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Design of Household Electricity Protection and Monitoring Automation With IoT ESP32

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Abstract—existence of a household electrical protection and monitoring system to minimize danger. Therefore, a prototype design tool for household electricity protection and monitoring automation with IoT ESP 32 is developed. With the aim of carrying out voltage protection and electricity monitoring with a normal voltage of 220 VAC. designed to increase the existing protection system in the household, not to replace the function of the MCB. With a success rate of 99.6% voltage measurement, 97.5% current and 97.8% power measurement. Testing the tool using an inductive load in the form of a 45 watt 35, watt, 26 watt LED lamp and a resistive load in the form of a 400 watt iron set at the maximum hot point. below 210 VAC.

Keywords: DHT11,IoT,NodeMCUESP32, PZEM004T, Protection

1. Introduction

The protection and monitoring system is a safety system for household electrical appliances. Equipment security will be active if there is a technical disturbance, natural disturbance, operating error and other causes [1],[2]. Each protection system must be able to work in accordance with its objectives and capabilities and functions, which will be determined against the type of disturbance that is occurring [3]. If a disturbance occurs and the protection is unable to work, it will result in a large loss. These losses include in terms of wider damage to the installation equipment itself and to the electrical equipment used [4],[5],[6].

With the existence of a protection and monitoring system, electrically related devices will be safe and protected from damage. The protection device that has been used in households so far is a Miniature Circuit Breaker or better known as an MCB which functions to limit the current. However, using the MCB alone is not enough to provide protection, because it only protects against overloads. The designed system aims to add the existing protection function in the household, not to replace the MCB function [7],[8].

The sensor used is PZEM-004T which functions to read the value of the voltage, current, active power and energy used and is equipped with a relay module as an actuator [9],[10]. To connect to the internet this tool uses ESP32, converts these data into values that can be read by humans and then will be sent to the database storage media using wifi internet services, and performs an automatic protection system if it occurs [11],[12],[13]. Overall this system has been able to provide protection by decides the current readings outside the electrical parameters when there is an overload. This system can also monitor turning on and off electrical equipment using a smartphone.

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2. Method

The method in this study was carried out in several stages to make it easier to work on the process of designing a prototype system for monitoring and protecting household electricity with IoT ESP32. The explanation of the system power components above can be explained, among others, PZEM-004T is a sensor that can be used to measure rms voltage, rms current and active power that can be connected via Arduino or other open source platforms. The DHT11 sensor is a sensor module that functions to set temperature and humidity objects that have an analog voltage output that can be further processed using a microcontroller. A potentiometer is an electronic component device that functions to regulate resistance, voltage and electric current flowing in a circuit. Arduino nano and Nodemcu ESP32 as controllers of PZEM sensors, Temperature and other components. LCD serves to display the value of the measurement. Buzzer functions to convert electrical vibrations into sound vibrations. The database serves to store data used by an application or website. The power supply functions as a converter of a high AC voltage into a lower DC voltage. And the relay functions as a tool that is like working as a switch, the principle of a mechanical switch that can be driven by electrical energy, as shown in Figure 1 below:

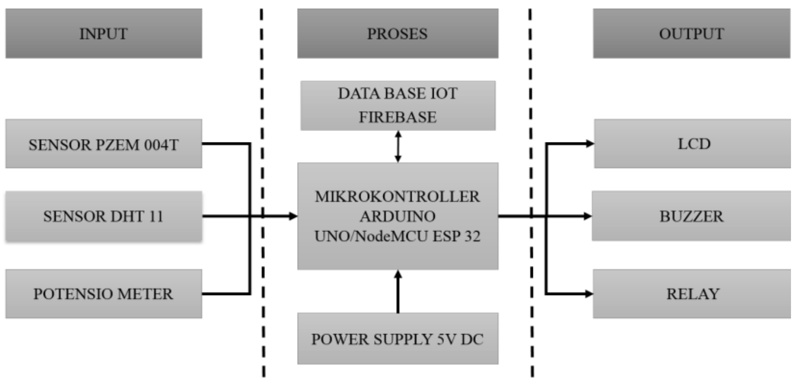

Figure 1. Power System Components

2.1 Overall Load Test Circuit

Then to describe the whole circuit by identifying the need for tools, namely, ESP32 WROOM-32, Power Supply, Arduino Nano 328P, 16x2 LCD, I2C LCD Module, PZEM-004T Sensor, MCB 6A, 5v 8 channel Relay Module, DHT Sensor 11. Design and making tools in the design and manufacture of a whole series of tools using the Coler Draw X8 application, as shown in Figure 2 below:

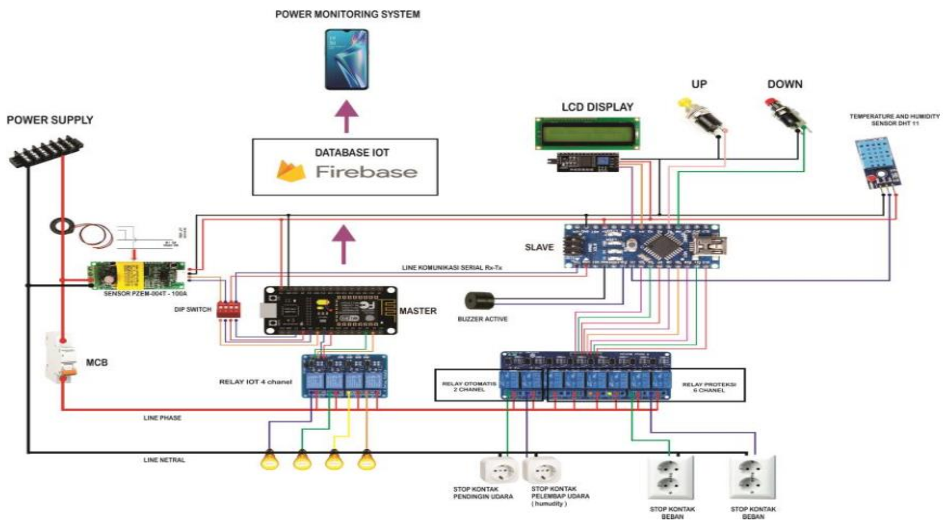

Figure 2. Overall Load Test Circuit

Arduino Nano installation includes sensor installation, namely DHT11 sensor installation, LCD installation, Buzzer installation, Push Button installation, Potentiometer installation, Relay Module installation. Installation of NodeMCU ESP32, installation of Zener Diodes and Dip Switches, Connection of Firebase with Smart Phones and Devices, installation of the PZEM-004T Sensor Module. The installation of this component's Mcb protection functions as a protection system in electrical installations in the event of an overload and short circuit of electric current. Installation of a power supply 5 Volt power supply adapter, is an adapter that can convert a large AC voltage into a small DC voltage. For example, from 220v AC voltage to 5v, 9v, or 12v DC voltage. Testing of tools testing tools is intended to find out whether the system that has been made is in accordance with what has been designed. This testing process includes reading the value of the voltage, current, active power and energy used.

2.2 Electrical Protection and Monitoring Automation Tools

In the protection system and tool testing, it is designed to have four IoT lights and one IoT outlet. The tool is designed to have two temperature and humidity outlets to turn on the automatic fan and air conditioner with a DHT 11 sensor. Then the tool is designed to have six Current and Voltage Protection Outlets. Lcd 16X2 To view the display of the Pzem-004t sensor measurement results, Pushbutton to shift the Lcd display, MCB as a protection system in electrical installations, Potentiometer functions to increase and decrease voltage and current. Furthermore, the PZEM-004T sensor coil is used to measure rms voltage, rms current and active power that can be connected via Arduino or other open source platforms, , as shown in Figure 3 below.

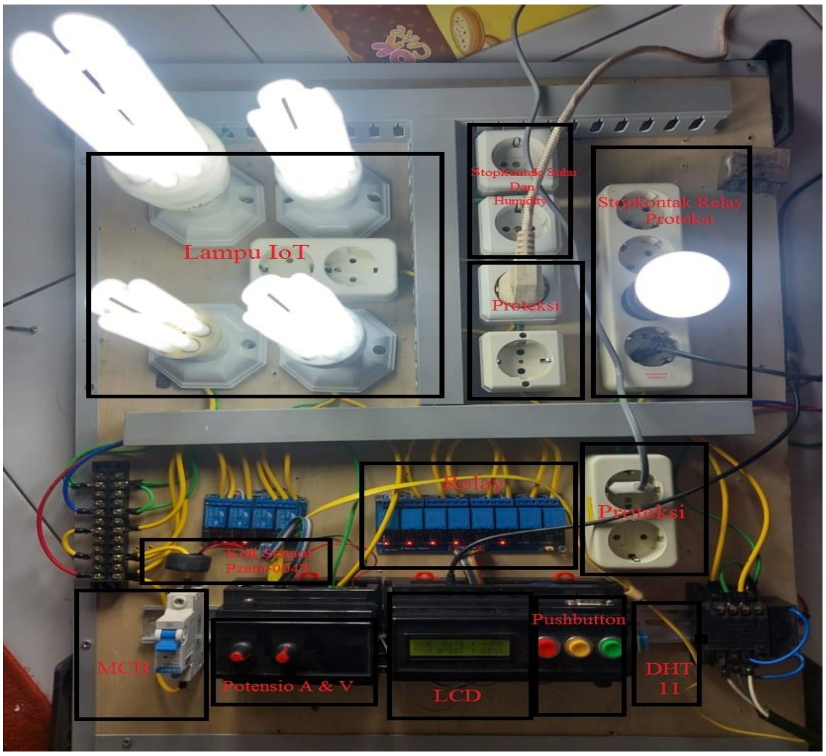

Figure 3. Electrical Protection and Monitoring Automation Tools

3. Result and Discussion

Testing the automatic fan ignition and turning on the air conditioner is carried out automatically using the data from the DHT sensor readings, for example if the temperature is too hot, for example exceeding 35.5^{o}c degrees then the fan will be active, and if the humidity is less than 52.5% then the humidifier will activate.

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Table 1. DHT11 Sensor Data Readout

No	Temperature DHT	Humidity DHT	Explanation
1.	33.1	85.0	Fan Off
2.	32.8	87.4	Fan Off
3.	35.5	80,7	Fan On
4.	35.6	77,3	Fan On
5.	43.2	53,4	air conditioner not working
6.	47.7	52.5	active air conditioning

Then the simulation results of undervoltage, overvoltage and measurement of Error Sensor PZEM-004T by comparing with measuring instruments, namely multimeter and tangampere. Measurements include the percentage of voltage error, the percentage of current error and the percentage of power error.

Table 2. Data Error Percentage Table

Explanation	condition	Volt	Ampere	Watt	Eror
Lamp 35 Watt	Lamp 1 ON	234.0	0,23	35.3	0,8%
Lamp 35 Watt	Lamp 2 ON	234.0	0.23	35.5	1,4%
Lamp 26 Wat	Lamp 3 ON	234.0	0.186	27.0	3,8%
Lamp 45 Watt	Lamp 4 ON	234.0	0.310	0.310	4,2%
Fan 50 Watt	Fan ON	237,7	0.211	49,6	0,8%
Iron 400 Watt	Iron ON	234.8	1,748	410,5	2,6%
	Average-Error				2,2%

To determine the percentage level of data error can be done by utilizing the following equation.

$$Er(\%) = \left| \frac{\text{True value} - \text{Read value}}{\text{True Value}} \right| \times 100\% \quad (1)$$

$$\%\ \text{Average Accuracy} = \frac{\sum \%\ \text{Accuracy}}{n} \quad (2)$$

$$\%\ \text{Average Accuracy} = \frac{13{,}6}{6} = 2{,}2\% \quad (3)$$

Power accuracy = 100% - 2,2%
Power accuracy = 97,8%

Based on the table and the results of manual measurements can be obtained the percentage value of power accuracy is 97.8%.

In this test, the overall load is connected to the IoT with parameters reading power, current, voltage and frequency. In this test, the monitoring system is seen on the 16x2 LCD display and from the IoT smartphone, in this condition, 1 time sampling is carried out. The overall system test display can be seen in Figure 4.

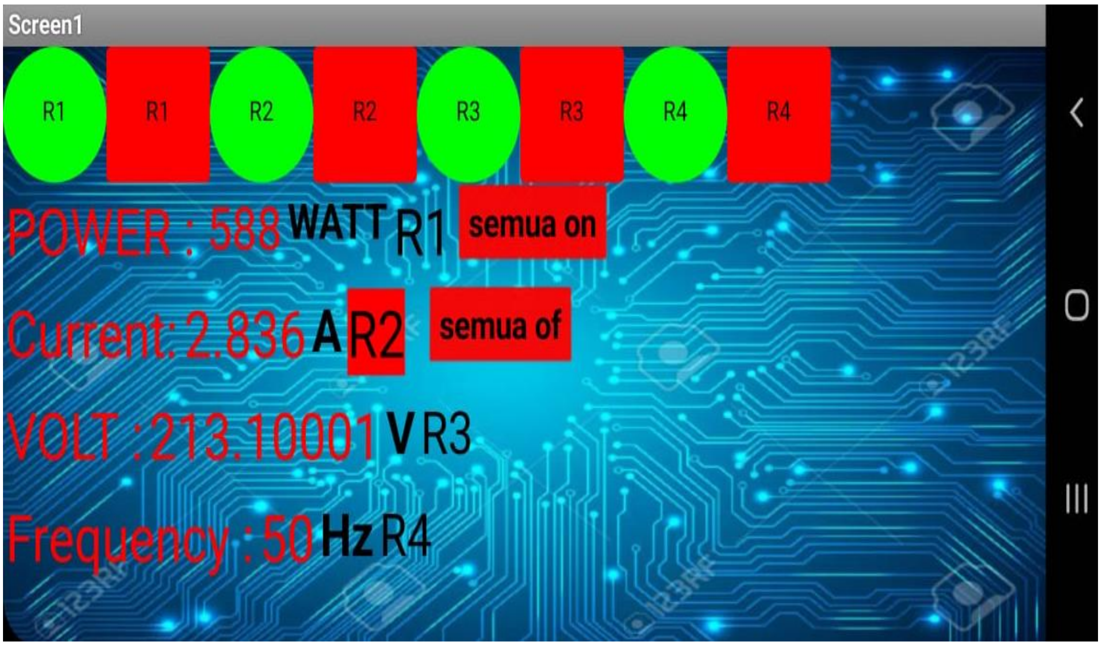

Figure 4. Display In App Given Overall Load Results 588 Watts, 2.836 A, 213 Volts, at 50 Hz Freq

Based on the measurement results above, the tool works normally and has an error percentage below 10%. Performance testing is done by adjusting the input and output of the tool according to its function, testing is carried out on all input components and produces the right measurements. used and suitable for Smart Home projects

Table 3. Under Voltage Protection Simulation

No	Volt Sensor	Volt Multimeter	Load	Protection	Buzzer
1.	238.0	237.0	Lamp 35 Watt	OFF	Off
2.	237,7	236.0	Lamp 45 Watt Lamp u 35 Watt	OFF	Off
3.	235.0	234.0	Lamp 26 Watt	OFF	Off
4.	234.0	233.0	Fan 50 Watt Iron 400 Watt	OFF	Off
5.	230.0	229.0		OFF	Off
6.	210.0	210.0	Lamp 35 Watt	ON	light up
7.	208.0	207.0	Lamp 45 Watt Lamp 35 Watt	ON	light up
8.	205.0	205.0	Lamp 26 Watt	ON	light up
9.	204.0	203.0	Fan 50 Watt Iron 400 Watt	ON	light up
10.	203.0	203.0		ON	light up

Based on the results of calculations carried out if the voltage decreases less than 207 Volts. Then the protection relay will disconnect. Then to see OverVoltase Monitoring can be seen in the table below.

Table 4. Overvoltage Monitoring

No	Volt Sensor	Volt Multimeter	Load	Protection	Buzzer
1.	230.0	229.0	Lamp 35 Watt	OFF	ON
2.	234.0	233.0	Lamp 45 Watt Lamp 35 Watt	OFF	ON
3.	235.0	234.0	Lamp 26 Watt Fan 50 Watt	OFF	ON
4.	237.0	236.0	Iron 400 Watt	OFF	ON
5.	238.0	237.0		OFF	ON
6.	240.0	239.0	Lamp 35 Watt	ON	light up
7.	241.5	240.0	Lamp 45 Watt Lamp 35 Watt	ON	light up
8.	242.0	241.0	Lamp 26 Watt Fan 50 Watt	ON	light up
9.	243.0	242.0	Iron 400 Watt	ON	light up
10.	244.0	243.0		ON	light up

Based on the results of calculations carried out if the voltage increases more than 241.5 Volts. Then the protection relay will disconnect. The PZEM-004T sensor has a fairly good sensitivity, the results of the voltage, current, frequency readings are close to the same results as the measuring instrument error accuracy of less than 10%. The results of the PZEM sensor readings carried out by the NodeMCU ESP32 are sent serially Rx-Tx to the Arduino Nano, and also sent to the Firebase Database. The results of the PZEM sensor reading data will be calculated by Arduino, if the current consumption exceeds the specified limit, the Arduino will turn off the 6 protection relays. In this developed tool there are 2 potentiometer units that are useful for limiting current consumption, and an overvoltage limit, based on the provisions that the author made, the maximum voltage limit is 242 Volts, which can be adjusted high and low using a potentiometer, while the low voltage limit is set at 210 Volts, if there is a measurement voltage below 210 then it is considered low voltage, then the protection relay works to turn off electrical equipment. In this tool there is a 16x2 LCD display to display the electrical value parameters that are read from the PZEM sensor and there are also 2 push button units to select the display you want to display. The use of the Arduino nano as an aid for the ESP is due to several reasons, namely, the working voltage level of the ESP is only 3.3 Volts, while the sensors and relays used are at a level of 5 Volts according to the Arduino, and avoiding shock currents that interfere with the ESP communicating with the firebase, ensuring the smooth process of sending data to the IoT, the number of ESP I / O pins is less, so it is necessary to use Arduino to help control the existing relays. The weakness of this tool is that it is not recommended to install an inductive load such as a large electric motor because of the large disturbance of the starting current of the electric motor when it is initially turned on.

4. Conclusion

Based on the results of testing automation tools for household electricity protection and monitoring using the IoT Node MCU ESP8266 and using the PZEM-004T sensor to read the value of the voltage, current, active power and energy used, equipped with a relay module as an actuator. This tool can be used with both with a voltage error of 99.6%, an average current error of 97.5% and a power error of 97.8%. The protection relay is capable of protecting when the voltage is above 240 VAC and below 210 VAC, and can be useful for learning in the electrical engineering department of the Medan Area University. This tool has 4 relays that can be controlled IoT with a Smartphone, 2 automatic relays controlled by the DHT sensor to turn on the fan and air conditioner if the measured temperature exceeds the specified limit, and there are 6 protection relays for other household electrical loads.

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