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Energy Meter for Residential Electrical Appliances

Irfan Farhan Zainulakramin[1], Muhammad Saufi Kamarudin[1]*

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, 86400, Johor, MALAYSIA

*Corresponding Author Designation

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Abstract: An energy meter is a measuring instrument that can be used to measure the quantity of electricity or energy in accordance with the amount of time that has passed. The current energy meter drawback is that the consumer will not be able to know how much the cost is to run a specific electrical appliance. This will contribute to the waste of precious energy by them. To solve this problem a prototype of an Energy Meter for Residential Electrical Appliances is produced to help the consumer to monitor the power consumption of their electrical appliances and the cost to use it. An Arduino Microcontroller and current sensor is the main electronic component that is used to produce this prototype. The prototype is tested on four different electrical appliances that can be found in a house. The data that is received from the prototype shows the voltage, current, power usage and the cost to run the electrical appliances. This data that is received by the end user can be used to estimate the monthly cost to run the electrical appliances.

Keywords: Energy Meter, Arduino Uno Microcontroller, Current Sensor

1. Introduction

Electricity is a basic need that almost everyone in the world depends on. There is a trend of growth in electrical consumption and demand across the globe. Households in Malaysia use electricity for daily use, such as lighting up the house, cooking, washing, and other things. electricity is utilised to provide energy services such as light, comfort, and entertainment in domestic buildings. Still, a complex set of interconnected and interacting socioeconomic, housing, and appliance-related factors [1]. Through electricity, electrical appliances can be used to ease the work that is previously done by hand. Electrical appliances make life much easier for people as it is more efficient and less time-consuming with better technology and better electrical appliances.

In West Malaysia, electricity is supplied by Tenaga Nasional Berhad (TNB) and has the right to distribute and charge for the electricity used all over the country, whether it be for residential use or

*Corresponding author: saufi@uthm.edu.my

commercial use. In a household, the tariff is used to calculate the amount of electricity used and how much must be paid for the used electricity. An energy tariff is a price a consumer pays for their electricity usage [2]. Hypothetically, as more and more electricity is used for electrical appliances, the higher the cost that has to be borne by the consumer.

Some electrical appliances may use more power than others, and consumers typically believe that appliances that use more power will result in higher electricity bills. This is a misconception among the consumer that must be changed. This is because even though the electrical appliances have a high-power rating, the time used for the appliances may be short. This means that the use of high-rating electrical appliances will not have a huge impact on the monthly electricity bills

Nowadays, electrical items are utilized everywhere. The increased use of electrical appliances will lead to a rise in power consumption and, consequently, higher electricity bills. Electrical energy demand in households also increases over the year as more and more developers build residential areas throughout the country. In 2018 households in Malaysia used 7759 ktoe compared to 3322 ktoe in 1998 [3]. Consumers typically do not aware of which electrical appliances consume the most power and which do not when using electrical equipment. Consumers will have difficulty identifying which electrical equipment is contributing to the increase in their home's energy use.

The second issue that most consumers face while using their electrical equipment is that they do not realize how much electricity their appliances require. Typically, the power rating shown on the appliance indicates the amount of energy it will consume every hour. However, not every device will be utilized for an hour or longer. As an example, consumers normally do not use water heaters for more than an hour. Due to this issue, consumers cannot possibly estimate how much it will cost them to use their appliances for such a brief period, nor can they determine how much electrical energy their equipment is consuming during that brief period.

To address this issue, a prototype of an Energy Meter for Residential Electrical Equipment is created to assist consumers in monitoring the power use and cost of their electrical appliances. A Microcontroller Arduino and a current sensor are the primary electronic components utilised to construct this prototype. The testing of the prototype demonstrates that it is compatible with a variety of electrical appliances, allowing consumers to estimate the monthly cost of using the electrical appliances.

The objective of this project is to develop a smart home energy meter that can help the consumer to be able to notice the usage of each electrical appliance in their house. This product will help increase consumers' awareness of how much the appliances they are using consume electricity. This product will be able to design an appliance that can calculate the amount of energy used in a period of time by an electrical appliance, determine the electrical power consumption of a household electrical appliance, to calculate the cost to run the appliances in a period of time.

2. Development of Portable Energy Meter

The prototype is developed by using 3 main components which are Arduino Uno Microcontroller, ACS712 current sensor and an LCD screen. The software uses to write the coding for the microcontroller is Arduino IDE software. The prototype is built through two phases which is wiring connection and code writing which will be explained further in this chapter

2.1 Electronic components

(i) Arduino Uno Microcontroller

The first electronic component used in this prototype is an Arduino Uno microcontroller as shown in Figure 1. The Arduino Uno is a microcontroller board that employs the ATmega328 (datasheet). This board contains 14 digital input/output pins (six of which can be used as PWM outputs), six analog inputs, a 16 MHz crystal oscillator, a USB port, a power jack, an ICSP header, and a reset button. People who work in the electronics industry are gradually recognising and accepting Arduino's role in their own projects. This development board can also be used to burn (upload) new code to the board by connecting it to a computer via USB. The Arduino IDE is a simplified integrated platform that runs on standard computers and allows users to write Arduino programs in C or C++.

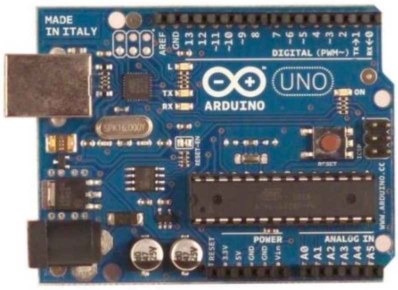

Figure 1: Arduino Uno Microcontroller

(ii) ACS712 Current Sensor

The ACS712 (Figure 2) is a current sensor that can work in both AC and DC environments. This sensor runs on 5 volts and outputs an analog voltage proportional to the current measured. A series of precision Hall sensors with copper lines make up this tool. When the current through the copper primary conduction path increases, the output of this instrument has a positive slope (from pins 1 and 2 to pins 3 and 4). The conduction path's internal resistance of this current sensor is 1.2 mΩ.

Since the output that is generated by the current sensor is analog, we can use a voltmeter to directly measure the output voltage, or we can use a microcontroller like Arduino's Analog Read pin or ADC pin to measure it.

Figure 2: ACS712 Current Sensor

(iii) Liquid Crystal Display

LCD as shown in Figure 3 is a type of electronic display module that is utilised in a wide range of circuits and devices such as mobile phones, calculators, computers, television sets, and so on. Multi-segment light-emitting diodes and seven segments are the most common applications for these displays. The main advantages of utilising this module are its low cost, ease of programming, animations, and the fact that there are no restrictions on displaying unique characters, special and even animations, and so on.

Figure 3: Liquid Crystal Display

2.2 Prototype Development

There are two main phases in the development of the prototype which are the wiring phase and the code writing phase. For the first phase, three essential wiring connections in this prototype are the connection between the power outlet and the current sensor, the connection between the current sensor and the Arduino Uno microcontroller, and the connection between the Arduino Uno microcontroller and the LCD display. This connection must be made according to the requirements to ensure that everything is functioning properly and to safeguard sensitive electrical components such as the microcontroller and the current sensor from harm. Multiple types of wire are utilized in the wiring of the prototype, including breadboard jumper wire, which is used to link the current sensor to the Arduino Uno microcontroller and the Arduino Uno microcontroller to the LCD display. In the prototype, a 1.5-millimeter-diameter wire was utilized to link the power outlet to the current sensor. The connection that is made for the prototypes is depicted in the figure that follows. Figures 3 - 5 show the wiring connection for the circuit.

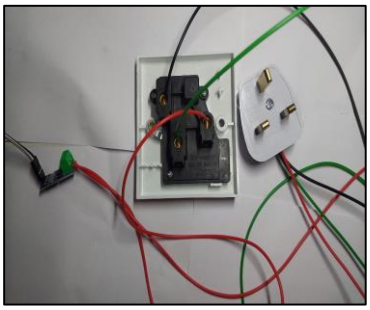

Figure 3: Wiring Between Power Outlet and Current Sensor

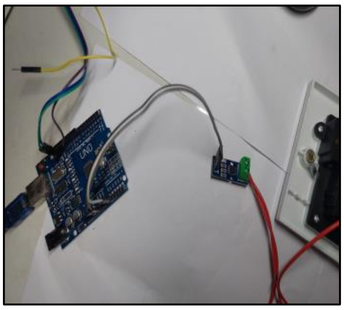

Figure 4: Connection Between Current Sensor and Arduino Uno Microcontroller

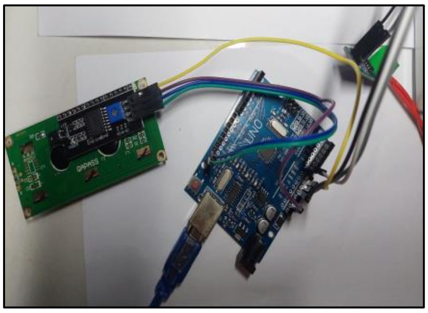

Figure 5: Connection Between Arduino Uno Microcontroller and LCD display

For the next phase, which is the code writing phase, coding for the Arduino Uno Microcontroller is done by writing the coding using C++ language in the Arduino IDE software. There are a few stages of writing the coding to ensure that the coding written is correct and the value that is expected to be generated on the LCD screen is shown.

3. Energy Measurement Result and Analysis

This section will explain the data collected from the various household electrical appliances. The selection process is influenced by both the power rating of the appliances and the typical daily usage duration. Four distinct types of electrical equipment have been selected a refrigerator, rice cooker, stand fan, and laptop battery charger which can be seen in the table below. The obtained data will be compared to gain an idea of the electricity consumption and cost associated with operating electrical equipment for a single day. Using this information, an estimate of the monthly cost of operating the appliances will be generated. This information is significant because it will assist the end user in better understanding the costs associated with operating their electrical appliances, and it will also aid the end user in regulating and reducing their future usage of electrical equipment. Table 1 shows the Electrical Appliances tested by the prototype.

Table 1: Electrical Appliances tested by the prototype

Electrical Appliances	Model Number	Figure
Stand Fan	MQ-P216ST	
Laptop Charger	A18-150P1A	
Refrigerator	GR-232SV	
Rice Cooker	FRC 218	

3.1 Results and Discussion

Table 2 shows the data collected by the prototype when implemented on various electrical appliances. The data collected shows that the refrigerator is contribute the most to the monthly electricity while the laptop charger contributes the least.

Table 2: The data collected by the prototype when implemented on various electrical appliances

Electrical Appliances	Typical Usage Time In One Day	Average Power Consumption While Operating	Total Power Consumption In One Day	Cost To Run In One Day	Estimated Cost To Run In One Month
Stand Fan	8 hours	136.7 Watts	1.13325 kW	RM 0.25	RM 7.00 – RM 7.75
Laptop Charger	5 hours	85.23 Watts	0.58188 kW	RM 0.13	RM 3.64 – RM 4.03
Refrigerator	24 hours	568.77 Watts	13.76134 kW	RM 3.00	RM 84.00 – RM 93.00
Rice Cooker	30 minutes	1971.53 Watts	0.86936 kW	RM 0.18	RM 5.04 – RM 5.58

4. Conclusion

In conclusion, the prototype achieved all the objectives that are set for the prototype. The prototype can show the power that is used by the electrical appliances and the cost to run it in one period of time. The prototype has been shown to work effectively and has accomplished all of the goals that were set for the project. The fact that the prototype was successfully implemented across a variety of electrical appliances demonstrates that it is user-friendly. The advantage that can be gained from the prototype is it is able to help in monitoring the energy usage of electrical appliances in the house, able to estimate the monthly cost to operate the electrical appliances, and help the user in determining which electrical appliances' electricity usage contributing the most to the monthly electricity bill and potentially help the user to reduce energy waste in their home

Acknowledgement

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