Design of Remote Warning System for Miniature Circuit Breaker (MCB) Power Shortage via Internet of Things (IOT)

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Abstract. Miniature Circuit Breaker (MCB) is an electro-magnetic device designed to cut off the circuit when an overcurrent occurs. This MCB system is essential in many fields that involved with electric and commonly found in industry, it will protect the electric component in the circuit from short circuit. The Internet of Things (IoT) technology is a new profound technology which will lead to a better and easy lifestyle world. One of the benefits of IoT system is the worker can monitor their work from home. With this new and promising technology, most of the work can be done at home by using mobile phone or a computer. As the title of the project presented, the project developed a microcontroller to monitor the MCB using the technology of the Blynk as the IoT platform. The system will send a message to the user to inform about the trips through a mobile phone by the Blynk application. At the same time, the alternating current (AC) of the MCB is record and graph at the mobile application.

1. Introduction

Miniature circuit breaker (MCB) is the most common used electromagnetic device to act as a switch of the circuit. The MCB will automatically cut off the circuit when power shortage or leakage occurs in the circuit to prevent the component in the circuit destroy or burn by over current or over voltage [1]. Normally, when the power supply trips, the worker cannot identify it and cost the company to loss profit or drag the schedule. Internet of Things (IoT) system is the physical device that connects with the internet. It is been widely used in most technology and devices by collect data and share data such as smart home [2]. Furthermore, it can also provide a better work efficiency as the worker or supervisor can be alerted when power supply is off while doing other task or outside the factory during break time or out station. By referring to some advantages of using IoT technology in the remote warning system for MCB power shortage, the combination of MCB and IoT will be used to create a remote wireless alarm system for the user to aware the condition of the MCB. The proposed system consists a microcontroller will be monitoring the MCB and send data to the cloud system when a trip occurs. Then, it will warn the user from an application in phone, this system can act as a surveillance system in a factory whether a fault or short circuit occurs. Circuit breaker is an electrical switch designed to cut off the circuit automatically when overload current or short circuit occurs, this is to prevent electrical circuit or device damage from excess current. It is a very important system for buildings, laboratory and industrial factory, to prevent fire or accident happen from a fault [3]. Nowadays, IoT device such as smart home is widely known for security and monitoring system as the user can be alert or observe the situation at home anytime anywhere. The warning system for MCB shortage via IoT can be integrated with the smart home for protecting electrical devices [4]. When a personal is around the DB box, it is hardly to notice the power supply is trip in a factory. With the IoT
system, the personal is immediately notify when trips. This paper presented, to develop a microcontroller to monitor the MCB using the technology of the Blynk as the IoT platform. The system will send a message to the user to inform about the trips through a mobile phone by the Blynk application. At the same time, the alternating current (AC) of the MCB is record and graph at the mobile application.

2. Literature from previous work
Er Chee Kong developed a long-range warning system for Miniature circuit breaker (MCB) power shortage using Global System for Mobile Communications (GSM). The system requires a sim card to access digital cellular network which used by mobile phone and send message. As the distances between the MCB and phone are further, the time taken for the phone to receive the massage will also be longer [5]. An Intelligent Power Outlet System for the Smart Home of the Internet of Things was proposed by Tiago M. Fernández. Each power socket attached with a ATmega328P (microcontroller) to monitor the current and read the radio-frequency identification (RFID) tag. The data obtained will be send to the main microcontroller with ZigBee interface to transfer the data to web application through USB [6]. In another research, Mr. Sumit D, Pople present a circuit breakers technology for short circuit and over voltage protection. The project is a fast-reacting circuit breaker technology; the current transformer will compare the current flow with the present value [7]. One project conducted by Ahmed H.H Imam, a smart home based on IoT using NodeMCU ESP8266 and Blynk were developed. The project is about using Blynk application in mobile phone to control the bulbs using switching relay and collect temperature data using LM35 temperature sensor [8].

3. Methodology
As a brief explanation on the structure of the project, the MCB powered by AC current. Then, MCB is connected to the relay and from relay back the AC power supply. The 5VDC supply is used to power up the microcontroller. The switching relay will give an input source to the microcontroller when an AC current flow through. To collect the AC current, a wire from MCB is passing through the hole of the current sensor and the current sensor will return the value to microcontroller. Afterward, the microcontroller is connected to the IoT module. A general structure design of the project structure is shown as Figure 1 below.

3.1 Hardware Connection
The connection of the hardware is shown as Figure 2 below which is drawn using Proteus 8 software. In this circuit, the switch symbol is representing the MCB because the Proteus 8 software does not have the symbol for MCB. The 240V sin wave AC supplies are the 240 VAC power source for the Live (L) and Neutral (N). The lamp symbol will represent the LED light bulb. The ZMCT103C is the current sensor, the Live wire actually go through the sensor’s hole with connection and it is supplied 5DCV from Arduino. Subsequently, the OMRON MY2N is the relay for switching. The TXD and
RXD pins in the Arduino Uno R3 are connected to the ESP8266. Then, the 3.3V pin and GND pin in the microcontroller which connected to ESP8266.

![Figure 2. Hardware Connection Diagram by Proteus 8.](image)

3.2 Software Development

Furthermore, there are 2 main software involved in this project. Firstly, Arduino IDE is the one of the main software that programs the Arduino Uno R3. It is the software specializes to program Arduino series microcontroller. Next is the Blynk software in mobile phone which used to interact with the microcontroller via IoT module. This is the software that enables the microcontroller send message to the phone.

3.2.1 Arduino IDE

Initially, the BLYNK library is included into the Arduino IDE manually. The library is downloading as zip file and added ZIP library option. In the preference, the https://arduino.esp8266.com/stable/package_esp8266com_index.json link is inserted in Additional Boards Manager URLs. Went to the Tools> Board> Boards Manager to install the ESP8266 board. The Arduino Uno board is selected as the Figure 3 shown below:

![Figure 3. Hardware Connection Diagram by Proteus 8.](image)
3.2.2 **Blynk Application**

The Blynk application is downloading in a smartphone from Google play store. A new project is created with a SuperChart 2 Value Display, a LED, and a Notification in the Widget Box. The digital value generated from the current sensor will be displayed as V2 and the calculated value will be displayed as V1. The V1 data will also be graphed on the SuperChart, root means square (RMS) current against time. The Arduino Uno is added to the application as devices and an authentication token is generated. The Figure 5 shows the full Blynk application created and the setting in it.

![Figure 5. Blynk Application Setting](image)

3.2.3 **Prototype of the project**

After the preparation of components and apparatus are completed, the prototype is constructed to achieve the first objective of the project. The Figure 6 shows the structure of the prototype.
4. Result and Discussion
A few tests are done to verify the functionality of the remote warning system for the MCB power shortage based on IoT technology. A simple test is performed to identify the capability of the prototype. The time taken for the microcontroller to connect to the mobile application is measured and the effects of Wi-Fi signal strength towards the microcontroller are recorded. Furthermore, 3 experiments are connected to test the functionally of the prototype where the Blynk application will notify in phone, to analyse the RMS current of different devices and collect current level when the MCB supply AC current to a burned lamp as shows in Table 1.

| Experiment | Title                                                      |
|------------|------------------------------------------------------------|
| Test 1     | Time taken for the microcontroller to connect to mobile application |
| Test 2     | The effect of Wi-Fi signal strength towards microcontroller |
| Experiment 1 | The functionally of prototype                        |
| Experiment 2 | Analysis of the RMS current on LED lamp and Electric stand fan |
| Experiment 3 | The current level when MCB supply AC current to a burned lamp |

4.1 The capability of the Prototype
Two simple tests were to measure the time taken for the microcontroller to connect to the mobile application and observe the effect of Wi-Fi signal strength towards the microcontroller. The data recorded are displayed in Table 2 and Table 3. Initially, the application was opened in smartphone and it will show that device is not connected. The power supply was given to the microcontroller and the stopwatch was started instantaneously. When the bottom of the application show “Device is connected”, the time was recorded. The similar procedures were repeated 5 times and the average time taken was calculated. The microcontroller takes about 21 seconds to connect to the application and collect data. The test carried out by increase the distance between the source of the Wi-Fi and at location where the signal meets the condition in the table. When the prototype receives strong Wi-Fi signal or mobile data, the prototype is fully functional. On opposite, the prototype will not operate when weak signal received even when the source connection is successful. On 2 bars Wi-Fi signal strength, the prototype able to connect with the Wi-Fi and application but the data transmitted is slow and some data are loss due to time out.
Table 2. Time Taken for The Microcontroller to Connect to Mobile Application

| Attempt | 1   | 2   | 3   | 4   | 5   | Average |
|---------|-----|-----|-----|-----|-----|---------|
| Time(s) | 22.64 | 22.23 | 21.84 | 21.94 | 21.97 | 21.12   |

Table 3. The Effect of Wi-Fi Signal Strength Towards Microcontroller.

| Signal Strength | Wi-Fi | Mobile Hotspot |
|-----------------|-------|----------------|
|                 | 1 bar | 2 bar | 3 or 4 bars | H+ | 4G |
| Source connection | Yes | Yes | Yes | Yes | Yes |
| Application connection | No | Yes | Yes | No | Yes |
| Responding | No | Slow | Fast | No | No |

4.2 Experiment 1

The experiment 1 was to test functionally of the prototype where Blynk application will notify in phone as shown in Figure 7. When the MCB is off, the user will be notified by the application in smart phone after the connection is established. When the MCB is on, the notification will be stopped, and the virtual LED will be closed. The data collection and calculation will be continued even when the MCB is off. The RMS current will be displayed and graphed on the Superchart on live; a general graph can be seemed when the time is scale change. The digital value display was used to overcome the zero error.

Figure 7. Result of MCB is Off and On.

4.3 Experiment 2

The analysis of the RMS current on different devices was conducted in experiment 2. There were 2 devices tested which were LED lamp and electric stand fan. Three similar tests were organized to get 3 stages of data as shows in Figure 8. A tabulation of data was done to calculate the average value and identify the difference. At stage 1, the MCB is on while the LED is off. The vampire current for LED
found was 0.22A with noises. At stage 2, there is no current spike unlike the other 2 graph and the current peak is around 0.6A, so the current used by the LED is 0.38A in this test. The final stage 3, MCB was completely cut off power supply and its present noises from current sensor.

![Figure 8. LED lamp.](image)

The Electric Stand Fan Graph 1 presented a zero error of 0.3A and insignificant vampire current. As shown in Figure 9. After the fan turn on the RMS current level rise to average of 1.55A, the current used was calculated with value of 25A.

![Figure 9. Electric stand fan graph.](image)

4.4 Experiment 3

This experiment was about the reaction of MCB when trips and it was conducted carefully. The procedures of this experiment were overseed and the AC power supply was plugged in at a solitary socket with no other device connected in the same series of circuit. A burned lamp was connected to the socket of the prototype and it was ensured that it was in off mode. As the experiment began, the microcontroller was supplied DC voltage and the MCB was supplied AC power. After the device is linked with Blynk application, the burned lamp was carefully switch on with the mind-set of switching it off immediately. Instantaneously, the MCB trips and all the switches in the connection were turned off. The current level when a trip was recorded. Unlike the previous experiments, this experiment was only conducted once due to its hazard and risk of damaging other components. The result was shown in Figure 10 below. As expected, the current spiked with a high current peak and MCB trips abruptly. The graph started at 0A where MCB was closed. When the burned lamp turned on, the current rocketed and fell to 0A as the MCB cut off the circuit.
5. Conclusion

This paper presents the design of remote warning system for Miniature Circuit Breaker (MCB) power shortage via Internet of Things (IoT). The hardware parts are the construction of the circuit connection and the outlook of the project (mechanical parts). The MCB system is connected with the ESP8266 to achieve an IoT device that able to connect with Wi-Fi. The components are arranged with boxes and the wires are organized. The prototype of Remote Warning System for MCB Power Shortage via IoT is built from reference of other literature sources and the first objective is achieved. Furthermore, the software parts are the program for the microcontroller and phone application. Initially, the microcontroller is programmed to connect with Wi-Fi and perform its functionality. The program is synchronized with the Blynk application for IoT purpose. When the prototype is power up, the system is able to notify the user if MCB trips and it will collect AC current data. Then, the data will be calculated and display in mobile phone. All the test conducted on the prototype is to proof that it can perform the required tasks and the analysis on RMS current on different devices were done. Thus, the second and third objectives of the project are achieved.

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