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Electrical Circuit Breaker Using Web Server with User ID & Password Protection

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ABSTRACT

This initiative introduces an Internet of Things (IoT) based circuit breaker system that utilizes HTTP Authentication (requiring a user ID and password) for access control. A significant number of fatal accidents among line workers occur due to electric shocks, often stemming from poor coordination or communication between the workers and substations. This project addresses this critical safety concern by leveraging IoT technology. The IoT Circuit Breaker is designed for high-speed operation, employing the internet to remotely manage electrical loads. It incorporates a NodeMCU ESP8266 Wi-Fi module connected to the network. An authorized user or operator can access the system remotely via any internet-enabled device. This requires logging in to the IoT web server, protected by an essential layer of HTTP Authentication security. Once logged in, the user can globally control the on/off state of connected loads through the web interface. A key benefit of this system over other remote circuit breakers is its use of the internet as a faster communication medium between the operator and the loads. This technology is vital for industrial safety, as its deployment effectively eliminates the risk of common workplace hazards, such as accidental electrocution.

KEYWORDS: *NodeMCU ESP8266, Relay Module, Transformer.*

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1. INTRODUCTION

Circuit breakers are vital for switching and protection in industrial electrical systems, making their reliable operation crucial. Failure can lead to significant issues, including revenue loss and fatalities. Circuit breakers degrade over time due to mechanical and electrical stresses from operation, power handling, and arc quenching, raising reliability concerns.

Currently, preventive maintenance is standard practice. This involves periodically taking breakers offline to measure parameters like trip coil current and spring charging motor current using specialized diagnostic tools. Furthermore, visual checks and cleaning of components such as contacts and coils are performed to confirm system health. However, this time-based approach increases system downtime, even if the equipment is functional. The reliance on specialized diagnostic gear also drives up maintenance expenses.

A major issue is the traditional control scheme, which uses hardwired control logic. This inflates the size of the control and metering cabinets and prevents easy integration with the Internet of Things (IoT). This rigid structure limits timely control circuit modifications and hinders real-time data access for decision-making.

Objectives:

- The main objective of this paper is to use open source platform to control the circuit breaker.
- There is a shift in the maintenance paradigm from time-based maintenance to as-needed maintenance. This shift comes with the benefit of maintaining adequate circuit breaker performance while reducing overall maintenance costs & unnecessary downtime.

2. HARDWARE DESCRIPTION:

The hardware components used in this project are mentioned below.

A. NodeMCU ESP8266:

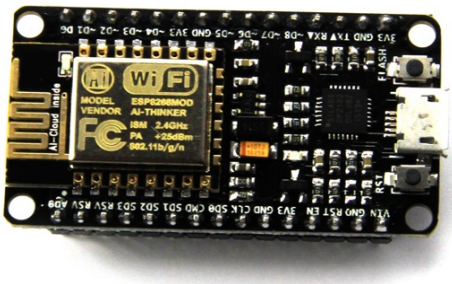

Fig.1: NodeMCU Development Board

The NodeMCU (*N*ode *M*icro*C*ontroller *U*nit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for the Internet of Things (IoT) projects of all kinds. NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications.

NodeMCU ESP8266 Specifications & Features

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Operating Voltage: 3.3V
- Input Voltage: 7-12V
- Digital I/O Pins (DIO): 16
- Analog Input Pins (ADC): 1
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- Flash Memory: 4 MB
- SRAM: 64 KB
- Clock Speed: 80 MHz
- USB-TTL based on CP2102 is included onboard, Enabling Plug n Play
- PCB Antenna
- Small Sized module to fit smartly inside IoT projects

B. 4 Channel Relay Module :

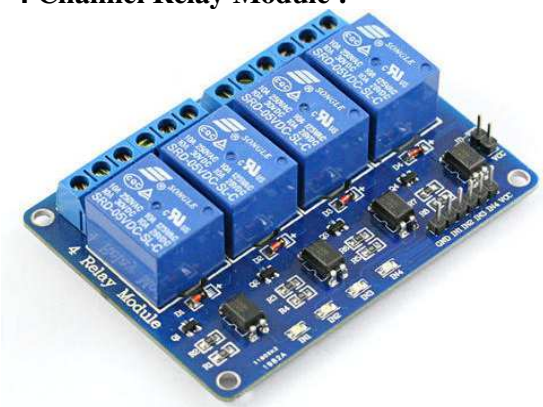

Fig 2 : Relay Module

The 4 Channel Relay Module is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps and AC load. It is designed to interface with microcontroller such as Arduino, PIC and etc. The relays terminal (COM, NO and NC) is being brought out with screw terminal. It also comes with a LED to indicate the status of relay.

Specification:

- Digital output controllable
- Compatible with any 5V microcontroller such as Arduino.
- Rated through-current: 10A (NO) 5A (NC)
- Control signal: TTL level
- Max. switching voltage 250VAC/30VDC
- Max. switching current 10A
- Size: 76mm x 56mm x 17mm

C. Transformer :

Fig 3: Transformer

A transformer is an electrical apparatus designed to efficiently change one voltage level to another while minimizing power loss.[1] These devices function exclusively with alternating current (AC). Transformers are classified into two main types: step-up (which increases voltage) and step-down (which decreases voltage) Typically, power supplies incorporate a step-down transformer to safely reduce the high, potentially dangerous, utility line voltage like230V AC to a much safer, lower voltage (such as 12V AC in this application).

As a passive component, a transformer transfers electrical energy between two or more separate circuits.[6] This transfer occurs when a fluctuating current in one winding creates a changing magnetic flux within the core, which, in turn, induces an electromotive force (EMF) across any other windings around that same core.[7] This means energy transfer happens inductively, without a direct metallic connection between the primary and secondary circuits. The physical phenomenon driving this is Faraday's Law of Induction, discovered in 1831, which mathematically describes the voltage induced in a coil by a changing magnetic flux passing through it.

3. SOFTWARE DISCRIPTION (ARDUINO IDE):

Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module. It is an officialArduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process. It is easily available for operating systems like MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment. A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more, each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code. The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board. The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

4. BLOCK DIAGRAM:

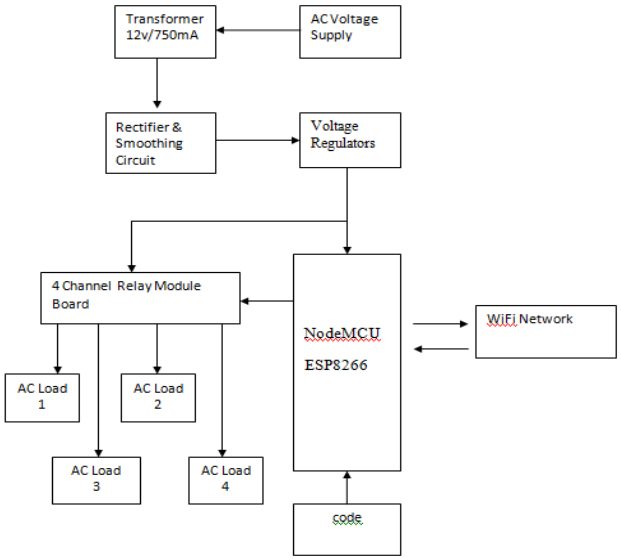

Fig 4: Block Diagram

Working Principle :

The NodeMCU ESP8266 Board is powered by dc 5v supply. The GPIO pins 5, 4 ,14, and 12 are connected to 4 inputs of 4 channel relay module as per circuit diagram. We have written code and upload the code in Arduino IDE. The code and its working as below,

How the Code Works:

Network Credentials

For connecting nodeMcu to our wifi network we need to insert our network credentials in the following lines:

```
const char* ssid="REPLACE_WITH_YOUR_SSID";
const char* password =
"REPLACE_WITH_YOUR_PASSWORD";
```

Setting Your Username and Password:

In the following variables set the username and password for your web server. By default, the username is admin and the password is also admin. We can change it to anything.

```
const char* http_username = "admin";
const char* http_password = "admin";
```

Logout Button:

In the index html variable we should add some HTML text to add a logout button. In this example, it's a simple logout button without styling to make things simpler.

```
<button onclick="logoutButton()">Logout</button>
```

When clicked, the button calls the logoutButton() JavaScript function. This function makes an HTTP GET request to your ESP32/ESP8266 on the */logout* URL. Then, in the ESP code, you should handle what happens after receiving this request.

Handle Requests with Authentication:

Every time as we make a request to the ESP32 or ESP8266 to access the web server, it will check whether we've already entered the correct username and password to authenticate.

Basically, to add authentication to web server, we just need to add the following lines after each request:

```
if(!request->authenticate(http_username,
http_password))
return request->requestAuthentication();
```

These lines continuously pop up the authentication window until you insert the right credentials.

Demonstration:

After uploading the code to ESP32 or ESP8266 board. Then, open the Serial Monitor and press the on-board RST/EN button to get is IP address. Open a browser local network and type the ESP IP address. The following page should load asking for the username and password. Enter the username and password and we will get access to the web server.

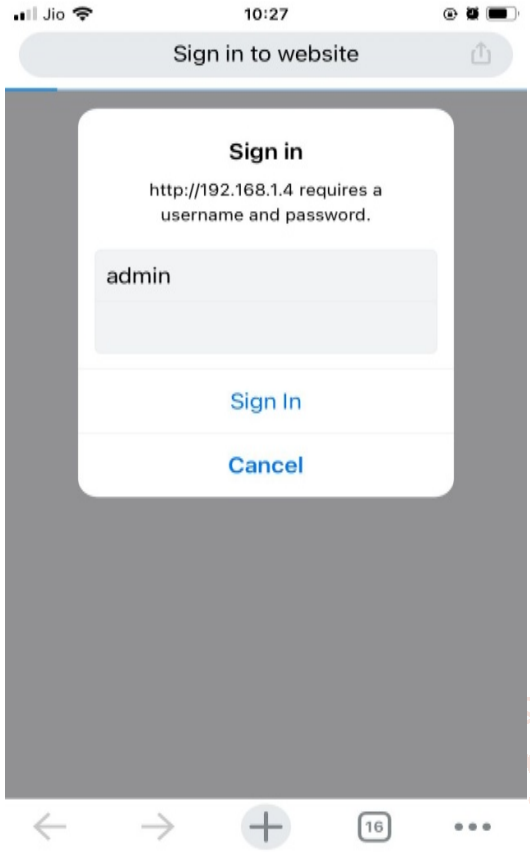

Fig 5: Login Page

After typing the right username and password, we will get access to the web server.

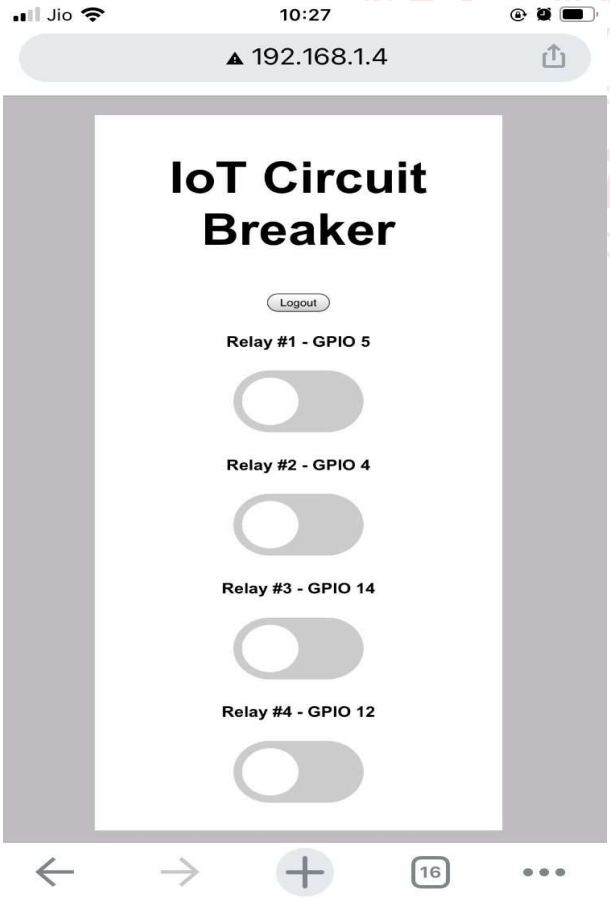

Fig 6: Web page after long in

5. CONCLUSION

The proposed system makes good use of GPS and ADXL335 sensor, vibration sensor. It gives the safety to travelers during travelling. The human deaths are reduced by this safe and secure system. It helps to find the current location of the vehicle. It is the traveler's safety mechanism. As per traveler's safety concern, the proposed system also gives massage to family members and also hospital telephone number so that in short time treatment is given to crash victim.

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