

Energy Meter Using a Smartphone

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Abstract: This project is conducted to establish a monitoring system for electricity consumption that can be controlled via IoT-based protocol enabling consumers to monitor their electricity consumption based on real-time and automatic reading of electricity meters at single-load electrical appliances. The goal of implementing this program is to allow consumers to improve their behaviour in terms of energy use by making efforts to manage electricity demand better and minimize carbon emissions. This device is constructed using NodeMCU, a microcontroller. The programming which contains the code for reading from the current transformer sensor will be submitted to the board of NodeMCU. The programming also includes formulae for measuring energy usage based on TNB's electricity tariff. The energy consumption information or data will be sent via Wi-Fi to Smartphone apps using the Graphic User Interface. With more excellent timeliness and ease of access for customers or energy suppliers, the program is expected to help customers regulate their electricity consumption.

Keywords: Electricity Monitoring, IoT-Based Metering, Online Energy Meter

1. Introduction

The conventional electricity metering system is an inadequate tool for managing electricity consumption since it depends on the monthly bill, uses manually to read from meters, and manages the field data. Not only this system cost more in managing areas, but it also is incapable of providing real-time pricing for customers to monitor their electricity consumption and contributes to excessive electricity utilization. The accessible source of electricity gets distributed to different electrical loads within the household without people being aware of the individual use per load since the overall cost is reported as a single number in the electricity bill[1]. Due to weaknesses of KWh meter which only counts for total household electricity consumption, careless usage of electricity by consumers who do not realize its cost.

In this project, the energy meter must be invented for more understanding of the power consumption of each load. This energy meter is based on the IoT platform, which will give the user to track the power consumption of each load using a smartphone with the time database analysis. It also will send the warning alert to users if the power consumption of the loads reaches the budget limit of power consumption that have been set. Therefore, the consumer will be aware of their wastage of electrical energy and take action on it. Users have to observe the specifications for every electrical equipment to know the energy used.

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2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study.

2.1 Materials

Selecting the right material and the right product to develop is crucial to making sure that every component that is connected works well. Besides, the components used must also have the correct specifications to prevent any damage.

The material used for the mainframe or case for prototype Energy Meter Using Smartphone is plastic as shown in Figure 1 and 2. It is because plastics can last longer than corrosive iron when products are used for long periods. Besides, the insulating plastic properties are also a significant factor in the design of this product. The approximate size of the product framework is 20 cm X 15 cm X 8 cm.

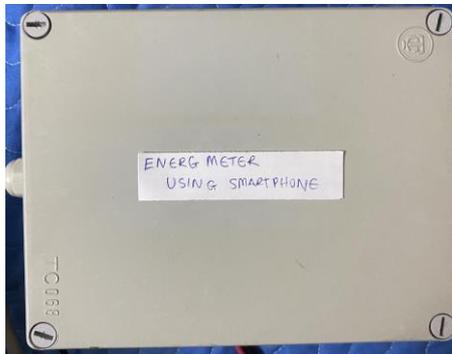


Figure 1: Material of product in front view



Figure 2: Material of product side view

2.1.1 Hardware used for product development

Table 1: Hardware used in the project

No	Hardware	Picture
1	Junction Box	
2	NodeMCU Esp32	
3	AC Current Sensor SCT-013-000	

ZMPT101B Voltage Detector



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2.2 Methods

The development of product circuits is a critical component of the prototype of this IoT energy-use monitoring system. This circuit connects between the current and micro detector ESP32 [2] sensors to the blynk application. Since the SCT 013 current detector uses an audio jack as an input connector, should make some modifications by cutting off the end of the audio jack and manually wiring it to the microcontroller. However, when the cable is cut, it will cause the wire to be exposed, and there is no resistance to prevent the excess current flowing into the micro-controller. To limit the current flowing between the ESP32 and the SCT 013 current detector. Here is the circuit diagram for the connection between ESP32 and the SCT 013 current detector.

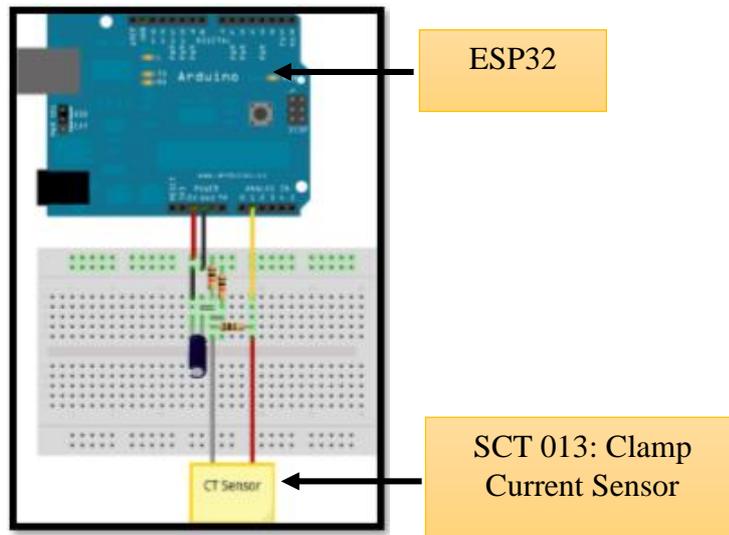


Figure 3:Diagram of connectivity circuit of SCT 013[3] and NodeMcu ESP32[2]

Next, some coding commands will be performed on the NodeMCU ESP32 controller to direct it to process and transmit data collected by the current detector to the blynk software, using Wi-Fi as a signal transmission medium. Once blynk receives the data from the microcontroller, it will translate the data into graphs for analysis by the user.

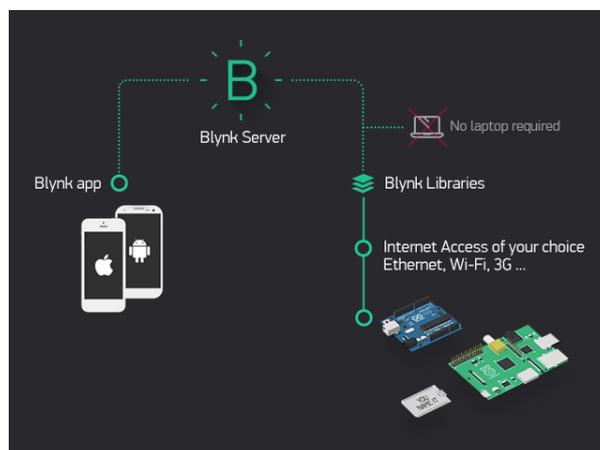


Figure 4:Concept blynk system [4]

2.3 Equations

Eq. 1 should be numbered based on the section number as the following:

$$P_{True\ Power} = V \times I \times 0.85 \quad \text{Eq.1}$$

For 0.85 is value power factor (pf) in Malaysia. Eq. 2 is:

$$Wh_{Watthour} = P_{True\ Power} \times \frac{1}{3600} \quad \text{Eq. 2}$$

This Application Blynk using Watthour because, in Kilowatt-hour, the value becomes smaller. Eq. 3 is

$$Billing = Watthour \times 0.218 \frac{1}{1000} \quad \text{Eq. 3}$$

For find value Billing in Eq. 3 use 1st block at table tariff Malaysia, it is 0.218. To find Billing need in Kilowatt-hour that why formula must need divide $\frac{1}{1000}$.

3. Results and Discussion

The results and discussion section present data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate. Functional energy meter using a smartphone is tested using three different types of loads rice cooker, air fryer and electric kettle. It is to ensure that the detector can detect different currents correctly. This energy meter using a smartphone can detect current, voltage value, power, kWh and billing that uses. Also, it will send notifications to users if there is excess energy used. For this test, has set the power limit to 1500W. The data view can be accessed through the Blynk application as well as Microsoft Excel software shown in Table 2.

Table 2: Energy meter display through blynk application

Type of Load	Data Display	Reading Voltage, Current, Power, KWh And Billing
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Rice Cooker



- a) Voltage = 242.288V
- b) Current = 2.11364 A
- c) Power = 435.294 W
- d) Wh = 0.142
- e) Billing = 0.000031sen
for 1min
For 30min =
0.009355sen
When use 3time in day
=0.0009355sen * 3
=0.002807sen for per
day
For 1month =
0.002807sen*30days =
0.084195sen

Air Fryer



- a) Voltage = 242.382 V
- b) Current = 5.41982A
- c) Power = 1116.62W
- d) Wh = 0.365
- e) Billing = 0.0000795sen
for 1min
For 30min =
0.0015867sen
When use 3time in day
=0.0015867sen * 3
=0.0047601sen for per
day
For 1month =
0.0047601sen *30days
= 0.142803sen

Electric Kettle



- a) Voltage = 241.097V
- b) Current = 7.25139A
- c) Power = 1486.05W
- d) Wh = 0.486
- e) Billing = 0.0001059sen for 1min
 For 30min = 0.0007413sen
 When use 3time in day = 0.0007413sen * 3 = 0.0022239sen for per day
 For 1month = 0.0022239sen * 30days = 0.066717sen

Notification when overpowering



- a) Power = 1646.37W
 Get Notification when overpower 1500W

Table 3 tabulated the billing display when using rice cooker 30 minute

Table 3: Billing display when using rice cooker 30 minute

Load	Billing Display		
	1	Billing	Timestam Date/Time
	2	0.000031	1.60E+12 29/07/2020 - 04:08:00
	3	0.0000615	1.60E+12 29/07/2020 - 04:09:00
	4	0.0000935	1.60E+12 29/07/2020 - 04:10:00
	5	0.0001255	1.60E+12 29/07/2020 - 04:11:00
	6	0.0001565	1.60E+12 29/07/2020 - 04:12:00
	7	0.0001870	1.60E+12 29/07/2020 - 04:13:00
	8	0.0002180	1.60E+12 29/07/2020 - 04:14:00
	9	0.0002500	1.60E+12 29/07/2020 - 04:15:00
	10	0.0002810	1.60E+12 29/07/2020 - 04:16:00
	11	0.0003130	1.60E+12 29/07/2020 - 04:17:00
	12	0.0003440	1.60E+12 29/07/2020 - 04:18:00
	13	0.0003745	1.60E+12 29/07/2020 - 04:19:00
	14	0.0004055	1.60E+12 29/07/2020 - 04:20:00
	15	0.0004365	1.60E+12 29/07/2020 - 04:21:00
	16	0.0004675	1.60E+12 29/07/2020 - 04:22:00
Rice Cooker	17	0.0004985	1.60E+12 29/07/2020 - 04:23:00
	18	0.0005295	1.60E+12 29/07/2020 - 04:24:00
	19	0.0005605	1.60E+12 29/07/2020 - 04:25:00
	20	0.0005915	1.60E+12 29/07/2020 - 04:26:00
	21	0.0006225	1.60E+12 29/07/2020 - 04:27:00
	22	0.0006535	1.60E+12 29/07/2020 - 04:28:00
	23	0.0006845	1.60E+12 29/07/2020 - 04:29:00
	24	0.0007165	1.60E+12 29/07/2020 - 04:30:00
	25	0.0007475	1.60E+12 29/07/2020 - 04:31:00
	26	0.0007785	1.60E+12 29/07/2020 - 04:32:00
	27	0.0008105	1.60E+12 29/07/2020 - 04:33:00
	28	0.0008415	1.60E+12 29/07/2020 - 04:34:00
	29	0.0008725	1.60E+12 29/07/2020 - 04:35:00
	30	0.0009045	1.60E+12 29/07/2020 - 04:36:00
	31	0.0009355	1.60E+12 29/07/2020 - 04:37:00
		Billing Rice Cooker	+

Rice Cooker

1	Billing	Timestam	Date/Time
2	0.000031	1.60E+12	29/07/2020 - 04:08:00
3	0.0000615	1.60E+12	29/07/2020 - 04:09:00
4	0.0000935	1.60E+12	29/07/2020 - 04:10:00
5	0.0001255	1.60E+12	29/07/2020 - 04:11:00
6	0.0001565	1.60E+12	29/07/2020 - 04:12:00
7	0.0001870	1.60E+12	29/07/2020 - 04:13:00
8	0.0002180	1.60E+12	29/07/2020 - 04:14:00
9	0.0002500	1.60E+12	29/07/2020 - 04:15:00
10	0.0002810	1.60E+12	29/07/2020 - 04:16:00
11	0.0003130	1.60E+12	29/07/2020 - 04:17:00
12	0.0003440	1.60E+12	29/07/2020 - 04:18:00
13	0.0003745	1.60E+12	29/07/2020 - 04:19:00
14	0.0004055	1.60E+12	29/07/2020 - 04:20:00
15	0.0004365	1.60E+12	29/07/2020 - 04:21:00
16	0.0004675	1.60E+12	29/07/2020 - 04:22:00
17	0.0004985	1.60E+12	29/07/2020 - 04:23:00
18	0.0005295	1.60E+12	29/07/2020 - 04:24:00
19	0.0005605	1.60E+12	29/07/2020 - 04:25:00
20	0.0005915	1.60E+12	29/07/2020 - 04:26:00
21	0.0006225	1.60E+12	29/07/2020 - 04:27:00
22	0.0006535	1.60E+12	29/07/2020 - 04:28:00
23	0.0006845	1.60E+12	29/07/2020 - 04:29:00
24	0.0007165	1.60E+12	29/07/2020 - 04:30:00
25	0.0007475	1.60E+12	29/07/2020 - 04:31:00
26	0.0007785	1.60E+12	29/07/2020 - 04:32:00
27	0.0008105	1.60E+12	29/07/2020 - 04:33:00
28	0.0008415	1.60E+12	29/07/2020 - 04:34:00
29	0.0008725	1.60E+12	29/07/2020 - 04:35:00
30	0.0009045	1.60E+12	29/07/2020 - 04:36:00
31	0.0009355	1.60E+12	29/07/2020 - 04:37:00

< >
Billing Rice Cooker
+

Table 4 tabulated the Billing display when using Air Fryer in 20 minute

Table 4: Billing display when using air fryer in 20 minute

Load	Billing Display			
Air Fryer	1	Billing	Timestamp	Date/Time
	2	0.0000795	1.6E+12	29/07/2020 - 04:46:00
	3	0.0001575	1.6E+12	29/07/2020 - 04:47:00
	4	0.0002373	1.6E+12	29/07/2020 - 04:48:00
	5	0.0003171	1.6E+12	29/07/2020 - 04:49:00
	6	0.0003966	1.6E+12	29/07/2020 - 04:50:00
	7	0.0004746	1.6E+12	29/07/2020 - 04:51:00
	8	0.0005541	1.6E+12	29/07/2020 - 04:52:00
	9	0.0006339	1.6E+12	29/07/2020 - 04:53:00
	10	0.0007134	1.6E+12	29/07/2020 - 04:54:00
	11	0.0007932	1.6E+12	29/07/2020 - 04:55:00
	12	0.0008727	1.6E+12	29/07/2020 - 04:56:00
	13	0.0009507	1.6E+12	29/07/2020 - 04:57:00
	14	0.0010302	1.6E+12	29/07/2020 - 04:58:00
	15	0.0011097	1.6E+12	29/07/2020 - 04:59:00
	16	0.0011892	1.6E+12	29/07/2020 - 05:00:00
	17	0.0012687	1.6E+12	29/07/2020 - 05:01:00
	18	0.0013482	1.6E+12	29/07/2020 - 05:02:00
	19	0.0014277	1.6E+12	29/07/2020 - 05:03:00
	20	0.0015072	1.6E+12	29/07/2020 - 05:04:00
	21	0.0015867	1.6E+12	29/07/2020 - 05:05:00
Billing Air Fryer				

Table 5 tabulated the billing display when using electric kettle in 7 minute

Table 5: Billing display when using electric kettle in 7 minute

Load	Billing Display			
Electric Kettle	1	Billing	Timestamp	Data/Time
	2	0.0001059	1.596E+12	29/07/2020 - 03:16:00
	3	0.0002118	1.596E+12	29/07/2020 - 03:17:00
	4	0.0003177	1.596E+12	29/07/2020 - 03:18:00
	5	0.0004236	1.596E+12	29/07/2020 - 03:19:00
	6	0.0005295	1.596E+12	29/07/2020 - 03:20:00
	7	0.0006354	1.596E+12	29/07/2020 - 03:21:00
	8	0.0007413	1.596E+12	29/07/2020 - 03:22:00
hilmimalik95@gmail.com_22599326				

Manual Calculation for result

Rice Cooker

$$P_{True\ Power} = 242.288V \times 2.11364A \times 0.85 = 435.294W$$

$$Wh_{Watthour} = 435.294W \times \frac{1}{3600} = 0.142Wh$$

$$Billing = 0.142Wh \times 0.218 \frac{1}{1000} = 0.0000310sen$$

Air Fryer

$$P_{True\ Power} = 242.382V \times 5.41982A \times 0.85 = 1116.62W$$

$$Wh_{Watthour} = 1116.62W \times \frac{1}{3600} = 0.365Wh$$

$$Billing = 0.365Wh \times 0.218 \frac{1}{1000} = 0.0000795sen$$

Electric Kettle

$$P_{True\ Power} = 241.097V \times 7.25139A \times 0.85 = 1486.05W$$

$$Wh_{Watthour} = 1486.05W \times \frac{1}{3600} = 0.486Wh$$

$$Billing = 0.486Wh \times 0.218 \frac{1}{1000} = 0.0001059sen$$

Based on the data collected, it can be observed that each load gives a different current and has an impact on energy consumption and billing. When has energy meter using a smartphone as well, it can analyze, observe changes in trends and monitor remotely on energy consumption. Therefore, it has achieved the objectives to be made with the development of this system.

4. Conclusion

Based on the observations and studies conducted, there are many problems and constraints faced by consumers who want to monitor, collect data and also analyze data on electricity consumption. Thus, a new energy meter using a smartphone system has been developed to improve the level of technological progress in the country.

Overall, the objectives are to develop an energy meter using a smartphone have been successfully achieved. With the development of this system, hopes to help further facilitate users in monitoring, collecting and analyzing data on electricity consumption by using IoT. The use of smartphones that are no stranger to this millennium can also help make it easier to explain the methods used by this system. However, after examining some aspects terms of design, size and limitations of this system, hoped this system could be improved in future. Some suggestions from the questionnaire will also be applied in future studies.

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