SMART KWH MONITORING AND CONTROL OF HOME APPLIANCES VIA INTERNET OF THINGS (IOT)

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also committed to my mother, who taught me that even the largest task could be accomplished if it is done one step at a time.

my supervisor who dedicatedly guides and motivates me throughout the research progress,

Dr. Nik Noordini Binti Nik Abd. Malik.

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In the name of Allah, the most beneficent, the most merciful. All the praises and thanks be to Allah, the Lord of the ‘Alamin, you alone we worship, and you alone we ask for help, guide us to the straight way, the way of those on whom you have bestowed your grace, not the way of those who earned Your anger, nor of those who went astray, here I am presenting my thesis.

“O, my Lord! increase me in knowledge.”

-Surah Ta-Ha-

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I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream, and sacrifice throughout my life. I am thankful for their sacrifice, patience, and understanding that it was inevitable to make this work possible. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. I cannot find the appropriate words that could adequately describe my appreciation for their devotion, support, and faith in my ability to achieve my dreams.

ABSTRACT

Electrical energy monitoring becomes more and more important nowadays for commercial buildings as well as residential buildings. By monitoring the electrical energy usage, one can make estimation moves in the economy and knowing how much the money spend on utility. Today IoT becomes convenient for people to send and receive information. IoT becomes convenient because it can send and receive data from a far distance. Apart from that, it also allows a user to control the appliances remotely despite the length. This research project is about the design and development of electrical energy monitoring system as well as appliances control using the Internet of Things (IoT) technology. The developed system consists of energy meter, one microcontroller, one Wi-Fi and one mobile App. The energy meter responsible reads the energy consumption of electrical loads. In contrast, the microcontroller processes the energy consumption signals and send those signals over an internet network using Wi-Fi module. At the receiver, mobile Apps is used to monitor energy consumption. The mobile Apps also have a few buttons for the user to control the appliances. In other words, the Apps serve two functions: one is controlled, and one is monitoring the energy signals. At the end of the research, a small prototype has been developed to demo on the first working of energy monitoring as well as appliances control using an internet network.

Keywords: IoT, appliances control, electrical energy consumption monitoring, internet, Arduino microcontroller and Apps.

ABSTRAK

Pemantauan tenaga elektrik menjadi semakin penting pada masa ini untuk bangunan komersial dan juga bangunan kediaman. Dengan memantau penggunaan tenaga elektrik, seseorang dapat membuat anggaran dalam ekonomi dan mengetahui berapa banyak wang yang dibelanjakan untuk utiliti. Hari ini IoT menjadi lebih mudah bagi orang ramai untuk menghantar dan menerima maklumat. IoT menjadi mudah kerana ia dapat menghantar dan menerima data dari jarak jauh. Selain itu, ia juga membolehkan pengguna mengawal perkakas dari jarak jauh. Projek penyelidikan ini adalah mengenai reka bentuk dan pengembangan sistem pemantauan tenaga elektrik serta kawalan peralatan menggunakan teknologi Internet of Things (IoT). Sistem yang dibangunkan terdiri daripada meter tenaga, satu mikrokontroler, satu Wi-Fi dan satu Aplikasi mudah alih. Meter tenaga yang bertanggungjawab membaca penggunaan tenaga beban elektrik. Sebaliknya, mikrokontroler memproses isyarat penggunaan tenaga dan menghantar isyarat tersebut melalui rangkaian internet menggunakan modul Wi-Fi. Pada penerima, Aplikasi mudah alih digunakan untuk memantau penggunaan tenaga. Aplikasi mudah alih juga mempunyai beberapa butang untuk pengguna mengawal perkakas. Dengan erti kata lain, Aplikasi ini melayani dua fungsi: pengendalian, dan pemantauan isyarat tenaga. Pada akhir penelitian, prototaip kecil tela dibangunkan untuk mununjukkan demo pemantauan tenaga dan juga kawalan peralatan menggunakan jaringan internet.

Kata kunci: IoT, kawalan peralatan, pemantauan penggunaan tenaga elektrik, internet, mikrokontroler Arduino dan Aplikasi.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT:	Internet of Things
kWh:	kilowatt-hour
LED:	Light Emitting Diode
I:	Current
P:	Power
μ:	Permeability
Ω:	Resistance
Wi-Fi:	Wireless Fidelity

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CHAPTER 1

INTRODUCTION

1.1 Background

A smart home becomes very popular. There are many research papers published on the design, issues, and technologies used in the smart home. The essential component in the smart home system is the Internet.

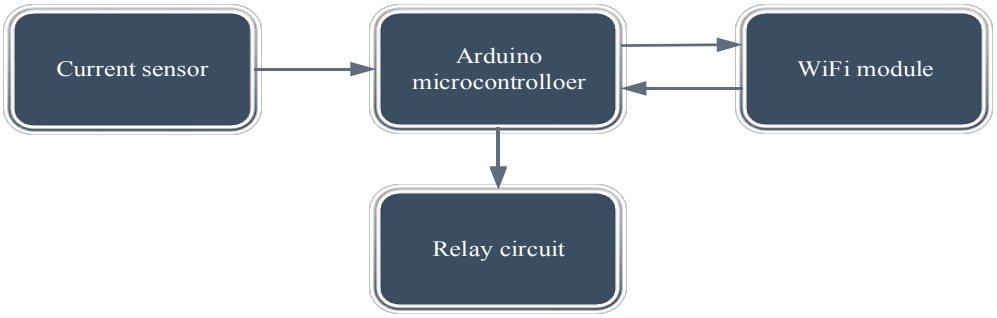
The Internet now is widely used to send and receive data. With the discovery of wireless sensor nodes and sensor signals, there is a need to send these signals over an internet network. Thus, this result with a new protocol developed. This protocol is an Internet of Thing (IoT) protocol stack where it is located differently from the IpV4 and IpV6. By logic, the sensor signals should not mix with internet data. This is because the sensor's signals are too small in size and vulnerable. Therefore, they should be isolated from the internet data and should send and receive separately.

The latest 5G network system has an IoT protocol stack. This allows the users to send and receive the IoT signals separately. The same is happening for signal monitoring systems like electrical energy consumption monitoring—the electrical energy monitoring system using different protocols from the Internet protocols. The monitoring has its protocol stack, which parks under the IoT protocol stack. All the monitoring data will be saved automatically in the database. The monitoring is 24 hours.

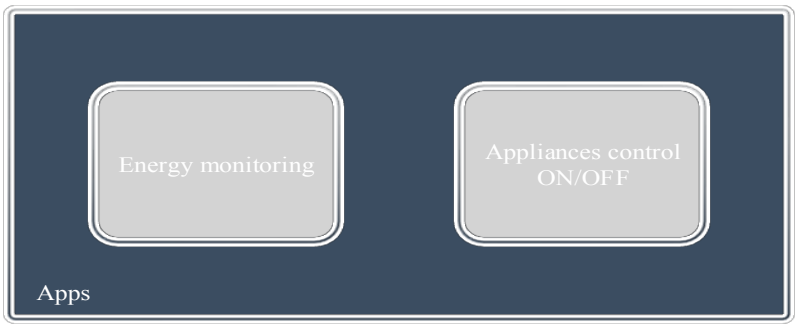
The electrical monitoring system using internet protocol should have a sensor and a microcontroller. The sensor used is a current sensor or energy sensor. The sensor produces analogue signals where the microcontroller should able to read and process the signals. In some cases, the signal could be current, and this current signal is then

multiplied with a constant voltage, say 240V AC to result in the power output. From the amount of time spend to consume power, the energy can be calculated.

In this research project, the idea of the project not only monitors the electrical energy usage by a load but also allow a user to control the electrical loads. A primary control ON and OFF the electrical load is adopted in this project. A simple button will be developed in the mobile Apps for a user to control electrical load ON and OFF. The purpose of developing this control function is to prove that the IoT signal is used in one-way communication but two ways (monitoring and control). Additional functions like humidity and temperature will be added into the system. The general idea and concept of the research project can be summarized in a block diagram, as shown in Figure 1.1.



(a) Hardware design



(b) Apps design

Figure 1.1 Idea of the research project.

1.2 Problem Statement

Electricity is an essential thing now, as technologies are going to grow, and new gadgets are being produced to make life easier. The power consumption of the residence can thus be doubled day by day. The unrestrained daily consumption of electricity causes the monthly bill for energy to increase until the user realizes that their electric power use outstrips their financial plan.

Today the energy meters used in most buildings only read and display the total energy consumption. The consumption of electrical energy is commensurate to the use of energy, and the increased use of electricity leads to higher billing costs. Consumers are unable to calculate their real-time consumption of power and are unable to measure how much of the actual use rate they have been utilizing.

People have no idea how many kWh units they use on a daily or weekly basis, and this will hold them in routine until the end of each month when they collect large bills for the use. If it exceeded their spending plan, that would cause them a financial issue.

Since the electrical energy monitoring system already exists in the market. The features designed only for monitoring function without second or third function. Thus, this is a disadvantage of the electrical energy monitoring system where it only serves one function. It is noticed that, if such electrical energy monitoring system only serves one function at a time, then it causes the IoT resource wasted. The IoT has plenty of spaces for users to send and receive the data. If the data send only without received, then the receive function is wasted and not use.

The designed monitoring system should have the ability to control the appliances as well. By doing that, the resource will not be wasted. The IoT capability could help this electrical monitoring system to monitor the use of power gradually. The utility should forward an acceptable request for side-activities to the family units to may their energy costs because of these stamina and power-related data.

The project is also aimed at developing a smart lighting network that allows the lighting to be managed in such a way that the lighting use correctly balanced the real need to enhance energy conservation and create the link between home lighting and mobile phones with some specific features that aim to improve the user experience.

1.3 Research Goals

The goal of the research is to show the ability to use IoT technology for two ways of communication. The load performances not only can be monitored but also can be controlled at the same time.

The goal is to prove the hypothesis (IoT two ways communication systems) via a prototype developed. It also proved that there is no collision of data when two signals (control signals and receive signals) send at the same time to the internet network.

1.4 Research Objectives

The main objective of this project is to develop a smart kWh to monitor and control home appliances via the Internet of things (IoT) with the following objectives:

- To design and implement a smart metering system that reads the energy consumption of the loads, upload the energy reading to the app, and control the appliances via a mobile App.
- To apply the Internet of Things (IoT) in the hardware and the system to send the energy readings and control the appliances.
- To find out the individual consumption of reactive power by each of the loads.
- To analyse the accuracy of the metering readings in Apps by comparing it with the commercial energy meter.

1.5 Scope of Project

The scope of the project focuses on the research of the SonOFF device, which is used to measure the current and the power. The scope also focuses on learning the programming part for nodeMCU interface with the Apps together with the SonOFF. The circuit constructions and for temperature and humidity sensors interface to the nodeMCU also will be learned in order for the Apps to display the temperature and humidity.

The final part in the scope is Apps design learning. The Apps is referring to the Blynk Apps. This Apps can be used to interface the nodeMCU but need to know the programming set up in the nodeMCU. By learning the coding of the interface to the Apps wirelessly, the data of humidity and temperature can be sent over an internet network and reached the Apps for display. An additional thing to be learned and the add-in is the appliances control via the buttons. This function allows the user to control electrical loads ON and OFF**.**

1.6 Significant of The Project

This project is essential for the user to check the electrical power consumption via the online system. The development of the Apps and the system allows user to monitor the power consumptions of the loads from a far distance and at any time.

Besides that, the user also can be informed about temperature and humidity around the house. Furthermore, the control of the electrical appliances via the Apps is possible because the Apps have several buttons for the user to control the appliances. Overall, it also helps the electrical provider to monitor the consumer's load operation from the centre without sending people to record the usage of electricity.

1.7 Arrangement on The Content of The Report

Chapter one introduces the overall idea behind the project. This chapter shows the objectives, problem statements, scope of the project, as well as the significance of the project. Overall, this chapter presents the idea behind the whole research project on energy meter reading and control.

Chapter two presents theories and reviews of the related researches. This chapter also presents the principles of engineering behind the project. The essential technical keys and system designs are shown in this chapter.

Chapter three shows the methodology of doing the project. This chapter presents the schematic diagram, programming designs and Apps used in the project.

Chapter four presents the results and analysis. The results present in this chapter is the experimental results and test results. Through the results, it can determine the success of the project.

Chapter five shows the conclusion and suggestion of some of the improvements needed in the project. This chapter concludes the works and states the improvement needed to improve the project.

REFERENCES

Afsar, M., Birch, J., & Clarke, R. (2018). Using Blynk and Internet of Things . *International Conferences on Apps Design* (pp. 4-39). New York : IEEE.

B.L.Theraja. (2016). *Electrical Technology* . India: EEE Indian Publisher .

Baker-Javis. (2018). *Temperature and Humidity Display Project* . Bradford : University of Bradford .

Ballo.D. (2019). *Humidity and Temperature Control for Smart Home* . London : University of Sunderland .

Banghegyi, G., Van, B. L., & Bokut, B. V. (2015). Revolution of Wireless Internt . *International Conference on Internet (ICI)* (pp. 1- 10). Bangkok: IEEE .

Bolton, W., Choy, T., & Fuller, A. (2015). Wireless Sensor Network and Design . *International Conferences on Computer and Simulation* (pp. 2- 16). Kuala Lumpur : IEEE.

Carsia.N, Guire.T, & Hui, H. (2015). Wireless Sensor Network Simulation. *International Conferences on Electronic and Eelctrical* (pp. 3-20). Johor Bahru : Digital IT solution .

Collin.R.E. (2018). *Design a Wirless Energy Meter* . New York : McGraw-Hill.

Cullen.A.L. (2019). *Using SonOFF for Energy Meter* . London: University of London .

Dw-Huges, & Fannis, C. (2018). Using Ubitdot as Platform for IoT Data . *International Conferences on Wireless Communications* (pp. 56-78). Jakarta: IEEE.

Jiles., D., Kittle., C., & Kong., J. (2016). ZigBee Solution for Wireless Sensor Network. *International Conferences on Wireless Network* (pp. 15-30). Kuching : IEEE .

Kumaran.S. (2017). *Embedded Technology and Applications* . India: EEE India Publisher.

Lakhtakia., A., & Lancaster., M. (2016). Simulation on ZigBee Network. *IEEE Trans on Wireless Sensor Network*, 23-36.

Lindell., A., Lines., M., & Gurin., F. (2016). Using XBee for Wireless Sensor Network. *IEEE Trans on Wireless Sensor Network* , 14-28.

Montore, M., Pendry, J., & Potschle, P. (2016). Using ESP8266 to Send Data in Wireless Sensor Network. *IEEE Trans on Electronic Communications*, 16-29.

N, C. a. (2018). Energy Meter Design for IoT . *International Conferences on Energy Efficiency* (pp. 44-109). New York: IEEE.

Rado, G., Ramo, S., & Sihva, A. (2016). Wireless Sensor Network Design using ESP8266 as a WiFi Module . *International Conferences on Wireless Sensor Networks* (pp. 24-100). Tokyo : IEEE .

Simit, J., Shen, J., & Robert, P. (2016). Connection of ESP8266 Issues to the Router . *International Conferences on Wireless Communications* (pp. 5-30). Taipei : IEEE.

Sohn.D.B. (2018). *SonOFF Applications* . London: Oxford Press .

Solymar, L., & Walsh, D. (2016). IoT Network Simulation using ESP8266 . *International Conferences on IoT* (pp. 10-30). Beijing : Digital Library .

Sun, G., Yao, K., & Liu, Z. (2017). Using Thingspeak.com to Display the IoT Data . *International Journal on Internet of Thing and Simulation* (pp. 15-45). Manila: IEEE.

Theron.J.P. (2016). *Internet of Things and Applications* . New York : Prentice-Hall.

Thuery, J. (2016). *Electrical Energy Measurement* . New York : McGraw-Hill.

Tinkham.M. (2017). *Apps Design for IoT* . New York: Prentice-Hall.

Tinoon.J. (2017). *Internet of Things and Data Base using Ubitdots.* New York : Prentice-Hall.

Urry.D, F. a. (2018). *Introduction to Thingspeak.con and IoT* . New York : McGraw-Hill.