



Faculty of Electrical Engineering

**SMART HOME ELECTRICAL APPLIANCES CONTROLLING VIA
ANDROID SMARTPHONE**

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**Bachelor of Electrical Engineering
(Control, Instrumentation and Automation)**

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**SMART HOME ELECTRICAL APPLIANCES CONTROLLING VIA ANDROID
SMARTPHONE**

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**A thesis submitted
in fulfilment of the requirements for the bachelor of Electrical Engineering
(Control, Instrumentation and Automation)**

Faculty of Electrical Engineering

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DECLARATION

I declare that this thesis entitled “Smart Home Electrical Appliances Controlling via Android Smartphone” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

APPROVAL

I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfilment of Bachelor of Electrical Engineering (Control, Instrumentation and Automation).

Signature :

Supervisor Name :

Date :

ABSTRACT

This project is entitled “Smart Home Electrical Appliances Controlling Via Android Smartphone”. The advancement of smart home technology had improved human’s quality of living. There are two types of smart home network technology which are wiring system and wireless system. For wiring system, the equipment is connected directly with the main power supply and the data is sent to activate or deactivate the home appliances. For wireless system, two important elements which are sender and receiver are involved. The appliances can communicate with other devices through wireless technology such as Wi-Fi, infrared, Bluetooth, radio frequency and IEEE 802.11. The motivations of this project are to decrease the cost of smart home products and to overcome the range issue of Bluetooth technology that had implemented in many existing smart home projects. Due to the busy lifestyles of people, many electrical appliances are left turned on when it is not in use. When residents go out without turn off their home appliances, they must go home to turn off the electrical appliances to avoid any additional of electricity consumption, so it is impossible for residents to waste petrol and time to do such action. With the advance of technology, the use of internet will be developed to this smart home system. The Android smartphone will be used for controlling and monitoring the home appliances using the application. A low cost smart home system also will be developed.

ABSTRAK

Projek ini bertajuk “Pengawalan Alatan Elektrik Rumah Pintar Menggunakan Telefon Pintar Android”. Kecanggihan teknologi dalam rumah pintar telah meningkatkan taraf hidup manusia. Terdapat dua jenis sistem rangkaian telah digunakan dalam sistem rumah pintar iaitu sistem pendawaian dan sistem tanpa wayar. Bagi sistem pendawaian, peralatan elektik rumah akan disambung terus dengan bekalan kuasa utama. Data akan dihantar melalui saluran dawai untuk mengaktifkan atau menyahaktifkan peralatan elektrik rumah tersebut. Bagi sistem tanpa wayar, sistem ini akan melibatkan dua elemen penting iaitu penghantar dan penerima. Peralatan elektrik rumah boleh berkomunikasi dengan peralatan lain melalui teknologi tanpa wayar seperti Wi-Fi, inframerah, Bluetooth, frekuensi radio dan IEEE 802.11. Motivasi projek ini adalah untuk mengurangkan kos produk rumah pintar dan mengatasi isu jarak teknologi Bluetooth yang telah digunakan dalam banyak projek rumah pintar yang sedia ada. Pada masa kini, gaya hidup masyarakat yang sibuk telah menyebabkan banyak peralatan elektrik rumah dibuka walaupun ia tidak digunakan. Apabila pemilik rumah keluar dari rumah tanpa menutup peralatan elektrik, mereka sepatutnya pulang ke rumah untuk mematikan peralatan elektrik untuk mengelakkan pembaziran penggunaan elektrik. Walau bagaimanapun, kebanyakan pemilik rumah tidak akan membazirkan minyak petrol kereta dan masa untuk pulang ke rumah. Dengan kecanggihan teknologi, penggunaan internat akan digunakan untuk membangunkan sistem rumah pintar yang lebih baik. Peralatan elektrik rumah boleh dikawal dan dipantau dengan menggunakan aplikasi Android. Sistem rumah pintar yang berkos rendah juga boleh dibangunkan.

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LIST OF ABBRECIATION

AC	-	Alternating Current
ADC	-	Analog-to-Digital Converter
API	-	Application Program Interface
APK	-	Android Package Kit
BDC	-	Business Development Center
COM	-	Common
CPU	-	Central Processing Unit
DC	-	Direct Current
GND	-	Ground
GPIO	-	General-Purpose Input/Output
GUI	-	Graphical User Interface
HTML	-	Hyper Text Markup Language
HTTP	-	Hypertext Transfer Protocol
HTTPS	-	Hypertext Transfer Protocol Secure
IDE	-	Integrated Development Environment
IEEE	-	Institute of Electrical and Electronics Engineers
IIC	-	Inter-Integrated Circuit
IN1	-	Input 1
IN2	-	Input 2
IN3	-	Input 3
IN4	-	Input 4
I/O	-	Input/Output
IoT	-	Internet of Things
IP	-	Internet Protocol
JSON	-	JavaScript Object Notation
LED	-	Light Emitting Diode

MIT	-	Massachusetts Institute of Technology
MQTT	-	MQ Telemetry Transport
NC	-	Normally Closed
NO	-	Normally Open
OS	-	Operating System
PLC	-	Programmable Logic Controller
PWM	-	Pulse Width Modulation
QEMU	-	Quick Emulator
RAM	-	Random Access Memory
SD	-	Secure Digital
SDK	-	Software Development Kits
SoC	-	System on a Chip
TCP	-	Transmission Control Protocol
UI	-	User Interface
USB	-	Universal Serial Bus
V _{in}	-	Input Voltage
WAP	-	Wireless Application Protocol

CHAPTER 1

INTRODUCTION

1.1 Overview

This section is an introduction chapter including research background, motivation, problem statement, objectives, scope and project outline. The research background discusses the definition of smart home, the function of smart home system in residential building, the development of technology in smart home and the introduction of IoT. Furthermore, there are two motivations are discussed including the high cost of current smart home system and the weakness of Bluetooth technology. For the problem statement part, it states the general problems that will be faced by the human in electricity usage and energy management. Thus, new solutions will be suggested. The objectives are also defined and several goals are set to accomplish the proposed project. The scope describes the functionality of the proposed project and introduces the open source software and low-cost hardware that can be implemented in this project. The thesis outline lists out and summarizes the content of each chapters that will be included in this research.

1.2 Research Background

“Smart Home” is a term that defined as a residential building that links all devices and appliances with special structured wiring to allow them to communicate with each other. [1] Smart home also is a house that merged the advanced automation systems to allow the residents to monitor and remotely control the sophisticated building’s functions such as multi-media, lighting, window and door operations, temperature, humidity and security system by using phone or internet. [2]

In 1984, American Association of House Builders introduced the concept of “Smart Home Automation”. The significant of the growth of smart home system is to control the devices and appliances automatically. [3] The technology becomes an essential part of human lives. The implementation of the system can improve human life more technology driven and easy managed. The implementation of smart home system comprises the implementation of several technologies such as microcontroller technology, wireless technology and smartphone application technology. With the advancements of those technologies, the system can be implemented efficiently.

In 21st century, the services of internet can be expanded to IoT. In 1999, Kevin Ashton introduced the concept of IoT officially in proposal form but the concept of IoT had been introduced unofficially for almost 25 years from now. The implementation of the IoT in the smart home system can improve the quality of human's life. By using the IoT, the huge amounts of intelligent objects can detect or accumulate the data and communicate with human by using sensor, phone and wireless technologies. The basic home tasks and features can be controlled automatically using internet from anywhere. [4]

1.3 Motivation

The first motivation of this project is to decrease the cost of smart home system. The basic installation of smart home system in the current market included basic starter kit, wireless mesh systems, monthly service, cloud automation and hardwired. All the costs are expensive. Furthermore, most of the smart home system in the market requires a professional to install the hardwired system. The cost to have such installation services is high. [5] The second motivation of this project is to overcome the weakness of Bluetooth technology for controlling the home appliances. The advancement of technology has raised the usage of IoT in smart home system. The wireless technology is the most popular technology that used in controlling the home appliances remotely in the indoor environment. Currently, there are many smart home systems using Bluetooth wireless technology to connect smartphone with the microcontroller to control the home appliances. However, the technology has a few disadvantages such as slow data speeds, poor data security, short range and shortened battery life. [6] Bluetooth is operating at frequency of 2.4 GHz, it connects to a device within a range of 10-20 m at the speed of 256 Kbps to 1 Mbps. [7] Due to the short communication range and resident can only control the home appliances at limited range environment. The wireless connectivity between smartphone with the microcontroller cannot be established using Bluetooth in an outdoor environment. By using internet network, people can use a smartphone to remotely control the home appliances over internet from anywhere around the world. Internet overcomes the problem of range which is challenged in Bluetooth technology. [8]

1.4 Problem Statements

Nowadays, people are living in a busy lifestyle. Many people are always rushing when leave from their residential building and spend long time staying at outside. A lot of energy will be consumed if the resident forgets to switch off the home appliances such as

lights or fan. This will lead to additional expenditure on electricity. Therefore, an internet based smart home control system is designed so that the resident can control remotely the home appliances using Android smartphone without necessarily being nearby or inside the residential building. [9]

1.5 Objectives

The objectives of this project are:

1. To develop the use of internet in smart home control system.
2. To develop a low cost smart home control system.
3. To develop an android application to control the home appliances.

1.6 Scope

The scope of this project is to remotely control the home appliances via Android smartphone over internet. The Android smartphone is required to connect with the WiFi network or mobile data, then user can use an application as an interface to switch on and switch off the home electrical appliances from anywhere around the world. This project uses the open source software such as Arduino IDE, MIT App Inventor 2, Anto and PushingBox platform and the low-cost hardware such as ESP8266-12E NodeMCU Development Board and 4-channels 5V relay module. For the prototype demonstration, the components such as resistors, LEDs, buzzer and DC motor are used to represent the electrical appliances. This project only involves four types of electrical appliances such as alarm, air-conditioner, lighting and fan.

1.7 Thesis Outline

Chapter 1 - This chapter is an introduction chapter that describes the research background, motivation, problem statement, objectives and scope.

Chapter 2 - This chapter is a literature review chapter that discusses the published information of the advantages of wireless technology, significance of smartphone, android, microcontroller, HTTP API request method, introduction to MQTT and the review of the previous related works about the smart home automation system.

Chapter 3 - This chapter is a methodology chapter that discusses the procedures to do the proposed project.

Chapter 4 - This chapter is a results and discussion chapter that discusses more on the hardware and how the whole system will be implemented together with the hardware and software.

Chapter 5 - This chapter is a conclusion and recommendation chapter that discusses the summary of the proposed project. The limitation and the weakness of the proposed project are presented in this chapter. Recommendations are suggested for the improvement of the proposed smart home system.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter is a literature review chapter that discusses the advantages of wireless technology, significance of smartphone, android, microcontroller, HTTP API request method, introduction to MQTT and the review of the previous related projects.

2.2 Advantages of Wireless Technology

Recently, the automation technology of smart home and modern building techniques increase the use of the wireless technologies such as WiFi, Bluetooth and Ethernet. The use of wireless technologies offers several advantages in home automation. The advantages of wireless technology are low installation costs, system scalability and easy extension, aesthetical benefits and integration of mobile devices. Since no cabling is required for wireless technology, the installation costs are considerably reduced. The installation of wired system requires materials for the cabling and manpower for the installation. The cost of the materials and the fee of the salary are expensive. Furthermore, when the new requirement of the smart home system is proposed or changed, it is beneficial if a wireless network is deployed. It is necessary to extend the network only and no cabling changes are required. Moreover, the wireless smart home system fulfils the aesthetical requirements because the system does not cover a large space and cable laying is not necessary. The building can remain its design and architecture. With wireless networks, the mobile devices such as PDAs and smartphones can be used to control the automation system from everywhere. As long as the device is within the range of the network, the physical location of the device is not a problem for the connection. The wireless technology is also easy to install and it does not burden the owner when owner wants to renovate and refurbish the building. [10]

2.3 Significance of Smartphone

Smartphone is defined as a portable electronic device that integrated with the advanced technologies which functions like a personal computer. Smartphone is not just a cellular phone in today's life, it is having a wide range of application in smart home, health care, education and entertainment. The improvement of smartphone in the functionality and

features increases the usage of smartphone in our lives and it influences our daily routine work. The smartphone is a typical device that widely used by everyone, therefore it is not difficult to get a smartphone. They will become more affordable and cheaper in the future. The aim of the smart home technology is to improve the convenience and comfort level of the living places in the application of energy efficiency, security and surveillance. There are several smart home systems using the wireless technologies such as Bluetooth, internet and SMS. The wireless technology is integrated with the smartphone. Thus, the smartphone can be established to the microcontroller of the smart home system using the wireless technologies. The application that created for the specific smart home system can be used as the user interface to remotely control and monitor the electrical appliances and lighting. Therefore, the smartphone is considered as a practical and convenient device for networking interaction than a computer and it is a best choice for the automation control solution. [11]

2.4 Android

Mobile OS is defined as a software platform that enables other programs to communicate and operate on mobile devices. It is important to ensure the compatibility of the functions and features such as application synchronization, WAP, keyboards, text messaging and email on mobile devices. Additionally, it is responsible for determining the third-party applications that can be used on mobile devices. Nowadays, there are several types of mobile operating systems are used by the mobile devices such as Android OS, Bada, IOS, MeeGo OS, BlackBerry OS and more. However, the Android mobile OS is the most popular and the fastest growing mobile OS that used widely around the world. Majority of mobile devices are using Android OS and it is developed by Google. Furthermore, it is a world-class and open development platform that everyone can write programs or customizes it for creating application and games that can run on any compatible mobile devices. The enhancements and improvements of the open source Android mobile OS have been developed under “dessert-inspired” version names in alphabetical order such as Cupcakes, Donut, Eclair, Gingerbread, Honeycomb and Ice Cream Sandwich. [12] [13]

Moreover, Android applications play the important role to widen the functionality of devices. The process to create and design new application for the Android OS is known as Android software development. For the Android software development, the Android SDK which comprises a set of software development tools is used and it is written in Java programming language. The SDK provides a debugger, software libraries, a handset emulator based on QEMU, documentation, sample code and tutorials. There are a few

Google's supported SDK IDE that can be used to create application's APK file such as Eclipse, Android Studio, NetBeans, Apache Cordova and MIT App Inventor 2. Then, the developers are available to publish the APK file to Google Play Store. Google Play Store as the primary application store program consists many third-party applications that can be acquired by Android device users. Users can install, update and remove the application's APK from their devices. [14]



Figure 1: Android's architecture diagram

Furthermore, the software stack of Android OS is shown in Figure 1. According to the Android's architecture diagram, it involves five groups of software program such as Linux kernel, Android runtime environment, libraries, application framework and application layer. Linux kernel is the primary part of the Android OS that allows manufacturer to modify the OS following the needs of mobile devices. Besides, it is a layer that can be used for managing memory, scheduling process and networking. The software of this layer is written in C/C++ language. On the top of Linux kernel layer is the Android layer that comprises the built-in libraries and the Android runtime layer that comprises Dalvik as a process virtual machine and the core Java-compatible libraries. The following

layer is Application Framework layer which is a high-level layer that enables developers to create a new Android application. Applications and widgets layer is the highest level of the Android system architecture. The application may contain of one or more activities and the activity classes will exhibit the interface screen. Due to the activity's life cycle is not depending to the process life cycle, the application still can program in the background even the process is completed. [14]

2.5 Microcontroller

Smart home controller is the main device of the system that can be used to receive and send signal to control the actuators. Microcontroller board is always used as the central controller for controlling the home electrical appliances. Microcontroller board is defined as a SoC that functions on an integrated circuit which contains all necessary circuitry for control purpose such as microprocessor, memory, RAM, clock generator and programmable input/output peripherals. Microcontrollers are used for embedded applications which are different from the microprocessors that are usually used for general applications consist of assorted discrete chips. Most of the microcontrollers embedded systems are advanced and only require small amount of memory and program length. Microcontroller has typical input and output devices to obtain the input signal and exhibit the output process respectively. For example, the sensor data such as the level of temperature, light and humidity can be obtained and gives signal to control the relays, switches, LED's and solenoids in real world through the microcontroller. There are several types of microcontroller can be used in smart home automation system such as microprocessor development board, PLC, Arduino, Raspberry Pi, PICAXE and NodeMCU. [15]

Currently, NodeMCU is the most popular microcontroller to be used to control the smart home system via internet network through WiFi connection. It is a type of single-board microcontroller and using XTOS as operating system. The CPU includes firmware which runs on the ESP8266 Wi-Fi SoC that integrated with a Tensilica Xtensa LX106 core. It consists 128KB of memory and provides 4MB of storage. The power can be supplied to the board through USB. Furthermore, it is based on ESP8266 and integrates GPIO, PWM, IIC, 1-Wire and ADC all in one board. The features of NodeMCU are open source, inexpensive, IoT platform and simple programming environment. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development

kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. [16]

There are three types of NodeMCU development boards and their names are shown in Table 1. The common names for the first generation, second generation and third generation are V1, V2 and V3 respectively. Figure 2 shows the hardware of ESP8266-12 NodeMCU development board. According to the figure, the first generation of NodeMCU is yellow in colour and the size of the board is very wide which equals to 47mm x 31mm. It is not convenient to use as the board will covers 10 pins of a regular breadboard. It uses ESP8266-12 chips.

Table 1: Names of ESP8266 NodeMCU development boards

Generation	Version	“Common” Name
1 st	0.9	V1
2 nd	1.0	V2
3 rd	1.0	V3



Figure 2: Hardware of ESP8266-12 NodeMCU development board

Figure 3 shows the hardware of ESP8266-12E NodeMCU development board. It is second generation of NodeMCU that fixed the weakness of first generation board. The board is narrower and can fit into breadboard easier. The chip is upgraded from ESP8266-12 to ESP8266-12E. There is no official third generation of NodeMCU is released. It is a version that invented by producer LoLin to minor improve the second generation of NodeMCU. For the third generation of NodeMCU, two pins will be reserved for a USB power output and an additional ground.