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# Analysis of Microcontroller-Based Electrical Control System for *Internet of Things (IOT)-Based Overcurrent*

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## ABSTRACT

An effective electrical control system is essential to prevent damage to electronic devices and maintain the continuity of electrical flow. This research aims to design a microcontroller-based electrical control system with overcurrent monitoring and control features using Internet of Things (IoT) technology. The system uses a current sensor to detect excess current and a microcontroller as a data processor, which can automatically cut off the power supply if an excess current is detected. The data from these current sensors will be transmitted to an IoT platform that allows real-time monitoring via mobile devices or computers. In addition, users can remotely control the electrical system, either to turn on or off the electric current, through a web-based or mobile application. System testing is carried out to verify the functionality of the device in monitoring, controlling, and protecting electrical equipment from overcurrent. The results show that this system can detect overcurrent with high accuracy and provide warnings to users in real-time. The implementation of this system is expected to improve energy efficiency and provide optimal protection for electrical equipment on a household and small industrial scale.

**Keywords:** Electrical Control System, Microcontroller, Overcurrent, Internet of Things (IoT),



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## 1. INTRODUCTION

Learning in Technology continues to grow rapidly in various fields, supported by advances in science and technology. This is marked by the emergence of tools that use digital and automatic control systems. Technology has become very important in human life, ranging from mechanical technology, electricity, to telecommunications. In the use of electronic devices, often users do not pay attention to energy consumption, so that power use becomes greater. Electrical energy is needed to meet lighting needs and also production processes involving electronic goods and industrial equipment. To find out the amount of electrical energy that is being used, it is necessary to measure the use of electrical energy. However, the measurement and recording process is still manual so that the data obtained cannot be done at any time and the results are too long to get because the measurement must be done directly on the spot.

Automatic Control and Current Consumption Monitoring System for Household Electrical Equipment Based on the Internet of Things (IoT). The concept of an IoT-based electrical equipment control and monitoring system is to extend the benefits of continuously connected internet connectivity, where this system can connect various equipment around us and perform various functions on the equipment. research related to "Arduino-Based Electric Current Load Control System" by using Arduino Atmega, ACS712 Sensor, and Relay as the main working system as the load controller of the electric current.

Currently, almost all people know the internet and use smartphones as a basic need to carry out their activities. With the Internet of Things technology, it is very easy to make objects or electrical appliances and electronic devices in the home connected to the internet. So that these electronic devices and electrical equipment can be monitored and controlled through Android smartphones. Regarding the case study, a system is needed that can monitor the use of electricity or more electric current. This can be overcome with a system consisting of a microcontroller that can control the use of electric current. Therefore, I am interested in conducting research on "Electrical Current Monitoring and Circuit Breaker Control for Internet of Things (IoT)-Based Overcurrent".

A circuit breaker or voltage circuit breaker (PMT) is a power system equipment used to disconnect or connect a power system circuit and a load side that can operate automatically when interrupted or manually when maintained or served. When PMT contacts are separated, potential differences between contacts create an electric field between those contacts. The Internet of Things (IoT) refers to the use of information technology, internet network connectivity, and sensors that allow devices that are not computers to be able to connect to each other through the internet network. In the design of hardware that performs the Alternating Current (AC) current and voltage monitoring function, there is a web interface for configuration and displaying the value of the monitoring results.

The hardware is designed to have ease of installation on 3-phase electrical installation line panels without the need to change installation conditions. This research is based on the need for an efficient energy transfer system that can be applied in various fields, such as wireless charging technology in electronic devices, electric vehicles, remote sensor systems, and so on. With the selection of the right type of cross-section, it is expected that the efficiency and energy transfer distance in wireless power systems can be improved, thereby providing benefits in terms of energy savings, comfort of use, and reduced dependence on physical cables or connectors.

In this study, it aims to analyze and design an energy transfer system using wireless power on different types of cross-sections. By understanding the influence of cross-sectional type, it is hoped that the optimal cross-section can be found in improving energy transfer efficiency in wireless power systems. This research is also expected to contribute and better understand the development of wireless power technology that is more efficient and practical.

## 2. LETERATURE REVIEW

### A. Control system

A control system is a set of tools and software designed to control, regulate, and monitor the operation of a process or machine, so that it works according to the goals and instructions that have been set. The control system has a central role in ensuring that all components and processes in a system run effectively, efficiently, and in accordance with predetermined parameters. The system operates through a feedback mechanism that allows automatic or manual adjustment when there is a deviation from ideal conditions.

**1. Main Components of the Control System**

The control system consists of several components that work synergistically to manage the operation of the system, including:

- Sensors: Serve to detect physical conditions such as temperature, pressure, current, voltage, or speed. Data from the sensor will be sent to the controller as input to monitor and assess the condition of the system.
- Controller: The main unit that processes data from sensors and performs actions based on algorithms or logic that have been programmed. In a microcontroller-based system, a controller such as an Arduino or Wemos D1 can control the flow of electricity or other processes.
- Actuator: A component that performs a physical action on command from a controller, such as a relay that cuts or connects electricity, or a motor that drives a mechanism.
- User Interface (HMI): Control systems are often equipped with a user interface that allows the operator or user to monitor the system's performance, provide instructions, or set specific parameters. These interfaces can be LCD screens, physical control panels, or IoT-connected web-based applications.

### B. Main Switch Board (Electrical Panel)

Main Switch Board or Electrical Switch Board, also known as an electrical panel, is an array of electrical components and equipment assembled in the form of a box or cubicle. These panels serve as the main part in the electric power system, which plays a role in the operation of the load and the power grid. The device is arranged in a control board (board) in such a way that the components are interconnected and function according to the needs of the system.
This electrical panel has several main functions, including:

- Turning the machine on and off: Through the buttons on the panel, the operator can control the operation of the machine manually.
- System condition monitoring: The panel is also equipped with measuring instruments and indicators that allow the operator to monitor various important parameters such as temperature, pressure, and engine speed (RPM) displayed on the panel screen.

With this function, the main switch board plays an important role in controlling, monitoring, and protecting equipment and power networks in various applications, both in the industrial and commercial sectors.

**C. NodeMCU ESP8266**

NodeMCU is a development board designed for Internet of Things (IoT) applications, based on the eLua Firmware and the ESP8266-12E System on Chip (SoC). ESP8266 itself is a WiFi chip that has a complete TCP/IP protocol stack, which allows connection to the internet network directly.
The NodeMCU could be thought of as the ESP8266 version of the "Arduino", but with the added ability to connect to WiFi. In contrast to the use of separate ESP8266 which requires complex wiring techniques as well as additional modules such as USB to Serial to program them, NodeMCU comes in a more compact board form. This board is equipped with various features like a microcontroller, including WiFi access, as well as a built-in USB to Serial module. Thus, to program the NodeMCU, it is enough to use a USB data cable like the one commonly used on smartphones.
The reason for using NodeMCU ESP8266 in this project is due to its ease of programming, sufficient number of I/O pins, and its ability to connect to the internet network via a WiFi connection, allowing for real-time data transmission and retrieval.

Figure : 1. NodeMCU ESP8266

NodeMCU ESP8266 v.3 specifications include:

1. 10 GPIO (General Purpose Input/Output) pins
2. PWM (Pulse Width Modulation) functionality
3. I2C and SPI interfaces for communication with external devices
4. 1-Wire interface for connecting sensors
5. ADC (Analog to Digital Converter) to read analog signals

NodeMCU is a popular choice in IoT project development due to its flexible capabilities, built-in WiFi features, and ease of programming that is compatible with the Arduino IDE development environment.

**D. Sensor PZEM-004T**

The PZEM-004T sensor is a multifunctional sensor module used to measure various parameters in the power flow, such as active power, AC voltage, frequency, active energy, and current. The use of this sensor is primarily intended for indoor measurements and must comply with predetermined power limits to avoid damage.
The data generated by the PZEM-004T sensor can be read via the TTL interface, but because this interface is passive, the sensor requires an external power supply of 5V. Therefore, in its use, all four ports (5V, RX, TX, and GND) must be properly connected in order for the sensor to function and communicate optimally.
Physically, the PZEM-004T sensor has dimensions of 3.1 × 7.4 cm. In addition, this sensor is equipped with a 3 mm diameter current transformer coil that is used to measure current. The measurement range

reaches 100A when using an external transformer, and up to 10A when using the sensor's built-in internal shunt.


Image : 2. PZEM-004T Sensor

## 3. RESEARCH METHOD

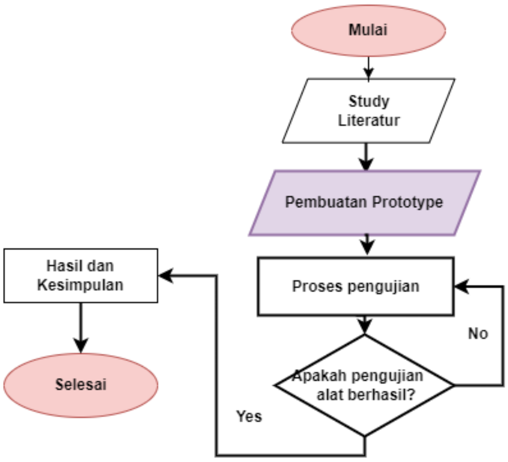



Image: 3. flowchart

Here is a description of the flowchart:

1) Start: The starting point of the process.
2) Literature Studies: Conduct research and review relevant literature to understand the theoretical background or gather information.
3) Prototyping: Designing and developing prototypes based on literature studies and problems at hand.
4) Process: Testing or analyzing a prototype through experiments or practical applications.
5) Does Tool Testing Work?: Decision points:
6) If "Yes", proceed to Results and Conclusions.
7) If "No", go back to "Prototyping" to improve the design or approach.
8) Results and Conclusions: Based on successful testing, analyze the data and summarize the results.
9) Done: The process ends here.

This flow shows the process of developing and testing the tool, starting from research to final conclusion.

## 4. Results And Discussion

Assembly and design of component placement

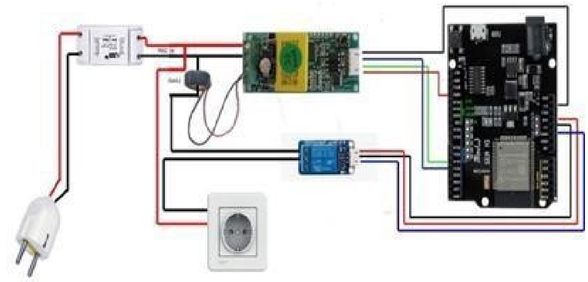


Figure : 4. Hardware Network

The Wemos D1 R32 microcontroller functions as a control center in the system, regulating the data processing of various input and output components. One of the main components connected to the Wemos D1 R32 is the current sensor, which serves to detect AC electrical current flowing through the conductor wire in a 3-phase electrical installation. The current sensor used is the PZEM-004T module, which has voltage measurement capabilities in the range of 80-260 VAC. The sensor is equipped with a measurement resolution of 0.1 VAC and a reading accuracy rate of 0.5%, making it ideal for accurate monitoring of electrical loads.
In the network configuration, as shown in the figure, the 5V pin of the PZEM-004T sensor module is connected to the 5V pin on the Wemos D1 R32. The RX pin of the sensor is connected to the IO18 pin on the Wemos D1 R32, and the TX pin is connected to the IO17 pin. For grounding, the GND pin of the sensor is connected to the GND pin on the microcontroller, ensuring a stable and interference-free signal flow.

The AC port of the PZEM-004T sensor module is then connected with a switch breaker and a plug that serves as the main power source of the PLN network. This current sensor will monitor the flow of electricity and signals received from the power lines that have been attached to the transmission cable. On the other hand, the signal port of the PZEM-004T sensor module is connected with an additional sensor component attached to one of the cables connected to the relay and outlet. This allows real-time monitoring of electrical conditions in each phase cable, so that the system can perform an automatic disconnect if an abnormal condition is detected.

The switch breaker on this system functions as the main safety that automatically cuts off the electric current when abnormal conditions occur, such as short circuits or equipment damage. In the image, it can be seen that the breaker switch is connected using a cable placed between the PZEM-004T sensor port and the plug, ensuring that the electricity flow from PLN can be monitored and automatically stopped if needed.

The relay in this system has the role of an automatic switch that disconnects the voltage from the AC source when the connected load exceeds the limit set by the user. In this configuration, the GIS pin on the relay is connected to the 3V3 pin on the Wemos D1 R32 to receive the control signal. The VCC pin on the relay is connected to the 5V pin for the power supply, while the GND pin is connected to the GND pin on the Wemos D1 R32 to complete the grounding circuit. These relays provide automatic voltage cut-off capability based on pre-programmed conditions, protecting the system from potential damage due to excessive loads.

With all components properly connected, the system is able to monitor the flow of electrical current, automatically disconnect the voltage in the event of an anomaly, and protect equipment from damage due to surges or short circuits. The combination of PZEM-004T sensors, switch breakers, and relays provides a high level of safety, while maintaining stable power flow in home or industrial installations.

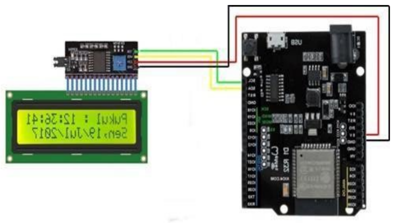


Figure: 5. 16x2 I2c LCD Network

A 16x2 LCD (Liquid Crystal Display) with an I2C module is used to display monitoring data on current, voltage, power, and limits that have been measured by the system. The I2C module simplifies communication between the LCD and the microcontroller by using only two pins for data transmission, thus saving pin usage.

As seen in the figure, the SCL (Serial Clock Line) pin of the LCD module is connected to the SCL pin on the Wemos D1 R32, and the SDA (Serial Data Line) pin is connected to the SDA pin on the Wemos D1 R32. In addition, the VCC pin of the LCD module is connected to the 5V pin on the Wemos D1 R32 for power supply, while the GND pin is connected to the GND pin to ensure a stable ground connection.

With this configuration, the 16x2 LCD will be able to display real-time monitoring results, such as current, voltage, power used, and predetermined limits, so that users can visually monitor the system condition.

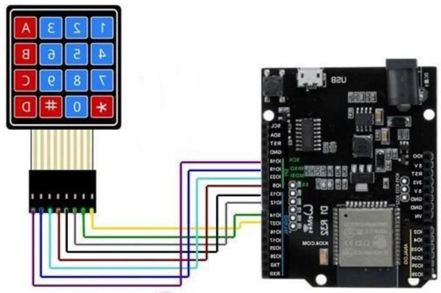



Figure : 6. Tool Range

Keypad Network

The 4x4 keypad connected on the Wemos D1 R32 is used as a control or input to set current limits directly, especially when there is no internet connection in some locations or under certain conditions. This keypad allows users to manually enter the current limit, so that the system can still operate without the need to rely on the internet network.

As seen in the image, some pins from the keypad are connected to the pinouts of the Wemos D1 R32. The pins are connected in order, namely: the keypad pins are connected to pins IO18, IO19, IO23, IO5, IO13, IO12, IO14, and IO27 on the Wemos D1 R32, according to the order on the keypad. With this configuration, the user can enter the current limit directly through the keypad, and the microcontroller will process that input to control the system according to the input limit. Users can then add loads as they wish. If the connected load does not exceed the pre-set current limit, the appliance and load will function normally. However, if the load exceeds the set current limit, the switch breaker will automatically cut off the current to prevent damage. At the same time, the buzzer and LED will light up as an alarm. The microcontroller will also send data to Firebase, and the app will receive that data in the form of overflow notifications and status monitoring.

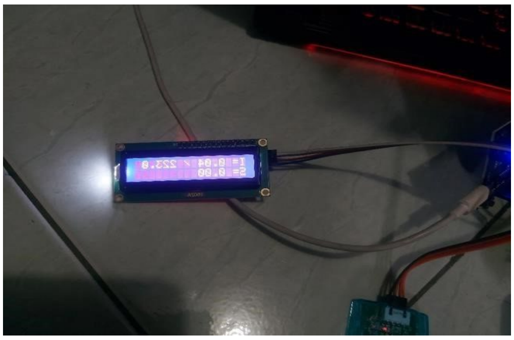
The hardware prototype is designed based on a design scheme, in which the PZEM-004T sensor is connected to a Wemos D1 R32 microcontroller. The 5V pin of the PZEM-004T sensor is connected to the

5V pin on the Wemos D1 R32, the RX pin is connected to the IO17 pin, the TX pin to the IO16 pin, and the GND pin to the GND pin on the Wemos D1 R32. The AC port of the PZEM-004T sensor is connected to the breaker switch input, and the breaker switch output is connected to the plug as the main power source from PLN. The signal port on the PZEM-004T sensor is connected to one of the cables connected by the relay, which acts as a sensor for power, voltage, and current.

Some pins of the 4x4 keypad are connected in sequence to the IO18, IO19, IO23, IO5, IO13, IO12, IO14, and IO27 pins on the Wemos D1 R32. For I2C LCDs, the SCL pin is connected to the SCL pinout, the SDA pin to the SDA pinout, the VCC pin to the 5V pin, and the GND pin to the GND pin on the Wemos D1 R32.

The relays on this system are connected as follows: the GIS pin is connected to the 3V3 pin, the VCC pin is connected to the 5V pin, and the GND pin is connected to the GND pin on the Wemos D1 R32. The relay output is connected to a cable connected to the outlet as the load output to be tested.

Finally, the buzzer and LED are paralleled using cables, then connected to the GND and IO25 pins on the Wemos D1 R32. With this configuration, the system can function to automatically monitor and control the current and provide notifications and protection when overcurrent occurs.



Gamabr: 7. LCD Test Series

**Load Testing**

The load tested was an iron, where the iron had a current value of 1,306A. Since this current value exceeds the current limit set by the user (e.g., 1.11A), the buzzer and LED will illuminate as an alarm. Furthermore, the relay will automatically cut off the flow of current to the iron, thus preventing damage to the device.

**Table 1. Tool Test Results**

| Burden | Max Voltage Switch Breaker 250V | Current Rating | Current Limit | Result | Information |
|---|---|---|---|---|---|
| Solder | 220V | 1.12A | 1.00A | Succeed | LED lights and buzzers turn on as alarms. |
| Magic Com | 240V | 1.24A | 1.10A | Succeed | LED lights and buzzers turn on as alarms. |
| Fan | 220V | 1.11A | 1.00A | Succeed | LED lights and buzzers turn on as alarms. |

| | | | | | |
|---|---|---|---|---|---|
| Refrigerator | 300V | 1.73A | 2.00A | Unsuccessful | The switch breaker cuts off the main power from PLN's electricity because the voltage owned by the refrigerator exceeds the maximum voltage limit of the switch breaker, which causes a power outage (trip/disconnection). |

**Discussion and Analysis**

In some experiments, a load with a current value that exceeds the current limit set by the user is successfully identified by the system. As a result, alarms in the form of buzzers and LEDs light up, and relays cut off the flow of electricity to the load, so that protection against the device is maintained. However, there was one experiment that didn't work, and that was in the test with a refrigerator. The refrigerator has a voltage that exceeds the maximum voltage limit of the switch breaker, so the switch breaker cuts off the main power from PLN, causing a power outage.

**Obstacles Found**

During the experimental process, there were several technical obstacles that affected the test results. The values displayed in the app don't change in real-time due to a poor internet connection, which causes data from Firebase to not update quickly. In addition, sending data from the keypad through the Wemos D1 R32 to the Firebase database experienced a significant delay due to a slow internet connection using a WiFi hotspot from a smartphone. During the analysis phase of the study, various advantages and disadvantages of this system are evaluated. The obstacles faced, such as delays in updating data due to poor internet connections, provide insights for future improvements. This research is expected to be the foundation for creating a better system, especially in terms of responsiveness and dependence on internet connections.

**Conclusion**

The microcontroller and IoT-based electrical control system was successfully designed using Wemos D1 R32 as the control center, which is connected with various components such as PZEM-004T current sensors, 4x4 keypads, relays, buzzers, and LEDs. The microcontroller is also integrated with the Firebase IoT platform for notification delivery and remote monitoring. Users can monitor and control electric current in real-time through IoT applications and platforms.

The main components needed in the construction of this system are the Wemos D1 R32 as a microcontroller, the PZEM-004T sensor to detect voltage and current, the 4x4 keypad as a manual input, the relay for load control, the buzzer and LED as an alarm, and IoT connectivity through the Firebase platform. In addition, a switch breaker is required for circuit safety, and an I2C LCD screen component as the user interface.

The implementation of the system is carried out by connecting various components to the Wemos D1 R32 according to the network design. Keypads are used to manually set flow limits when there is no internet connection, while Firebase is used for data delivery and notifications when overcurrent occurs. The system can detect currents that exceed the limit, cut off power through relays, and provide warnings to users through LEDs, buzzers, and IoT notifications. Tests show that the system successfully protects the device from overcurrent, except in cases where the voltage exceeds the limit of the breaker switch, which causes an automatic power outage.

**REFERENCES**

A. Riantiarto, D. Suryadi, "Design and Build a Current Monitoring Device on Household Electrical Load Using Web-Based Arduino Uno R3," Journal of Electrical Engineering, 2019.

F. Abadi, "Automatic Control System and Current Consumption Monitoring of IoT-Based Household Electrical Equipment (Internet of Things)," 2017.

M. S. Budiawan H, "Arduino-Based Electric Current Load Control System," 2017.
S. Alfarisy, "Design and Build a Nodemcu-Based Home Electrical Equipment Control System ESP8266 Using the Google Assistant Application," 2020.
R. Kurniawan, "Design of Current Monitoring Device on Circuit Breaker Using ACS712 Sensor and LCD Display," Journal of Informatics, Management, and Computers, vol. 10, no. 1, 2018.
Prayitno, P. Palupiningsih, H. B. Agtriadi, "Prototype of an Internet of Things Based Monitoring System for Electrical Power Usage of Household Electronic Equipment," Journal of Electrical Engineering, vol. 12, no. 1, 2019.
Sains et al., "Hardware Design of Portable Monitoring System for Monitoring Electrical Current and Voltage Using Raspberry Pi," 2018.
M. Zaini, Safrudin, and M. Bachrudin, "Designing a Voltage, Current, and Frequency Monitoring System for IoT-Based Microhydro Power Plants," 2020.
Tama, A. R., & Winardi, S. (2022). Electrical Current Monitoring and Circuit Breaker Control for Internet of Things (IOT)-Based Overcurrent. Journal of Technology and Computer Science Prima (JUTIKOMP), 5(2), 87-93.
Hendrawati, T. D., Wicaksono, Y. D., & Andika, E. (2018). Internet of Things: Power Control-Monitoring System for Electronic Devices. JTERA (Journal of Engineering Technology), 3(2), 177-184.
Hayaty, M., & Mutmainah, A. R. (2019). An IoT-based electricity usage control and monitoring system using Wemos and the Blynk app. Journal of Computer Technology and Systems, 7(4), 161-165.