IMPLEMENTATION OF ELEVATOR CONTROL SYSTEM USING RASPBERRY PI

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by

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ABSTRAK

Memastikan lif di bangunan menyediakan pengalaman yang menyenangkan memerlukan penyelenggaraan lif, perkhidmatan dan sokongan yang kerap oleh profesional. Pelaksanaan algoritma yang betul dalam sistem kawalan lif adalah penting untuk memastikan sistem berjalan lancar. Tujuan utama projek ini adalah untuk mencadangkan satu algoritma untuk mengawal pergerakan lif menggunakan Raspberry Pi. Daripada menggunakan pengawal logik boleh diprogram, Raspberry Pi dipilih untuk bertindak sebagai pengawal induk untuk melaksanakan algoritma logik yang mengawal pergerakan lif. Pilihan ini membolehkan pengguna akhir interaksi mesin-manusia lebih mudah, akses log data mudah, dan pelbagai peluang pengembangan masa hadapan. Raspberry Pi GPIO telah digunakan untuk meniru kelakuan butang tekan. Sistem ini berfungsi dengan menerima isyarat daripada butang input dan kemudian mengawal putaran motor untuk memindahkan kabin ke destinasi yang dikehendaki.

ELEVATOR CONTROL SYSTEM

ABSTRACT

Making sure the elevators in the building provide a pleasant experience requires regular elevator maintenance, service and support by professionals. Implementation of the proper algorithm in the elevator control system are vital to make sure system to run smoothly. The main purpose of this project is to propose an algorithm to control the movement of the elevator using Raspberry Pi. Instead of using programmable logic controller, a Raspberry Pi was chosen to act as the master controller to perform the logic algorithm that control the movement of the elevator. This choice enabled easier end-user human-machine-interface, convenient data log accessibility, and a wide variety of future expansion opportunities. Raspberry Pi GPIO's have been used for emulating push button behaviour. The system works by receiving the signal from the input button and then control the motor rotation to move the cabin to the desired destination.

CHAPTER 1

INTRODUCTION

1.1 Research background

The height of the building has grown at the same rate as the economic development. With the increase in population and henceforth congested places, most of the building in this country are very high. The heavy passenger traffic within the buildings causes the need for elevators to increase[1].

Without the elevators, people would have to use the stairs to go to another level in the building. For those having work places in high buildings, using the stairs can be considered time-consuming and can cause delays for the workers to arrive at their work place on time. However, by having the elevator system, this issue can be eliminated and it will indirectly improve the productivity of a company. As a results, their level of safety and ride comfort under vibrating conditions haves become subjects of interest[2].

Currently, the elevator controller has three types; relay based controller which utilises electromechanical switching, solid-state logic technology, and programmable logic controller which utilises computer-based technology.

The use of algorithms and smart strategies are the important parameters in the control system that can lead to improving the energy efficiencies. The energy consumption can be reduced by having an elevator which operates using smart and energy efficient control strategy and tries to minimize the waiting time for the passenger at the same time. The traditional way of elevator control system has some disadvantages such as, bad dependability, complicated circuits, high faults ratios and

high effect on the elevator's running quality. The electronic use in microcontroller is also safe to be operated.

1.2 Problem Statement

The previous system of elevator controller is relay-based controller, solid-state logic technology and PLC controller. A relay-based controller is designed to act on one type of input signal only. It may have adjustments for a range but can only perform one function. The systems with relay feedback control can be seen as switched systems with a complex behaviour[3].

For the solid-state logic technology, it is hard to design because the solid-state logic technology is fixed by the manufacturer and the designer needs to follow the pin configuration. Besides, its programming is hard to upgrade, and the design will need more than one chip to perform the process[4].

Compared to relay-based controller and solid-state technology, PLC controller has the advantages of high reliability, and strong flexibility[5]. However, to upgrade an additional expansion for the PLC controller such as Omron PLC, it requires a specialist knowledge and can only be done by the manufacturer. Thus, make the PLC controller hard to upgrade for future expansion[6, 7].

Raspberry Pi can be made to perform many different functions including the functions of relays. This is done by selecting the type of inputs and outputs required and then programming to suit the functions wanted. Unlike any other PLC-based controller, Raspberry Pi is easier to upgrade, and the controller will be only one chip for the whole system[8]. Due to this, it can be seen as a potential alternative to the other PLC-based controller for the elevator system.

1.3 Objectives

The objective of this project is to propose an algorithm to control the movement of the elevator using Raspberry Pi.

1.4 Scope of Project

In this project, the focus is to propose an algorithm to control the movement of the elevator using Raspberry Pi. This project is divided hardware development which consist of electronics and mechanical parts, and software development which using the Raspberry Pi as the main controller.

This project is specified on the controlling the elevator in the three-floor building. A control strategy that collect passengers going to the same direction is important to make sure the time and energy efficiency. The rotating duration of the motor should be taken into consideration to make sure the stopping accuracy at which floor the car supposed to stop. The suitable speed of the motor is important for the time consumption and comfortability.

Overall, the project is developed using Raspberry pi as the main controller. Python programming language are used to program the Raspberry Pi that will control the motor. The motor is used to lift the cabin up and down. Other additional item such as seven segment and LED are used as a display. The switch will be used to trigger the input to the Raspberry Pi and the controller will send the signal to move the motor.

1.5 Thesis Outline

Arrangement of the thesis chapters were prepared in a way that the whole project could be expressed clearly from the literature review to the methodology part.

Chapter 1 which is Introduction part, it described the details about research background, problem statement, objectives, scope of research and this thesis outline.

Chapter 2 which is Literature Review, it describes the fundamental theories and the previous invention by the professionals.

Chapter 3 which is Methodology, reveals the objectives of the project which explains the entire works from the beginning until the end. Each criteria of the project are discussed.

Chapter 4 which is Result and Discussion, shows the performance and final results based on the entire control system. The projection problem encountered is discussed in this chapter.

Chapter 5 which is Conclusion, concludes the project and give the suggestion of improving that can be done in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will elaborate about the elevator controller that being used in the elevator production company. The specification of each controller is reviewed and discusses. The differences between these controller is compared. The elevator specs for each controller is also discussed.

2.2 Manually-controlled elevator

This is an early elevator with no automatic landing positioning. It was operated using a motor controller by operators and often not have many relays. The controller is controlled by switches that pulls on the adjacent ropes. There is safety interlock feature to make sure the inner and outer doors are closed before the elevator move.

2.3 Automatic-controlled elevator

Nowadays, all the elevator control systems are using the use the automatic controller as the controller. There are three types of controller, Relay based controller (electromechanical switching), Solid state logic technology, and PLC controller (computer-based technology). Automatic controller can control the car speed and the

movement when passing by the floors can be adjust. It can perform the logic algorithm and helps to reduce the waiting time by coordinating the movement of the elevator.

2.3.1 Relay based controller (electromechanical switching)

The electromechanical relay basically is a switch in a circuit that control electrical flow and perform logic operation with it. The device consists of an electromagnet that opens and closes contacts. Electromechanical relay acts as logic elements much like digital gates (AND, OR, etc.) may be connected to perform logic and control function. The oldest relay-based automatic controller used the principal of collective control[9]. This is where the car will stop at the nearest call in their moving direction. However, the disadvantages of the scheme are the phenomenon where several cars arrive at the floor at the same time and thus making the average waiting time much more longer. The number of relay required also make it difficult to troubleshoot if there is problem occurs.

A relay-based controller can serve a simple elevator with few stops. The drive speed of the device is up to 1 m/s and suitable for passenger lift in low traffic and in low-rise building situation with not more than three floors.

Figure 2.1: Relay based controller (electromechanical switching)

2.3.2 Solid State Logic Technology

Solid-state logic technology is a combination of discreet transistor and integrated circuit board. Compare to relay-based controller, it is more reliable with lower power consumption. It has built in diagnostics system for easier troubleshoot process. Digital landing system make floor levelling more accurate. The controller is suitable for passenger lift in low traffic situation and medium rise building with not more than 12 floors where the drive speed is usually up to 2m/s.

One of the elevator that used the solid-state controller is, **Otis 2000 E**. This is a passenger elevator that primarily for low and mid-rise building. It can serve up until 10 floors with travel speed of 2.5m/s. the capacities are up to 1600 kilograms (21 persons).

Figure 2.2: Solid State Logic Technology

2.3.3 PLC controller (computer-based technology)

Figure 2.3: PLC controller (computer-based technology)

PLC is an industrial controller system where we have hardware and software specially adapted to industrial environment. Many types of industrial equipment and entire automated systems is controlled by PLC[10]. PLC controller uses scan time

processing task and depend on the program running to monitor the input and outputs, makes logic-based decisions and ensure the lift work with the right program. They are the most dependable, compact, and simple to troubleshoot. The control system structure for PLC is simple, thus make the external circuit simple. It is easier to add or change the control function of the PLC because of the usage of the software to control the circuit. At present, because of their advantages, most of the relay-based controller has been replaced by PLC controller[11, 12].

Computer based controller are suitable for all lifts types, all drive speeds and all lift groups sizes. One of the current product that use this type of controller is, **Otis Elevonic 401** with the capacity of 3000 lbs. per cab for double deck. It can serve up to 70 floors and can have a rear door. This product is one of the most advance elevator so far.

Raspberry pi is very similar with the PLC as uses the microcontroller to control the whole system. PLC hardware components consist of central processing unit (CPU) that acts as the brain of the PLC. CPU direct the PLC to execute the instruction, carry out logic and arithmetic operation, connect with another device, and perform the troubleshoot.

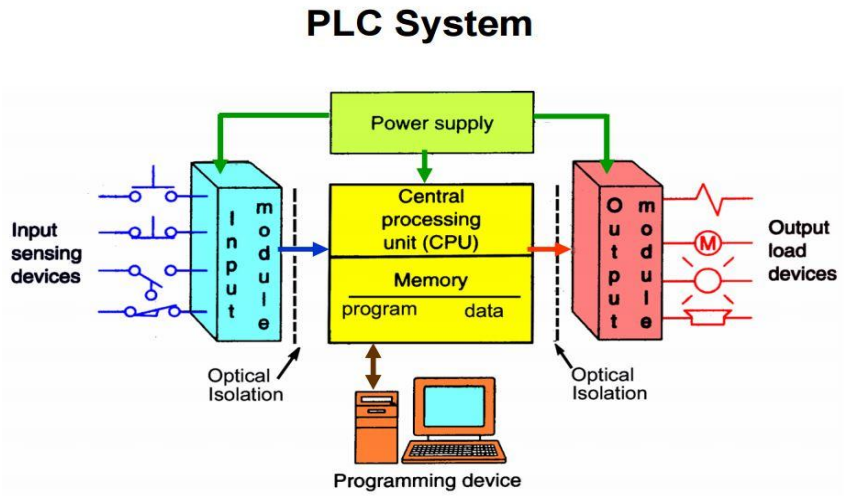

Figure 2.4: PLC system structure

PLC operation consist of input scan, program scan, output scan, and housekeeping. For the input scan, PLC read signals for the input device (switch, push button, sensor, etc.). It then will execute the program logic through the program scan process and then generate the desirable output (motor, actuators, LED etc.). The housekeeping process is performed by checking the software and perform the other request according to the preference.

Table 2.1: Comparison of all the automatic controller

Controller	**Advantages**	**Disadvantages**
Relay based controller (electromechanical switching)	• Cheaper cost • Suitable for low-rise building	• Very complex circuit • Hard to troubleshoot
Solid State Logic Technology	• Lower power consumption • Has built in diagnostic system	• Hard to set up
PLC controller (computer-based technology)	• Extremely reliable • Easy to add and change control function • Easy to troubleshoot	• Need to have software knowledge to set up and troubleshoot it • Hard to upgrade for additional expansion

Overall, all the automatic controllers can perform the logic algorithm. But, most reliable controller in improving power efficiency and waiting time is PLC controller and all the operation in PLC can be set up through programming the software. However, additional hardware such as computer is needed to program the controller. The relay-based controller and solid-state logic technology required a hardware setup to perform the logic algorithm which is very complex to assembled and troubleshoot.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will discuss about the proper method for this project. The first part will discuss the overall flow of the project. Next, both hardware and software used are explained in detail. Finally, the protocol for the control algorithm are explained in detail and shown in figure 3.3 and table 3.1.

3.2 Project Layout

In this project, several stages have been prepared for the project to be implemented. The electronic flow system, mechanical flow system, software flow system, assembly part and project testing are conducted to collect the data. The data will then be analysed to match with the objective of the project.

In earlier stages, the concept is planning on how to design the elevator control system function. Based on the research that have been carried out, the best type of controller is chosen, in this case, PLC. And while raspberry pi is very similar to PLC, plus much more simple, Raspberry Pi is chosen as the main controller.

Next, the electronic flow system, mechanical flow system, and software flow system is designed. For the electronic part, the circuit for the switch input function, stepper motor and Led display is designed to connect to raspberry pi. The circuit is then

will be tested on together with the coding. If there are any problem occur, troubleshooting process will be carried out.

For the mechanical part, the idea of the elevator construction system is designed. After that, the suitable material for the prototype is listed down.

In the software part, python programming language is used to program the raspberry pi and control the logic of the entire circuit. The coding for forward and reverse function for stepper motor and the input switched is created. Then, these two parts is combined and led function is added as the display. The code is compiled and test in raspberry pi

Finally, all the part is assembled and tested together. The observation will be made based on the different scenario that will be tested. The process will be repeated until the desire and satisfying results is achieved.

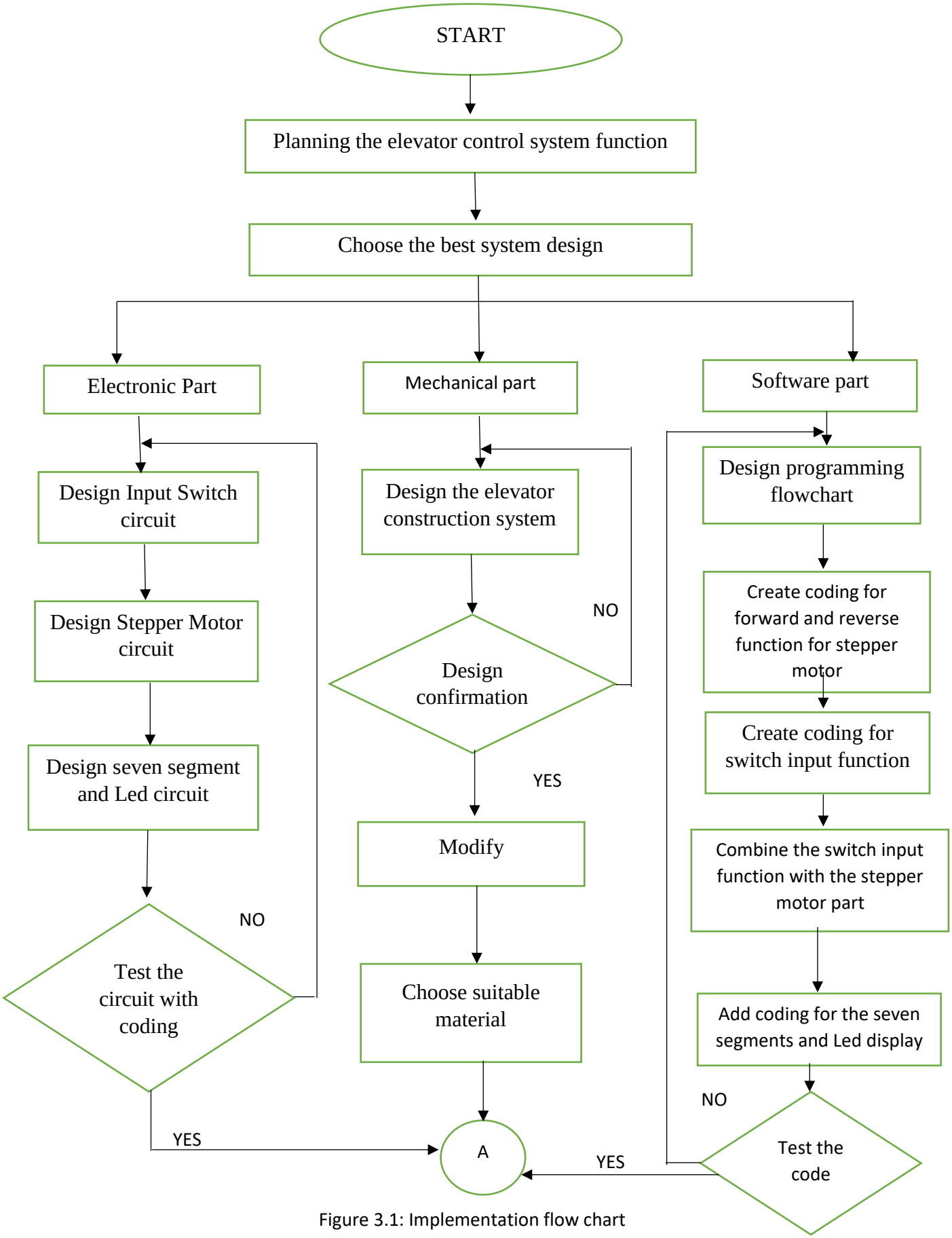

Figure 3.1: Implementation flow chart

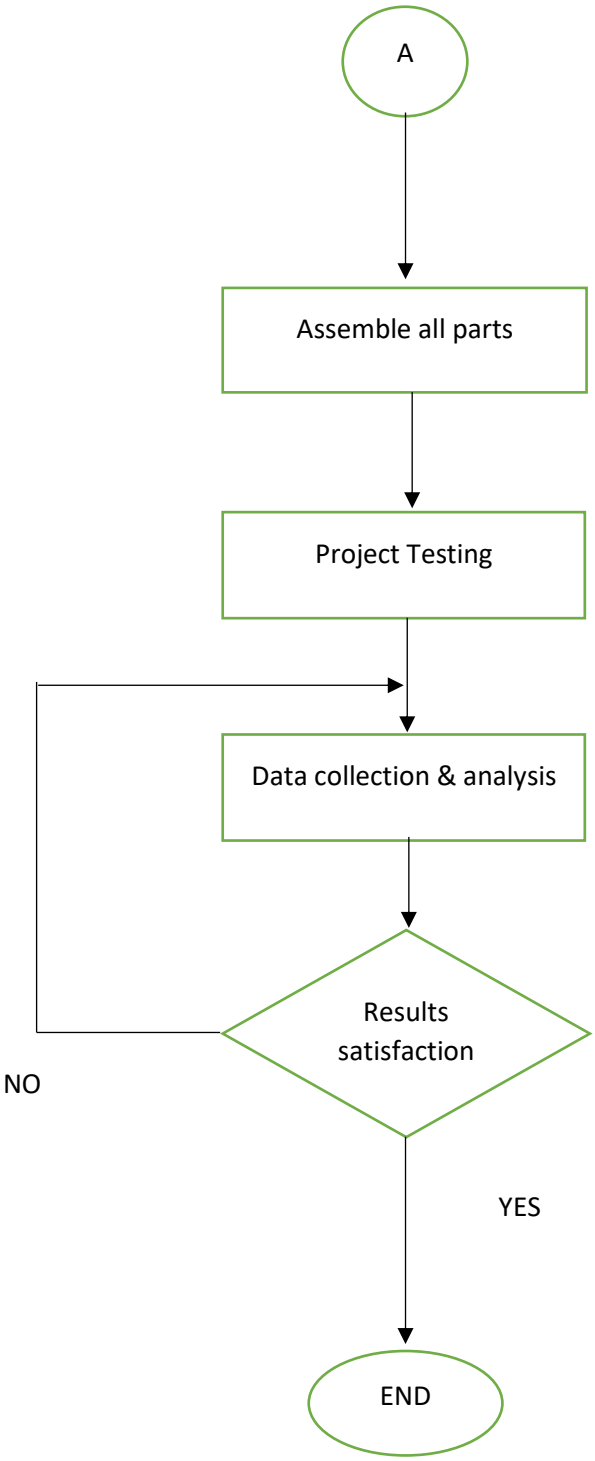

Figure 3.1: Implementation flow chart

3.3 Controller system

The controller is the most important part in elevator system production. The controller will be used to control and set the logic algorithm to the system. In this project, the control strategy has been studies to design the best controller system.

3.3.1 Raspberry Pi 3

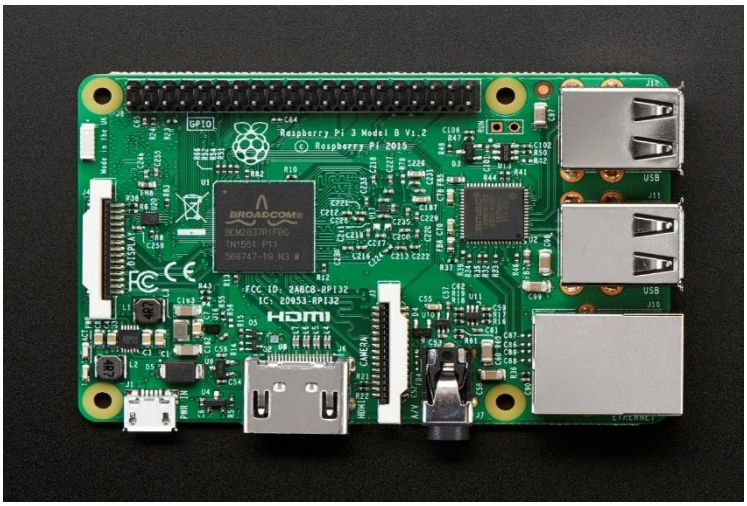

Figure 3.2: Raspberry Pi 3

There are many types of microcontroller that can be used as the controller. But the most suitable one is, Raspberry pi 3 because it has many functions just like a mini computer and one of the latest microcontrollers with affordable price. It is widely used among students for studies and research purpose.

Raspberry pi required an operating system to operate. The most compatible and widely used operating system for raspberry pi is Raspbian. It is equipped with 40-pin header for the input and output connection. The GPIO's pin can provide maximum of 5V of power supply. HDMI port will allow the microcontroller to be connected to PC

monitor. USB port will make it easier to connect with other input such as mouse and keyboard. Ethernet port and wireless function will allow it to be connected to internet without any pc or laptop.

The language that be used to program the raspberry pi are python programming language. Compared with other programming language, python is simpler to code yet very powerful. The raspberry pi also equipped with the SD card thus the written program code can be directly save into the raspberry pi.

3.4 Software component

The operating system used for the raspberry pi is Raspbian. It contains basic program and utilities that enable the raspberry pi to run.

3.4.1 Python Programming language

Python programming language is the programming software that compatible and work smoothly with raspberry pi. It is already pre-installed in the Raspbian. In this project, the python programming language are used to program and set the movement of the stepper motor based from the input from the push button switch.

3.5 Control Algorithm

In this project, the protocol for the control algorithm is strategized to make sure the motor rotates in the right direction when the button is pressed. Figure 3.3 shows the control algorithm of the elevator system. The level of the elevator is initially set to level