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Real Time Electrical Energy Computing Tool

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Abstract

This paper presents a design and implementation of real time electrical energy computing tool to measure and record the electrical energy based on type of detection devices, Hall Effect current sensor and Microcontroller. The tool was installed on the system power supply of the room and compared with kWh meter. Finally, we found that the energy record has error of average power calculating results is 0.077%.

***Keywords**: Hall Effect current sensor, Microcontroller, kWh meter*

1. INTRODUCTION

Studying the way people use electricity makes us know their behaviour in using power each day. Because of this, it creates appropriate and effective power management. This is why studying power using behaviour is considered very useful. However, collecting the amount of electrical energy used in houses needs to be kilowatt-hour meter (kWh meter) type, since it can’t be collected as real-time information, so the information can’t be analyzed to find power using behaviour.

Therefore, the researchers have created the real time electrical energy computing tool, which is used to measure and record the amount of electrical energy by using Hall Effect current sensor. This equipment is capable for measuring low electricity that is linear. In addition, the researchers used the Microcontroller AVR (model ATMEG 16) [1] which can convert information from A/D signal. This way, it reduces steps in designing the equipment. Then, the equipment will be installed in power releasing system with kWh meter, so that we can compare electrical energy quantity. We will also use C-Programming [2], [3] to the Microcontroller compile electrical energy using information.

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2. DESIGN STRUCTURE AND CONTROL

This study is divided into 2 parts: The structure designing and the controlling use Microcontroller. There are calculating current, voltage, power, and expenses based on the conditions of the researchers determination.

2.1 Design Structure

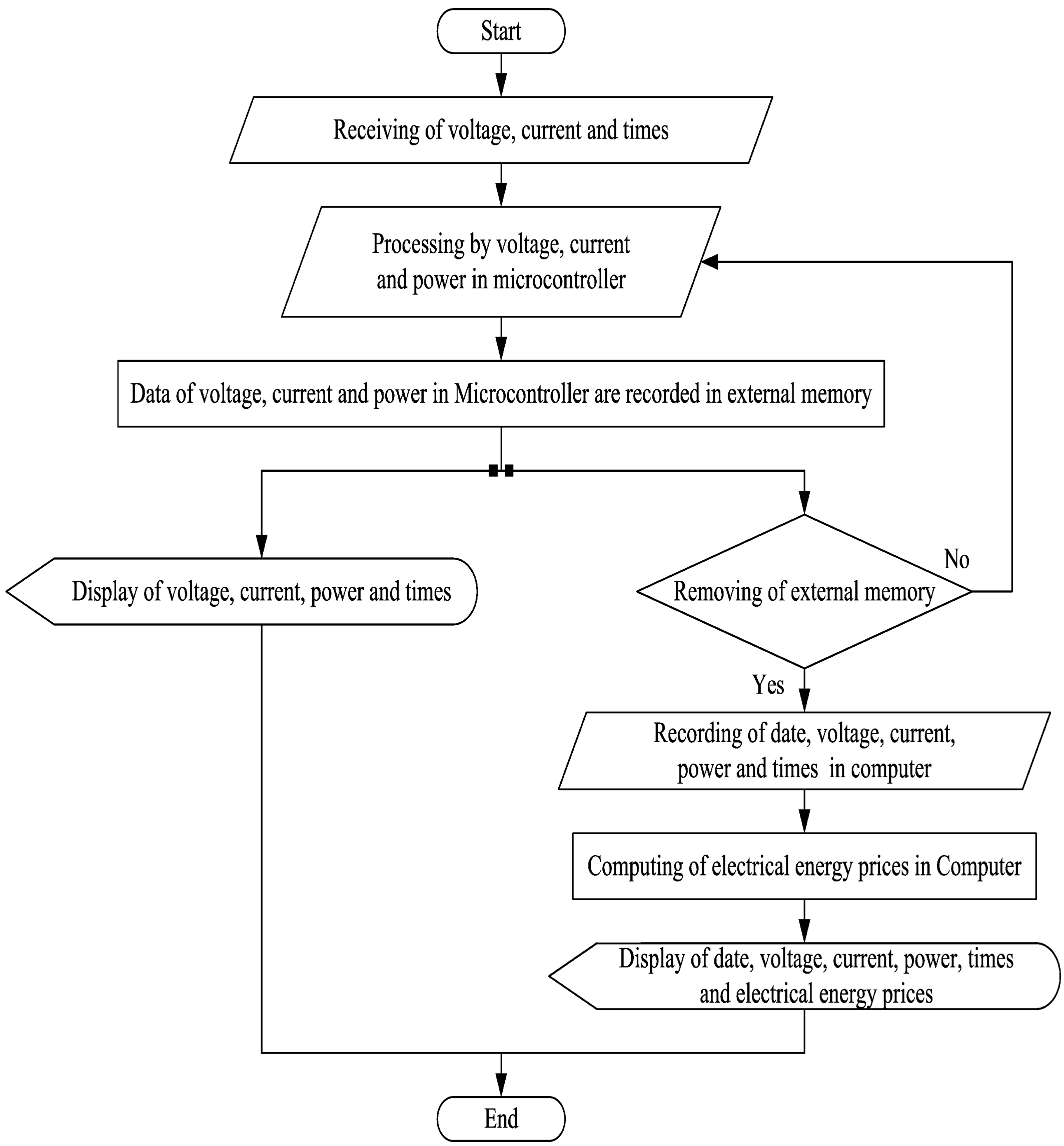

Figure 1. Flow chart of electrical energy computing tool.

From Fig. 1, it's a flow chart showing general working of the system. In the experiment, the researchers designed equipment to measure and record electrical energy by using Hall Effect current sensor [4] and Microcontroller AVR (Model ATMEG16). Also, the sampling of signal measurement is to calculate and record real time power using. Date and time are recognized by Real Time Clock (RTC) Model DS1307 which is installed in electric current system with error 0.74% of kWh (MITSUBISHI) Model MF-33E [5]. When it is tested with load 100 watt to compare the error of the equipment and record the tested electrical energy quantity from the design.

2.2 Controls by Microcontroller

In this study, the researchers used Microcontroller to receive the voltage from Hall Effect current sensor. We also adjusted the information to be analogy by using A/D converter. The binary can be calculated form eq. 1.

$$ADC = \frac{V_{IN} \cdot 1024}{V_{REF}} \quad (1)$$

Where V_{IN} is an input voltage, V_{REF} is a reference voltage.

Calculating power quantity being used in each period needs to be measured voltage and current flow. So the researchers installed Hall Effect typed to find the result for calculating the quantity of electrical energy use as in Fig. 2.

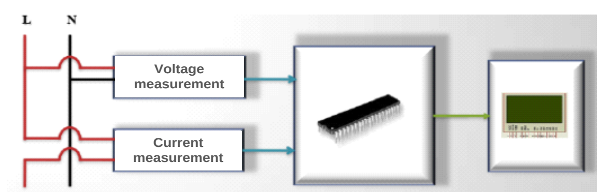

Figure 2. Set up of Hall Effect sensor.

Mmeasurements of voltage and current flow can be done by sampling method. For each sine wave will do the sampling for 20 times. In this step, the researchers tested sampling rate from 100 time/period, and the rate was reduced til 10 time/period. It was found that 20 time/period sampling is still accurate according to the multi-meter that was used to measuring. It also required least sampling information storage. Fig. 3 shows the sampling rate and Fig. 4 shows information of the digital sampling rate respectively.

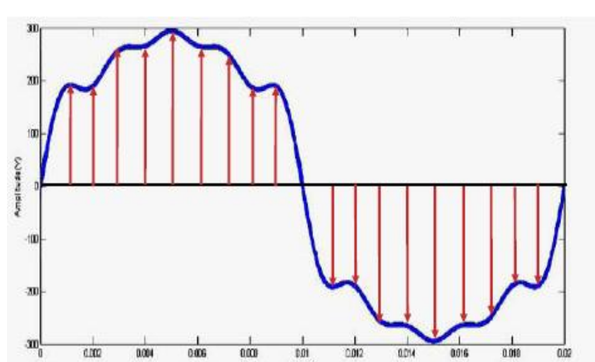

Figure 3. Sampling rate for 20 times/sine wave.

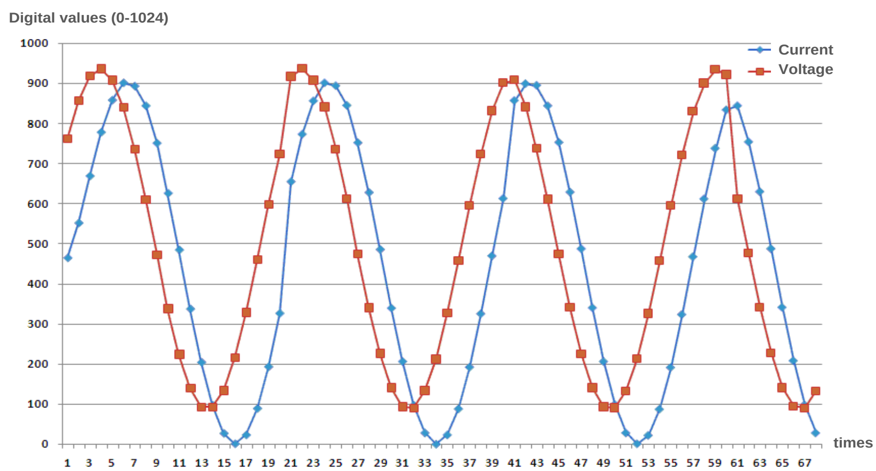

Figure 4. Information of the digital sampling rate.

From Fig. 4, it is the information of voltage and current from eq. 1, which is in peak positive. So, the information in peak minus will be adjusted to peak positive, using eq. 2. The voltage and current that are adjusted by eq. 3 will be shown in Fig. 5 respectively.

$$F(x) = \begin{Bmatrix} eq_a \ then \ ADC < 512 \\ eq_b \ then \ ADC > 511 \end{Bmatrix} \tag{2}$$

When $F(x)$ is output digital 8 bit.

and
$$eq_a = 512 - ADC$$
$$eq_b = ADC - 512 \tag{3}$$

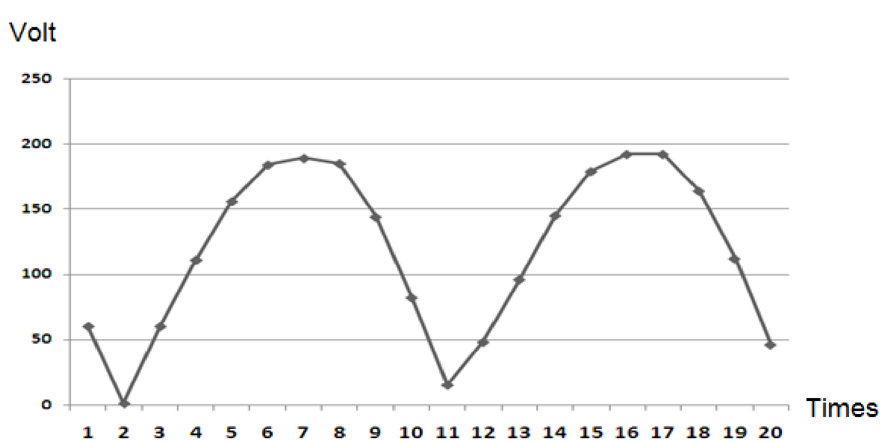

Figure 5. Information of digital voltage after adjusting the voltage.

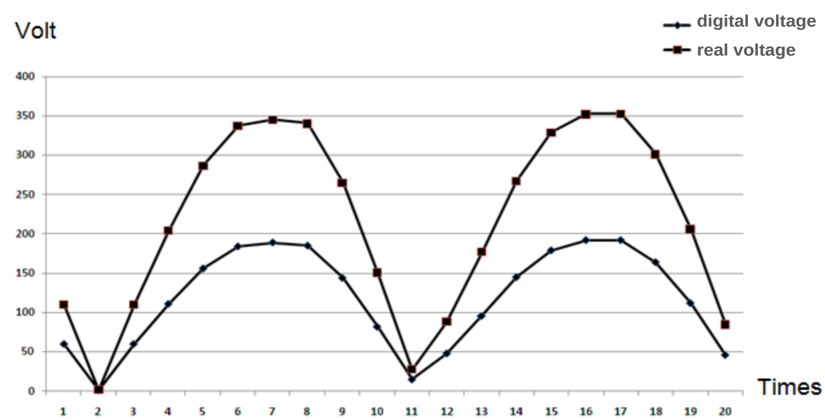

Figure 6. Information of digital voltage and real voltage.

From Fig. 6, the comparison between digital voltage information which is from reducing adjustment and real voltage measuring using oscilloscope shows that each period of the sampling both information are related in direct variation. The information of voltage from the measurement is divided into 2 parts which are information of voltage that flows through load, and information of current. The both information is calculated to find electrical energy value in each period by using eq. 4.

$$P = D_v \times D_i \tag{4}$$

When

P is electrical energy each period of the sampling.

D_v is data of voltage.

D_i is data of current.

When the equation 4 is used to find the result of electrical energy, the researchers find the total of each sampling by using Integrate method in the first til the twentieth sampling to find electrical energy value in each period. Then the researchers find the total result of the electrical energy used in 1 second. The total value will be recorded and used to calculate the electrical energy using per hour in the future.

3. EXPERIMENTAL RESULTS

The researcher has created the electrical energy measuring by sampling using Microcontroller. Also, the errors in the result are tested. The design tool will store the information in its SD card memory and will show electrical energy using quantity on the LCD screen when the power calculation electrical energy is installed. The information is collected in May, 2014 for 3 rooms.

3.1 Record of information

The researchers collected the results of power using quantity by using the designed tool to compare with kWh meter. The information was recorded once a day for 31 days. The results are shown in table I.

Table 1. The results of recorded information

D/M/Y	kWh meter			Design tool		
	Room 1	Room 2	Room 3	Room 1	Room 2	Room 3
01-05-14	0.000	0.000	0.000	0.000	0.000	0.000
02-05-14	2.360	2.480	2.745	2.360	2.482	2.749
03-05-14	2.360	2.480	3.230	2.360	2.482	3.234
04-05-14	3.150	2.480	4.020	3.150	2.482	4.024
05-05-14	3.950	4.000	4.820	3.952	4.003	4.824
06-05-14	4.743	4.507	5.613	4.747	4.510	5.617
07-05-14	5.538	5.267	6.408	5.543	5.270	6.412
08-05-14	6.333	6.027	7.203	6.340	6.031	7.207
09-05-14	7.128	6.787	7.998	7.136	6.791	8.002
10-05-14	7.923	7.547	8.793	7.933	7.551	8.797
11-05-14	8.718	8.307	9.588	8.729	8.312	9.592
12-05-14	9.513	9.067	10.383	9.526	9.072	10.387
13-05-14	10.308	9.827	11.178	10.322	9.833	11.182
14-05-14	11.103	10.587	11.973	11.119	10.593	11.977
15-05-14	11.898	11.347	12.768	11.915	11.354	12.772
16-05-14	12.693	12.107	13.563	12.711	12.114	13.567
17-05-14	13.488	12.867	14.358	13.508	12.875	14.362
18-05-14	14.283	13.627	15.153	14.304	13.635	15.157
19-05-14	15.078	14.387	15.948	15.101	14.396	15.952
20-05-14	15.873	15.147	16.743	15.897	15.156	16.747
21-05-14	16.668	15.907	17.538	16.694	15.917	17.542
22-05-14	17.463	16.667	18.333	17.490	16.677	18.337
23-05-14	18.258	17.427	19.128	18.287	17.438	19.132
24-05-14	19.053	18.187	19.923	19.083	18.198	19.927
25-05-14	19.848	18.947	20.718	19.880	18.959	20.722
26-05-14	20.643	19.707	21.513	20.676	19.719	21.517
27-05-14	21.438	20.467	22.308	21.472	20.480	22.312
28-05-14	22.233	21.227	23.103	22.269	21.240	23.107
29-05-14	23.028	21.987	23.898	23.065	22.001	23.902
30-05-14	23.823	22.747	24.693	23.862	22.761	24.697
31-05-14	24.618	23.507	25.488	24.658	23.522	25.492
01-06-14	25.413	24.267	26.283	25.455	24.282	26.287

3.2 Finding Errors

From the information collected in table I, the efficiency of the this tool can be found by considering the occurring errors. This is comparing the power values derived from the designed tool and the kWh meter as shown in table II.

Table 2. Error results

Room	Result of Energy (kWh)		
	kWh meter	Design tool	Error
1	25.413	25.455	0.126%
2	24.267	24.282	0.064%
3	26.283	26.287	0.041%

From table II, it is found that the errors from the two types of tool occurred in 3 rooms but there were very few error values. The error value of the average power is only 0.77%. This error happen from the frequency in sampling to measure the signals. If there is a lot of sampling, there will be limited by memory sizing.

4. CONCLUSION

When the real time electrical energy computing tool is installed in main system with kWh meter, it is found that it can measure and record electric power value efficiently according to the objectives the researchers created. Moreover, recording electrical energy values have very few errors for the electrical energy calculating tool in each room.

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