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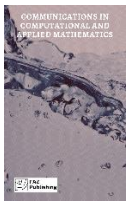

Integration of IoT on Power Monitoring and Control for House Electrical System

Nadiah Nordin[1,a], Omar Abu Hassan [1,b]

[1]Department of Electrical Engineering Technology, Universiti Tun Hussien Onn Malaysia, Johor,

Email: [a]n.nadiahnordin97@gmail.com

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Abstract: IoT (Internet of Things) was the development of the advanced technology that is increasing popularity. Due to this increasing popularity, IoT growing the interest for the used in home such that the housing electrical load is controlled online by using IoT devices which it can be controlled anywhere and anytime. This can make the life of the person becoming more easy and better in line with the technology which becoming more advanced. The manual way which is traditional ways for controlling ON/OFF switching of the housing electrical load can be changed to online controlling by using the IoT devices. Some of the reasons of this change due to the attitude of the people becomes lazy or tend to become forgetful due to their busy life. In order to prevent this to be happened which lead to the increasing of electricity bill, this project is introduced. This project system works by using the Arduino Nano with the connection of ESP8266 Wi-Fi module in the process of developing of Internet of Things (IoT). This can make the users can control the switching of electrical load online by using phone when interfacing with Blynk platform. Besides, the system also included of online power monitoring system using ACS712 current sensor to monitor the amount of current and power consumption for the housing electrical load that will be display in Blynk application.

Keywords: Internet of Things (IoT), Arduino Nano, ESP8266 Wi-Fi module, Blynk Application

1.0 Introduction

Electricity had become the essential part in this contemporary life which all the devices mostly need the electricity to functions such as energizing lights, appliances, air conditioning and many other conveniences [1]. Electricity arrived at the house from the distribution substation near the house by a power line or underground through a conduit [1]. KWh meter will be installed and monitored by TNB (Tenaga Nasional Berhad) where the electricity was entered the house. The value of voltage for the residential system usually were 400V for the three-phase and 230V for the single-phase installations. This type of electrical supply users was in the categories of domestic user as it received low voltage supply such as 400V and 230V.

In the house, all the electrical devices will be conventionally controlled through the switches. This controlling process was done manually such whenever the users want to use one specific devices, he or she need to go to that switch which connect to that devices and turn it on. But, with the latest technology and the emergence of IoT, everything in the house that involving all the electrical devices can be controlled smartly which changed this conventional way. The terms of IoT which referred as Internet of Things have been widely used and apply in line with the current development in Malaysia.

Internet of Things can define as a smart network that can detect, control, and program objects automatically which come to represent electrical or electronic devices, of varying sizes and capabilities, that are connected to the Internet [2]. Internet of Things allows its surroundings to be connected and communicate directly and indirectly by connecting objects to the internet and using the connection to provide remote monitoring or control over the object [2]. The effect of this development was the smartification in the process of the electrical power system. Besides, IoT that have been generated growing interest for the uses in home such that the housing appliances can be controlled online using internet with the developing of IoT that can make the life of the person becoming more easy and better in line with the technology which becoming more advanced.

This advanced technology for the better quality of living make the smart home was introduced. A smart home consists of many technologies via home networking for improving quality of living. IoT played the important roles in the process of building of smart home that allowed on the controlling and monitoring almost the entire object in the house by using the Internet. A smart home is a place that has highly advanced automatic systems for controlling and monitoring lighting and

**Corresponding author: n.nadiahnordin97@gmail.com*

temperature, home appliances, multi-media equipment, and security systems and many other functions [3].

A smart home control system acts as a hub that enables you to interact with all of your devices through one intuitive interface, typically an application such that all of the devices use the same networking protocols, whether that be Wi-Fi, Bluetooth or Z-Wave [4]. For monitoring systems, the smart home monitoring provided the feedback on electrical energy uses. It provides real-time information on household electrical demand and records historical measured data for future analysis, this system potentiates electric energy efficient use, leading to significant environmental, political and economic benefits [5]. Smart monitoring system was beneficial for the consumer when it used a low-cost, user friendly and flexible monitoring system. This type of system, which is exclusively developed to help consumers manage and reduce their electricity use, doesn't replace the traditional meter and has the advantage of being portable [5].

The literature review will explain about the theory about the IoT, theory of smart home, the theory about Blynk, Arduino Nano and ESP8266.Wi-Fi module, the hardware that were implemented in this project.

2.1 Internet of Things (IoT)

The Internet of Things (IoT) is a new paradigm that is increasing in popularity. This occurred due to it becomes an important technology that promises a smart human being life with allowing the communications between object, machine and everything together with people [6]. IoT can be referred as concept that basically connecting any device with an on and off switch to the Internet (and/or to each other) [7]. The IoT is a giant network of connected things and people – all of which collect and share data about the way they are used and about the environment around them [8]. The concept of Internet of Things can be said that with the internet of things, anything's will able to communicate to the internet at any time from any place to provide any services by any network to anyone. This concept will create a new types of applications can involve such as smart vehicle and the smart home, to provide many services such as notifications, security, energy saving, automation, communication, computers and entertainment [6].

The first person that mentioned about IoT was Kevin Ashton, co-founder of the Auto-ID Centre at MIT in a presentation he made to Procter & Gamble (P&G) in 1999. In his presentation, he wanted to bring the attention to the P&G's senior management about the radio frequency ID (RFID) so he called that presentation was "Internet of Things" to incorporate the cool new trend of 1999: the internet [9]. IoT has evolved from the convergence of wireless technologies, microelectromechanical systems (MEMS), micro services and the internet. The convergence has helped tear down the silos between operational technology (OT) and information technology (IT), enabling unstructured machine-generated data to be analysed for insights to drive improvements [9]. The IoT was initially most interesting to business and manufacturing, where its application is sometimes known as machine-to-machine (M2M), but the emphasis is now on filling our homes and offices with smart devices, transforming it into something that's relevant to almost everyone [10].

Although the definition of "Things" has changed as technology evolved, the main goal of making a computer sense information without the aid of human intervention remains the same[11]. This evolution of the current Internet into a network of interconnected objects becoming more advances such that it does not only harvest the information from the sensing equipment and interacts with the physical control or actuation but also uses the Internet to provide services information transfers and communications [11]. IoT has stepped up as the Internet revolution rising to led to the interconnection between people at an unprecedented scale and pace [11]. Cell phones become the best tool to provide information and can downloaded the latest information. Some device that was designed can store all the information in its database which it available to user who needs any related information from that device.

2.2 Smart Home

A smart home is a convenient home setup where appliances and devices can be automatically controlled remotely from any internet-connected place in the world using a mobile or other networked device [12].

Smart home network technology can be classified into two main types, which are wiring system and wireless system. In wiring system, the equipment will be connected into the main power supply directly, so the data will be sent to the devices to activate or deactivate them. Many home automations are connected through wiring system such as new wire (twisted pair, optical fiber), powerline and busline [15]. In wireless system, the main two elements must have that consists of sender and receiver. Many new appliances use wireless technology to communicate with other devices. The example of wireless communication system are microwaves, Infrared (IR), radio frequency (RF), Wi-Fi and Bluetooth [13]. For instance, example of wireless communication system for smart home is Z-wave, which is a reliable and affordable wireless home automation solution [13].

Two of the most prominent radio networks in home automation are ZigBee and Z-Wave. Both of these technologies are mesh networks, meaning there's more than one way for the message to get to its destination. Both are mesh network technologies, they use short-range, low-power radio signals to connect smart home systems. Though both target the same smart home applications, Z-Wave has a range of 30 meters while ZigBee ha a range of 10 meters [14]. Smart home creates remotely controllable network by working together on smart devices and appliances. This will be controlled by the automation controller that often been called a smart home hub. The smart home hub is a hardware device that acts as the central point of the smart home system and is able to sense, process data and communicate wirelessly [14].It combines all of the disparate apps into a single smart home app that can be controlled remotely by homeowners.

2.0 Arduino Nano

Arduino Nano is a surface mount breadboard embedded version with integrated USB [15]. It is small, complete and a breadboard-friendly based on ATmega328P (Arduino Nano 3.x) [16]. It have the same functions as Arduino Uno but it came in a different package. The lacks of Arduino Nano only on a DC power jack and this Arduino Nano works with a Mini-B USB cable instead of a standard one [16].

Table 1, Figure 1 and Figure 2 show the technical specifications of the Arduino Nano based on its microcontroller, operating voltage, input voltage, analog input pins, digital I/O pins, DC current on I/O and 3.3V pins, flash memory. SRAM. EEPROM, frequency (Clock Speed) and the communication.

Table 1: The Technical Specifications of Arduino Nano

Microcontroller	**ATmega328P – 8 bit AVR family microcontroller**
Operating voltage	5V
Recommended input voltage for Vin pin	7-12V
Analog input pins	6 (AO-A5)
Digital I/O pins	14 (Out of which 6 provide PWM output)
DC Current on I/O pins	40mA
DC Current on 3.3V pin	50mA
Flash Memory	32 KB (2 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz
Communication	IIC, SPI, UART

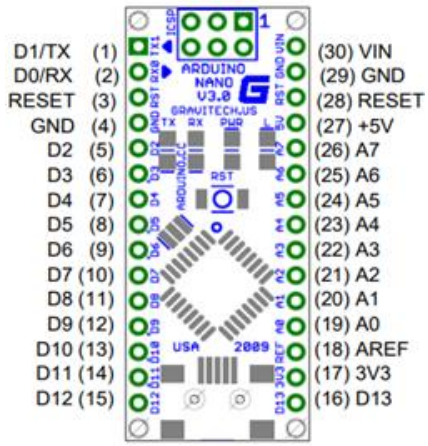

Figure 1: Arduino Nano Pin Layout

2.4 ESP8266 Wi-Fi Module

ESP8266 Wi-Fi module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network [17]. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor [17]. AT command set firmware comes pre-programming with ESP8266 module which can simply hook this up to Arduino to get as much Wi-Fi ability which implemented the concept of Internet of Things (IoT).

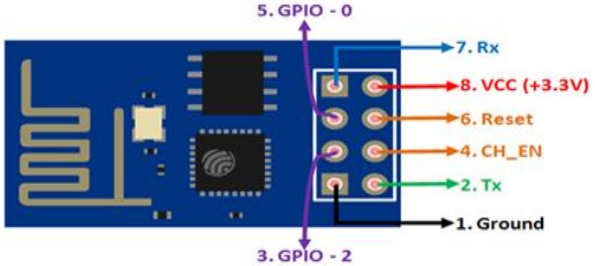

Figure 2: ESP08266 Wi-Fi module Pin Layout

2.5 Blynk

Blynk was designed for the Internet of Things. This interfaces can control hardware remotely, display sensor data, store data and visualise the data [18]. Blynk is type of IoT platform that can control microcontroller such as NodeMCU ESP8266, Raspberry Pi and also the main components that was used in this project which is Arduino Nano with the connection of ESP8266 Wi-Fi module. It is a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets. Blynk support the connection of the microcontroller board (hardware) with the Blynk Cloud and Blynk's personal server such as Ethernet, Wi-Fi, Bluetooth, cellular and serial [19].

Figure 3: Blynk Platform Logo

The Blynk platform includes these components such as Blynk app builder, Blynk server and Blynk libraries. Blynk app builder allowed to build apps for projects using various widgets. It is available for Android and iOS platforms, as shown in Fugre 3 and Figure 4. Next, Blynk server was responsible for all the communications between mobile device that's running the Blynk app and the hardware. You can use the Blynk Cloud or run their private Blynk server locally. It's open source, so it could easily handle thousands of devices, and can even be launched on a Raspberry Pi. Moreover, Blynk libraries was for all the popular hardware platforms - enable communication with the server and process all the incoming and outcoming commands

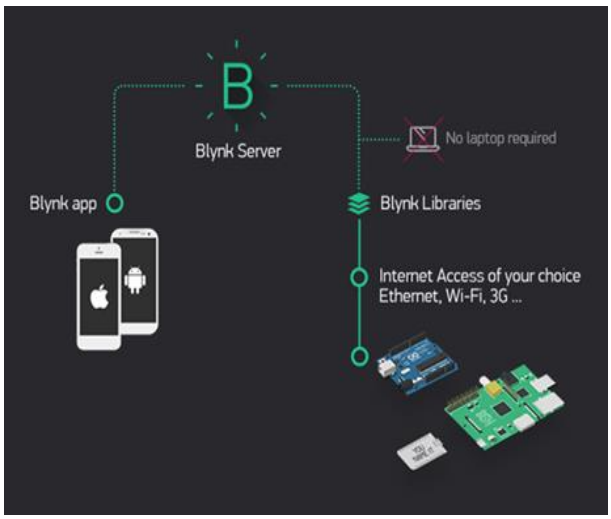

Figure 4: Blynk Architecture

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3.0 Methodology

This chapter discussed more about the software and hardware developments and implementation of this project and the procedures for process of developing the projects in order to accomplish the project. The equipment, tools and processed used also were being included in this chapter. This project applied both software and hardware construction. Figure 5 shows the workflow of this project which indicates the process need to be done first and which need a longer time to proceed. Components selection for the hardware was also important as the purpose for the project built must be cost reducing, system efficiency increasing and reliability of circuit also increasing.

3.1 Flowchart of Power Monitoring and Control System

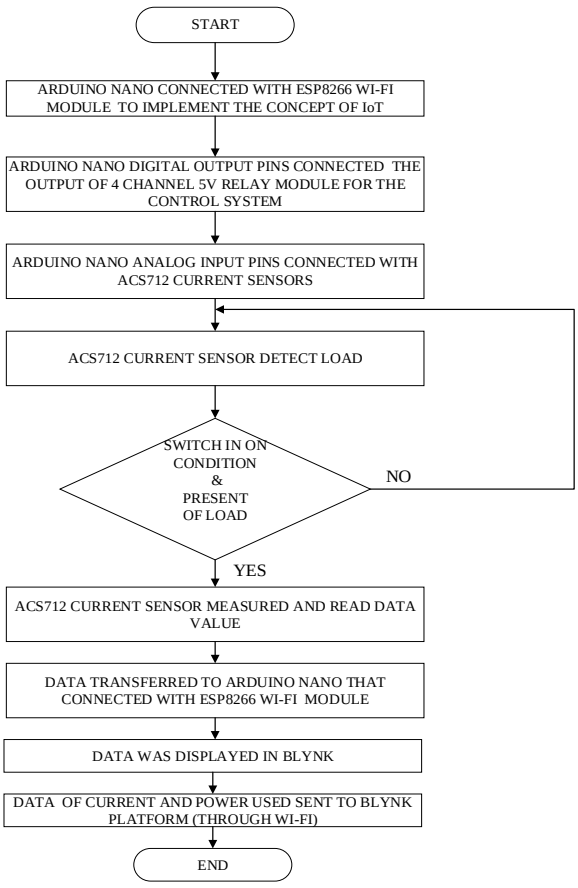

Figure 5: Flowchart of Power Monitoring and Control System

The online controlling and monitoring of electrical house system started to operate first when Arduino Nano connected with ESP8266 Wi-Fi module for the purpose of implementation of IoT. For the online controlling using Blynk application, Arduino Nano digital output pins connected to 5V relay. Next, Arduino Nano analog input pins connected with ACS712 current sensors for the purposes of monitoring on housing electrical system. . The ACS712 current sensors detected the presence of load that were connected to it. The load can be any type of the housing electrical loads such as lamp, fan and others. When switches connected to loads in ON condition and there was the load presence, ACS712 current sensor read and measured the current that flow through the load. This data was transferred to the Arduino Nano that connected with ESP8266 Wi-Fi module that acts as a microcontroller for the purpose of monitoring amount of current and power consumption used when it was connected with load. This analyzed data will be sent to the Blynk platform to display the current and power measured through internet for the user to read and monitor the data.

3.2 Block Diagram of Project

The block diagram of this system was shown in Figure 6 below. ACS712 current sensor placed between load and supply to measure the current of the load. The measured data was sent to Arduino Nano that act as microcontroller for the further calculation of monitoring system. ESP8266 Wi-Fi module act as the components that give Arduino Nano access Wi-Fi network. The relay was used for controlling the electronic component which act as it received the data from Arduino Nano and execute the command. The relay connected to load such lamp, mini ac fan and 13A socket. Blynk application was used as it connected with the controller and internet. Once Arduino Nano supported with Wi-Fi network when connected to ESP8266 Wi-Fi module, it will start developing the IoT platform. Arduino Nano used Arduino programming language for the coding implementation. Arduino Nano sent the data to the Blynk server for monitoring current used and power consumption information.

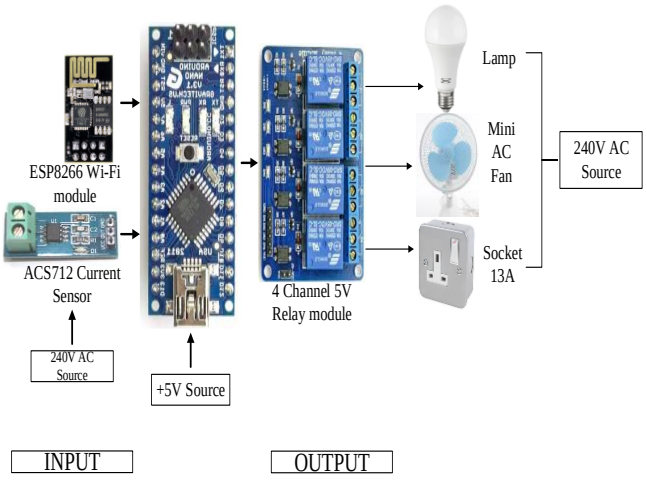

Figure 6: Block Diagram of Project

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3.3 Schematic Diagram of System

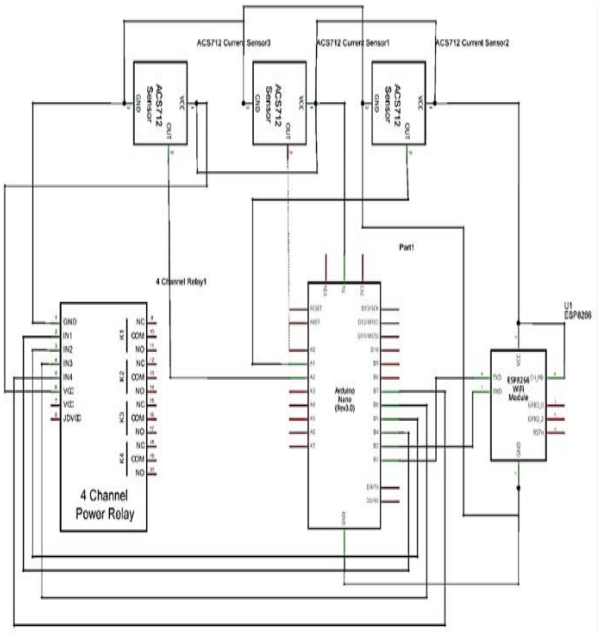

Figure 7 shows the schematic diagram of the system

Figure 7shows the schematic diagram of the system of the project. This schematic diagram was based on the block diagram of the project above that showed the briefing for the complete connection of the main circuits to make the system could achieved the objectives of project. Analog input pins A0, A1 and A3 used to connect with ACS712 current sensor that measured and read the amount of current used. Digital output pins D4, D5, D6 and D7 connected to 4 channel 5V relay module to make the system can be controlled online by using Blynk Application. RX and TX pins in ESP8266 Wi-Fi module connected to digital input pins D2 and D3 to make the Arduino Nano have connection to access Wi-Fi network.

4.0 Results and Discussions

4.1 Porotype Designation Layout

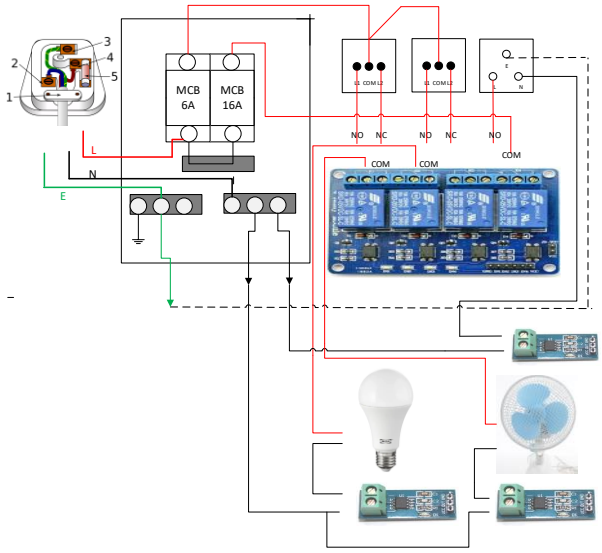

Figure 8: Prototype Designation Layout

Figure 8 shows the designation layout of project prototype. This project works when MCB connected to two ways switch that functions as manual switch. The command port of two ways switch was connected from MCB 6A while L1 and L2 were connected to the 5V relay normally opened (NO) and normally closed (NC) respectively. The command of relay was connected to load such as lamp and fan to make the system can also be controlled online by using Blynk Application. For the 13A socket, MCB 16A at first was connected to command port of 5V relay and the port normally opened (NO) was connected to the live port of the 13A socket. Fan and lamp can be controlled by manual switch or online switch by using Blynk while 13A socket only can be controlled by using online switch on Blynk when the relay was triggered. ACS712 current sensors was connected using neutral wire in connection of lamp and fan due to the safety purposes such the connection with both live wire will have the high possibility of danger due the explosion of the load and burn current sensor. This current sensors used in this circuit to measure the amount of current and power used when having connection with load. ACS712 current sensor, 4 channel 5V relay were connected to Arduino Nano which have the connection with ESP8266 Wi-Fi module. This make all the data be sent through Wi-Fi to Blynk application for the purpose of control and monitoring of housing electrical system.

4.2 Wiring Diagram of System

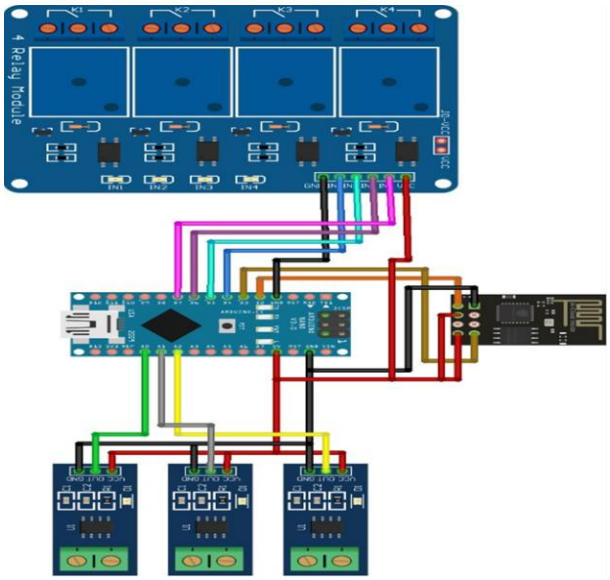

Figure 9: Wiring Diagram of System

The figure 9 above shows the wiring diagram of system which consists of the main components of the circuit for control and monitoring for housing electrical system such as ACS712 current sensors, 4 channel of 5V relay, Arduino Nano and ESP8266 Wi-Fi module. This wiring diagram shows how the connections from Arduino Nano that act as microcontrollers to other part of components to make the complete circuit this project of control and monitoring system successful. This wiring diagram was designed and used as it was compatible with the coding used in the project that gave the output results achieved the objective of the projects.

4.3 Hardware/Implementation

Figure 10: The Hardware/Prototype Implementation

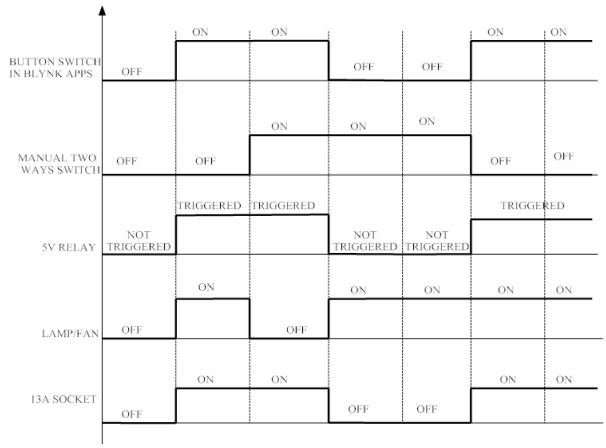

Figure 11: The Waveform Results of Control System

Figure 10 and Figure 11 shows the waveform results of control system in this project when the prototype testing was conducted. The waveform results shows that when buttons switch in Blynk Application was on, the relay triggered and electrical loads was in ON condition and relay was still remain to trigger even though electrical loads was OFF. Manual two ways switch can make the lamp and fan ON as long as the button switch in Blynk Application was in OFF condition. Lamp and fan was in OFF condition if manual two ways switch and button switch in Blynk Application was ON at the same time. Next, for 13A socket the load that connected to this socket followed the button switch in Blynk application as it only can be control by using online controlling. The load connected to 13A socket was ON when the relay triggered after button switch in Blynk application was ON.

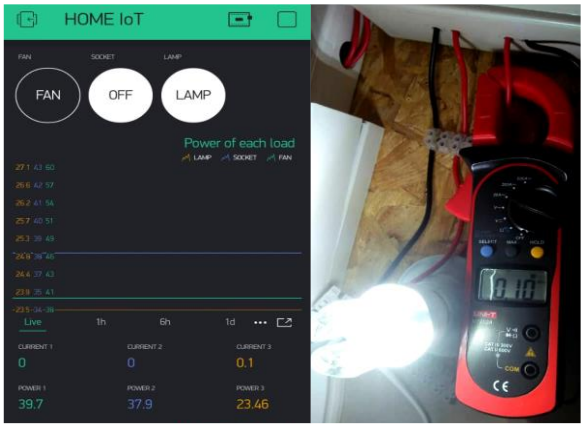

Figure 11: Value of Current when Lamp was ON

Figure 11 above shows that the amount of current when the lamp was ON as the value display on Blynk at Current 3 (0.1A) was same as the value got when tested with clamp meter.

Figure 12: Value of Current when Fan was ON

Figure 12 above shows that the amount of current when the fan was ON as the value display on Blynk at Current 3 (0.19A) was almost the same as the value got when tested with clamp meter (0.18A) due to the offset.

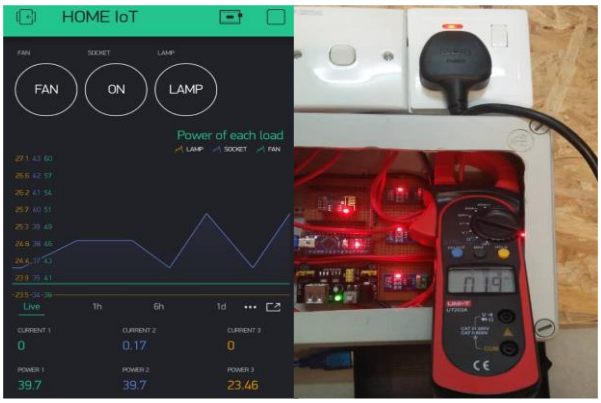

Figure 13: Value of Current when 13A Socket Connected with Load

Figure 13 shows that the amount of current when the 13A socket when connected with load (fan) was ON as the value display on Blynk at Current 3 (0.17A) was almost the same as the value got when tested with clamp meter (0.19A) due to the offset.

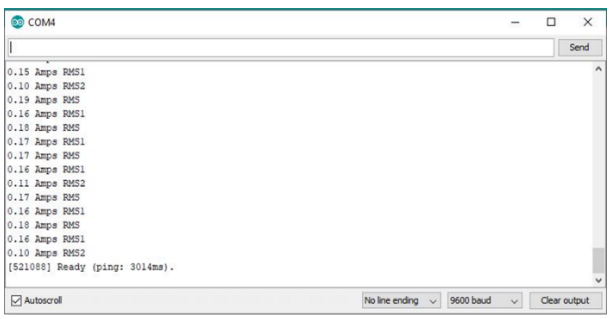

Figure 14 Serial monitor display amount of current used by lamp, fan and socket connected with load.

Figure 14 above shows the serial monitor display amount of current used by lamp, fan and socket connected with load. This values displayed when the ACS712 current sensor detect the load and if no load connected, amount of current displayed from the load is 0A.

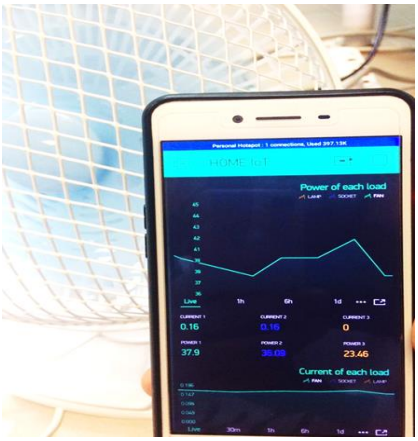

Figure 15: The Graph of Current and Power Consumption on Fan which was Monitored in Blynk

The figure 15 above shows that the graph of current and power consumption shows on Blynk application in real time that can make the users know their power consumption of load on the house. The duration of time can be settings to certain period such as for 30 minutes, 1 hour, 6 hours or one day such that users can set by their own to monitor the current and power consumption.

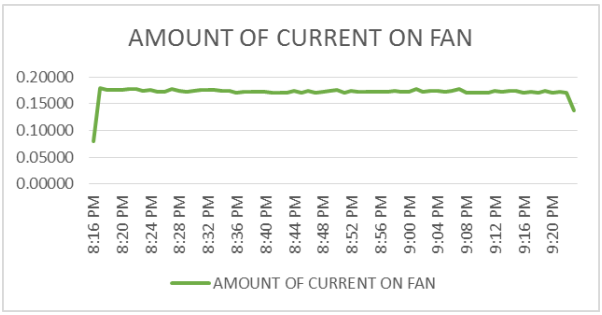

Figure 4.10: Amount of current used on fan

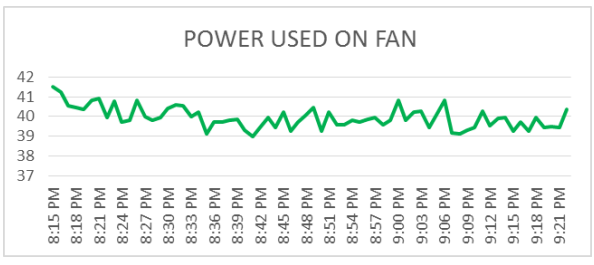

Figure 4.11: Power consumption used on fan

Figure 4.10 and 4.11 above shows that the amount of current used and power consumption by fan respectively that were monitored in Blynk Application for a certain period using Superchart widget in Blynk. The certain period of time can be set in Superchart widget settings to get the values according the duration that the users wanted.

5.0 Conclusions

As a conclusion, this project was done to control and monitor amount of current and power used for housing electrical system that can be observed through the internet. This project can help a lot of users to reduce wastage of electrical energy due to their busy life which can reduce the electricity bills. The first objective in this project was to study the IoT devices that can be used on housing electrical system for monitoring and control system. This objective have been achieved during in PSM1 and PSM 2 as the project was focused to study on characteristics of IoT devices such as NodeMCU ESP8266 and Arduino Nano. This make the change in the microcontrollers used for this project as it was changed from NodeMCU ESP8266 to Arduino Nano with the connection of ESP8266 Wi-Fi module. Next, the second objectives in this project to design and simulate the housing electrical load for control and monitoring system with IoT functionality. The objective have been achieved when user able to online and control and monitor through internet (Wi-Fi) using Blynk application.

For the future improvement, user can add sensor into the system that can make the control system will automatically controlled by this sensor. The sensor can improve the quality of housing electrical system as it automatically ON or OFF the load by detecting the motion, light and temperature that works according to user required. Next, for ESP8266 Wi-Fi module can be changed to ESP32, which was most powerful comparing to ESP8266 as it contains more GPIOs with multiple functions, faster Wi-Fi, and can support Bluetooth. In this project, when ESP8266 that connected to Wi-Fi give signal to 5V relay, it have a delay in time as it have slower connection of Wi-Fi while when using ESP32, the delay in time will not occur due to the characteristics of ESP 32 which have a faster Wi-Fi connection.

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