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Power Rates Calculation Monitoring Prototype Electricity Using NODEMCU ESP32

Muhammad Syafarrudin[1], Endah Fitriani[2]
[1.2] Department of Electrical Engineering, Faculty of Science and Technology, Binadarma University
Jl. Jenderal Ahmad Yani No.3, 9/10 Ulu, Seberang Ulu I District, Palembang City, South Sumatra
Email: msyafar5@gmail.com, endahfitriani@binadarma.ac.id

ABSTRACT

The use of tools for monitoring electric power rates and controlling the use of electric power rates is urgently needed. Homeowners often leave the electricity. For example, they use a *refrigerator and a magic jar that is always turned on, which wastes electrical Energy and makes electricity bills expensive. This report aims to create a tool to monitor electric power in real time and calculate the electricity rates used, which users can be controlled on a WebApp. The hardware used is the Pzem-004T* sensor, a reader of the overall electric power, *OLED 128x64 as a display of used electric power rates, Proximity as a distance sensor, Push button as a reset button for electric power rates, DS1307 RTC module as time accuracy and S.D. module Card as log data storage and NodeMCU ESP32 as input and output process, by utilizing the wifi from NodeMCU ESP32 as a link between the device and a cellphone or computer to be able to open the WebApp dashboard. On the WebApp dashboard, there is information on recording electricity rates every month, and there are options to reset bills and change billing limit notifications. A message will appear if the account exceeds the limit, and the OLED screen will continue to live. Electricity bill rates are automatically reset every month, and the data will be stored, which can be seen on the WebApp dashboard.*

Keywords: *Power Monitoring of Electric Power Rates, Pzem-004T Sensor, OLED 128x64, Proximity Sensor, NodeMCU Esp32, WebApp.*

Introduction

Electricity is the primary need for human life in various aspects. Because electricity is an immediate need, most people ignore electricity use, resulting in more expensive monthly electricity bills [1][2]. Some consumers sometimes feel displeased about the rising electricity bill cost. Uncontrolled consumption of electrical Energy is one of the causes of the increase. Technology is needed to track electricity expenditure to help consumers control their electricity consumption [3][4]. Monitoring the calculation of electricity rates is made so that consumers can know the use of electricity every day, knowing that consumers can consider making it more efficient in using electricity [5]. For this reason, a WebApp is provided as a regulator in the event of a waste of predetermined limits, and there will be a warning notification [6].

In previous scientific work, a system was used to consume electrical power by cost tenants to calculate electricity and electricity bills. Designed using NodeMCU ESP32, Pzem-004T sensors and channel relays installed in each boarding room to find out the electrical data that will be sent to the Firebase Realtime Database, which is processed via a smartphone and monitored from a distance using a thinkable application that requires internet [7][8]. The difference from the previous scientific work is that this scientific work added infrared Proximity as a proximity sensor, OLED as an information display, SD Card module as a data log storage medium, and RTC as time accuracy and to access it not using the internet only using wifi from Esp32 which is connected to the client without using the internet at the local wifi range Esp32 [9][10].

The reason for the need for prototype monitoring the calculation of electrical power rates is the use of electricity that cannot be controlled by electronic equipment when used continuously without thinking about electrical energy bills, resulting in waste [11][12]. Thus, a system that can control the use and monitoring of electricity bills during use is needed to calculate usage and save electrical Energy in the electricity of the residential house [13]. Electricity rates can also be monitored by a smartphone device or computer that can interfere with use in case of waste through WebApp [14][15].

Research Methods

Planning Tools

In the process of making tools, designing has an important role. Because the design of a device is expected to produce good tools as well and by what is expected. This design stage includes all stages related to the tool suite, namely hardware and software (programming languages), such as component selection, component installation, and tool testing [16]–[19].

Hardware Tightening

Hardware Planning is a tool plan that begins with creating a block diagram and an overall schematic design. This planning includes the components to be used. The hardware components used are as follows:

1. NodeMCU ESP32 as the central processing tool programming and connecting components as well as connecting to the client
2. MCB as limiting electric current and safety when there is more load
3. Pzem-004T sensor as current, voltage, and power reader
4. Proximity sensor as a proximity sensor for OLED display
5. Push the button to reset button electricity bill and total kWh
6. NTC as temperature readings on the tool
7. PTC as protection of D.C. power components
8. PSU (Power Supply) as voltage converter 220 V_{AC} to 5 V_{DC}
9. OLED as a display of current, voltage, power, temperature, and electricity bills
10. RTC as time accuracy to be sent to ESP32
11. SD Card module as log data storage
12. Socket as electrical load.

Block Diagram Design Tool

In making a design and building a tool, a block diagram is needed to facilitate creation by understanding the inputs and outputs of the chart. The following is the tool's design in the form of a block diagram in figure 1.

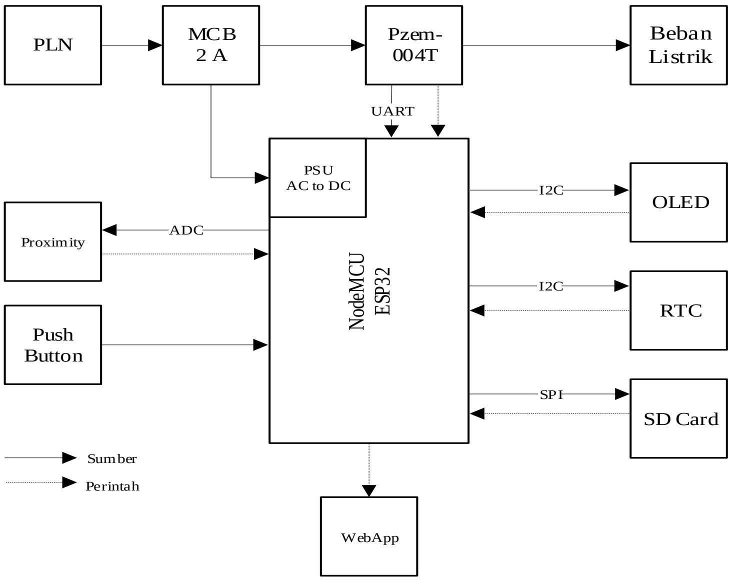

Figure 1 Tool Design Block Diagram

Based on the tool design block diagram in Figure 1, the MCB is input from a PLN voltage source of 220 VAC. From MCB, it outputs the first two outputs directly, leading the PSU to change the voltage to 5 VDC as a voltage source for proximity sensor devices and push buttons, as well as OLED, RTC and SD Card devices give commands and data on the ESP32 NodeMCU. The other MCB voltage output leads to the Pzem-004T sensor as a V_{AC} voltage source. From Pzem-004T it outputs two results also. One leads to the ESP32 to provide data, and the other leads to an electrical load. From ESP32, give the command to connect to the client via wifi from ESP32.

Planning Tools

In tool planning, there is a project board planning to facilitate the installation of the components needed to make the tool, as shown in figure 2 below.

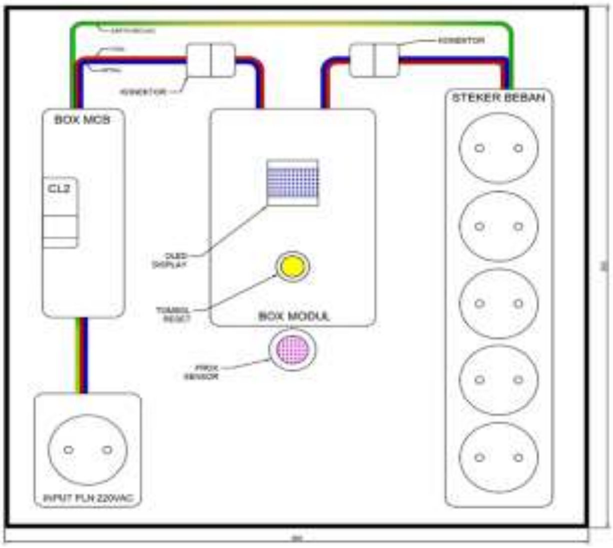

Figure 2 Planning Tools

In the planning plan, the tool uses a length of 300 mm and a width of 300 mm. With this size, it is enough to make a prototype on an acrylic board using a PCB board as a constituent and connecting the components in the module box so that this does not happen. PCB board design can be seen in Figure 3.

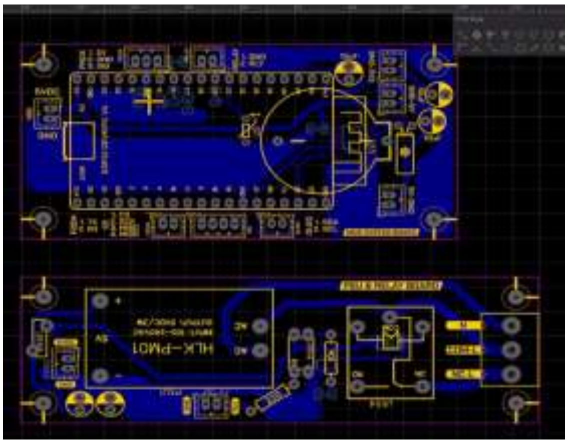

Figure 3 PCB Board Design

WebApp Dashboard Design

In the monitoring prototype of electricity rates calculated using the ESP32 nodemcu for monitoring electrical power rates and control, on the WebApp dashboard, there will be a curve display structure that includes the voltage, current, power, and Energy used every second as well as the frequency and power factor of the tool used, as follows:

Figure 4 WebApp Dashboard

In Figure 4, there is a button to change the PLN TTL and change the billing limit displayed on the OLED and a reset button to reset kWh and billing costs.

Results and Discussion

Tool Design Results

The results of the design of the prototype monitoring of electricity rates protection using ESP32, in this scientific work where monitoring the calculation of the output electricity rates is in the form of an outlet consisting of 5 holes.

Figure 5 Tool Installation

Figure 5 shows a prototype monitoring of electricity rate calculations using nodemcu Esp32. Using acrylic size 300x300 mm is suitable for all tool components.

Calculation Results

Measurement of components is carried out five times to determine the optimal value. Furthermore, the average result will be obtained using the formula:

$$\bar{X} = (x_1 + x_2 + x_3 + x_4 + x_5)/n = Sxi/n \quad (1)$$

Where:

Sxi/n = Sum of all samples
X1 = Measurement
N = Total

x̄ = Average value

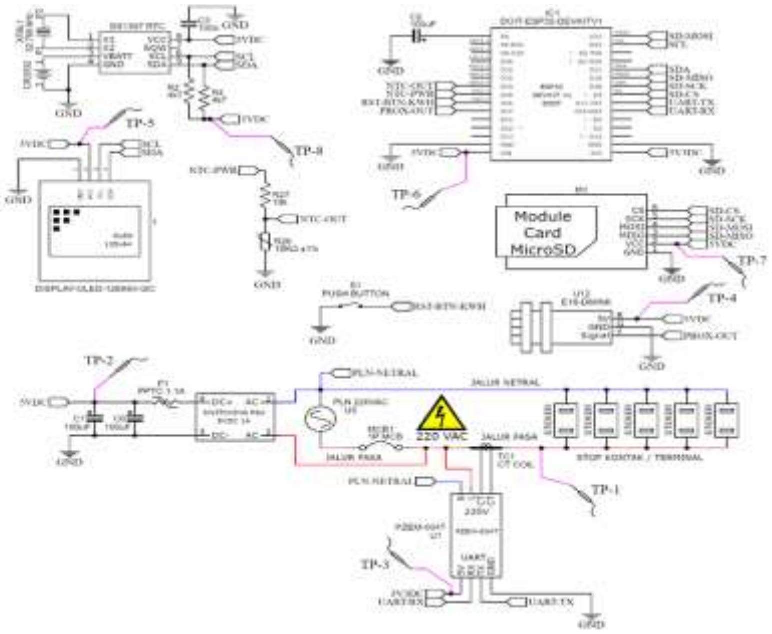

Figure 6 Schematic of Measuring Points

Table 1 Component Measurement Results

No	Measurement Points	Unit	Measurement Results					x	Information
			1	2	3	4	5		
1	PLN voltage	V_{AC}	231,7	231,8	231,8	231,7	231,5	231,7	Voltage input from the PLN source
2	AC-DC Module HLK-PM01 220VAC - 5VDC @600mA	V_{DC}	5,03	5,05	5,04	5,03	5,02	5,034	Voltage output results from AC-DC module voltage drop
3	Sensor PZEM-004T	V_{DC}	3,3	3,2	3,25	3,28	3,2	3,25	The voltage on the power supply pin of the PZEM-004T sensor module
4	Sensor Proximity	V_{DC}	4,94	4,95	4,96	4,95	4,94	4,948	The voltage on the proximity sensor power supply pin
5	OLED I2C 128x64	V_{DC}	5,01	5,02	5,02	5,01	5	5,012	The voltage on the V_{CC} pin of the OLED module

6	ESP32 DevkitC V4	V_{DC}	5,03	5,04	5,04	5,03	5,04	5,036	The voltage on the V_{CC} pin 5V of the ESP32 development module
7	SD Card Module	V_{DC}	4,99	4,98	4,98	4,97	4,97	4,978	The voltage on the V_{CC} pin 5V SD Card module
8.	RTC module	V_{DC}	4,95	4,96	4,94	4,95	4,96	4,952	The voltage on pin V_{CC} 5V RTC module

Table 1 shows the value of each component when measured for the Pzem-004T and Proximity sensors, which have an output voltage of less than 5 VDC by looking at the sensor datasheet's reference data is 3,3 V_{DC} to 5 V_{DC}. For the Pzem-004T and Proximity sensors, it will run stable properly.

Proximity Sensor Testing

The proximity sensor is tested when an object approaches the OLED screen. The OLED screen will light up and vice versa if the thing is about to turn off.

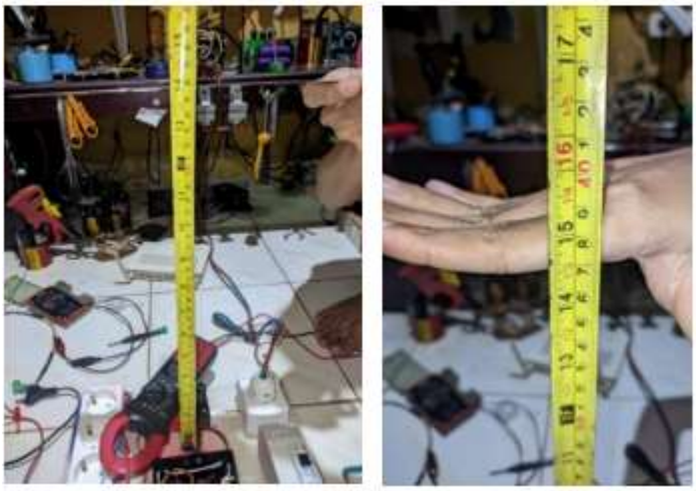

Figure 7 Proximity Sensor Testing

Based on Figure 7, in figure (a) above, the object is close to 36 cm toward the sensor, and the OLED screen lights up. In figure (b), the object moves away 37 cm toward the sensor, and the OLED screen turns off. The sensor experiments for other distances are as follows:

Table 2 Sensor Detection Experiments

No.	Sensor Trial Distance	Object Seonsor Detection	OLED Screen State
1.	35 cm	Detected	Live
2.	37 cm	Undetectable	Die
3.	38 cm	Undetectable	Die
4.	36 cm	Detected	Live

Testing Tools

In testing, the tool must use power from PLN as input and plug the load of the A.C. power tool into the output of the socket to be able to see the results of the calculation of power and electricity rates. The tools that have been tested are as follows:

Table 3 Tool Output Testing

No.	Tools	Power (W)	Current (A)	Time
1.	Fan	54,39	0,253	1 hour
2.	Charge Laptop	51,3	0,411	1 hour
3.	Charge Handphone	27,4	0,104	1 hour
4.	Washing Machine	177,2	0, 87	½ hour
5.	Rice Cooker	370,5	1,727	½ hour

In the test from Table 3, five tools are measured. Each device has a different power, current, and voltage displayed on the OLED screen. As for what was measured simultaneously with the three tools tested below:

Figure 8 Tool Test Results

Tool Output Calculation

The electricity bill rate for 1 phase with 1,300 VA power is 1,444.70 Rp/kWh for residential homes. So for calculating the tool test using a rate of 1,444.70 Rp/kWh. Testing the output of the tool requires calculations to calculate energy and electricity bills as follows:

$W = P \times t$ .... (2)

Rates = W x TTL .... (3)

Where:

P = Power (Watts)
t = Time (Hours)
W = Energy (kWh)
TTL = Electricity Tariff (1.444,7) (Rp/kWh)
Rates = Cost Incurred (Rp)

Table 4 Electric Power Rates

No.	Tools	Energy (kWh)	Rates (Rp)	Time
1.	Fan	0,05439	78,58	1 hour
2.	Charge Laptop	0,0513	74,11	1 hour
3.	Charge Handphone	0,0274	39,58	1 hour
4.	Washing Machine	0,0886	128	½ hour
5.	Rice Cooker	0,1852	267,63	½ hour

Testing WebApp Dashboard Monitoring

Monitoring testing using a WebApp accessed via Mobile or Computer, this test is carried out to determine the performance and ability to send data and set a limit on the use of electricity bills.

Figure 9 WebApp Dashboard

Figure 10 shows the recording time of total kWh and total bills, where each date of the following month will be automatically reset and stored in a table. To see the total kWh and tabs, there is an option to select the month and year, and if it has been selected, the recording history will appear.

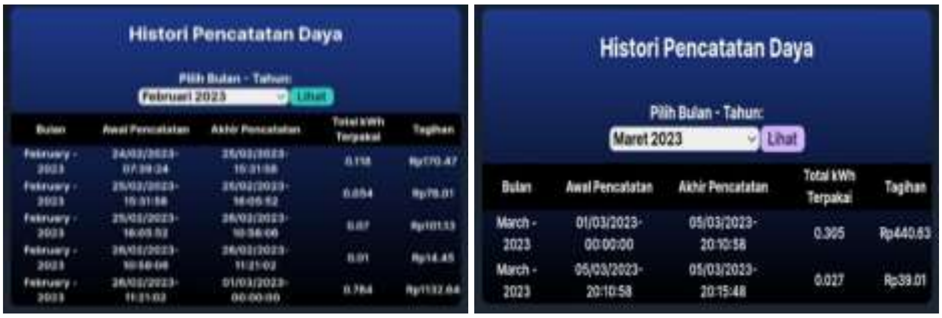

Figure 10 Power Logging History

Conclusion

Monitoring electrical power rates can be seen from the OLED screen with objects approaching the screen 36 cm and can also be seen on the WebApp. A comparison of the output results on the Pzem-004T sensor and multimeter has been measured with an error rate not exceeding the maximum error, so it can be concluded that the Pzem-004T sensor has good accuracy. The display on the OLED screen is in the form of current, voltage, power, frequency, power factor, total Energy, and total electrical power rates. The calculation of each tool tested uses 1 phase with a capacity of 1,300 VA-2,200 VA, which is 1,444.7 Rp/kWh, and uses five testing tools in the form of a fan, charge laptop, charge handphone, washing machine, and rice cooker. Control of plastic usage limits can be set via WebApp that relies on wifi from NodeMCU Esp32. Write down the conclusions of your paper and further research suggestions in the form of narratives and not in *bullet* or *numeral form.*

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