

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

Lim Hong Quan¹, Mohd Zamri Hasan^{2*} and Nurul Syahirah Khalid³

^{1,2,3} Faculty of Electrical Engineering Technology, Universiti Malaysia Perlis, UniCITI Alam Campus, Sungai Chuchuh, 02100 Padang Besar, Perlis

ABSTRACT

In this modern era, the Internet of Things (IoT) technology is a new profound technology which leads to a better and easy lifestyle world. With this technology, office workers will not require to present in a company and industrial workers will no longer needed in a factory to monitor manufacture process. With this new and promising technology, most of the work can be done at home by using mobile phone or a computer and even a machine can run itself with a single button. As the title of the project presented, the project proposed an application of the Miniature Circuit Breaker (MCB) using the technology of the IoT. This project is a warning system when a black out occurs, it will send a message to the user to inform about the trips through a mobile phone. Sometimes, workers overlook the short circuit of the machine which results in a loss to the company and delay of the product. In this project, a prototype of the MCB system with the IoT technology will be developed and created to achieve the objective of project. Furthermore, the prototype will be tested to show that the prototype is functional and efficient as it is a remote warning system via Wi-Fi.

Keywords: Miniature Circuit Breaker (MCB) , Internet of Things (IoT), Power Shortage.

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 from being destroyed or burnt by over current or over voltage [1]. Normally, when the power supply trips, workers cannot identify it and causes loss of profit of the company or even 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 collecting and sharing 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 be aware of the condition of the MCB. The proposed system consists of a microcontroller which will be monitoring the MCB and send data to the cloud system when a trip occurs. Then, it will warn the user by using an application in the mobile phone where this system can act as a surveillance system in a factory whenever a fault or short circuit occurs. Circuit breaker is an electrical switch which is designed to cut off the circuit automatically when overload current or short circuit occurs as well as preventing 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 to 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 alerted or observed the situation at home anytime and anywhere. The warning system for MCB shortage via IoT can be

*Corresponding Author: zamrihasan@unimap.edu.my

integrated with the smart home for protecting electrical devices [4]. When a personal is around the DB box, it is hard to notice the power supply is tripped in a factory. With the IoT system, the personal is immediately notified when there is a trip. Based on the project conducted by Er Chee Kong (2014), the IoT system can replace the Global System for Mobile Communication (GSM) system which will be unable to function in low signal strength area as IoT system has a wider signal range. A battery is also suggested to add to the circuit so that the system will send the message even when the total power is off [5].

1.1 Literature from previous work

Er Chee Kong developed a long-range warning system for Miniature circuit breaker (MCB) power shortage using Global System which used Mobile Communications (GSM). The system requires a sim card to access digital cellular network 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 message 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 is attached with a ATmega328P (microcontroller) to monitor the current and read the radio-frequency identification (RFID) tag. The data obtained will be sent to the main microcontroller with ZigBee interface to transfer the data to web application through USB [6]. In another research, Mr. Sumit D, Pople presented a circuit breakers technology for short circuit and over voltage protection. The project is a fast-reacting circuit breaker technology where the current transformer will compare the current flow with the present value [7]. One project conducted by Ahmed H.H Imam where 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 by using LM35 temperature sensor [8].

2. METHODOLOGY

As a brief explanation of the structure of the project, the MCB is powered by AC current. Then, MCB is connected to the relay and from the relay back to 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. In order to collect the AC current, a wire from MCB passes through the hole of the current sensor and the current sensor will return the value to microcontroller. Subsequently, the microcontroller is connected to the IoT module. A general structure design of the project structure is shown as Figure 1 below.

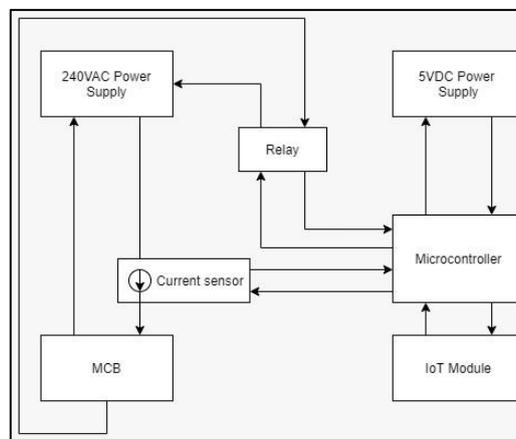


Figure 1. General Design Project.

2.1 Software Development

Furthermore, there are 2 main software which involve 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. The second one is the Blynk software in mobile phone which is used to interact with the microcontroller via IoT module. This is the software that enables the microcontroller send message to the phone.

2.1.1 Arduino IDE

Initially, the BLYNK library is included into the Arduino IDE manually. The library is downloaded 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 in Figure 3. In the Arduino IDE program, the Arduino Uno library, Blynk library and ESP8266 library are used. The Wi-Fi ID and password are inserted in the Blynk code along with the authentication token to connect to the Wi-Fi and Blynk mobile application. A few inputs and variables setting are done with the calculation for the current. Figure 2 shows the main programming for microcontroller.

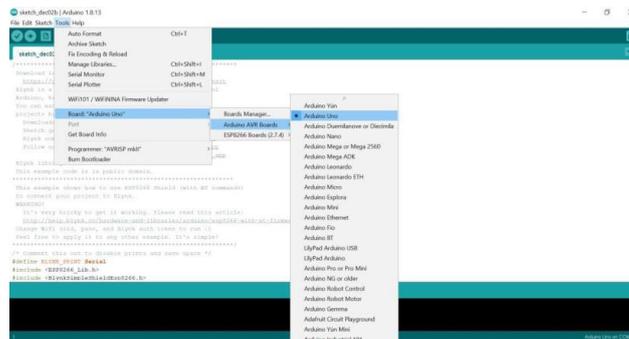


Figure 2. Hardware Connection Diagram by Proteus 8.

2.1.2 Blynk Application

The Blynk application is downloaded 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 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 a device and an authentication token is generated. The Figure 3 shows the full Blynk application created and the setting in it.

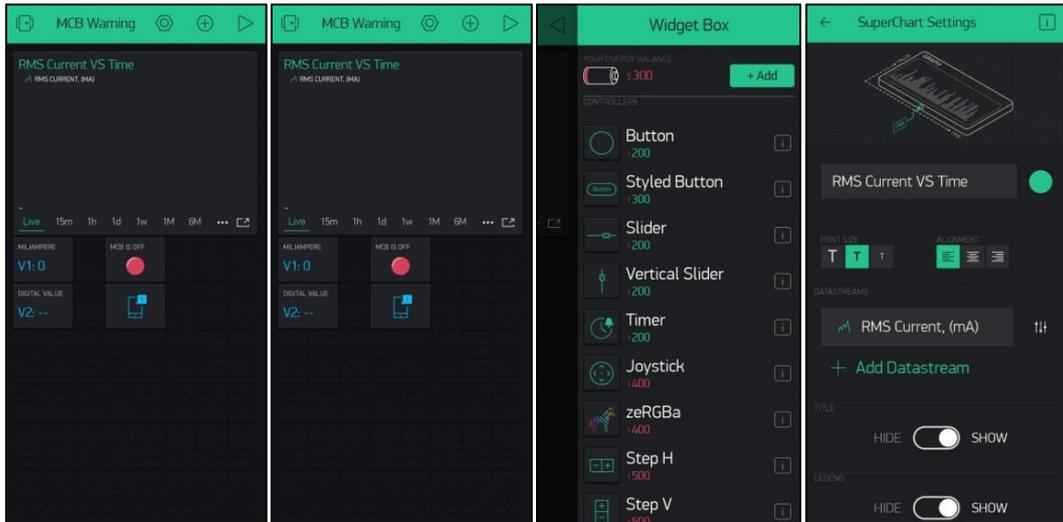


Figure 3. Blynk Application Setting.

2.2 Hardware Development

The connection of the hardware is shown as Figure 4 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 and the Live wire actually go through the sensor's hole with connection and it supplies 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 and GND pins in the microcontroller are connected to ESP8266.

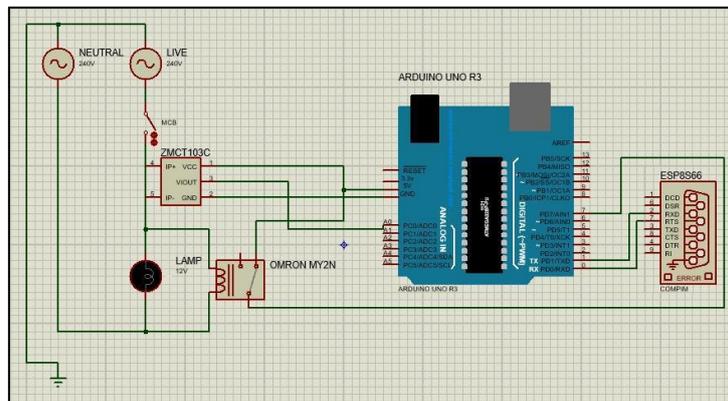


Figure 4. Hardware Connection Diagram by Proteus 8.

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 5 shows the structure of the prototype.



Figure 5. Prototype of the Remote Warning System for MCB Power Shortage via IoT.

2.4 Program flow

After the program is uploaded to the Arduino Uno R3, the microcontroller will function as the program flow as Figure 6. When the microcontroller is given 5VDC supply, it will check the status of the ESP8266. If the status is fine, ESP8266 will connect to the Wi-Fi with the given ID and password. It will continue to link with the Blynk application using the auth token. If the microcontroller is connected, the phone application will show that the device is connected. Now, the microcontroller will follow as the general program flow which it will continuously collect and graph the data, while checking the status of the MCB. For the status of MCB, the relay will send input value of 1 if the MCB is on. In contrast, it will send input value 0 if MCB is off. When MCB is off, the application will notify the user and light up the virtual LED.

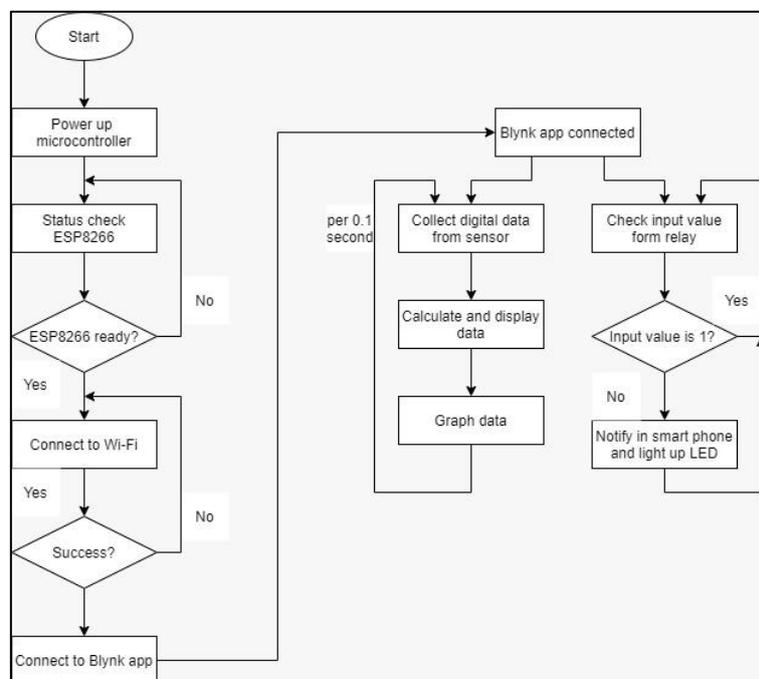


Figure 6. Program Flow

2.5 Experiment Setting

A simple test is conducted to get the time taken for the microcontroller to connect to the mobile application and how the Wi-Fi signal strength will affect the microcontroller. Furthermore, 3 experiments are also conducted. The first experiment is done to test the function of the prototype where the Blynk application will notify in the smart phone. The next experiment is about the RMS current of different devices. The final experiment is to test the MCB and collect current level when trip.

3. RESULTS 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 conducted to test the function of the prototype where the Blynk application will notify in the smart phone. This is also done to analyse the RMS current of different devices and collect current level when the MCB supply AC current to a burned lamp.

Table 1 List of Experiments

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 functionality of the prototype
Experiment 2	Analysis of the RMS current on LEAD lamp and electric stand fun
Experiment 3	The current level when MCB supply AC current to a burned lamp

3.1.1 The Capability of Prototype

Two simple tests were done to measure the time taken for the microcontroller to connect to the mobile application and also to observe the effect of Wi-Fi signal strength towards the microcontroller. The data recorded are displayed in Table 2 and Table 3.

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

Initially, the application was opened in a smart phone and it will show that the 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 the data.

Table 3 The effect of Wi-Fi signal strength towards microcontroller

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

The test is carried out by increasing the distance between the sources of the Wi-Fi at a 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. Whereas, the prototype will not operate when weak signal is received even when the source connection is successful. On 2 bars Wi-Fi signal strength, the prototype is able to connect to the Wi-Fi and application but the data transmitted is slow and some data are lost due to timeout.

3.1.2 Experiment 1

The experiment 1 was done to test the functionality of the prototype where the Blynk application will notify in the smart phone as shown in Figure 7 and Figure 8. 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 where a general graph appeared when the time scale changes. The digital value display was used to overcome the zero error.

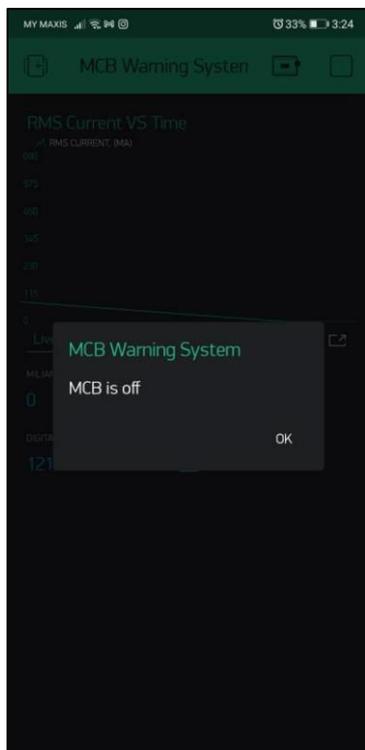


Figure 7. Result of MCB is OFF



Figure 8. Result of MCB is ON

3.1.3 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.

3.1.3.1 LED Lamp

Three similar tests were organized to get 3 sets of data as in Figure 9(a), Figure 9(b), and Figure 9(c). A tabulation of data was done to calculate the average value and identify the differences.



Figure 9 (a). LED Lamp graph 1

Based on Figure 9(a), 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 graphs and the current peak is around 0.6A, so the current used by the LED is 0.38A in this test. In the final stage 3, the MCB has completely cut off the power supply and there were noises from the current sensor.

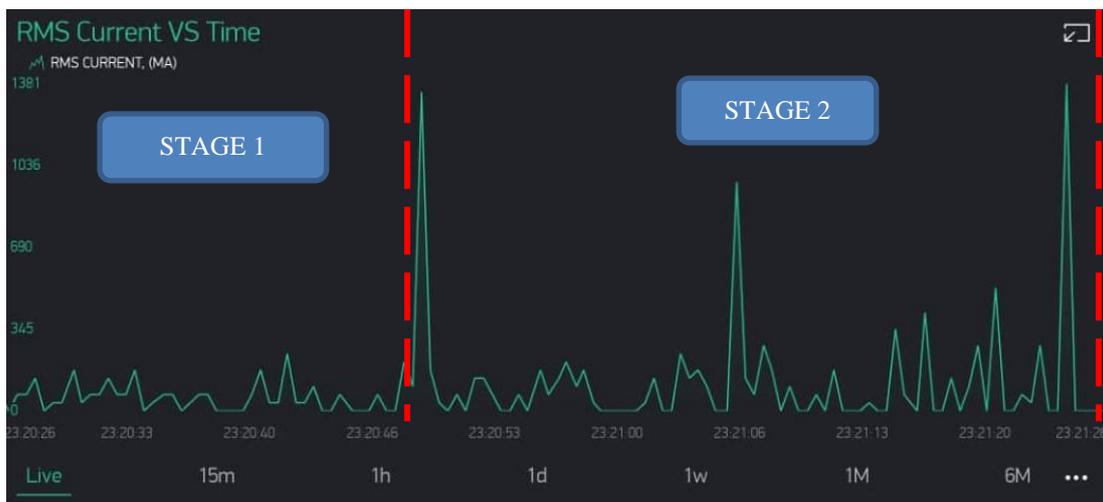


Figure 9 (b). LED Lamp graph 2

Figure 9(b), at stage 1, the vampire current was considered 0.1A with noises. In the beginning of stage 2, there was a current spike, and the average current peak was 0.3A. The last part of the graph, MCB was completely turned off and it presented 0A.

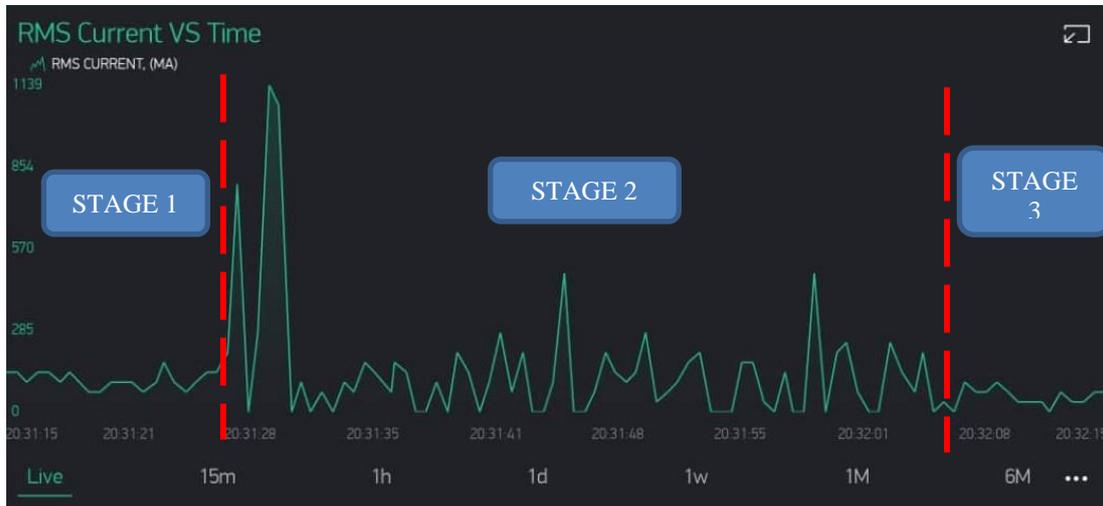


Figure 9 (c). LED Lamp graph 3

According to Figure 9(c), at stage 1, there is a zero error of 0.05A and vampire current of 0.06A. After the current spike, the graph showed current peaks about 0.3A which the current consumed was 0.24A. At stage 3, the power supply was cut off and it showed only the zero error of 0.05A.

Table 4 Data Tabulation of LED Lamp

Attempt	1	2	3	Average
Zero Error, (A)	0.00	0.00	0.05	0.016
Vampire Current, (A)	0.22	0.10	0.06	0.126
Noise	Exist	Exist	Exist	Exist
RMS Current by LED, (A)	0.38	0.20	0.24	0.273

Based on the Table 4, all tests consist of noise and vampire current which have average value of 0.016 even though the value is independent in each graph. Only the third attempt has the zero error. The average of RMS current is 0.273A and the current level obtained was low because the LED is not a power consuming device.

3.1.3.2 Electric Stand Fan

Four duplication tests were managed for better accuracy and the test's data were easier to obtain due to the high-power consumption of electric stand fan compare to LED lamp. The graphs of RMS current of stand fan were displayed in Figure 10(a), Figure 10(b), Figure 10(c), and Figure 10(c).



Figure 10 (a). Electric Stand Fan Graph 1

The Electric Stand Fan Graph 1 presented a zero error of 0.3A and insignificant vampire current. After the fan was turned on, the RMS current level rises to the average of 1.55A. The current used was calculated with the value of 1.25A.

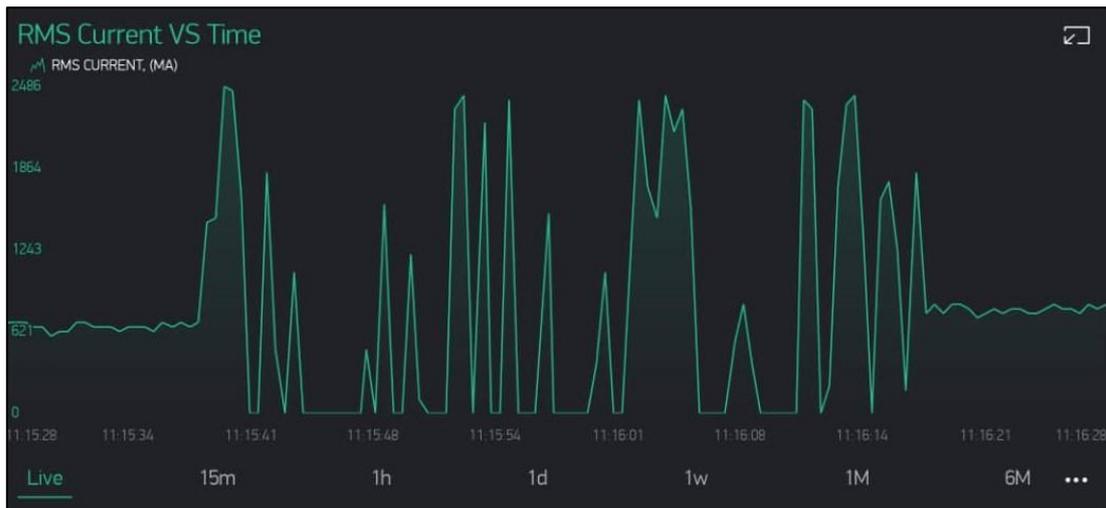


Figure 10 (b). Electric Stand Fan Graph 2

The Electric Stand Fan Graph 2 in Figure 10(b) shows zero error of 0.62A with insignificant vampire current. After the fan was turned on, the RMS current level rises to the average of 2A. The current used was calculated with the value of 1.38A.

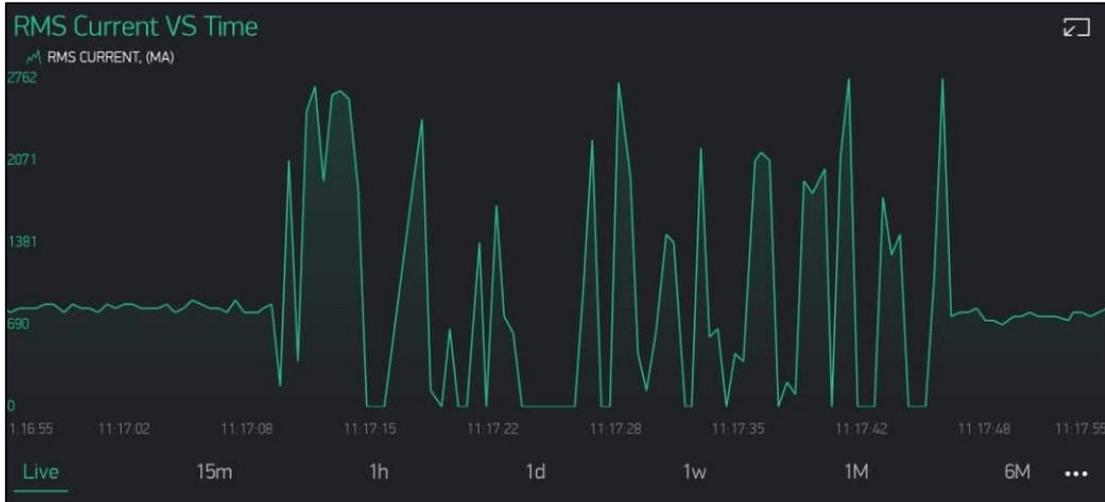


Figure 10 (c). Electric Stand Fan Graph 3

The Electric Stand Fan Graph 3 in Figure 10(c) shows zero error of 0.7A with insignificant vampire current. After the fan was turned on, the RMS current level rises to the average of 2A. The current used was calculated with the value of 1.3A.

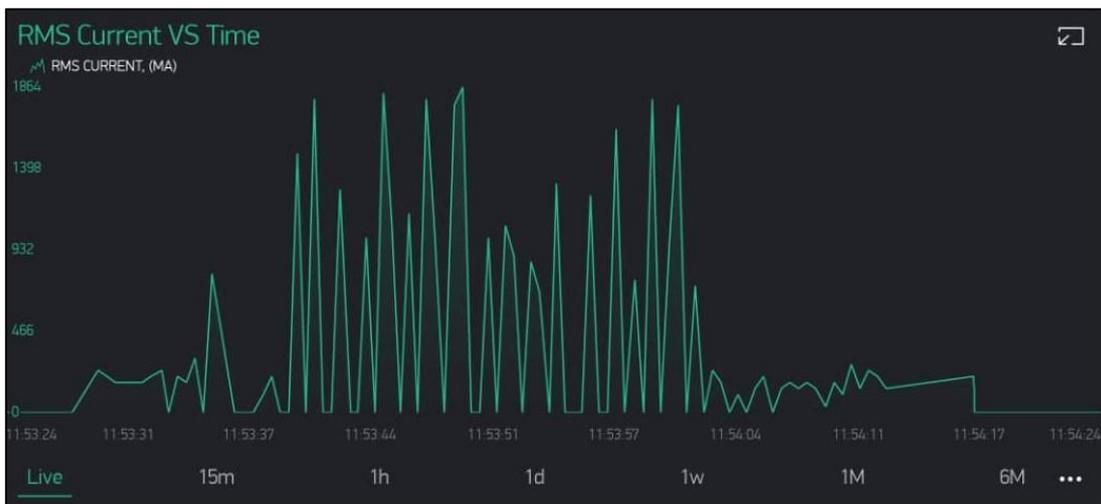


Figure 10 (d). Electric Stand Fan Graph 4

The Electric Stand Fan Graph 4 in Figure 10(c) shows no zero error with 0.2A vampire current. After the fan was turned on, the RMS current level rises to average of 1.4A. The current used was calculated with the value of 1.2A.

Table 5 Data Tabulation of Electric Stand Fan

Attempt	1	2	3	4	Average
Zero Error, (A)	0.30	0.62	0.70	0.00	0.41
Vampire Current, (A)	0.00	0.00	0.00	0.20	0.05
RMS current used by Fan, (A)	1.25	1.38	1.30	1.20	1.28

Based on Figures 10 and Table 5, the noises and vampire current were negligible except for the fourth attempt with the existence of 0.2A vampire current. The average zero errors were calculated with a value of 0.41A even though the zero errors were independent from its graph. The average RMS current consumption of the stand fan is 1.28 A. In all the trial, no current spike was found.

3.1.4 Experiment 3

This experiment was about the reaction of MCB when trips occur and it was conducted carefully. The procedures of this experiment were over seed 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 supplied DC voltage and the MCB supplied AC power. After the device is linked with Blynk application, the burned lamp was carefully switched on with the mindset of switching it off immediately. Instantaneously, the MCB trips and all the switches in the connection were turned off. The current level when trips were 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 11 below.

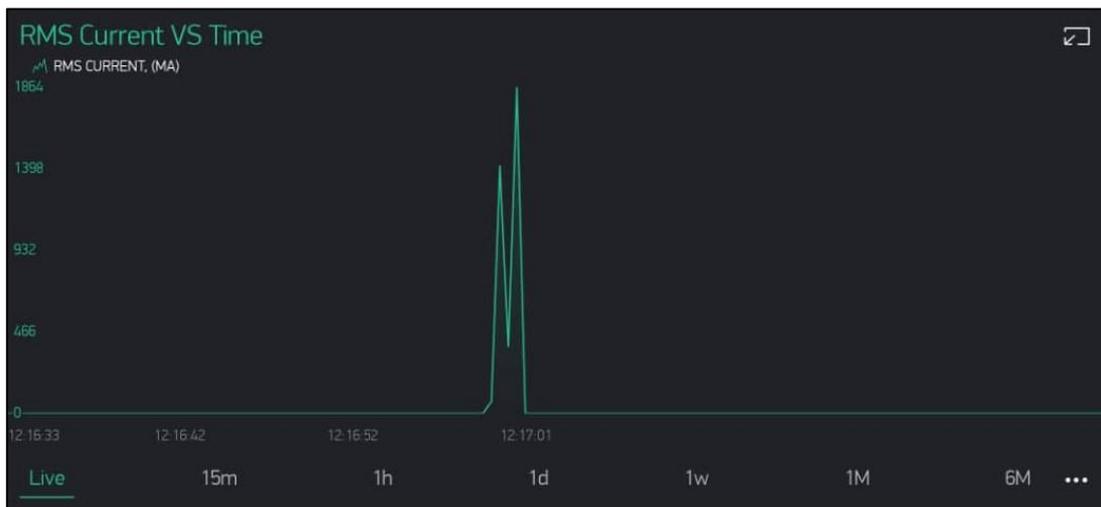


Figure 11. Graph when MBC Trips

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.

4. DISCUSSION and 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 which is able to connect to 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 to 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 displayed in smart phone. All the test conducted on the prototype were 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.

REFERENCES

- [1] Goh H H, Sim S S, Hamzah N I, Mazlan S, Ling C W, Chua Q S and Goh K C 2017 Indonesia Journal of Electrical Engineering and Computer Science 8 pp 213-220
- [2] Patel K K, and Patel S M 2016 International Journal of Engineering Science and Computing 6 pp 6122-6131
- [3] Pople S 2019 Int. J. Res. Appl.Sci. Eng. Technol 7 pp 989-995
- [4] Machidon O M, Stanca C, Ogrutan P, Gerigan C, and Aciu L 2018 Public Library of Science 13 e0208168
- [5] Kong E C 2014 Design and Analysis of Data Transferring Using GSM Based Long Range Remote Warning System for Miniature Circuit Breaker (MCB) Power Shortage (Universiti Malaysia Perlis) pp 14-20
- [6] Fernández-Caramés T M 2015 Int. J. Distrib. Sens. Networks 2015 (Hindawi Publishing Corporation) p 11
- [7] Pople S D, Patel P A S, and Kiranagi A P A P 2017 International Journal of Advanced Research in Science and Engineering 6 pp 1108-1112
- [8] Imam A H H 2019 A Simple Smart Home Based on Iot Using Nodemcu and Blynk (Universitas Muhammadiyah Surakarta) pp 3-6