GSM to use module WI-FI to send more specific information about electrical consumption at home to consumers.

2.0 PREVIOUS WORKS

The previous works in journal Smart Energy Meter for Load Control using Mobile Communication Technology by Aniedu A.N., Inyiama H.C., Chukwuneke C.I., and Asogwa D.C. was using Atmel microcontroller as the main part for evaluating consumed electric power and Power Factor. The GSM module has been used to send the notification to the consumer and design to use in two communications. The method in previous works that have been uses in these journals was taking the power supply as input and sending the reading kilowatt per hour to metering unit and microcontroller AT89C52. The information that has been sending to the microcontroller will sending through GSM and it will notification the consumer.[1]

The previous works from the journal GSM Based Smart Energy Meter with Arduino Uno, written by Norfadzlia Mohd Yusof, Siti Asma Che Aziz and Win Adiyansyah Indra was proposed to demonstrated Smart Energy Meter that users can monitor their existing power consumption (bill) from anywhere via short message services (SMS) via their mobile phone. The methodology was used in this journal the supply was reading by automatic meter reading and send the information to Arduino UNO and microchip RTC DS1307. The microchip only reading the clock real time and send the record to

Arduino UNO that can storage the billing in every first month. The output in these projects was GSM SIM900 and Zigbee where the information was sent to consumer through mobile phone.[2]

Journal GSM Based Smart Energy Meter with Arduino Uno from the previous work, written by Henry Amhenrior was proposed to shown the Development of an SMS-Based Prepayment Energy Meter Monitoring System for monitoring and control the consumption using mobile phone. The methodology that has been use in previous work was the use two microcontroller, Arduino Atmega2560 used for meter control, monitoring functions and communication. The software that been used in these previous works was programmed in C ++ to read and send SMS from Arduino to the communication between the modem (SIM900) and controller.[3]

The journal of previous work, written by Patrick Mapulane, Tshepang Letshwiti, Mompati Molibe, and Oagile Gaogane was proposed to develop Smart Meter Energy using the Arduino ATMEGA328 as a process. The methodology that been used in the previous work the smart meter was using the Arduino as a microcontroller and uses the GSM to send the notification to the consumer. The reading of power consumption continued after all the system on and send the notification to mobile phone after the reading were past the limit. [4]

The journal GSM Enabled Smart Energy Meter and Automation of Home Appliances was written by Himshekhar Das and L.C.Saikia. the research project was using the Arduino UNO and the operate with ATmega328 and take measurement of current was using the Allegro Current Sensor (ACS712-30A) as the input. The previous research project show that Arduino UNO calculate energy consumption and sends it to the utility once per hour and utility smart meters through communication with data for demand-side management. The consumer can with off using the communication of GSM and were alert when the energy consumption exceeds. Energy consumption information from the Arduino connect to a virtual instrument program on display at home.[5][6]

3.0 MATERIALS AND METHODS

Block Diagram

The element in this chapter includes a block diagram, flow chart, circuit schematic diagram, software and cost estimation. In the block diagram, the input, process and output will be mentioned.

Smart Meter and Electrical Energy Monitoring Devices will develop by using the Arduino UNO, WI-FI module, current sensor and logic level converter. This project to collect the data of electrical consumption to monitoring through the mobile phone and controlling output of electrical by cutting the switch like lamp or fan in the house.

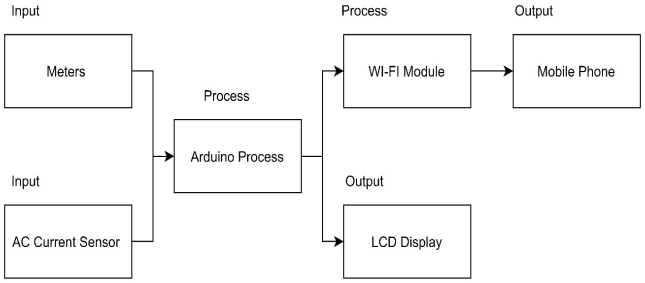

Figure 1: Block Diagram

The input from the Figure 1 is the load. The load is connected with electrical appliance and the current will flow when the power supplied the load. Second input is AC current sensor. From AC current sensor, the reading of ampere will be sent to the Arduino UNO to process the calculation on watt, kilowatt per hour ampere, and Ringgit Malaysia (RM) data to output. The module Wi-Fi is a process of the data after the reading the ampere was calculate in Arduino. The data in module W-Fi will be sending to the output of mobile phone in appearance of notification. For the output of LCD display in Figure 1, the process from the Arduino UNO will sending the data of watt, kilowatt per hour, ampere and Ringgit Malaysia (RM) to the output of LCD display on the device.

Flowchart

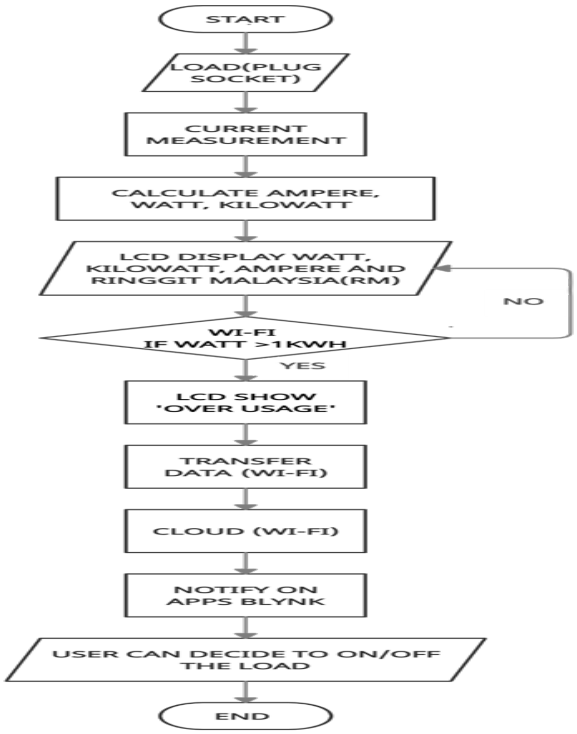

Figure 2: Flowchart

The system in this flowchart from Figure 2 is the supply from TNB will supplied to the load and through the AC current sensor. The AC current sensor in this flowchart is to measure the current that flow from the load and will send the information reading of ampere to Arduino UNO. The AC current sensor output will be reading the current and transfer the data by using Arduino UNO through analog read pin.[7] The Arduino UNO will process and calculate the reading of ampere in watt, kilowatt per hour(kWh), ampere and Ringgit Malaysia (RM). The calculation of the consumption electrical will be sending the result on the LCD display in watt, kilowatt per hour(kWh), ampere and Ringgit Malaysia.

The setting of limits kilowatt per hour can be set by the consumer for the usage of electrical appliance at home. The example limits of usage electrical appliance for the project that been setting to 1kWh. if the usage electrical are more than the limit of usage of electrical at home or equal with 1kW, the information will proceed to next system were sending the data to the cloud and notify on mobile phone via module Wi-Fi. The data will show as the 'over usage' on the LCD display and the data also will notify on the application Blynk. When the user gets the notify on the mobile phone, the user can decide to turn on or turn off the load of electrical appliance. If the usage electrical are less than 1kW, the system eventually returns to LCD display. The system using the module Wi-Fi must be connected to the device of Wi-Fi at home to ensure the Wi-Fi module can send the information to consumer's mobile phone.[8]

Circuit Diagram

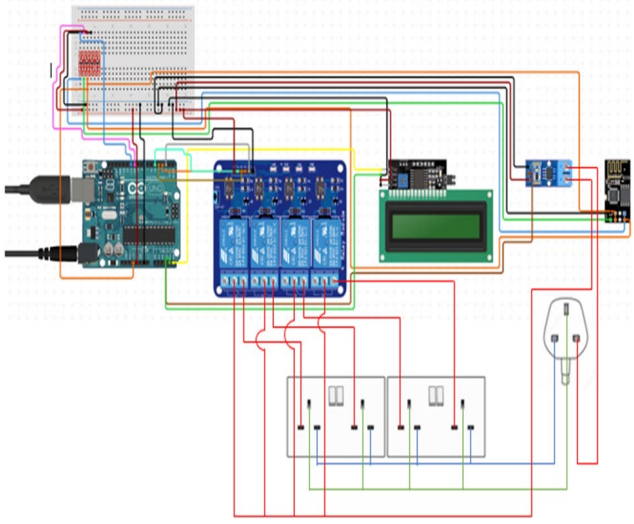

Figure 3: Circuit Diagram

From the Figure 3, the circuit diagram shows the connection wire of component between Arduino UNO, AC current sensor, LCD display, ESP8266-01- module Wi-Fi, relay 4 channel and plug 3 socket 4 slot. Each component needs the supply from the Arduino UNO. The component that uses 5V are relay, LCD display, and AC current sensor. For the module W-Fi, the supplied need is 3V. The wire on the LCD display is connected to analog in on the Arduino UNO for to display the data. For the relay, module Wi-Fi, and Ac current sensor are connected to the digital in on the Arduino UNO for to send the data at LCD display. The wiring of the plug 3 socket 4 slot is wire with relay 4 channel. From the supply, there is three wires. The wire on red is live, for the blue is neutral and the green wire is earth. The wire live is connected with relay before wiring on the plug and then the wiring will go to the plug. The live wire on the relay will be wiring on the plug with separately. From the supply, the wire neutral and the wire earth are connected to plug. Arduino UNO can be supplied with two type of power supply. The first one is using the USB type A male to B male. The second one is using the adapter 5V to supplied the Arduino UNO.

4.0 RESULTS

The application of the project system on smart meter and electrical monitoring device, has been installed and incorporated coding into Arduino UNO as the main brain in controlling and monitoring electrical consumption. The power comes from the 5V adapter supplied to the Arduino UNO.

The project used 4 relay to control the load as switch on and switch off. The 4 relays were connection with each plug adapter before putting the electrical appliance. When the Arduino UNO supplied by the adapter power supply 5V, all four relays become switch on plug adapter and the electrical appliance can be used. The electrical appliance that applied on each relay were, toaster, vacuum, table fan and iron cloths. Each relay was controlled by using application Blynk and the module Wi-Fi ESP8266-01 was the medium connection between telephone and the Arduino UNO. The result was show on the LCD screen and the data consumption of electrical appliance when using the single plug adapter was record in application Blynk.

Each plug adapter was label as 1, 2, 3, and 4. The electrical appliance on the plug adapter. The result was show on the LCD screen and the data consumption of electrical appliance when using the single plug adapter was record in application Blynk. The first plug adapter was used for vacuum and the result of power consumption on the LCD screen shown in Figure 4 and the result by the application Blynk shown in Figure 5.

Figure 4: Result of watt, ampere, kilowatt per hour and Ringgit Malaysia (RM) on LCD screen for vacuum

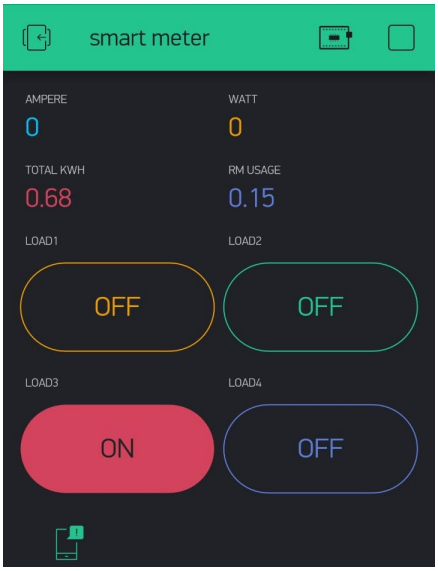

Figure 5: Result of watt, ampere, kilowatt per hour and Ringgit Malaysia (RM) on application Blynk for vacuum

The result when over usage is shown on LCD screen when the reading of kilowatt hour on figure 6 was higher than 1KWH. The limit setting for kilowatt per hour in the Arduino UNO shown the project is successful and the notification is sent to mobile phone through application Blynk. The result of the notification was on Figure 7.

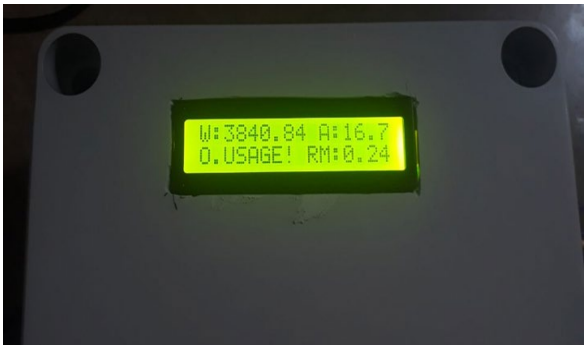

Figure 6: Over usage after total kilowatt per hour 1KWh

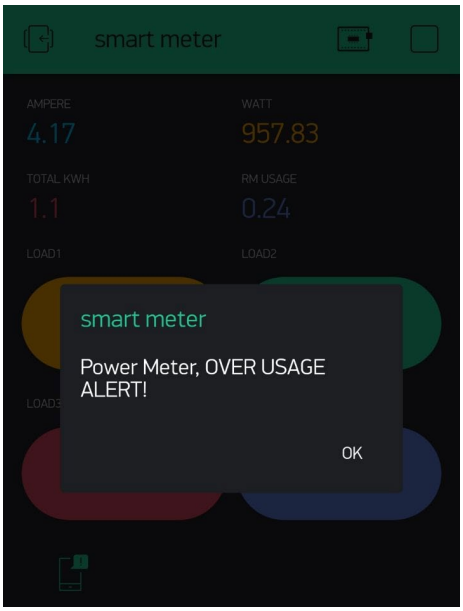

Figure 7: Notification of over usage power consumption on application Blynk

5.0 DISCUSSION

To ensure the success of Smart Meter and Electrical Energy Monitoring Devices design, a number of challenges in terms of coding and testing of electrical appliances used to obtain the desired results. The challenges faced while doing this project are the difference of power readings with the equipment used shown on the LCD screen and the power consumption limit shown in the description on the electrical appliances. This is because the system only load with unity power factor is tested, as the system is not design to monitor and measure load with lagging power factor.

By installing proper transducer for power measurement which includes the phase differences between the voltage and current can improve the accuracy of the power measurement. Further study and comparison must be done to analyze the accuracy of the measurement.

Apart from that, even though it can inform and notify the consumers of over usage, the consumer need to choose manually which load to be disconnected if needed to reduce consumption. This could be done by having the option to preset which load to be disconnected if necessary.

6.0 CONCLUSION

In conclusion, the smart meter and electrical energy monitoring device project has been achieved according to the objective requirement. Therefore, these three objectives have been achieved and the project is ready to be developed in a timely manner. Results have shown that power consumption can be measured and priced

accordingly. Warning system is also incorporated to warn the consumer of usage above a certain limit set earlier.

Further progress on this work could be done by adding its technical capabilities of measuring a three phase installation and loads and also loads with varying power factor. This is especially important for it to be working in industrial plants and commercial buildings.

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