REMOTE-CONTROLLED ELECTRO-PNEUMATIC ACTUATOR FOR REMOTE RESPONSE UNIT

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This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Thermal Fluid)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2017

DECLARATION

I declare that this project report entitled "Remote-Controlled Electro-Pneumatic Actuator for Remote Response Unit" is the result of my own work except as cited in the references

Signature : .....

Name : .....

Date : .....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal Fluid).

Signature :. .....

Name of Supervisor : .....

Date : .....

DEDICATION

To my beloved mother and father

ABSTRACT

The purpose of this study is to develop a remote operated construction robot by implementing teleoperation command and control system. Robotic technology has been used widely in industrial field that give positive feedback in terms of its accessibility, convenience and safety. Robotic technology is versatile on doing various job from simple repetitive jobs to dangerous situation. A remote-controlled robot can help human on solving problems that believe to be hazardous and need experts to be at the specific location which in this case is human. Robot have high reliability and more efficient mobility instead of conventional control system. Remote control system allowed human to carried difficult task at several distances away. The system will be developed using Arduino control system that will be used in the control of the pneumatic construction vehicle. The remote-controlled system will be controlling the movement of the mini robot. The control system will be developed using two methods for the initial method which using the Arduino programming and the SKPSW wireless transmitter. The remote controller project is developed by using PS 2 controller as a base system that will send the data from the remote control and send output data to the system. This system uses Arduino coding logarithm that has been developed in Integrated Development Environment (IDE) and uploaded to the Arduino board by USB making the Arduino as the prime controller. The Arduino system that attached with wireless receiver will receive data from the remote control and process the data to be sent to the output digital pins. The remote controller system used Arduino software and hardware as the controller that has been successfully tested by actuating cylinder that carried out operations of the mini robot when the PS2 controller button is pressed.

ABSTRAK

Tujuan kajian ini dijalankan adalah untuk menghasilkan sebuah teknologi robot menggunakan sistem teleoperasi sebagai pusat kawalan dan arahan. Teknologi robotik digunakan secara meluas dalam bidang industri dan mendapat maklum balas yang baik dari segi kebolehcapaian, kemudahan dan keselamatan. Teknologi robotik juga serba boleh dalam menjalankan tugas yang berulang dan merbahaya. Penggunaan alat kawalan robotik dapat menyelesaikan kerja yang dijalankan oleh manusia dan mudah untuk menjalankan kerja yang bahaya, serta ianya perlu dikawal oleh pakar iaitu kepakaran manusia. Teknologi robotik mempunyai kebolehpercayaan yang tinggi dan kemudahan pergerakan yang efisien yang jauh lebih baik daripada kawalan konvensional. Alat kawalan boleh digunakan oleh manusia untuk menjalankan kerja yang sukar pada jarak yang jauh. Sistem ini menggunakan Arduino sebagai asas kawalan untuk mengawal kenderaan pembinaan hidraulik. Sistem kawalan jauh ini akan digunakan untuk mengawal pergerakan robot. Sistem kawalan akan dibangunkan dengan menggunakan dua kaedah iaitu untuk kaedah awal, ia menggunakan pengaturcaraan Arduino dan pemancar tanpa wayar SKPSW. Projek untuk alat kawalan dibangunkan menggunaan alat kawalan PS2 yang akan menghantar data kepada sistem. Keseluruhan sistem ini menggunakan Arduino logaritma yang akan dihasilkan menggunakan perisian Arduino, kemudian data akan dihantar kepada papan Arduino menggunakan USB dan menjadikan Arduino sebagai kawalan utama dalam projek ini. Sistem Arduino yang dilampirkan dengan penerima tanpa wayar akan menerima data dari alat kawalan jauh dan memproses data untuk dihantar ke pin digital pengeluar. Sistem kawalan jauh menggunakan perisian Arduino dan perkakasan sebagai pengawal yang diuji oleh penggerak silinder bagi 'mini' robot apabila butang pengawal PS2 ditekan.

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to my supervisor Dr. Ahmad Anas Bin Yusuf for giving me this opportunity to do final year project with him. He never hesitated to give me advice and guidance whenever I confronted problems. I am thankful for his patience and advice while leading me in this project.

I would express my gratitude to Fluid Power lab technician, Mr Ikhmal Hisham Bin Ibrahim @ Ibarahim who is willing to share with me their knowledge and give advice about my final year project. I would like to thank my course mates for giving me their support, patience and encouragement. Finally, I would like to thank my family for their support

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LIST OF ABBREVIATION

LED	Light-Emitting Diode
PS2	Play Station 2
IDE	Integrated Development Arduino
V	Voltage
VCC	Positive Supply Voltage
GND	Ground
USB	Universal Serial Bus

CHAPTER 1

INTRODUCTION

1.1 Backgrounds

Remote controls system is now widely used in many industry and it became essential for every human being. Nowadays, the remote-control capability built in many devices such as toys cars, video game consoles and ceiling fans. Remote controls allowed us to perform many tasks that would be difficult and dangerous. Remote control works by sending signal over a frequency through transmitter to the model that being controlled. The transmitter is the component used the send signal of the command from the board to the model.

For the last few years, human tend to use remote control system for other commercial use. Remote control system in many technical machine helps people to perform security tasks, building maintenance and construction. There is some development of the robotics technology which use remote control system to operate. This technology has emerged drastically now in order to decrease the need of human power. It also helps us to perform a difficult and dangerous task. For example, the remote-controlled excavator that operate in inclined and dangerous area can be controlled by the human from long range. This will make the human to deal with any situation they may encounter autonomously. (Nathan Chandler,2011)

The function and operation of remote-controlled electro-pneumatic actuator is same with the remote-controlled robot that used widely nowadays. So, the focus of this subtopic is on the wireless remote-controlled of any devices or machine. The working tasks done by the robots is way more safe and reliable. As an example, a tele-operated service robot called ROSE (Remotely Operated Service robot) was developed to perform the human task. The operator can control the ROSE from the distance of 8 km.(Van Osch et al. 2014). This kind of robot can lead to other service robot which specialized in performing security tasks, building maintenance and construction. For

instance, the robot could be built for construction work such as lifting the heavy objects or build the building wall. This will make the human less work and safe from performing dangerous task. In chemical industry, the robot can be used to lift and move the chemical objects which hazardous for human. (" How do remote controlled toys work?",2016)

The tele-operation excavator using a human arm also was developed to perform the task like digging, material handling, demolition, general grading and mining. This resulting in positive effect for those don't have experience to operate and manipulate a mechanical excavator. They do not need a long learning process to gain skills and knowledge required in operating the overall excavator motion. Apart from that, they also do not need to operate the excavator at the dangerous place such as the inclined hill which can lead to instability of the excavator. This tele-operation excavator used the Bluetooth wireless communication as the connection between operator and excavator. In long range, the operator can simply give the command to the excavator. So, there is no potential risk of accident involved for the operator. (Kim et al. 2009)

1.2 Problem Statement

There is problem in developing the program that can control the electro-pneumatic actuator as the program provide many alternative ways to established code. The program need to be established by creating the command system for remote response unit. There is also problem in creating the command system as there is lot of coding that need to be learned to get a fully complete function of the remote response unit.

The problem with the previous remote response unit need to be resolved. This remote response unit is done by the previous student and it have some problem with the system. The problem is all LED bulb of the unit is light up when the power on. The LED should be light up when the button is pressed and the LED is turned off when the button is released. Therefore, the identification of the problem regarding with the circuit or the coding of the program need to be done.

1.3 Objective

The objectives of this project are as follows:

1. To modify electro-pneumatic actuator controller programming for the previous remote response unit.
2. To develop a new complete control system platform for the remote response unit.

1.4 Scope of Project

The scopes of this project are:

1. To program electro-pneumatic actuator controller for mini robot by using Arduino software. (objective 1)
2. To build a control panel for control system platform. (objective 2)
3. To survey and buy components to build the control panel. (objective 2)
4. To implement the failure mode and effect analysis on the project.

1.5 General Methodology

The actions that need to be carried out to achieve the objectives in this project are listed below.

1. Literature review
   Journals, articles, or any materials regarding the project will be reviewed.

2. Software study
   The Arduino software need to be practice commonly by studying the tutorials in YouTube.

3. Modify Arduino command

The coding for the remote-controlled electro-pneumatic actuator need to be established in the Arduino software in order to get the exact output.

4. Testing

   Testing will be made based on the coding input from the Arduino software to the board by testing it.

5. New panel development

   New panel of the remote response unit will be built

6. Report writing

   A report on this study will be written at the end of the project.

The methodology of this study is summarized in the flow chart as shown in Figure 1.1.

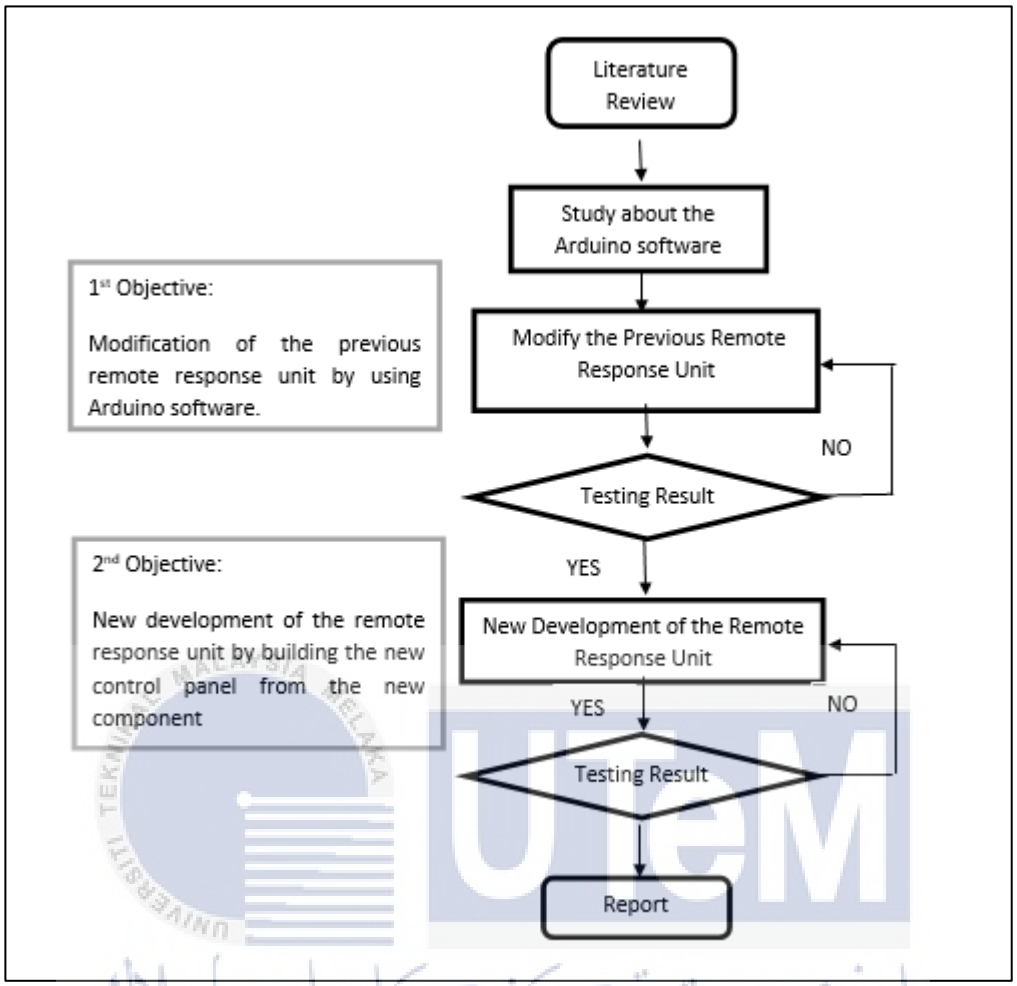
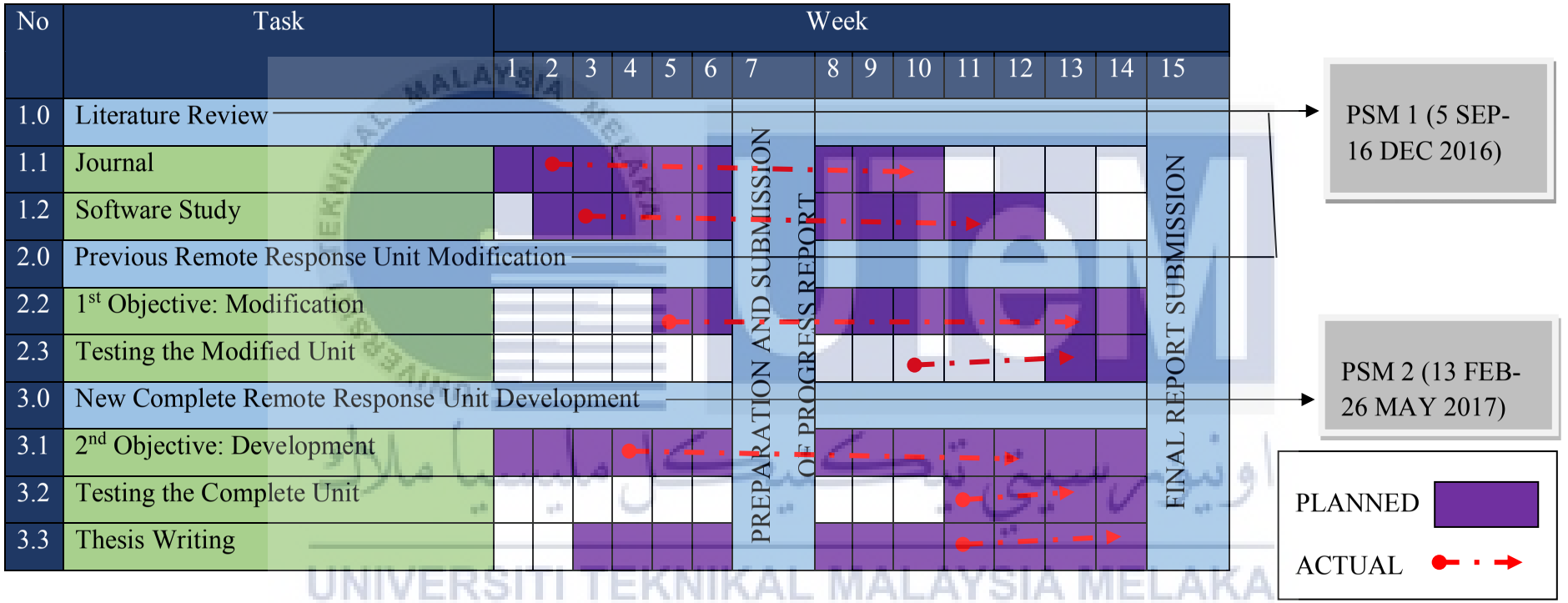


Figure 1.1: Flow chart of the methodology

Table 1.1 below shows the project schedule of PSM 1 and PSM 2 in the form of Gantt Chart.

Table 1.1: The Gantt Chart for PSM 1 and PSM 2



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Teleoperation System Control

Machine that enables a human operator to move about, sense and mechanically manipulate objects at a distance is called tele-operator. Most generally any machine which can perform a person's mechanical action beyond her reach is called tele-operator. One of the subclass of the tele-operator is tele-robot. It is a robot which can receive a command from a human operator at specific distance. The transmission of command input through the installed sensors or other control mechanisms can make the robot to perform live actions at a distant environment. The transmission process take place in between sensors and effectors with the support of the human operator to communicate with both. Whereas, teleoperation is a mechanism in which operation of robot take place using human intelligence. This operation need a suitable adequate human-machine interface that can be easy to handle. Figure 2.1 below shows the schematic diagram of the command flow in the tele-operation system (Cui et al. 2003).

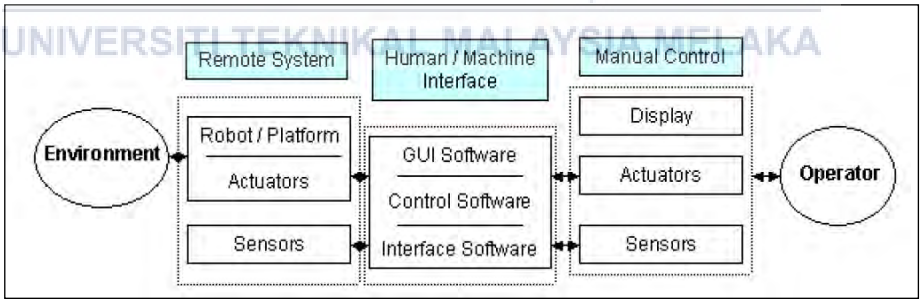


Figure 2.1: The Schematic Diagram of the Command Flow in the Tele-Operation System (Cui et al. 2003)

Mobile robots can be considered as an example of teleoperation system because they can be remotely controlled by human to accomplish certain tasks (Muhammad Hafiz, 2016). Nowadays, remote-controlled based robot technology is developed rapidly in order to take place of human in performing the task especially the repetitive task. Robot can be used in two general sector which are industrial and

service. Based on the International Federation of Robotics (IFR), service robot is defined as a robot which operates on semi or fully automatic to perform services useful to the well-being of humans and equipment (Yusoff et al. 2012).Hence, the main function of the teleoperation system is to help human to perform and accomplish complex or difficult tasks in hazardous and less structured environments, such as space, nuclear plants, battlefield, surveillance, and underwater operations. Figure 2.2 below shows the remote-controlled arm robot (Computing 2013).

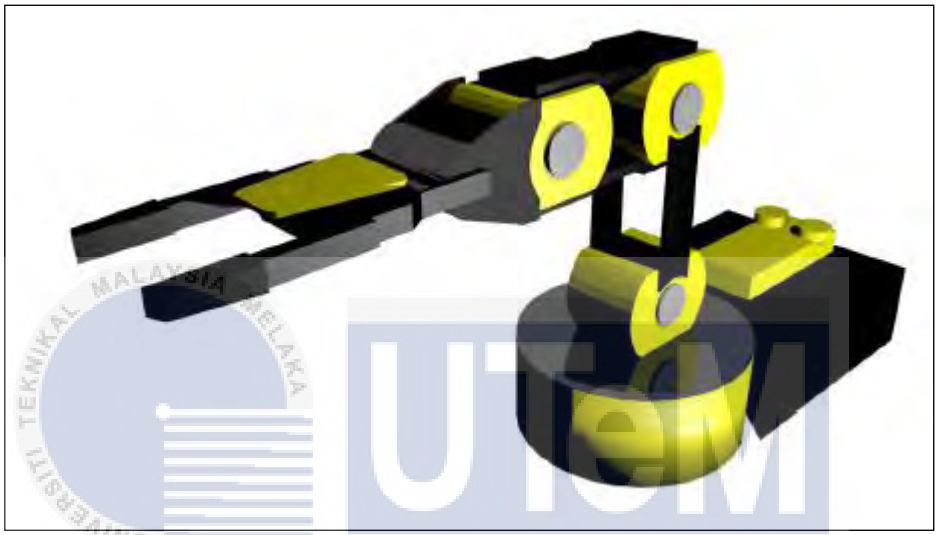


Figure 2.2: The Remote-Controlled Arm Robot (Computing 2013)

2.2 Teleoperation Application

The application of teleoperation increasing rapidly because of the easy access to the Internet and other related technologies. Nowadays, almost all sector provides dangerous task to the human. This force human to use other equipment especially the tele-operated machine to perform this kind of task. Teleoperation system is a kind of task which need a continuous interaction between the human operators, tele-operator system and the environment in order to make the system run properly.

2.2.1 Undersea Application

Teleoperation system is developed for the operation in the undersea which is very difficult and dangerous task for the human. Some of the task in this sector limit

the human to accomplish the task completely without the help advanced technology like tele-operated machine. Teleoperation used in the undersea application mainly for inspection to know the real situation happening beneath the sea. Figure 2.3 below shows the undersea vehicle Jason which is used to locate the Titanic ship that sink under the sea. This vehicle developed by the Argo-Jason, so the vehicle is named after him (Cui et al. 2003).

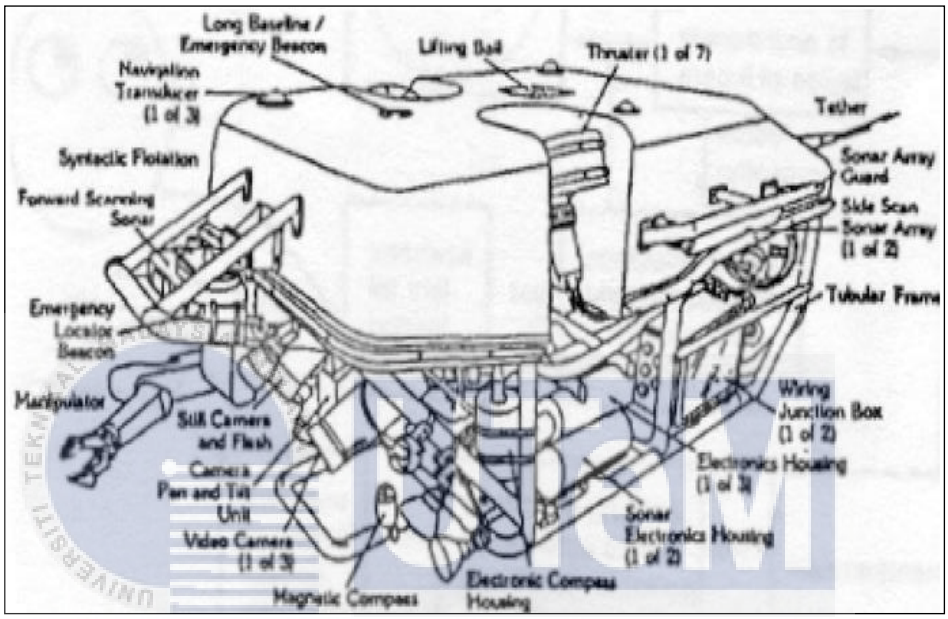


Figure 2.3: The Undersea Vehicle Jason (Cui et al. 2003)

2.2.2 Space Application

Space also used teleoperation system in some case mostly to deal with the space environment which is not suitable for human. Most of the deep space probes use teleoperation system which can interact with the human in long distance. It has some features using simple control such as take pictures, travel in the space and ability to be reprogrammed. In 1993, the first space tele-robot called 'Rotex' was successfully built by the German. This discovery proved the ability to control the tele-robot in space in a distance. (Cui et al. 2003)

2.2.3 Toxic Waste Clean-up Application

Teleoperation is one of the un-substitutable function in toxic waste cleanup especially in nuclear in plants. Teleoperation is very important in this sector because the worker there expose to the hazardous environment and they should handle it using the tele-operated machine. In nuclear power plant, tele-operated machine is use to throw away the unused components that emit high gamma radiation which is dangerous to the human. Size of the system may vary considerably depending on the size of the task but the main concept of remote control and teleoperation remains the same. For example, the big size remote-controlled truck is used to carry heavy load of waste (Cui et al. 2003).

2.2.4 Other Application

Tele-operated system also used for other application mainly for the difficult and complex task. In medical sector, teleoperation is used to guide the device through the complex part of the human body and it is one of the surgical procedure for the medical purpose. Tele-operation system is very known for the engineer as they used it for the engineering purpose mainly at the nuclear reactor, clean rooms and other hazardous environment area (Cui et al. 2003).

2.3 Types of Control Method used for Teleoperation

There are many methods in teleoperation and each of them have different concepts to perform a desired action. The methods may be suitable for the tele-operated machine depending on the system and application requirements. Different control method may produce the different response for the tele-operated machine. Hence, there is no unique controller to remedy all requirements of the tele-operated machine (Cui et al. 2003). Hence, the decision must make on choosing the suitable control method in order to fulfill the requirement and produced the desired system response.

2.3.1 Wave Variable Method

Anderson and Spong were discovered the wave variables. Wave variables use the theory of passivity by a modification or extension, which offers a robust base to approach arbitrary time delay problem. Figure 2.4 below shows the basic wave transformation which relates velocity, force, right and left moving waves (Cui et al. 2003).

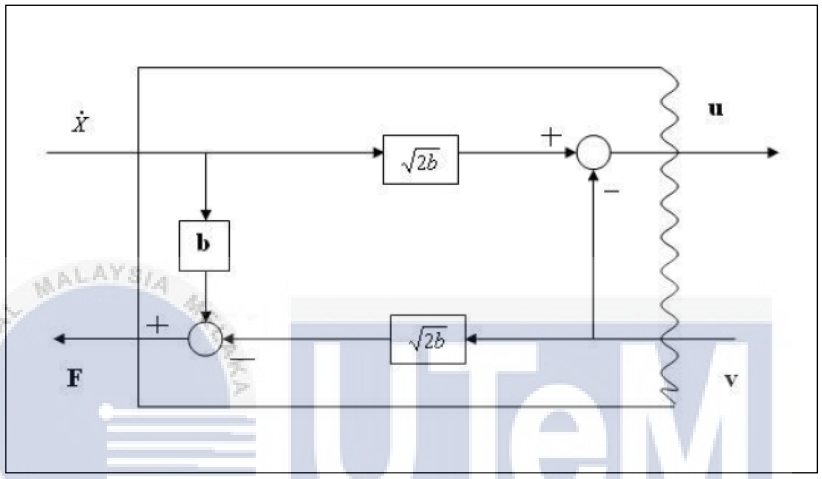


Figure 2.4: The Basic Wave Transformation (Cui et al. 2003)

2.3.2 Supervisory Control Method

Argentinean researchers, Garcia, Postigo and Soria, were discovered one of the hybrid control methods which they call supervisory control method. This system includes features of both discrete events and continuous signal and they are modeled by using differential or difference equations for continuous signals, and also by using an automaton for discrete events. Figure 2.5 below shows the supervisory control used in teleoperation systems.(Cui et al. 2003)

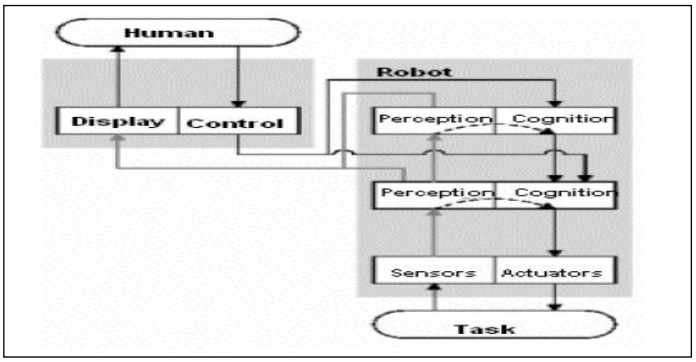


Figure 2.5: The Supervisory Control used in Teleoperation Systems (Cui et al. 2003)

2.3.3 Nonlinear adaptive control

It is a typical teleoperation system consists of two basic manipulators which is a local master manipulator (master site) and a remotely located slave manipulator (slave site). The human operator controls the local master manipulator to drive the slave one in order to accomplish certain task. Figure 2.6 below shows the overall nonlinear adaptive control system(Cui et al. 2003)

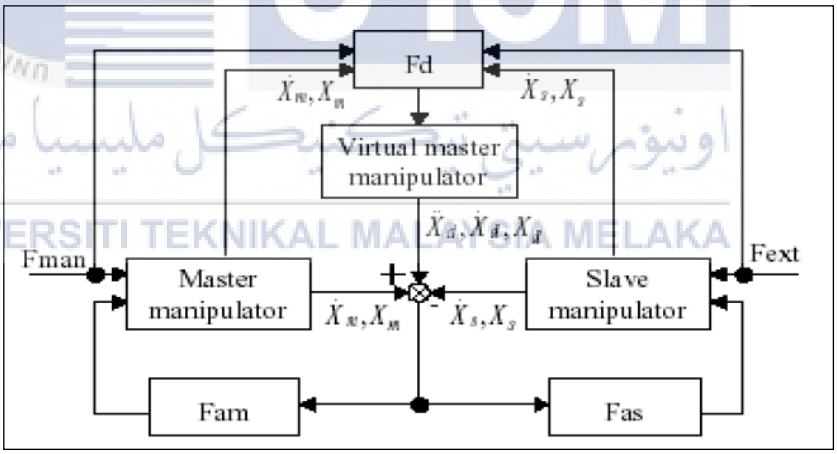


Figure 2.6: The Overall Nonlinear Adaptive Control System (Cui et al. 2003)

2.3.4 Robust Neuro-Fuzzy Control

The fuzzy control method has been introduced to have positive effect on industrial applications and theoretical analysis in term of robustness. Neural networks introduced as specialized elements to process data as the robot control deal with numerous data comprising various interactions organized into a hierarchy. Figure 2.7

below shows the neuro-controller model which performed positioning task (Cui et al. 2003).

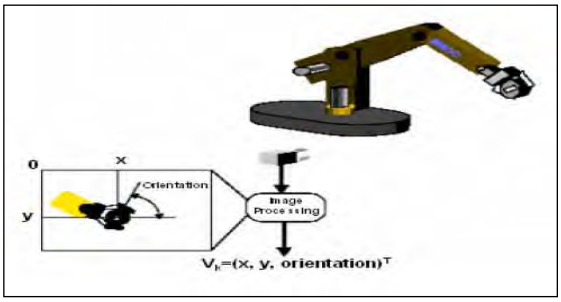


Figure 2.7: The Neuro-Controller Model (Cui et al. 2003)

2.3.5 PID method

PID is the method on which a controller monitors the error in the system and makes correction based on the proportional, integral and derivative criteria. Proportional response is based on the magnitude of the observed error, the Integral of that error which is the error accumulated over time, and the Derivative of the error which is the rate at which the error changes over time. PID only work on a stable motion and it cannot cope with time delays(Cui et al. 2003).

2.4 Arduino Software

Arduino software is an open source tool that used for various application and designed to interact with various environments, taking input and output from sensors, controlling the switches, devices using software or with human interaction. Arduino Integrated Development Environment (IDE) similar to C++ with some slight simplifications and modifications in programming which used a Wiring-based language (syntax and libraries) (Yusoff et al. 2012).

2.4.1 Wireless Mobile Robotic

For this project, the actuator (arm robot) is controlled by generating pulse width modulation through PWM from the pin at Arduino Mega board and the robot will be

controlled in the all directions. Figure 2.8 below shows the overall system of the robot arm.

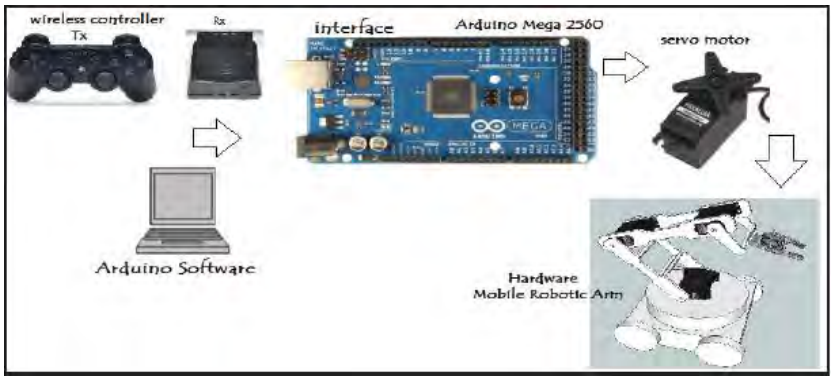


Figure 2.8: The Overall System of the Robot Arm (Cui et al. 2003)

The electrical design can be constructed using Proteus simulation and each electrical component can be arranged with the Arduino board which can send command. Ps2 wireless controller can be used to control the robot arm. There is coding related the movement of robot arm which sync the controller and the Arduino board that receive input signal. (Yusoff et al. 2012). Arduino code can be developed in the Arduino tool 'Sketch' and the can be tested. Figure 2.9 below shows the sample Arduino tool 'Sketch' (Coleman Benson,2012).

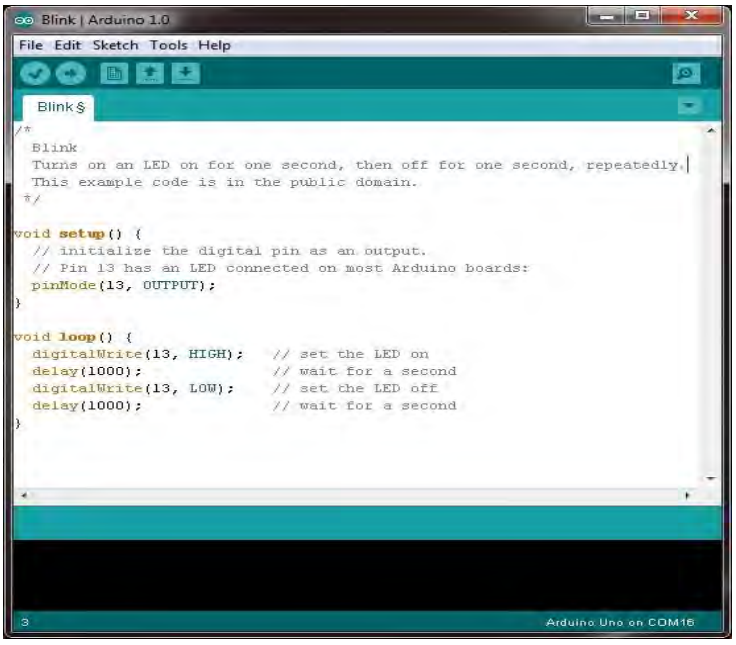


Figure 2.9: The Sample Arduino Tool 'Sketch'

The board have a buffer to receive the signal and that signal will be sent to analyzer for the identification of the signal order. Then, the signal will be decoded to tell the actuator module about the work need to be done and that actuator have 10 to 14 digital pins in which used to define which parts of the robot should move in which direction (Computing 2013). The Arduino also have library which can be used by other user for development of program. For example, the 'rosserial' which is the library of the ROS robot is add to the libraries to the Arduino source code, in order to emulate ROS language directly in Arduino code (Araújo et al. 2014). Apart from that, Arduino can be used to create complex project like Robonova robot created by HiTec which use the Arduino DUE that far more powerful than those of traditional Arduinos. This robot use the Arduino Due because it have complex parts that used for stability and motion control (Candelas et al. 2015).

2.4.2 Vehicle based on Intel Galileo Platform

Intel Galileo Platform is the Arduino compatible base which can be used to replace the classical radio controlled vehicle. The two H-bridges on the car which is one for the steering motor control and the other one was used for acceleration

(forward/backward motor) is controlled by the Intel Galileo platform with a WI Fi wireless module which can replace the short distance communication between the remote control and the vehicle, like Bluetooth or Infrared. The Intel Galileo platform have embedded system for vehicle control that can interact with the Android device through Wi-Fi. The Wi-Fi network is act as an access point and communication medium for only authorized device that need to be controlled (Aneiba & Hormos 2014). Figure 2.10 below shows the process flow for vehicle based on intel Galileo platform (Sumalan et al. 2016).

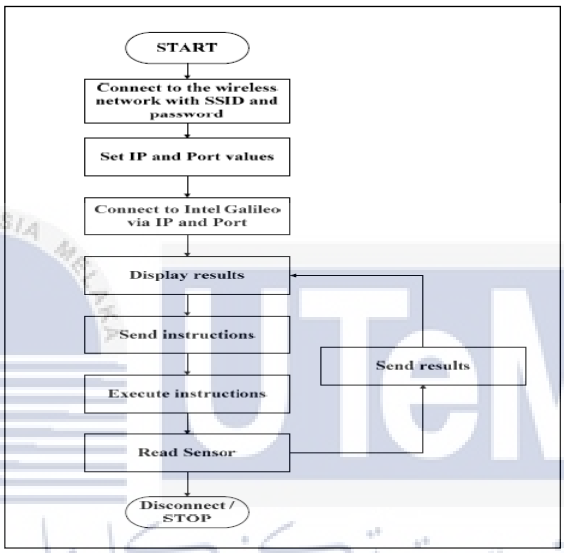


Figure 2.10: The Process Flow for Vehicle Based on Intel Galileo Platform (Sumalan et al. 2016)

2.5 Teleoperation for Excavator

The slave part of the mini excavator will be controlled and manipulated by the master component or joystick system like PS 2 controller. Solenoid valves is used to move the mini excavator parts are used and it is energized when there is electric current flowing through and eventually activating the hydraulic components of the mini excavator. This solenoid can be activated via the teleoperation control that attached to it (Muhammad Hafiz, 2016). The slave part is composed of the actuators in the excavator which include proportional valves, and an embedded computer like Arduino based control system to control the actuators (Kim et al. 2009).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describe the process flow of the project to achieve the objective of the project. This project is start by studying the Arduino software to get deeper understanding of the Arduino program of the project. The investigation on the previous remote response unit is conducted to know whether the problem is related with the circuit or the coding of the program. The procedure of troubleshooting the problem for the previous remote response unit based on the Arduino is somehow difficult as the circuit of the unit is quite messy and take time to understand. There are several procedures is carried out to fix the remote response unit such as make a new wiring for the circuit and troubleshoot the problem in coding.

3.2 General Methodology of this Project

The project getting started with literature review regarding with the topic of tele-operated device and Arduino software. Then, there is some basic practice of the Arduino software is studied to know the basic process of the Arduino. The circuit and the coding of the program is obtained from the thesis of the previous student. The thesis is studied to get a better understanding about the project. Figure 3.1 below shows the flowchart of the current progress of the project.

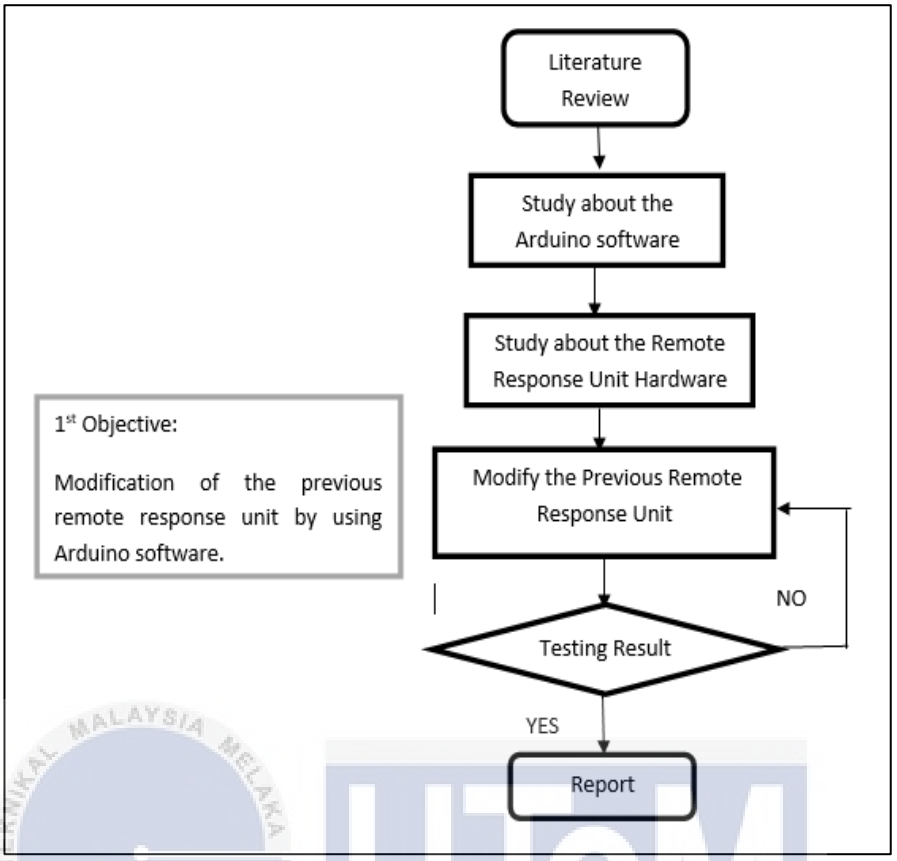


Figure 3.1: Flow chart of the Current Progress of the Project

3.3 Study about the Basic Knowledge of the Arduino Software

The Arduino software basically can be learned from various sources especially from the YouTube videos. Arduino have a platform to develop a coding which is called as Arduino Integrated Arduino Development (IDE). In this software platform, there is void setup where setup code is developed here and void loop where main code is developed here. The code that developed can be verify and the verification result will appear at the black box message. The verified can be uploaded via the USB cable to the Arduino board to run the command. Figure 3.2 below shows the interface of the Arduino Integrated Arduino Development (IDE).

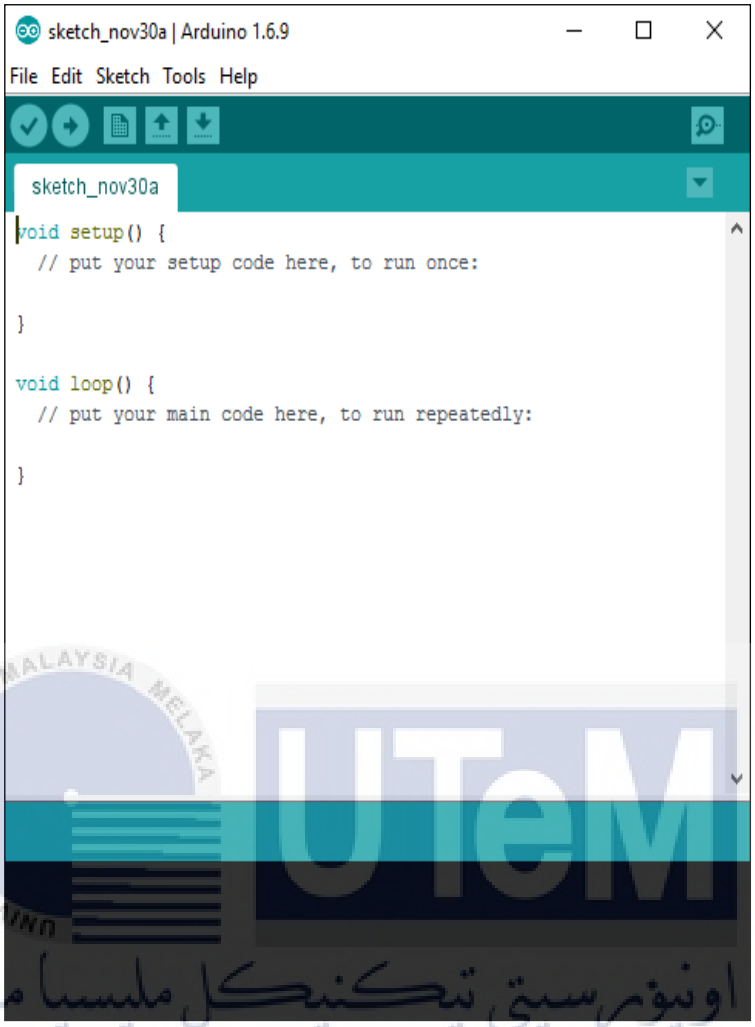


Figure 3.2: The interface of the Arduino Integrated Arduino Development (IDE)

3.3.1 Examples at the Toolbar of the Software

There are built-in examples included in the Arduino Software (IDE) which is the sketches that can be demonstrated to learn all basic Arduino commands. Figure 3.3 below shows the list of the examples in the Arduino Software (IDE).

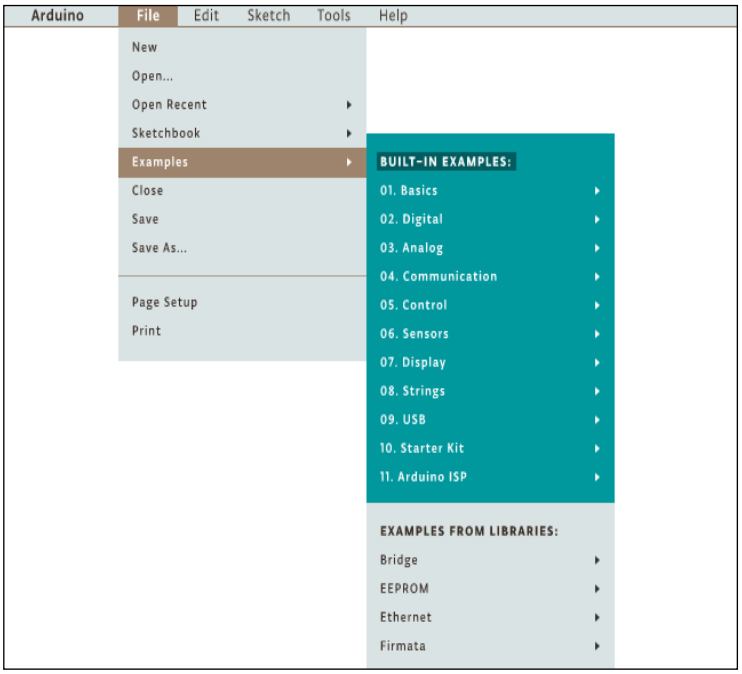


Figure 3.3: The List of the Examples in the Arduino Software (IDE)

The basic blink sketch is the simplest example that can be do with an Arduino to see the physical output which is the blinks of the LED on the board. The blink sketch can be uploaded to the Arduino board and the LED will blink according to the time interval set in the coding at the Arduino Software (IDE). Before uploading process, check the board and port used whether is correct or not which can be click on the tools in the Arduino Software (IDE). After uploading process, the verification result will appear at the black box message to shows whether the coding debug is success or not. If the coding verification failed, it will show the list of error in the coding. If the coding verification succeed, the pin 13 LED will blink for 1 second's interval if the delay is set at 1000 at the void loop coding. Figure 3.4 below shows the example sketch of the blink.

Figure 3.4: The Example Sketch of the Blink

Apart from that, there is also other examples that can be practiced such as LED brightness and button controlled LED. This kind of examples can be learned from the tutorial video at YouTube.

3.4 Study about the Remote Response Unit Hardware

The existing remote response unit built with some elements to complete the circuit. The remote response unit interact with both software and hardware to enable the complete function of the system. However, there is problem with this existing remote response unit because it lights up the LED on the relay board when the unit is switched on. The LED should be light up if the PS2 controller button is pressed else it should not be light up. Figure 3.5 below shows the existing remote response unit that have problem.

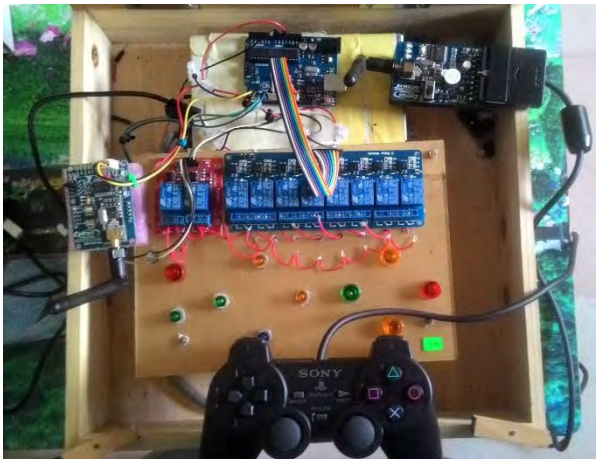


Figure 3.5: The Existing Remote Response Unit that have Problem

3.4.1 Arduino Uno Board

In this project, Arduino Uno board is use as the main programming processing unit to execute the command. It has 14 digital input/output pins on which 6 of them can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It is a simple system that can support any microcontrollers and it can be get started by simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery (Arduino – ArduinoBoardUno,2016). Figure 3.6 below shows the Arduino Uno board (Muhammad Hafiz,2016).

Figure 3.6: The Arduino Uno Board

3.4.2 PS2 Controller

PS2 controller is used as the main control unit to manipulate the output of the system. The LED in the relay board will light up when the button in the PS2 controller is pressed. Figure 3.7 below shows the PS2 controller (New and Used PlayStation 2 Controllers, Cables, Memory Cards, and Accessories,2016).

Figure 3.7: The PS2 Controller (New and Used PlayStation 2 Controllers, Cables, Memory Cards, and Accessories,2016)

3.4.3 SKSPW Wireless Transmitter

SKPSW is the wireless version of SKPS which is built to support the PS2 controller signal transmission. SKPSW used a 2.4GHz transceiver with frequency that can switch to another frequency band automatically when there is interference. There are two types of SKPSW which are SKPSW-TX and SKPSW-RX. The SKPSW transmitter used in this project is SKPSW-TX which can connect to the wired version of PS2 controller and powered by 2 x 18650 Li-Ion battery (PS2 Controller Starter Kit – Wireless,2016). Figure 3.8 below shows the SKPSW-TX transmitter.

Figure 3.8: The SKPSW-TX Transmitter

3.4.4 Relay Board

Relay board used in this project is 8-Channel 5V Relay Module with Opto-Isolated inputs. Relay board is used to supply power to the high voltage equipment from the microcontroller. Each relay can be used individually by making connection between Opto-Isolated digital input and microcontroller output pin (Arduino board). It can handle the voltage up to 5V. The power LED on the board will light up when the relay coils on the board is generated. The power connection on the VCC and GND must be applied correctly because the wrong connection make the board damaged. Figure 3.9 below shows the 8-Channel 5V relay module (8-Channel 5V Relay Module with Opto Isolated inputs,2016).

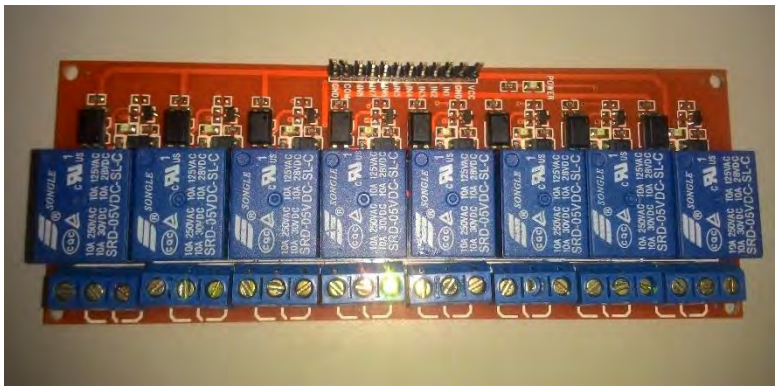


Figure 3.9: The 8-Channel 5V Relay Module

3.4.5 Wire and USB cable

The wire used in this project must be suitable according to the components involved because there is different wire have different voltage value. The male and female wire is used to make connection on the microcontroller input. Figure 3.10 below shows the male and female wire. USB cable is used to transfer programming code to Arduino board. Figure 3.11 below shows the USB cable for Arduino.

Figure 3.10: Male and Female Wire

Figure 3.11: USB cable for Arduino

3.4.6 The Working Process of the Arduino Control System

There is two existing remote response unit done by the previous students on which one is work and another one is not work properly. The study is done on the working remote response unit. The main coding of this project is very important to manipulate the output of the control system. The main coding used the shield PS2 library to develop the output. The shield PS2 library which can be downloaded from

the internet content information which define the PS2 button and used to process data from SKPS wireless receiver. The main coding is developed to execute the desired output. The desired output is the manipulation of the channel of relay module by using the input signal from PS2 controller. The connection between transmitter and receiver is considered bind if PS2 LED on the receiver light up whenever the PS2 controller connected to the SKPSW transmitter is switched on. The complete setup will enable the PS2 controller to manipulate the relay module. The LED on the relay module will light up when there is current flowing through the relay. This means the relay energized when one of the PS2 controller button is pressed.

3.5 Implementation of the Failure Mode and Effect Analysis (FMEA)

First need to understand each electrical and electronic component used in this project to apply FMEA. FMEA is a tool to develop a reliability of the product by assigning a systematic method to identify the problem in the product and prevent them from occur again. FMEA is not also for evaluating reliability but also used to prevent other possible risks in the project. This is to ensure the safety of the person and the product involved. The main objective of the FMEA is to prevent mode failure of the product and to predict the incoming failures that may occur from usage of the product (Glossary of Key Terms, 2016). In this project, the FMEA is applied by the following steps.

3.5.1 Understand Each Function of the Equipment

Each equipment contains different modules and unit that consumed different amount of voltage. Different types of equipment have different mode failure based on the resistance used in it. For example, the different color wire has different types of resistance. Hence, each wire can only carry limited amount of current. Wrong usage of wire can cost the damage in wire and to the components involved.

3.5.2 Understand the Circuit flow

This is basic steps involved to avoid any damage to the components. The wire must be connected properly based on its value of voltage. This is a sensitive case that need to be considered especially when involved microcontroller. Wrong connection of wire such as between VCC and GND will cause a serious damage to the board.

3.5.3 Documentation of the Failure Modes of Components.

Each failure occurs during the process handling the project is documented to prevent the failure from occur again. In this project, the relay module is damaged because of the wrong connection of wire between VCC and GND. Hence, this failure is documented to prevent this kind of a mistake repeated. From each failure, the library of preventive action is developed for the future use.

CHAPTER 4

DATA AND RESULT

4.1 Modification on the Previous Remote Response Unit

There is some modification done on the previous remote response unit to get a solution for the problem. The hardest part is troubleshooting the problem on the previous remote response unit. Basically, the previous remote response unit does not give a desire output when the control system is switched on. It lights up automatically 4 out of 8 relay and the PS2 controller cannot control the relay. This does not make sense with the uploaded coding on the Arduino board. Based on the coding, the relay will only activate when the PS2 controller button is pressed. Hence, there is some trial and error method to get a solution for the problem.

4.1.1 Make a New Wiring for Circuit

Basically, the previous remote response unit quite have a messy wiring. Some wire connected by soldering method and this will sometimes make the wire not connected properly because the use of thin wire. Hence, the connected wire is cut down and connected again with the wire connecter. Figure 4.1 below shows the wire connector. The wire connector makes the circuit connection in an orderly manner. Figure 4.2 below shows the process of wiring.

Figure 4.1: The Wire Connector

Figure 4.2: The Process of Wiring

4.1.2 Check the Arduino Board

The Arduino board used in the problematic remote response unit is tested on the remote response unit that function properly. After tested, if it still shows the same problem. This means the problem is not on the circuit connection but on Arduino board. The checking on the Arduino board is important to know the problem whether on the Arduino board or on the coding uploaded on the Arduino board. Sometimes the damaged Arduino board cannot process the code properly hence interrupt the main function of the system.

4.1.3 Troubleshoot the Problem on the Main Coding

The main coding is re-uploaded for several times on the Arduino board. The library used in the main coding also checked to ensure the validity of the library. The main coding is tested by deleting some of the coding and left the coding for only one defined PS2 controller button. This is to test only one button of the PS2 controller whether it activate the relay or not. Figure 4.3 below shows the fixed remote response unit. This procedure provides the solution for the problem as there is some error in the main coding. The main coding consists of 12 control code for the relay but there is only 10 relay. Hence, the relay only need 10 control code to manipulate them by using the input signal from PS2 controller. The ‘if else’ command reduced from 12 to 10 to make sure the control system work properly. Figure 4.4 below shows the fixed main coding in the Arduino (IDE) software.

Figure 4.3: The Fixed Remote Response Unit

```
sketch_dec03a§
{
if( ps2.getval(p_r1)==0) //LED on Main Board will light up if Select button is pressed
{
digitalWrite(LEDPIN9,HIGH);
}
else
{
digitalWrite(LEDPIN9,LOW);
}
}
{
if( ps2.getval(p_l2)==0) //LED on Main Board will light up if Select button is pressed
{
digitalWrite(LEDPIN10,HIGH);
}
else
{
digitalWrite(LEDPIN10,LOW);
}
}
{
if( ps2.getval(p_l1)==0) //LED on Main Board will light up if Select button is pressed
{
digitalWrite(LEDPIN11,HIGH);
}
else
{
digitalWrite(LEDPIN11,LOW);
```

This Command removed from the main coding to ensure there is only 10 'if else' command for 10 relay.

Figure 4.4: The Fixed Main Coding in the Arduino (IDE) Software

4.2 Development of the New Remote Response Unit

The new remote response unit have been developed with plastic board as the casing to cover electronic devices. The electronic equipment such as Arduino board, relay module, 12 V power supply and SKPSW PS2 controller starter kit have been

assembled in the plastic board. All the equipment had been attached to the board properly. The USB and power supply hole have been made through the board for the Arduino board. This will make easier to transmit coding and power up the Arduino board. Figure 4.5 below shows the plastic board with the equipment.

Figure 4.5: The Plastic Board with The Equipment

After the assembly process is finished, the proper wiring had to be made in between the equipment. The Arduino board is programmed to light up the relay module with the PS 2 controller, hence the output wire from the Arduino board must be connected to the input of the relay module. SKSPW receiver will be connected to the Arduino board which will act as the medium for PS 2 controller transmitter. Then, the indicator from relay module will be attached at the top of the board. The function of the indicator is to show the sign of the relay module that have been triggered. The indicator will light up when one of the relay module activated. Figure 4.6 below shows the completed circuit of Arduino project. There are some changes made in the circuit where there is addition of switch.

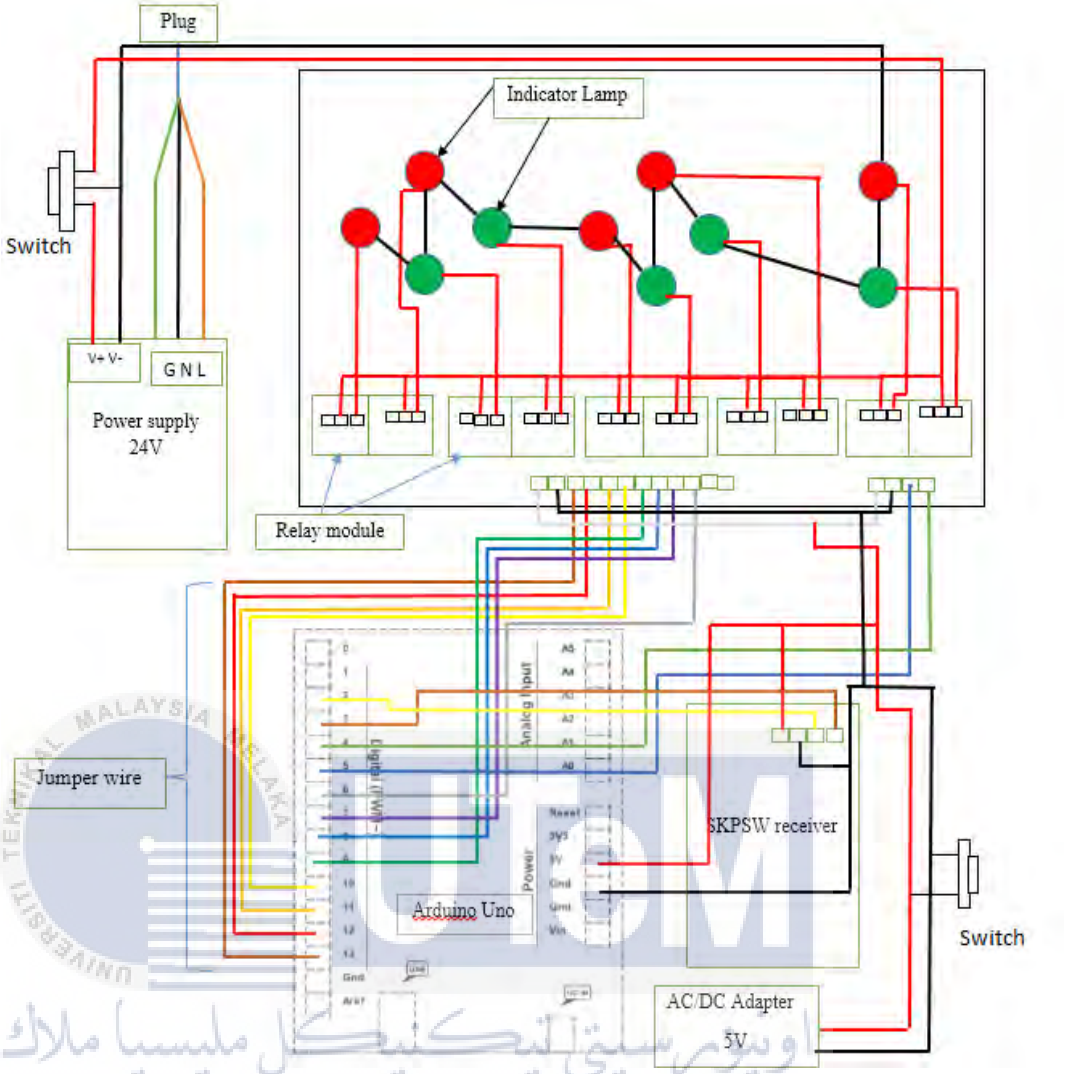


Figure 4.6: The Completed Circuit of Arduino Project

The wiring on the board is done based on the circuit above to make sure the project can run well. Figure 4.7 below shows the completed wiring in the board.

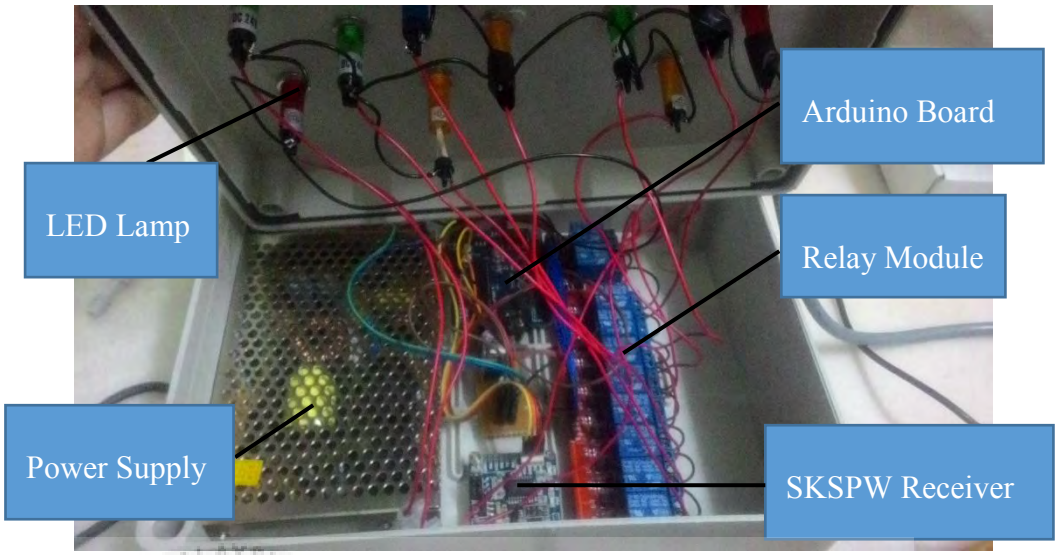


Figure 4.7: The Completed Wiring in the Board

4.2.1 Upload the Coding in the New Remote Response Unit

After that, the developed coding will be uploaded to the Arduino board. The library for the SKSPW PS 2 controller starter kit will be embedded in Arduino software. The library contained the declaration for the PS 2 controller button which is used in the main coding. The developed main code for the control panel system is shown below;


```
#include <SoftwareSerial.h>
#include <Cytron_PS2Shield.h>
//declare class object
//PS2 ps2 = PS2(); //PS2 class object: ps2
Cytron_PS2Shield ps2(2, 3);
#define LEDPIN 13
#define LEDPIN1 12
#define LEDPIN2 11
#define LEDPIN3 10
#define LEDPIN4 9
```

```
#define LEDPIN5 8
#define LEDPIN6 7
#define LEDPIN7 6
#define LEDPIN8 5
#define LEDPIN9 4

void setup()
{
 ps2.begin(9600); //initialize the main board to use desired (baudrate, rx, tx)
//This baudrate must same with the jumper setting at PS2 shield

  pinMode(LEDPIN, OUTPUT);
  pinMode(LEDPIN1, OUTPUT);
  pinMode(LEDPIN2, OUTPUT);
  pinMode(LEDPIN3, OUTPUT);
  pinMode(LEDPIN4, OUTPUT);
  pinMode(LEDPIN5, OUTPUT);
  pinMode(LEDPIN6, OUTPUT);
  pinMode(LEDPIN7, OUTPUT);
  pinMode(LEDPIN8, OUTPUT);
  pinMode(LEDPIN9, OUTPUT);

  //digitalWrite(LEDPIN,LOW);
}
void loop()
{

  if ( ps2.readButton(PS2_SQUARE) == 0)   //0 = pressed, 1 = released
  {
    digitalWrite(LEDPIN, HIGH);
  }
  else
  {
```

```
  digitalWrite(LEDPIN, LOW);
}
if ( ps2.readButton(PS2_CROSS) == 0)
{
  digitalWrite(LEDPIN1, HIGH);
}
else
{
  digitalWrite(LEDPIN1, LOW);
}
  if ( ps2.readButton(PS2_CIRCLE) == 0)
{
  digitalWrite(LEDPIN2, HIGH);
}
else
{
  digitalWrite(LEDPIN2, LOW);
}
if ( ps2.readButton(PS2_LEFT_1) == 0)
{
  digitalWrite(LEDPIN3, HIGH);
}
else
{
  digitalWrite(LEDPIN3, LOW);
}
if ( ps2.readButton(PS2_RIGHT_1) == 0)
{
  digitalWrite(LEDPIN4, HIGH);
}
else
{
  digitalWrite(LEDPIN4, LOW);
```

```
}
 if ( ps2.readButton(PS2_LEFT) == 0)
{
  digitalWrite(LEDPIN5, HIGH);
}
else
{
  digitalWrite(LEDPIN5, LOW);
}
if ( ps2.readButton(PS2_RIGHT) == 0)
{
  digitalWrite(LEDPIN6, HIGH);
}
else
{
  digitalWrite(LEDPIN6, LOW);
}
 if ( ps2.readButton(PS2_DOWN) == 0)
{
  digitalWrite(LEDPIN7, HIGH);
}
else
{
  digitalWrite(LEDPIN7, LOW);
}
if ( ps2.readButton(PS2_LEFT_2) == 0)
{
  digitalWrite(LEDPIN8, HIGH);
}
else
{
  digitalWrite(LEDPIN8, LOW);
}
```

```
 if ( ps2.readButton(PS2_RIGHT_2) == 0)
 {
  digitalWrite(LEDPIN9, HIGH);
 }
else
 {
  digitalWrite(LEDPIN9, LOW);
 }

}
```

Basically, each cylinder will be manipulated with two buttons that control operations of extend and retract of the cylinder shaft. For controller coding, the code is translated to pin mode to generate output easily. The pin mode in Arduino is called as LEDPIN which is used to configure the specified pin as an output and it works as a command when one of the PS 2 button is pressed. Each LEDPIN of the relay module is assigned to different PS2 button. The name of each button of the PS 2 can get from the SKSPW library. Table 2 below shows the name of the PS 2 button in the library. This name is used for the button declaration in the main code.

Table 4.1: Name of the PS2 button in the Library

Digital Button	Analog Button
PS2_SELECT	PS2_JOYSTICK_LEFT_X_AXIS
PS2_JOYSTICK_LEFT	PS2_JOYSTICK_LEFT_Y_AXIS
PS2_JOYSTICK_RIGHT	PS2_JOYSTICK_RIGHT_X_AXIS
PS2_START	PS2_JOYSTICK_RIGHT_Y_AXIS
PS2_UP	
PS2_RIGHT	
PS2_DOWN	
PS2_LEFT	
PS2_LEFT_2	
PS2_RIGHT_2	
PS2_LEFT_1	

PS2_RIGHT_1 PS2_TRIANGLE PS2_CIRCLE PS2_CROSS PS2_SQUARE	

The main coding had been developed which mostly 'if else' command which is used to declare the button of the PS 2. The button declaration is basically from the SKSPW library. Hence, the main coding must be synchronised with the library. The SKSPW library used to assist on the main coding by simply call the declared PS 2 controller button. The SKSPW library can be included in the main code by simply use (#include) command as shown below.

```
#include <SoftwareSerial.h>
#include <Cytron_PS2Shield.h>
```

In SKPSW library, transmitter and receiver has its own function declaration for transfer and receive data. The declaration code is as follow:

void init(long baudrate, byte rx, byte tx);

The code shows the baud rate which is signal transfer speed. Baud rate indicator on the receiver board is normally is set at 9600. Initialization of the transmitter and receiver byte can be declared or ignored.

'If else" command is used to declare the PS2 button that have been triggered and didn't triggered. The command declaration for each Analog button is differ. For example, the left joystick of the PS 2 controller is pressed towards up, the command is as follow:

```
if ( ps2.readButton(PS2_JOYSTICK_LEFT_X_AXIS) == 0)
```

There are X and Y axis for joystick. The value of axis is depending on the Analog value. The middle value of the axis is 128 and will change to 0 or 255 based

on the direction of the Analog is push. The Analog value for the left and right joystick is shown in the figure 4.8 below.

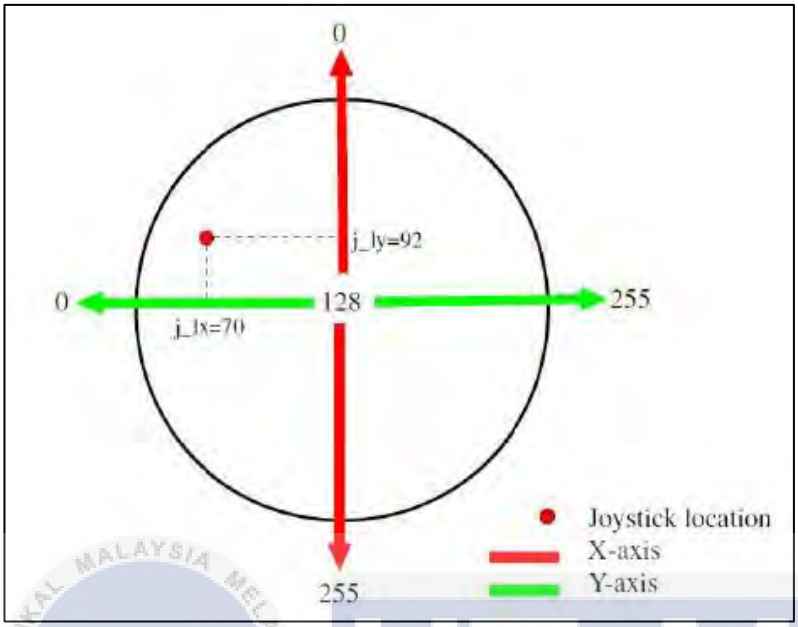


Figure 4.8: The Analog Value

digitalWrite function used to send the value of LEDPIN to the main function. *digitalWrite* refers to HIGH it sets the value of the corresponding bit of the register to 1, or to make the pin LOW, it sets the bit 0. 'HIGH' is the command for the LED to light up whereas the 'LOW' is the command for the LED to go out.

4.2.2 Simulation of Control Panel System.

The control panel system can be powered up with the two power sources which is one to power up the Arduino board and other one to power up the indicator and solenoid. Then, PS 2 controller that connected to SKPSW transmitter is switched on and it will bind with the receiver that connected to the Arduino Board. Table 4.2 below shows the status of PS2 controller with the SKSPW.

Table 4.2: PS 2 Controller Status with SKSPW

LED state	**PS 2 controller status**
Blinking	PS 2 controller is not detected
Light up steadily with low brightness	PS 2 controller is detected, but no button is pressed and joystick is not moved.
Light up steadily with high brightness	PS 2 controller is detected and either one of the button is pressed or joystick is moved.

There are ten outputs (5 channels) which is based on the coding developed in Arduino Integrated Development Environment (IDE) and each relay will activate when there is current flowing through it. Figure 4.9 below shows the complete set of the control panel system.

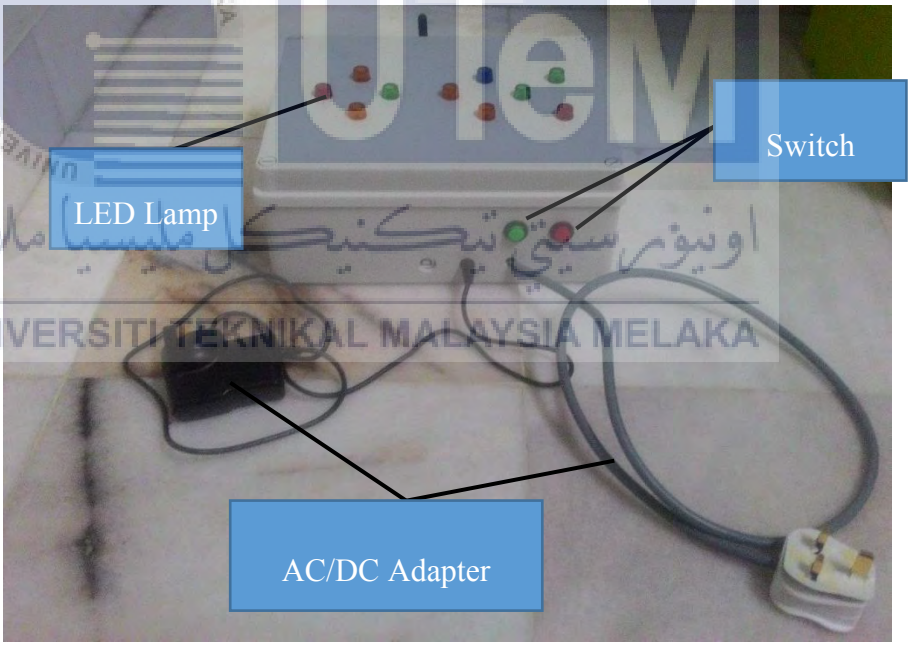


Figure 4.9: The Complete Set of the Control Panel System

The indicator help to show the sign of the extend and retract of the double acting cylinder. The LED will light up whenever the PS 2 controller is pressed. Figure 4.10 below shows the simulation result of the control panel system.

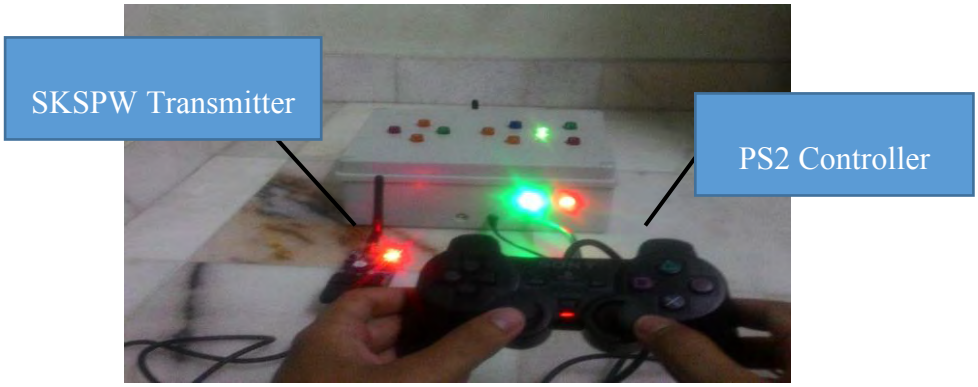


Figure 4.10: The Simulation Result of the Control Panel System

Apart from that, the case of the previous remote response unit is also modified with the latest case. This latest case is more light in weight and easy to carry. Figure 4.11 below show the two latest modified case of the remote response unit.

Figure 4.11: The Two Latest Modified Case of the Remote Response Unit

4.2.3 Assembly of the Arduino Remote Response Unit to the Pneumatic Actuator of the Mini Robot.

Arduino remote response unit is connected to the mini robot for testing process. The mini robot will be controlled by PS 2 controller from Arduino remote response

unit. There are 5 output from the remote response unit and each of them is connected to the solenoid. Figure 4.12 below shows the connection to the solenoid.

Figure 4.12: The Wire Connection to the Solenoid

The mini robot can perform five complete movement which consists of head clamping, head clamp rotation, horizontal movement, vertical movement and rotation. This robot used to clamp object and carry forward the object in any direction. Figure 4.13 below shows the complete mini robot.

Figure 4.13: The Complete Mini Robot

The control mechanism of the mini robot is done with the PS 2 controller. Each time the indicator will light up when the PS 2 controller is pressed. Figure 4.14 below shows the indicator sign when PS 2 controller is pressed.

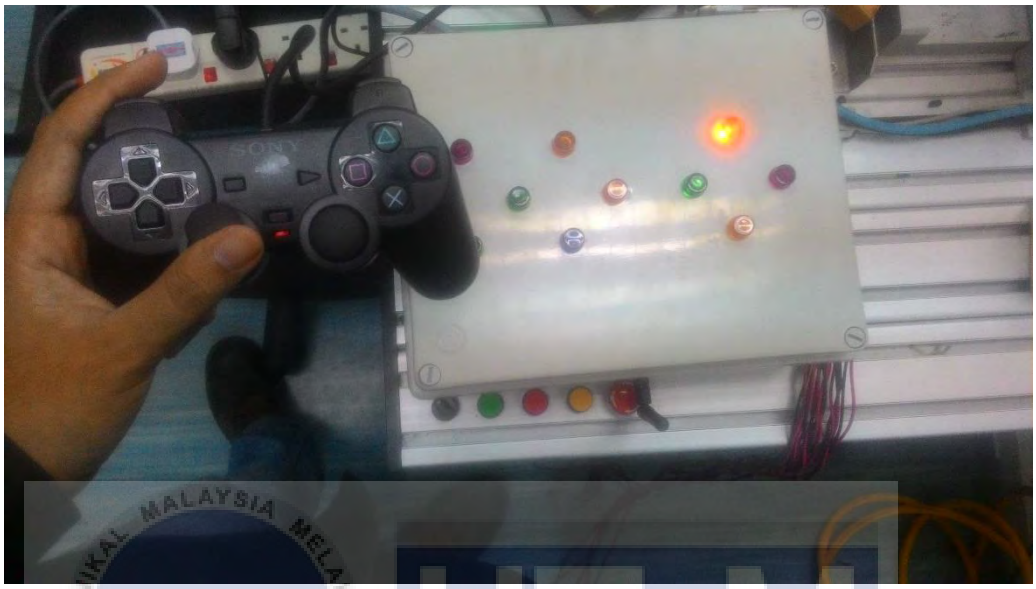


Figure 4.14: The Indicator Sign when the PS 2 Controller is Pressed

The control mechanism of PS 2 controller is only involved button only. The mini robot will perform movement when the button is pressed. Figure 4.15 below shows the assigned movement of the mini robot in the PS2 controller.

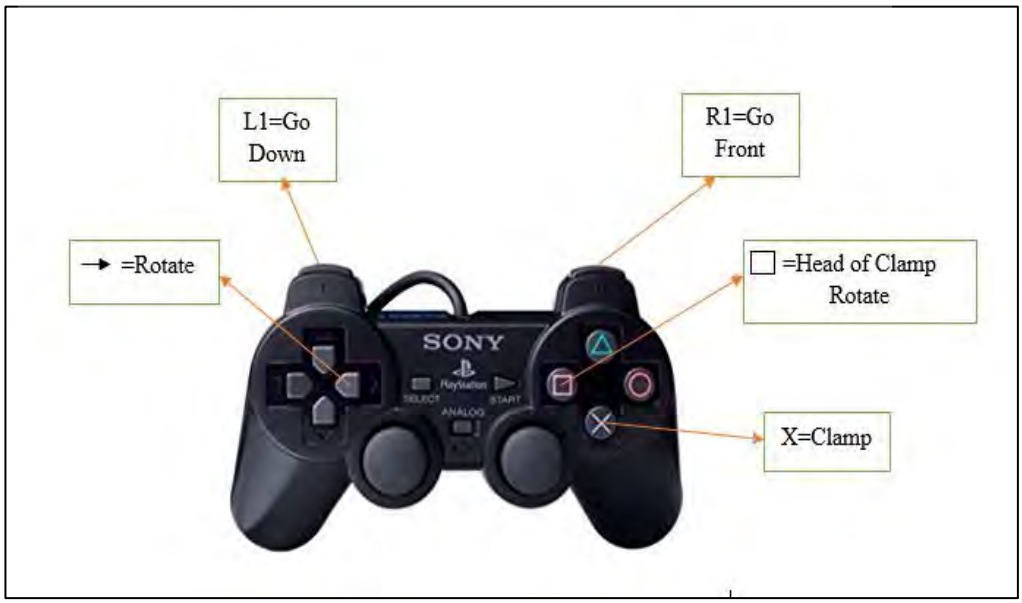


Figure 4.15: The Assigned Movement of the Mini Robot in the PS2 Controller

The PS 2 controller is connected to the transmitter. The PS 2 controller is powered up with lithium ion battery in the transmitter. Figure 4.16 below shows the PS2 controller with the transmitter and its case.

Figure 4.16: The PS2 Controller with the Transmitter and Its Case

When the PS 2 controller is pressed, the signal will be transmitted from transmitter to the receiver in the Arduino remote response unit. The receiver will send the signal to the Arduino board to be processed. Arduino will process the signal and send the input signal to the relay module. The input from the relay module will energized the solenoid. The energized solenoid will allow the pneumatic air to move through actuator and move the parts of mini robot. Figure 4.17 below shows the flowchart of overall operation of the Arduino remote response system.

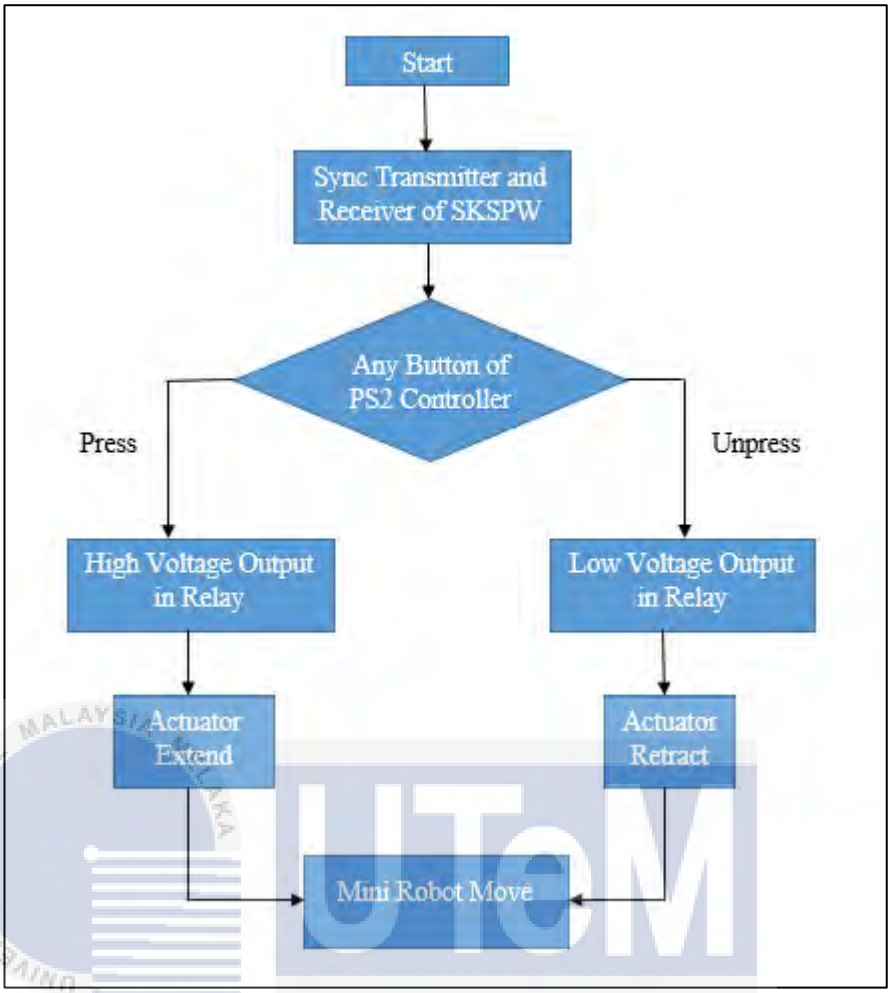


Figure 4.17: The Flowchart of Overall Operation of the Arduino Remote Response System

CHAPTER 5

DISCUSSION AND ANALYSIS

5.1 The Failure Mode and Effect Analysis

There are many error and problem occur during the process of developing the remote response unit. The list of error is recorded in the table for the future reference. There are many problems occur during the process of developing the remote response unit. Firstly, the relay module get damaged because of the wrong connection of wire in between VCC and GND in the module input. Secondly, there is problem in output of the relay module because of the error in the uploaded code. Thirdly, there is problem detected in the receiver of the previous remote response. The receiver of the remote response unit cannot receive the signal from the PS 2 controller. The possibility cause of the damage in the receiver is because of the unfixed position of the receiver board. The unfixed receiver tends to move in the case and there is friction in the moving board that causes damage. Hence, the failure, consequences, root causes, corrective actions and failure defence task is tabulated. Table 5.1 below shows the failure mode and effect analysis

Table 5.1: The Failure Mode and Effect Analysis

Equipment	Failure Mode	Consequences	Root Causes	Corrective Actions	Failure Defense Task (FDT)
Relay module	Relay module damaged	The remote response cannot execute the command	Wrong connection of wire between GND and VCC	Replace the relay module and make sure the wire connection between GND and VCC is correct on the	Regularly check the wire connection between GND and VCC on the relay module

				new relay module	
Relay module	The individual relay does not give desired output	The remote response cannot execute the command	1. Wrong connection of wire 2. Some error in coding	1. Check the connection in wire 2. Troubleshoot the problem in the coding and reupload the correct coding	1. Regularly check the wire connection 2. Regularly check the function of remote response unit
SKSPW PS 2 Receiver	The receiver board damaged	The remote response cannot execute the command	The unfixed position of the receiver tends to make the receiver to move and cause damaged on the receiver board	Need to replace the new SKSPW receiver and mounted the receiver in the fixed position	Regularly check whether the equipment in the case is mounted and fixed

5.2 The Functionality of the Arduino Remote Response Unit

The function and operation of remote-controlled electro-pneumatic actuator is same with the remote-controlled robot that used widely nowadays. The Arduino remote response unit can make the working task of the mini robots is way more safe and reliable. The human can control the mini robot at some distance. This kind of robot can lead to other service robot which specialized in performing security tasks, building

maintenance and construction. Based on the International Federation of Robotics (IFR), service robot is defined as a robot which operates on semi or fully automatic to perform daily task for the well-being of humans and equipment (Yusoff et al. 2012). Arduino software is chosen as the main platform to develop the algorithm code for the command task of the remote response unit. This software is one of the familiar tool for the mini project developer.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study on the development of the remote response unit has been presented in this report. There are many ways of control method to develop a remote response unit. The Arduino software is used as the main control method in this study. The study on the Arduino software is done to understand the main algorithm coding for the remote response unit. The study on each component used in the remote response unit is done to know how the remote response unit work. Hence, remote-controlled technique is one of the important aspect in robotic development that is useful for human being. The control mechanism of the Arduino remote response is one of the technique that can be used for the robotic development. In this project, Arduino remote response unit is tested with the mini robot that built with the solenoid. By applying this knowledge, remote controller for robot can be done and can be fully utilized in the industrial world especially in construction field.

6.2 Recommendation

There are some improvements can be done on this remote response unit. The main code can be modified to improve the safety of the mini robot. The safety of the mini robot will be improvised if the control mechanism of the PS2 controller is modified which means the mini robot is controlled with more systematic ways at one specific time. Apart from that, the platform for the PS2 controller can be developed. The PS2 controller can be kept safe in the case and there are monitor in the case. This monitor can display the action of the mini robot in long range. In addition, the single acting actuator of the mini robot can be changed to the double acting actuator to control the stopping point of the mini robot at the desired location. This is the future work for the continuous improvement of the project.

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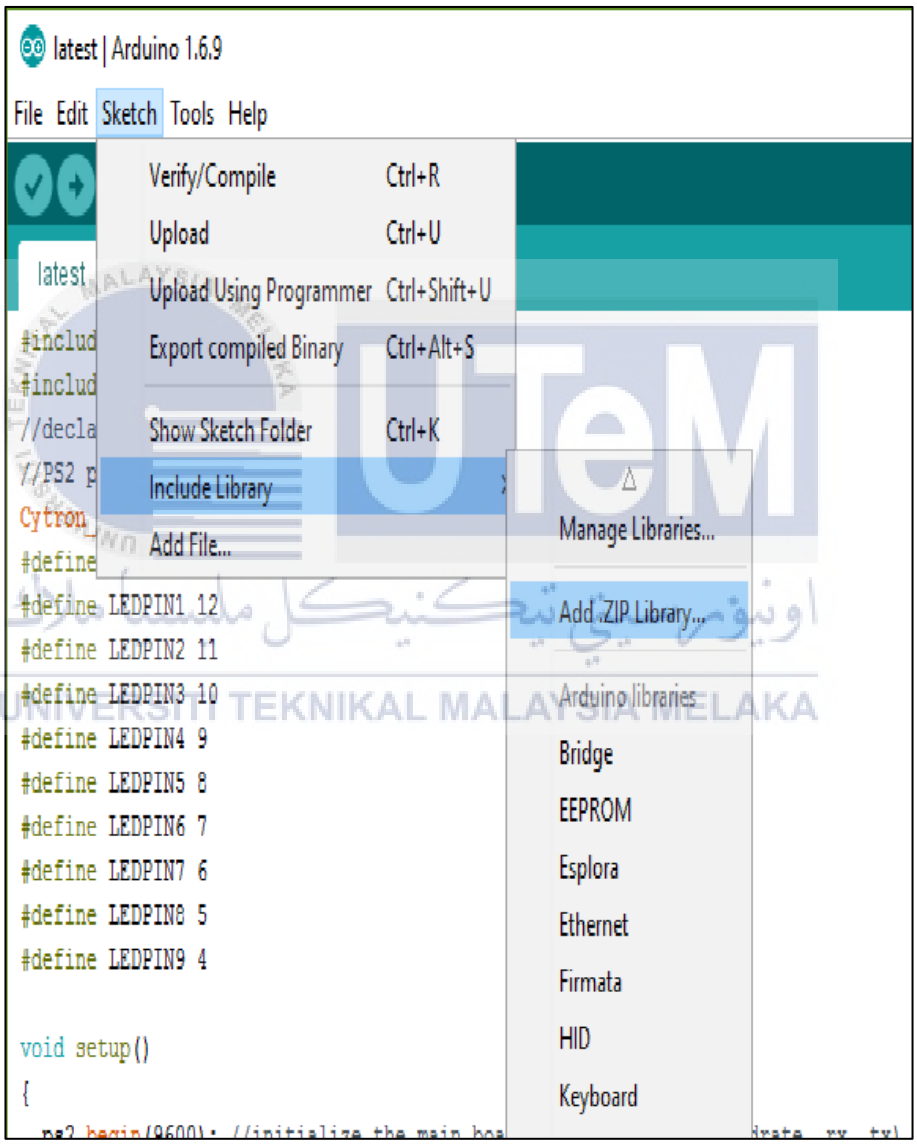
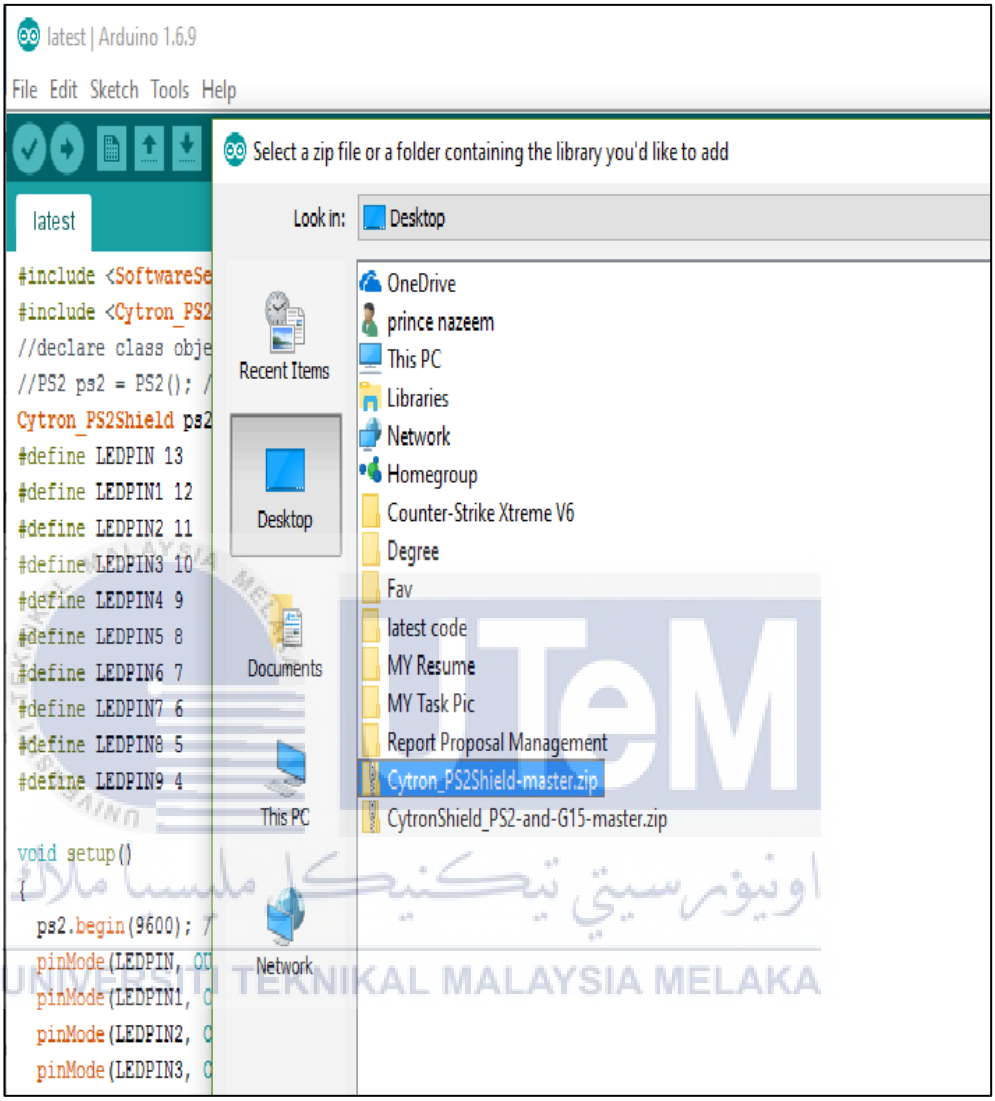
APPENDIX

How to add library in the Arduino

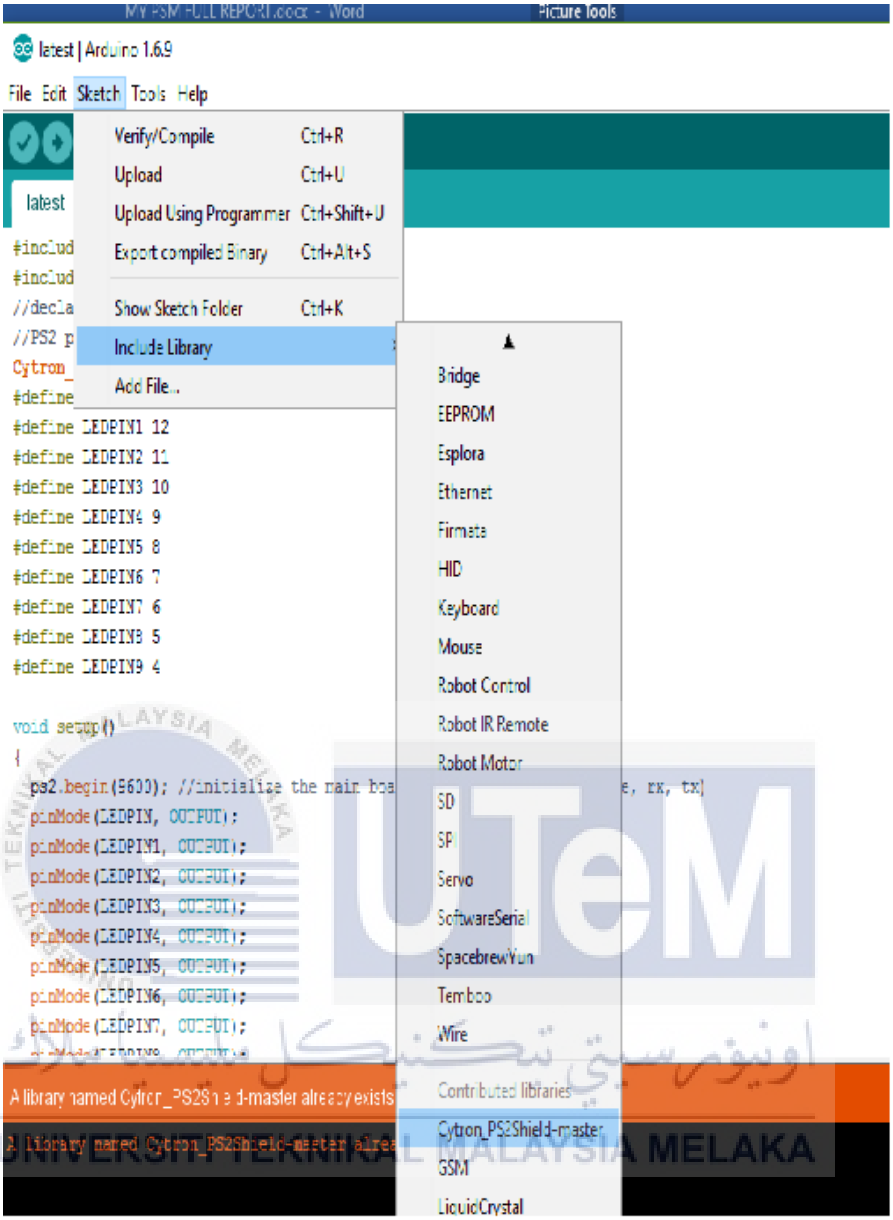
1. Go the sketch



2. Click the downloaded library named (Cytron_PS2Shield-master) from the website github.com



3. After add the library, the library will appear in the 'include library' of the IDE. The library (Cytron_PS2Shield-master) can be used in the main code. The library can be added in the main code by simply selecting the needed library. After this, the detail like #include will appear in the main code. For example, #include <Cytron_PS2Shield.h>


latest | Arduino 1.6.9
File Edit Sketch Tools Help
Verify/Compile Ctrl+R
Upload Ctrl+U
Upload Using Programmer Ctrl+Shift+U
Export compiled Binary Ctrl+Alt+S
Show Sketch Folder Ctrl+K
Include Library
Add File...
Bridge
EEPROM
Esplora
Ethernet
Firmata
HID
Keyboard
Mouse
Robot Control
Robot IR Remote
Robot Motor
SD
SP
Servo
SoftwareSerial
SpacebrewYun
Temboo
Wire
Contributed libraries
Cytron_PS2Shield-master
GSM
LiquidCrystal
A library named Cytron_PS2Shield-master already exists

4. The added library in the main code

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```
#include <SoftwareSerial.h>
#include <Cytron_PS2Shield.h>
//declare class object
//PS2 ps2 = PS2(); //PS2 class object: ps2
Cytron_PS2Shield ps2(2, 3);
#define LEDPIN 13
#define LEDPIN1 12
#define LEDPIN2 11
#define LEDPIN3 10
#define LEDPIN4 9
#define LEDPIN5 8
#define LEDPIN6 7
#define LEDPIN7 6
#define LEDPIN8 5
#define LEDPIN9 4
```

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