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Design and Build Household Electrical Power Limiters Based on Priority Lines for Electricity Usage with Arduino Microcontroller Based

Atmiasri[1], Andik Ariyanto[2], Akhmad Solikin[3], Linda Dwi Rohmadiani[4] , Arif Yachya[5] , Ika Maylani[6]

[1]Electrical Engineering, Faculty of Engineering and Science, PGRI Adi Buana University Surabaya
[2] Electrical Engineering, Faculty of Engineering and Science, PGRI Adi Buana University Surabaya
[3] Electrical Engineering, Faculty of Engineering and Science, PGRI Adi Buana University Surabaya
[4] Regional and City Planning, Faculty of Engineering and Science, PGRI Adi Buana University Surabaya
[5] Biology, Faculty of Engineering and Science, PGRI Adi Buana University Surabaya
[6] Statistics, Faculty of Engineering and Science, PGRI Adi Buana University Surabaya

email : [1]atmi.asri@unipasby.ac.id. [2]andik.ariyanto@gmail.com, [3]solikinakhmad@unipasby.ac.id, [4]linda@unipasby.ac.id, [5]arif@unipasby.ac.id, [6]ikamaylani@unipasby.ac.id

Abstract - To realize energy savings, especially electrical energy on a household scale, one thing that is usually done is turning off unnecessary equipment. However, this kind of conventional method requires high discipline and the success rate is quite low due to many factors, one of which is forgetting. One solution that can be applied to this problem is the need for tools that can force electricity users to turn off electricity if usage has exceeded a certain limit. To be able to measure electricity consumption, an energy measuring sensor is used which is then processed on the microcontroller and drives the circuit breaker relay. In making this tool using the experimental method, by planning based on references from the literature and experiments directly to the equipment. With this, it is hoped that the expected tools will be realized and can contribute to saving energy in the community.

Keywords :*KWh Sensor, Arduino Nano, Electrical Power Meter*

I. INTRODUCTION

Currently, saving electrical energy has become a topic that is commonly discussed in the community. This is due to the increase in the price of electricity bills that must be paid. One of the reasons for this high electricity bill is the use of electricity for non-essential purposes. Uses that are not important, for example the use of garden lights or pond pumps, whose presence will not be a problem if the equipment is turned off.

The saving steps that have been taken so far have been carried out manually through a switch so that these efforts are very limited and inefficient. Therefore, we need a tool that can make users limit electricity consumption by turning off electrical equipment whose use is not important, such as garden lights, decorative lights and the like. This tool must be able to calculate / estimate the use of electricity so that when the estimated usage exceeds the predetermined target, the relay will cut off the power line for equipment that is not prioritized.

Broadly speaking, this tool uses several main components, namely Arduino Nano as a data processing and processing center, PZEM-004T sensor as an energy sensor that measures the amount of electrical energy consumption, RTC as a timer, Relay as a circuit breaker and several other supporting components. .

This research has several objectives as follows:

1. To find out how to measure KWh using an energy sensor.
2. To find out how to limit the use of electricity on non-priority lines if the total electric power has met the specified threshold.

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II. METHODS

This product is basically a measure of the power used in household electricity using a current sensor and a voltage sensor which is then calculated based on the priority of the type of electrical equipment used.

To be able to determine the priority of using this electricity, household appliances are first sorted based on the type of need. In the design of this tool, household appliances are separated based on 2 types of priorities, namely:

1. Priority Line, contains household appliances which are equipment that must zbe turned on without any restrictions.

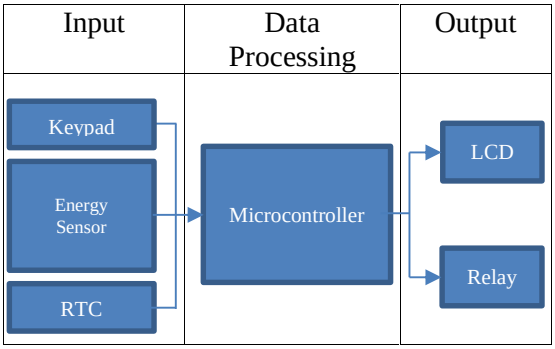

Figure 1 . Diagram Design

These appliances include house lights, refrigerators, etc.

2. Non Priority Line, contains household appliances whose presence is not too important and is not a problem if turned off but will make electricity use wasteful if turned on continuously. This equipment includes garden lights, decorative lights, fountain pumps in ponds, etc.

Broadly speaking, this equipment is divided into several parts, as shown in the following block diagram:

The input part of this tool is a current sensor, voltage sensor, and RTC which is then processed by the microcontroller. The results of the microcontroller will be applied to the relay which can disconnect or connect the power line and the LCD as a display of the work of the microcontroller.

The explanation for each block diagram is as follows:

1. Input block , in this section consists of current sensors, voltage sensors and RTC. The current sensor functions to measure electric current in each line where in this design it is determined that there are 2 lines, namely the priority line which is the path of electrical equipment that must be continuously lit and the non-priority line which contains electrical equipment that is not required to be lit. The sensor used is PZEM-004T. The next component used is RTC. This component functions to find out the date and time in real time. This RTC is used to determine the time to reset the KWh meter data.
2. Data Processing Block , in this section data processing from the input block is carried out. Data from current and voltage sensors will be taken and processed every few moments to be able to find out the power used at any time.
3. Output block , in this section the results of data processing are visible. The value of the used voltage, current and power will be displayed on the LCD. The results of this data processing will also produces a measured and accumulated power value in the last month and will be seen on the relay which can cut off the current if the accumulated usage in that month has exceeded the specified limit.

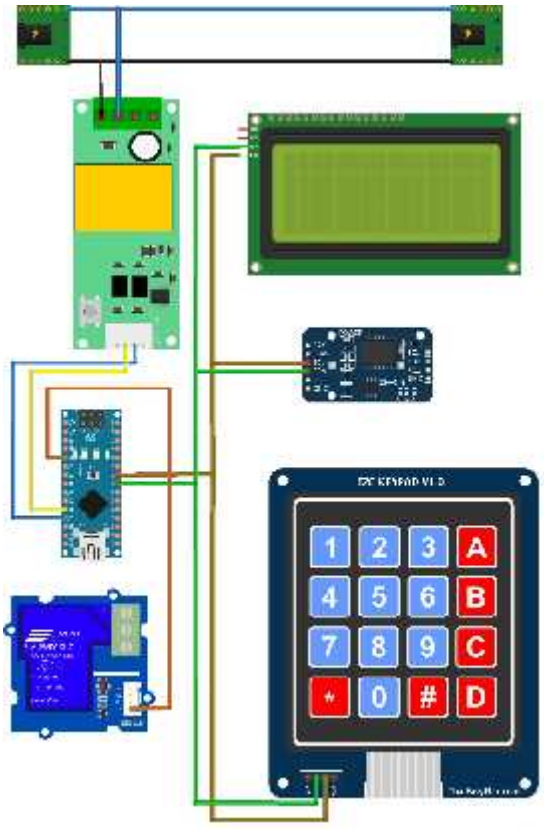

Figure 2. Device Circuit Schematic

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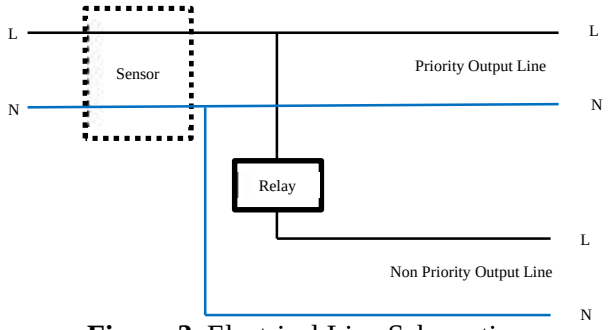

Figure 3. Electrical Line Schematic

Figure 2 shows a complete circuit of the components used. LCD, RTC and keypad use I²C data lines that use the same 2 data lines to simplify wiring and each of these components can be accessed separately using a different address. The PZEM-004T sensor is accessed by the microcontroller using serial communication.

Figure 3 describes the image of the power line which is a priority line and a non-priority line. On the input line, sensors are placed to measure the energy used, after that the power line is branched into 2 lines, namely the priority line and the non-priority line. On the non-priority line, a relay is added as a breaker if the desired energy limit has been reached.

III. RESULTS AND DISCUSSION

After carrying out the design stage, the tool is made according to the circuit drawing with the result in the form of equipment as shown in Figure 4.

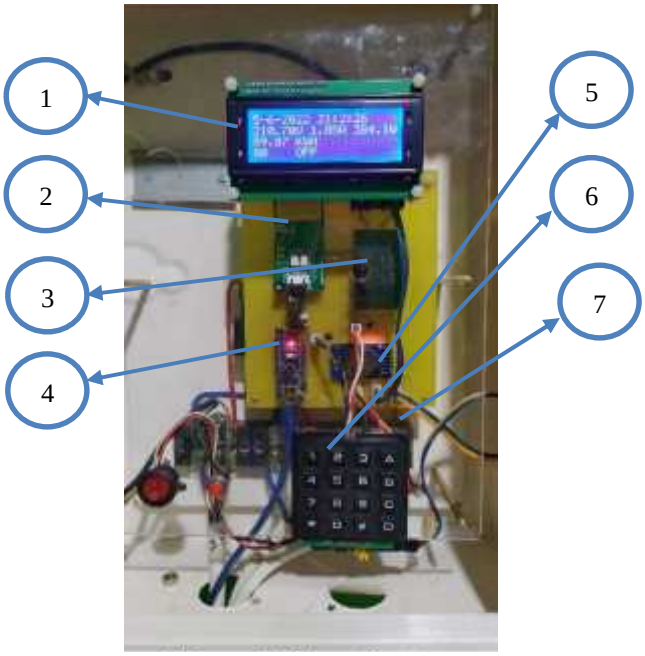

Figure 4. Photo Tool

Component Description :

1. LCD
2. Sensor
3. Power Supply
4. Microcontroller
5. RTC
6. Keypad
7. Relay

After making hardware, then proceed with making software. Making software using the Arduino IDE application which is the default application for making Arduino software. The software development is divided into several parts, among others, the data reader section, both sensors, keypad and RTC, the data processing section and the data display section to the LCD and relay drive.

The results of the evaluation on the results of this equipment, the equipment can function as expected by the researcher. The weakness of this tool is that the display on the LCD is difficult to read, so in the future it may be necessary to use an LCD model that can display more characters so that it is easier for users to read the display from the device.

How the Tool Works

In the design of the electrical power limiter based on the priority of use, it has the following way of working:

1. This tool is installed at the entrance to the installation to be measured and its use is limited.
2. The tool will read the voltage, current and energy using sensors for further processing on the microcontroller.
3. Users can set their own limit on how many KWh non-priority lines will be turned off. This number limit entered will be stored in the EEPROM of the arduino. Entering the KWH limit is enough to do once as long as there is no change the value will still be stored.
4. Every month the measured KWh value will be reset back to 0. This reset date can be determined by the user and will be stored in the Arduino EEPROM.
5. When the KWh value read on the sensor has reached the limit value according to the number entered (as explained in number 3), the non- priority line will be turned off by the relay.

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6. Every month that coincides with the date as entered in the explanation of number 4, the KWh number on the sensor will be reset to 0 and the non-priority line will turn on again.

Data Analysis

standard measuring instrument was used as a reference for measurement. The tool used is an electric meter from Sinotimer. The measurement test process can be seen in Figure 5.

Figure 5. Sensor Testing Process

The test results on the equipment used give the following results:

Table 1. Current Measurement Test Results

No	Measurement Time (Hour)	Measurement Results (A)		Error Percentage
		Current Sensor	Ampere Meter	
1	07.00	1.21	1.17	3.42
2	08.00	1.15	1.10	4.55
3	09.00	2.41	2.35	2.55
4	10.00	1.34	1.29	3.88
5	11.00	1.61	1.54	4.55
6	12.00	4.41	4.42	0.23
7	13.00	1.38	1.32	4.55
8	14.00	1.06	1.02	3.92
9	15.00	1.58	1.48	6.76
10	16.00	1.67	1.62	3.09
11	17.00	1.60	1.51	5.96
12	18.00	2.10	1.94	8.25
13	19.00	2.15	2.05	4.88
14	20.00	2.10	2.03	3.45
15	21.00	1.78	1.71	4.09
Average				4.27

In table 1 , the results of measurements and calculations of the percentage of current measurement errors from the 15 data taken are obtained, the average value of the measurement error is 4.27%.

Table 2. Voltage Measurement Test Results

No	Measurement Time (Hour)	Measurement Results (V)		Error Percentage
		Voltage Sensor	Voltmeter	
1	07.00	212.50	213.90	0.65
2	08.00	210.80	210.00	0.38
3	09.00	213.90	212.00	0.90
4	10.00	211.40	212.10	0.33
5	11.00	209.80	210.90	0.52
6	12.00	211.00	210.00	0.48
7	13.00	211.00	211.50	0.24
8	14.00	211.30	211.60	0.14
9	15.00	211.10	212.00	0.42
10	16.00	210.70	210.50	0.10
11	17.00	205,90	206.30	0.19
12	18.00	206,10	206,10	0.00
13	19.00	210.90	209.70	0.57
14	20.00	209.50	209.00	0.24
15	21.00	207.60	207,40	0.10
Average				0.35

In table 2 , the results of measurements and calculations of the percentage of voltage measurement errors are obtained from the 15 data taken, the average value of the measurement error is 0.35%.

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Table 3. Energy Measurement Test Results

No	Measurement Time (Hour)	Measurement Results (KWH)		Error Percentage
		Energy Sensor	KWH meters	
1	07.00	43.26	42.50	1.79
2	08.00	43.48	42.70	1.83
3	09.00	43.78	43.00	1.81
4	10.00	44.10	43.30	1.85
5	11.00	44.38	43.60	1.79
6	12.00	44.85	44.10	1.70
7	13.00	45.32	44.50	1.84
8	14.00	45.56	44.80	1.70
9	15.00	45.85	45,10	1.66
10	16.00	46,16	45,40	1.67
11	17.00	46.49	45,70	1.73
12	18.00	46.89	46,10	1.71
13	19.00	47.42	46,60	1.76
14	20.00	47,90	47,00	1.91
15	21.00	48,20	47,40	1.69
Average				1.76

In table 3 , the results of measurements and calculations of the percentage of energy measurement errors are obtained from the 15 data taken, the average value of the measurement error is 1.76%. The results from table 3 can be illustrated by the graph in Figure 6.

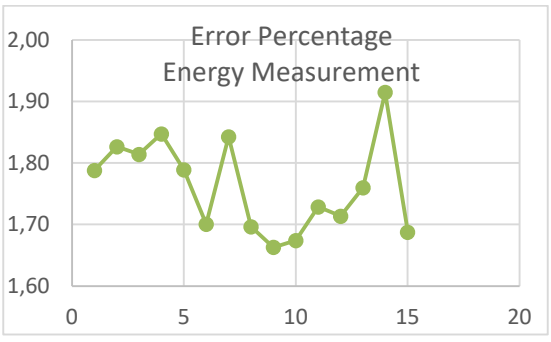

Figure 6. Graph of Energy Measurement Test Results

After testing the results of the energy sensor, then proceed with making software to limit electrical power according to the value entered by the user.

Table 4. Software Test Results

No	Test Type	Experiment result
1	Line limiting relay	Succeed
2	Automatic energy reset	Succeed

From the tests carried out on the software that has been made, the results are as in table 4.

IV. CONCLUSION

From the research and testing of this tool, it can be concluded as follows:

1. This equipment serves to limit the use of electrical energy on electrical lines that are not a priority.
2. This tool works by utilizing the PZEM-004T sensor as an energy reading sensor.
3. The desired power limit to be limited is entered manually by the user at the time of setting up the equipment.
4. Every month the energy data will be reset back to zero automatically.

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