

Intelligent Tenaga Nasional Berhad (TNB) Single Phase Power Supply Cut-off

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Abstract— This paper presents the development of an Intelligent Tenaga Nasional Berhad (TNB) Single Phase Power Supply Cut-off by using Internet of Things (IoT) technology. This project offers a new method for TNB to replace their traditional approaches; pulling-out the fuselink near the electrical meter to cut the electricity supply. The available system may cause difficulties to TNB because their workers need to go to the meter location, which located inside the gated or inaccessible area. This situation requires TNB to send their workers back until the problem is resolved. Through this intelligent system, TNB workers no longer has constrains to go to the customers' premises to plug-in or plug-out the fuselink and the electricity supply can be switched on or off via WiFi connectivity. A web server is used as a user interface to control the programmable NodeMCU that is attached to the main supply. To cut-off or turn-on the power supply, an authorized worker can access this interface through smart phone. To control the power supply, a worker needs to connect their smart phone to the NodeMCU using the WiFi connection and then selects the 'OFF/ON' button on the web server interface. Once the 'OFF' button is selected, relay that is connected to the main power supply will trigger to cut-off the main power supply. All these can be accomplished without the need for the worker to be presence nearby the electrical meter. The WiFi coverage for this project is up to 150 meters, which is far enough to communicate with the meter located inside a gated area. The response of the relay increases with increase of the distance. However, it can still be considered as fast response since it is only up to 150 milliseconds.

Index Terms—ESP8266; IoT; NodeMCU; Single Phase Supply; TNB.

I. INTRODUCTION

Electricity is an essential part of secondary energy sources in modern life. The world has been so dependent on electricity and it pervades all aspects of human lives; home, entertainment, medical, industries, transportation, and others. A large amount of electricity supply is needed to meet the demand of the projected peak electricity.

In Malaysia, Tenaga Nasional Berhad (TNB) is the leader of electricity utility company, which delivers electricity services to more than 8.6 million customers across the Peninsula, Sabah and Labuan. Until now, TNB is still a major player in the electricity generation, transmission and distribution. In 2014, TNB was capable to generate 16,901MW capacity of electricity from the thermal and hydro generation. It has been able to completely supply the peak of consumer demands in residential, commercial and industrial sector including the comprehensive transmission network; National Grid [1].

Similar to other electricity utility companies, TNB also

distributes the electricity sources for trading in the regulated market. All the electrical supplies provided by the TNB are charged in a form of usage rate per month. In recent years, TNB has been using 'plug-out fuselink' method to cut-off the power supplies when a consumer failed to pay their monthly bills. TNB workers normally have the authority to plug-out the main fuse at TNB meter, terminating the supply electricity to the premise. However, the TNB meters are usually installed inside the customer's premise, causing difficulties to most of the TNB workers to plug-out the fuselink when stubborn customers leave their gate locked. This constrain causes a lot of wastage of time and money. Hence, a suitable mechanism should be designed in order to cut-off the supply by implementing an appropriate tool. Based on the situation, there is no comprehensive method to solve this difficulty. Therefore, the objective of this project is to introduce an intelligent prototype of TNB power supply tools to cut-off a single phase electric supply by using Internet of Things (IoT) technology. Nowadays, the large-scale of IoT systems are intensively exploited by cloud computing technologies [2-5]. For this project, an intelligent single-board microcontroller; NodeMCU is used as a platform for developing an interactive IoT application and building more accessible environments.

Furthermore, TNB provides two types of power supply phase for residential sector: single phase and three-phase supply. A single phase is covered through two wires from 230V supply while three-phase is covered through four wires from 415V supply [1]. Typically, Malaysian residential consumers use a single-phase power supply for their resident. Therefore, this project will only focus on a single-phase power supply for residential sector. At the meantime, some of rules and regulations from Garis Panduan Pendawaian Elektrik Di Bangunan Kediaman by Suruhanjaya Tenaga Malaysia are followed.

II. SYSTEM DESIGN

Essentially, the Intelligent TNB Single Phase Power Supply Cut-off development is divided into two sections; control block and output block implementation. Figure 1 shows the overall system block diagram. WiFi standard is used as a communication medium between the blocks.

NodeMCU with ESP8266 WiFi module has been placed in the control board to be attained as the distribution board controller inside the output block. Originally, NodeMCU was introduced at the end of year 2013 and consists of an open-source hardware board designed with XTOS operating system. Besides, NodeMCU is ESP8266-based [6-7], where it can be integrated with Tensilica Xtensa LX106-core which is commonly used in IoT applications. NodeMCU gives a

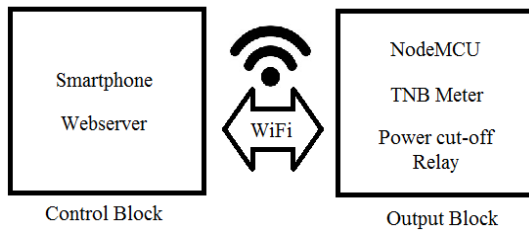


Figure 1: Overall System Block Diagram

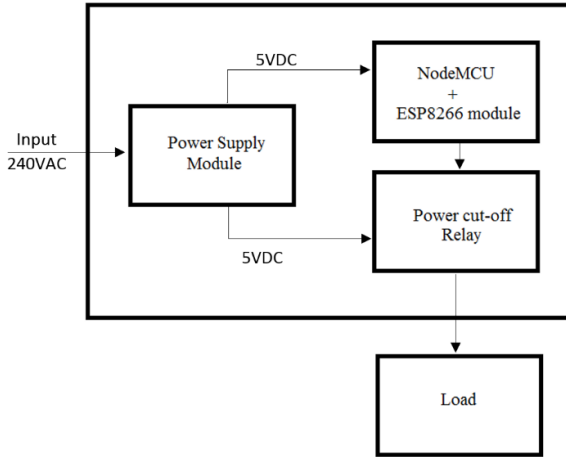


Figure 2: Block Diagram of Output Block

simple Integrated Development Environment (IDE) that can run on a personal computer or smartphone.

Figure 2 demonstrates the output block, which consists of power supply module comprising a block of power meter, 12VAC transformer, rectifier, and LM7805 voltage regulator. This module is activated after receiving 240VAC from a single phase supply. The power supply 240VAC flows through the neutral link and the main fuse at the power meter to activate the system. Next, 12VAC transformer is required to step down the 240VAC to 5VDC [8]. Then, the rectifier board converts the alternating to direct voltage and current. The supply flows through the LM7805 voltage regulator to maintain the constant voltage level, 5VDC to operate the NodeMCU. The output from NodeMCU is connected to the power cut-off relay to control the load [9].

There are two main IDE used to handle the output block operation; NodeMCU Flasher and ESPlorer IDE. NodeMCU Flasher is used as a firmware programmer to program the ESP8266 module. It operates as a ‘translator’ to perform any command that can be accomplished by NodeMCU. NodeMCU Flasher needs to be installed to burn the program inside ESP8266. Figure 3 shows the NodeMCU Flasher interface.

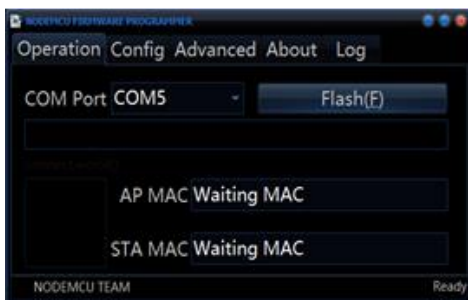


Figure 3: NodeMCU Flasher Interface

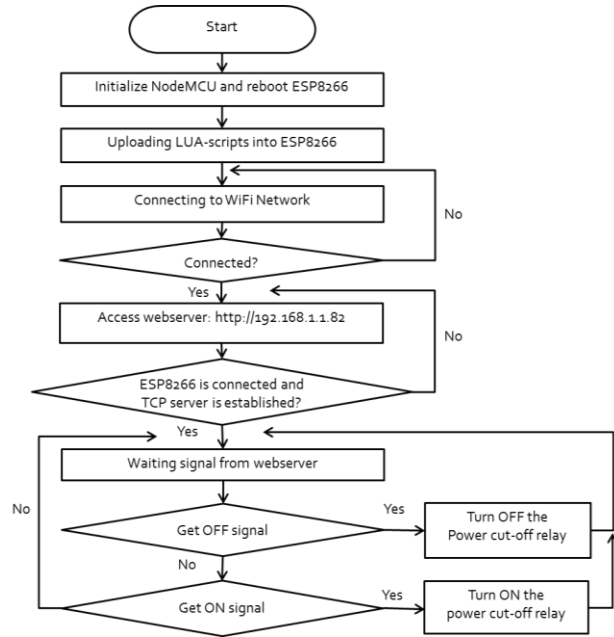


Figure 4: Design Flowchart

Besides, ESPlorer is an IDE for ESP8266 developer used to build a standalone web server to control NodeMCU. The ESP8266 General Purpose Input Output (GPIO) changes ESP8266 into a wireless web server [10]. It is coded in LUA scripting and remotely controls the NodeMCU inside the output block via WiFi communication. A private wireless network is used between the control block and the output block to enlarge the bandwidth and minimize the latency in data communication. Data communication between control block and output block can be achieved through the built-in ESP8266 module inside NodeMCU. It allows NodeMCU to connect to the control block through a WiFi based on serial interfacing requirements.

Based on the design flowchart in Figure 4, a new firmware needs to be flashed inside NodeMCU once the hardware connection setup is done. Then, ESP8266 needs to be set into the upload mode by connecting GPIO-0 to GND. After flashing through NodeMCU Flasher and rebooting ESP8266, the LUA-scripts is uploaded into ESP8266 by using ESPlorer. Besides, to configure WiFi connection in output block, user needs to pass the Service Set Identifier (SSID) and password to ESP8266 module inside NodeMCU. Then, ESP8266 module emits some information to make LUA interpreter execute LUA scripting. After smartphone is connected to the same WiFi network; user needs to type http:// protocol along with the IP address to access the web server [11-13]. When ESP8266 is connected and TCP server is established, the user is able to switch the meter directly through web server. After the output block is initialized, it leaves in a standby mode waiting for the signal status from the control block.

III. RESULT AND DISCUSSIONS

A. Experimental Result

The user interface for web server in output block is used as a main switch to cut-off power supply for every TNB customer and this operation only can be done through an authorized TNB worker. Afterwards, NodeMCU will get the information from the web server to control the power cut-off relay either ON or OFF in the output block.

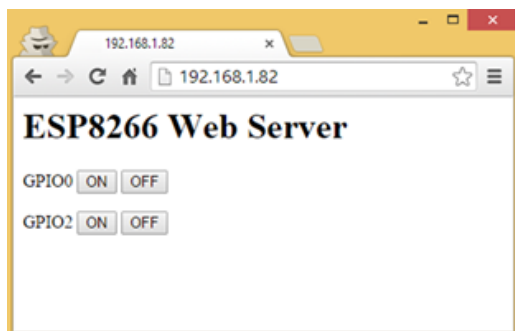


Figure 5: ESP8266 Web Server Interface

For this prototype, an encrypted IP address; 192.168.1.1.82, as shown in Figure 5, was used to open the web server interface from the smartphone. After both control and output block are ready, the system is left in a standby mode; waiting for the command from the web server. The load from the single phase power supply can be manipulated remotely via WiFi. If the user presses the “OFF” button inside the web server, the load will automatically turn off. Besides, the load will turn on right after the “ON” button is pressed; as shown in Figure 6.



(a)



(b)

Figure 6: Result from Output Block (a) Load is turning “ON” (b) Load is turning “OFF”

B. WiFi Performance Analysis

Figure 7 shows the WiFi performance analysis that has been conducted to test the performance of the prototype outside the customer premise. Based on the graph, the delays were increased as the distance increased. Regarding to WiFi limitation range, there was a lost of connection between the smartphone and the output block after 150 meters. Besides, obstacles reduce the effectiveness of the WiFi transmission due to path loss [14]. The prototype worked better in a less obstacle environment.

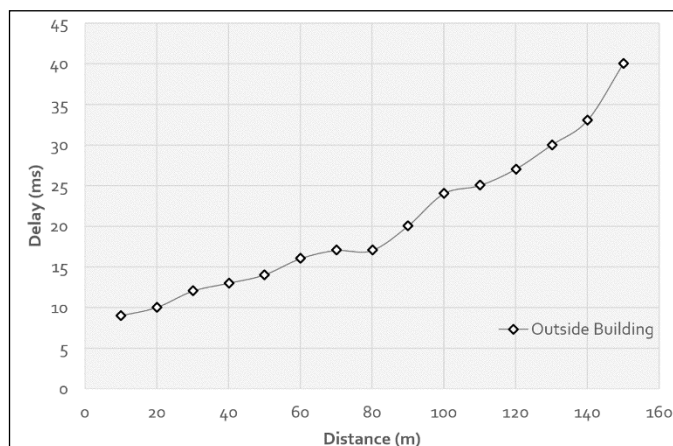


Figure 7: WiFi Performance

IV. CONCLUSION AND FUTURE WORKS

There are some recommendations for future works. In future, to decrease the power consumption and improve the efficiency of the design, the power cut-off relay will be exchanged with a solid state relay (SSR). An android application with security features also will be implemented in this system. This could be done by introducing application protocol encryption. Furthermore, the WiFi networks have a range, which is limited by some parameters such as the transmission power, antenna type and location. A typical antenna for wireless router has a range around 32 meters long to receive an excellent signal. The use of directional antennas can extend the signal with many kilometers between stations for outdoor point-to-point arrangements.

The result for this prototype shows that power cutting-off for TNB customer premise can be accomplished through the Intelligent TNB Single Phase Power Supply Cut-off. The resulting of this project shows that the single-phase power supply can be controlled by NodeMCU through web server without plugging-out the fuselink inside the customer premises. This method can avoid the wastage of time for TNB workers to collect and pull-out the main fuse at the customer premises. Furthermore, it is important to make the circuits smaller is because of the limitation on the size of meter used in this prototype. Besides, it also more practical and easy to make a troubleshooting or maintenance. Moreover, the result is in agreement with Tenaga Nasional Berhad and the Guidelines of Electric Wiring for Residential Buildings by the Malaysian Commission of Energy (*Garis Panduan Pendawaian Elektrik Di Bangunan Kediaman by Suruhanjaya Tenaga Malaysia*) in order to be implemented in the future.

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