Design and Control Motorized Circuit Breaker in Electrical Distribution Panel

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Abstract. A circuit breaker is the main part of the distribution panel that needs to control for safe operation. It is important for protection and switching in the power system. Automatic control of circuit breakers using motorized can be realized by the microcontroller scheme. In this paper, a microcontroller equipped with wifi and an internet connection is used to control and monitoring the circuit breaker. The design of the circuit is proposed and experiment result is obtained. The response time is about 1 second to complete the process to control the circuit breaker. Error in monitoring application is about 3\% for voltage measurement and 3.5\% for current measurement. The proposed circuit system showed good and reliable control and monitoring of circuit breakers in every condition include of closing, opening, and monitoring.

1. Introduction
Circuit breakers are the main equipment in the electrical system for protection and switching operation. A good condition and control of circuit breaker are very important to a backup power system. A problem is circuit breaker operation can create great trouble in the power system. Circuit breakers have a lot of parts including mechanical dan electrical components. The lifetime of circuit breakers is limited to the time and number of operations.

Regular and preventive maintenance is needed to maintain the condition and reliability operation of the circuit breaker. Some maintenance can be done in the preventive maintenance program. They are checking the closing coil, tripping coil, motor charging equipment, and visual inspection of the circuit breaker. Special tool measurements are used to check circuit breaker conditions. By using a time-based maintenance program can increase the condition of circuit breakers become more healthy and reliable operation.

Nowadays, controlling using the microcontroller is a trend because it can realize controllable equipment without hardwiring. This type of control scheme has been applied in a lot of equipment especially in circuit breaker switchgear apparatus. Microcontroller is remote control of circuit breakers using internet connection and wifi. It has effective and efficient control compared with conventional control.[1,2,3]

Online control through the internet is the main principle method for the internet of things operation in distribution circuit breakers. This control is very useful to give information about circuit breaker conditions and can give earlier attention to the problem and failure of the circuit breaker. The information and control are sent to the system by using the internet via a wireless connection. Microcontroller equipped with wifi facility and modem with internet connection is needed to support control of circuit breaker.[4]
1.1. Microcontroller
A microcontroller is the main central processing unit of the circuit breaker control. This microcontroller type is wemos that use esp8266 for wireless connection. This board has some digital input and output pins that can be connected to other circuits for control, communication, and give some commands. Wemos has a micro USB android cable to program from the computer. It needs a power supply from micro USB power or external dc power supply with voltage range 7-12 Vdc. Wemos is similar to Arduino Uno. The pin in wemos is similar to the Arduino Uno pin. Programming wemos can use Arduino ide software because of the similarity with Arduino but need some wemos library to add for compatibility operation and programming. There are some differences between wemos and Arduino Uno especially in the name of pin, In Arduino Uno uses D0 to D15 for a generated pin but wemos use GPIO0 to GPIO15 for an initial pin. For general display can be shown in Figures 1a and 1b.

![Figure 1a. Arduino uno ; b. wemos](image-url)

In Figure 1, can be shown that Arduino Uno and wemos have a similar pin to a connected circuit. Programming wemos with Arduino ide software must follow the initial pin from GPIO0 to GPIO15 based on the wemos manual [5,6].

1.2. Blynk Application
Internet is like a virtual connection from one person to another. Nowadays, the internet also can connect and control equipment from another location. Blynk is an application to connect equipment especially circuit breakers in the platform scheme by using an internet connection. This application is open source so it's simple and easy to operate. Blynk can be installed on the android platform using the play store from google. The design of control can be done online from this application. Controlling push button, input and output state will connect to wemos through internet cloud via blynk application [7,8].

1.3. Circuit Breaker Control
Control of circuit breaker divided into the manual and automatic scheme. Microcontroller is the automatic control of circuit breakers. According to a distribution circuit breaker, there is a local and remote control for operating this equipment. Local control is operating the circuit breaker directly from the panel. Remote control is operating the circuit breaker from another place that is far away from the panel. Microcontroller is the type of remote control of circuit breakers because using the internet to operate circuit breakers from another place. Designing remote control of circuit breakers must follow the operating manual of the circuit breaker manufacturer [9,10,11]. The operating manual of the circuit breaker can be shown in figure 2.
Figure 2. Manual operating control of circuit breaker

From figure 2, the type of circuit breaker is Easy Pact Series with a 0-100A rating from Schneider Electric. This circuit breaker is completed with motor charging equipment for charging and discharging the spring mechanism. Remote and automatic control selection are must be set for supporting the control system [12].

2. Methodology

Design and control using a microcontroller will be implemented in the blynk platform. In the beginning, Proteus software is used to design the circuit and control circuit breaker.

2.1 Motorized Circuit Breaker Control

Motorized circuit breaker control is applied using the schematic diagram shown in figure 3. The supply control is 220Vac from single-phase voltage sources input.

Figure 3. Motorized circuit breaker control schematic

The system in fig.3 uses the input of single-phase 220V for control and operating the circuit breaker. There is some component inside the circuit breaker. First is charging motor (M) to charge spring for closing and opening operation CB contact mechanism. MN is Undervoltage release to
tripping CB when there is nothing voltage input detected. MN must be always connected with input sources voltage of CB. Closing coil and tripping coil are used for closing and opening CB with temporary voltage supplied by push button on (BPF) and push-button off (BPO). BPO and BPF will be controlled by a microcontroller to support remote control operation. ON OFF indication CB is done by auxiliary contact 11(common) - 12(Normally Open)- 14(Normally Close).

2.2 Microcontroller Design and Control of Circuit Breaker
A microcontroller is used to provide a remote controlling circuit breaker (CB) by using the platform. This system schematic can be shown in figure 4.

![Circuit breaker control schematic using microcontroller](image)

**Figure 4.** Circuit breaker control schematic using microcontroller

Relay 1 (RLY1) is used to control CB ON by using normally open contact. RLY1 is operated by a control signal from D0 wemos. Relay 2 (RLY2) is used to control CB OFF by using normally open contact. RLY2 is operated by a control signal from D1 wemos. Relay 3 (RLY3) is used to control remote CB by using normally open contact. RLY4 is operated by a control signal from D2 wemos. Relay 4 (RLY4) is used to control Load at Phase R by using normally open contact. RLY4 is operated by a control signal from D3 wemos. Relay 5 (RLY5) is used to control Load at Phase S by using normally open contact. RLY5 is operated by a control signal from D4 wemos. Relay 6 (RLY6) is used to control Load at Phase T by using normally open contact. RLY6 is operated by a control signal from D5 wemos. Relay 7 (RLY7) is used to control Load at Phase N by using normally open contact. RLY7 is operated by a control signal from D6 wemos. Relay 8 (RLY8) is used to spare control by using normally open contact. RLY8 is operated by a control signal from D7 wemos. All control commands send by wemos to the blink android application via wireless and internet connection.

A monitoring system is provided by voltage sensor and current sensor. This system uses wemos dan Arduino Uno to complete requirement control and monitoring. Voltage sensor ZMPT101B connects analog input A0 of Arduino Uno and sends data sensor wemos. Serial communication via TX
and Rx pin is used to collect data from Arduino Uno to wemos. Wemos send the data via a wireless connection through the internet to the blynk cloud. Current sensor ACS712_05B connects analog input A0 of wemos. Wemos send the data via a wireless connection through the internet to the blynk cloud. Blynk application receives data sensors and commands from wemos for monitoring and controls the circuit breaker.

2.3 Blynk application
Blynk is a platform to support control and monitoring systems using the internet cloud. Blynk has three main components. They are the blynk application, blynk server, and blynk library. Blynk application can be installed on Android smartphones or ios.

![Blynk platform in android](image1)

**Figure 5.** Blynk platform in android

Blynk can be installed from the play store. It is started by registering an account with an active email. Project for blynk can be customized by selecting a component in control and monitoring element (push button, toggle switch, gauge, etc). In every project, a token will be sent in email. Programming Arduino ide for microcontroller must be listed the token and blynk library. All the programs will be compiled and injected to wemos to guarantee the blynk platform can run in normal conditions.

3. Results and Discussion
Experiment results are obtained from the proposed circuit. Set up experiments are divided into two-part. They are microcontroller circuits and circuit breakers. The microcontroller circuit in figure 8 uses Arduino Uno and wemos microcontroller to control the circuit breaker. There is 8 relay control used to specific function according to section 2.2. The human-machine interface is displayed on a smartphone using the Blynk platform. MIFI modem is used to connect to the internet. Android command and monitoring is sent to blynk and then to wemos for controlling and monitoring circuit breaker. Display operation in an android smartphone can be shown in figure 9.

![Microcontroller circuit and Blynk platform in android](image2)

**Figure 6.** Microcontroller circuit and Blynk platform in android
Figure 7. Android smartphone display

From figure 9, each button is considered with activated control relay (RLY1-RLY8). Each button and control relay has a specific function according to section 2.2 (CB ON, CB OFF, Remote, Load R, Load S, Load T, Load N, Spare). Tegangan (Volt) gauge represents the value of voltage from the voltage sensor (ZMPT101B). Arus (milliampere) show the current value from a current sensor (ACS712_05B).

The operating sequence and requirement condition of the circuit breaker is shown in table 1. Controlling CB ON or OFF from blynk android only can be done when control REM is activated (RLY1 activated). Load R-S-T connected after CB is ON condition. Load R is connected to supply when load N (RLY7) and load R (RLY4) are activated. Load S is connected to supply when load N (RLY7) and load S (RLY5) are activated. Load T is connected to supply when load N (RLY7) and load T (RLY6) is activated. Spare is an additional control relay (RLY8) for upcoming purposes.

Table 1. Operation control sequence of circuit breaker

| Blynk Android | CB | Time |
|---------------|-----|------|
| Button REM    |     |      |
| Button CB ON  |     |      |
| Button CB OFF |     |      |
| Load N        |     |      |
| Load R        |     |      |
| Load S        |     |      |
| Load T        |     |      |
| Spare         |     |      |

The monitoring circuit breaker can be shown in the blynk android with voltage and current gauge display. Voltage gauge display has 0-600 Vac scale rating to show single-phase and three-phase phase voltage. This system uses single-phase voltage measurement according to the 0-220 Vac measurement.
range of the ZMPT101B voltage sensor. The current gauge has a 0-5000 milliampere scale according to the 0-5A current measurement range of the ACS712 current sensor.

| Table 2. Voltage monitoring and measurement |
|---------------------------------------------|
| Volmeter | Blynk | Error (%) |
|-----------|-------|-----------|
| 1         | 221   | 214       | 3.2       |
| 2         | 218   | 210       | 3.7       |
| 3         | 216   | 211       | 2.3       |
| 4         | 224   | 217       | 3.1       |
| 5         | 220   | 214       | 2.7       |

From table 2, the data sensor displayed by blynk android is compared with voltmeter measurement. Android blynk can show the voltage value nearest to the real voltage measured by a voltmeter. The average error for the voltage sensor is 3%.

| Table 3. Current monitoring and measurement |
|---------------------------------------------|
| Load | Amperemeter | Blynk | Error (%) |
|------|-------------|-------|-----------|
| 1    | 25 W        | 115 mA| 110 mA    | 4.3       |
| 2    | 40 W        | 182 mA| 176 mA    | 3.3       |
| 3    | 60 W        | 274 mA| 267 mA    | 2.6       |
| 4    | 100 W       | 456 mA| 438 mA    | 3.9       |

From table 3, the data sensor displayed by blynk android is compared with amperemeter measurement. Android blynk can show the current value nearest to the real current measured by an amperemeter. The average error for the current sensor is 3.5%.

Figure 10 shows the connection between the microcontroller and the circuit breaker. CB ON is controlled by RLY1 using wemos. CB OFF is controlled by RLY2 using wemos. Wemos connected to blynk platform from android through wireless and internet.

Figure 8. Circuit breaker connection

4. Conclusion
The experiment has been carried out from the proposed circuit. From the experiment results, it is obtained that the proposed design can be applied to circuit breaker control and monitoring. There is 6 main components for the system. They are circuit breakers, Arduino microcontrollers, wemos microcontroller, blynk platform, voltage sensor, and current sensor. The system has efficient operation according to the platform used. Remote control and monitoring of circuit breakers also can be done with a fast response with microcontroller. The control response blynk android platform to circuit breaker needs about 1 second to complete the process. Error value for voltage sensor and the current sensor is about 3% and 3.5%. According to the experiment result, the system complies with
requirement control and monitoring of circuit breakers and can be applied not only in circuit breakers but also in other equipment.

5. References

[1] Abhijit Das, K. Kalimuthu, S.S Biswas 2018 *IoT Based Circuit Breaker Monitoring and Control* (India: Internation of Applied Engineering Research) Research India Publication

[2] Shaikh Viquar A, Chaudari A.L, 2015 *Development of Microcontroller Based Tool for Effective Learning of Concept in Control System* (India: International Journal of Electronics and Communication Engineering) Vol.2 Issue 9.

[3] Utkarsh Chaurasia, Sripad G, Desai, 2021 *Industrial Automation Using Microcontroller* (India: International of Innovative Research in Technology)

[4] Bhagwan Kharat, Durvankur Sarwade, Dhananjay Bidgar 2017 *Internet of Thing (IoT) Based Controlling and Monitoring of Circuit Breaker* (India: International Research Journal of Engineering and Research Technology)

[5] Shantos A.K, Jayashri Shrirang Bhagwat, Nilima S.B 2020 *IoT Based Circuit Breaker* (India: International Research Journal of Engineering and Research Technology)

[6] Kalyani S.S, Dhsa D.K, Smaruddhi B.P, 2020 *IoT Based Circuit Breaker Control and Monitoring* (International Journal of Engineering Research) Page 05-07

[7] Ari Asmawati, Fajar Januar, Lionel Richi 2019 *Control LED Through Nodemcu Based Internet with Blynk Application* (Indonesia: APTISI Transaction of Technopreneurship ) Vol.1 no.2

[8] Octavian M.M, Cornel C, Petre O, Carmen G, Lia A, 2018 *Power System Protection Device with IoT Based Support for Integration in Smart Environment* (Portugal : Plose One )

[9] M.d Sanwar H, M. Rahman, M.D Tuhin S, M.d Ershadul H.J , 2019 *A Smart IoT Based System For Monitoring & Controlling The Sub Station Equipment* (ReserachGate )

[10] Kalaivanan S, Sangeetha M, 2016 *Monitoring and Controlling of Smart Homes Using IoT and Low Power Wireless Technology* (India: Indian Journal of Science and Technology )

[11] Ida Bagus G.P, I Nyoman S.K, Made S, 2020 *Application of IoT Based System for Monitoring Energy Consumption* (Indonesia: International Journal of Engineering and Emerging Technology ) Vol.5 No.2

[12] Schneider Electric 2018 User Manual *Compact NSX Circuit Breaker and Switch Disconnector 100-630A* (www.se.com)