PSZ 19:16 (Pind.1/07)

UNIVERSITI TEKNOLOGI MALAYSIA

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : GO TING LOONG

Date of birth : 03 MARCH 1989

Title : RESCUE ROBOT

Academic Session : 20112012/02

I declare that this thesis is classified as :

[ ]	**CONFIDENTIAL**	(Contains confidential information under the Official Secret Act 1972)*
[ ]	**RESTRICTED**	(Contains restricted information as specified by the organisation where research was done)*
[/]	**OPEN ACCESS**	I agree that my thesis to be published as online open access (full text)

I acknowledged that Universiti Teknologi Malaysia reserves the right as follows :

1. The thesis is the property of Universiti Teknologi Malaysia.
2. The Library of Universiti Teknologi Malaysia has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by :

SIGNATURE	**SIGNATURE OF SUPERVISOR**
890303-01-5435	DR. ZOOL HILMI BIN ISMAIL
(NEW IC NO./ PASSPORT NO.)	**NAME OF SUPERVISOR**
Date : 28 JUNE 2012	Date : 28 JUNE 2012

NOTES : * If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organisation with period and reasons for confidentiality or restriction.

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor in Engineering (Electrical-Mechatronics)"

Signature	:
Name of Supervisor	: DR. ZOOL HILMI ISMAIL
Date	: 28 JUNE 2012

RESCUE ROBOT

GO TING LOONG

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Bachelor of Engineering (Electrical-Mechatronics)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2012

I declare that this thesis entitled *"Rescue Robot"* is the result of my own research except as cited in the references. The thesis is not been accepted for any degree and is not concurrently submitted in any candidature of any other degree.

Signature	:
Name	: GO TING LOONG
Date	: 28 JUNE 2012

Acknowledgements

First and foremost, I would like to take this opportunity to express my sincerest gratitude towards my project supervisor, Dr. Zool Hilmi Ismail for all his guidance, advice, trust and freedom gave to me in the process of conducts this project.

My outmost thanks also go to my family members who have given me support throughout the process of conducts this project and my academic years. Without the support and encouragement from them, I might not be able to become who I am today.

Last but not least, my sincere appreciation also extends to all my fellow friends and course mate for your constructive suggestions and encouragement. The teaching and tips from you are definitely useful for me to conduct this project.

Abstract

This project presents the development of a low-cost Rescue Robot where it encompasses into three main parts: mechanical design, wireless remote control and wireless video transmission.

In the mechanical design, track wheels have been used rather than conventional wheels to enable the robot to travel through different type surface or rough terrain. Beside, a pair of lifting arm with has been attached to the body of the rescue robot in order to climb up the stair or obstacle.

Moreover, a wireless camera has been attached to the robot as a monitoring system. With the monitoring system, the robot operator is able to search for survivor or any harmful device.

Last but not least, the robot has been designed by wireless control so that the operator able to remote controls the robot. The wireless control allows the operator away from the harmful environment or harmful device and avoids the wire or cable interrupts the robot motion.

Abstrak

Projek ini membincangkan reka bentuk Rescue Robot yang berkos rendah. Project ini dibahagikan kepada tiga bahagian utama iaitu reka bentuk mekanikal untuk struktur robot, kawalan jauh tanpa wayar dan penghantaran video tanpa wayar.

Reka bentuk mekanikal untuk struktur robot, roda lipan dipilih dan digunakan untuk membolehkan Rescue Robot menjalan di atas permukaan yang berlainan. Selain daripada itu, sepasang lengan mekanikal dipasangkan kepada Rescue Robot. Tujuan memasanglkan lengan mekanikal adalah membolehkan Rescue Robot mengatasi tangga atau halangan.

Satu IP kamera tanpa wayar dipasangkan kepada robot tersebut untuk mengawal and merakamkan “live video” sekeliling Rescue Robot. Dengan kawalan secara tanpa wayar, operator robot tersebut dapat mengawal situasi kawasan bencana dan mencari mangsa yang terselamat di kawasan bencana.

Untuk mengelakkan operator Rescue Robot terancam daripada benda atau alat yang membahayakan, Rescue Robot direka bentuk dengan kawalan jauh tanpa wayar. Dengan sistem kawalan secara tanpa wayar, robot tersebut tidak akan mengacaukan operasi robot.

Table of Contents

List of Table

List of Figure

List of Abbreviations

PS2	-	PlayStation 2
IP	-	Internet protocol
PIC	-	Peripheral Interface Controller
UART	-	Universal Asynchronous Receiver/Transmitter
IC	-	Integrated Circuit

CHAPTER 1

INTRODUCTION

1.1 Overview

A robot can be defined as a programmable, self-controlled device consisting of electronic, electrical, or mechanical units. More generally, it is a machine that functions in place of a living agent. Robots are especially desirable for certain work functions because, unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions; they do not get bored by repetition; and they cannot be distracted from the task at hand.

Due to the several advantages of the robot, it has been used for industry production and domestic application. One of the domestic robots is V-Bot Robotic Vacuum Cleaner (RV-8) which having smart cleaning program that enables sequence of four cleaning movements and several sensor such as Cliff-avoidance sensor to prevents V-Bot from falling down staircases. In industry application, the robots are use to position car frames, bolt pieces together, and even do welds and priming.

From the statement above, it is known that the robot is very useful and helpful for our human being. However, the robot may have other function other than helping human being in their life. In fact, the robot may save our life as well when the robot was used it the rescue propose. In the country having natural disaster like Japan, China and Philippines, the development of the rescue robot is gaining momentum. However, the development trend in Malaysia is still far behind those countries. In fact, Malaysia may face the natural disaster in the future according the research of several researchers and experts.

1.2 Problem Statement

According to Centre for Research on the Epidemiology of Disasters (CRED), the statistics of the natural disaster is keep increase from year to year. The statistics below showed that the number of disaster is increasing yearly from 1990 to 2000.

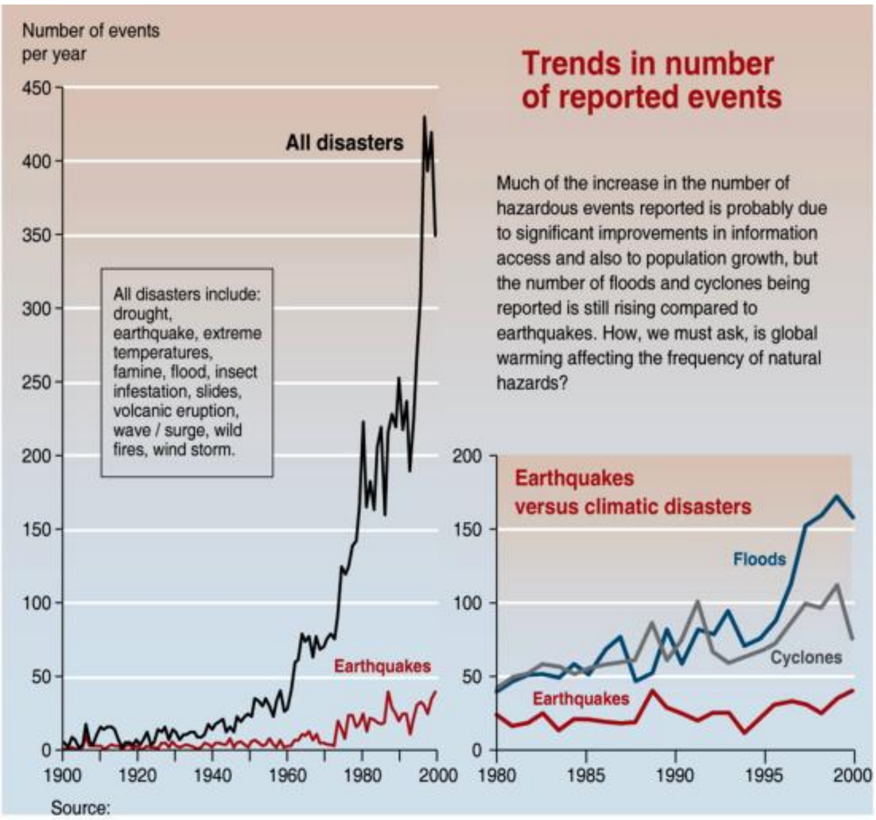


Figure 1.1: The statistics of Natural disaster (1990 - 2000)

Malaysians think earthquakes will never occur in the country. But in reality, they do, with the most recent one with its epicentre in Manjung, Perak, occurring on 29 April 2009.

In fact, Malaysia has a small history of earthquakes. The region around Sabah, especially around Ranau, Kudat and Lahad Datu, is no stranger to earthquakes, and according to a seismological expert, it is not uncommon for two or three to strike the area yearly.

Beside, according to the Engineering Seismology and Engineering Earthquake Research Group (E-Seer) of the faculty of civil engineering, Universiti Teknologi Malaysia, there is a possibility of a much larger earthquake occurring in Malaysia, especially if the earthquakes in Indonesia trigger the inactive fault lines running in peninsular Malaysia.

Figure 1.2: Mohd Zamri Ramli, Engineering Seismology and Engineering Earthquake Research Group (E-Seer) of the faculty of civil engineering, Universiti Teknologi Malaysia

Dr Norhisham Bakhary, another researcher from E-Seer, says that with the exception of the Penang Bridge and KLCC, buildings or structures in Malaysia are not designed to resist the force of an earthquake.This means that if an earthquake with a high magnitude occurred in Malaysia, there is a high possibility that most buildings would collapse.

Dr Norhisham says that buildings in this country are only designed for a top or "normal" load and not for a lateral or side-to-side load which earthquakes cause.
He adds that for buildings to be able to withstand earthquakes, structural members have to be bigger in size, besides many other design considerations. This means more material is needed for construction, which translates into higher costs.

"Nobody wants to spend that much because they think it will never happen. I have spoken to building owners but no one really seems to care," says Dr Norhisham. "The firemen can't check the connections which are covered. Do we have to wait until something happens before we take any preventive action?"

He says that to ensure buildings are still safe after an earthquake, post-earthquake assessment is essential, which would first entail visual inspection. If needed, non-destructive tests can be conducted to identify unseen damage in structural members. Based on the results of the assessment, the rehabilitation process can proceed, if required.

Figure 1.3: Dr Norhisham Bakhary, Engineering Seismology and Engineering Earthquake Research Group (E-Seer) of the faculty of civil engineering, Universiti Teknologi Malaysia

From the statistics and research of several researcher and experts, there is a high possibility for Malaysia facing the natural disaster in the future and there is a high possibility that most buildings in would collapse since Malaysian do not take earthquake into account.

If the disaster suddenly happens in Malaysia, are Malaysia Polis Force and Malaysian Fire and Rescue Department able to rescue the victim immediately?
As a leader of technology institution in Malaysia, something should be done to prevent or reduce the affect before any disaster happens in Malaysia with the advanced technology knowledge.

1.3 Objectives

The objectives of this project are:

1. To develop a low-cost rescue robot that have highly potential and demand in the present and future market.

2. To design a robot to search for the survivor in the disaster area and assist the rescue worker in the rescue mission.

1.4 Scope of Project

The scopes of study of this project are as followed:

1. In the robot structure design, track wheels have been used rather than conventional wheels to enable the robot to travel through different type surface or rough terrain. Besides, a pair of lifting arm with has been attached to the body of the rescue robot in order to climb up the stair or obstacle.

2. The wireless control system and the wireless monitoring system was used in this project to allows the robot operator away from the harmful environment or harmful device and avoids the wire or cable interrupts the robot motion.

3. For the wireless control system, wireless PS2 controller and Cytron PS2 Starter kits was used to control the robot motion. Beside, the microcontroller P16F877A interface was used as the main processing unit and C language as the programming language.

4. For the wireless monitoring system, a wireless IP camera has been attached to the robot as a monitoring system. The video from the wireless IP camera can directly view by using computer, laptop or smart phone.

CHAPTER 2

THEORY AND LITERATURE REVIEW

2.1 Introduction

This chapter reviews the paper works, researches, books, article and journals which are related to this title. The theoretical and methodological recommendations from these academic materials have been studied so that the advantages could be applied to this project.

2.2 Previous Related Works

2.2.1 ROBHAZ-DT3

ROBHAZ-DT3, the Robot for Hazardous Application, has been created for Korean troops in Iraq. It was jointly developed by Yujin Robot and the state-run Korea Institute of Science and Technology. It is equipped with portable remote controlled station and wireless communication of Image & data.

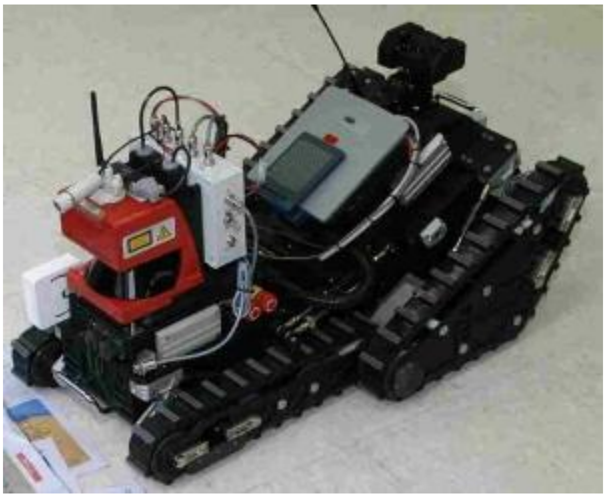


Figure 2.1: ROBHAZ-DT3

It is equipped with laser sensors; this enables the remotely-operated bot to create a map of the place where a disaster has taken place. Infrared cameras are used to detect victims. The robot also features foldable arms, four cameras and a set of temperature sensors. The ROBHAZ-DT3 has a unique set of tank treads that enable it to adapt easily to uneven terrain. Note that the design allows waterproof, great flexibility; earlier (and smaller) versions were able to climb stairs.

2.2.2 Hibiscus

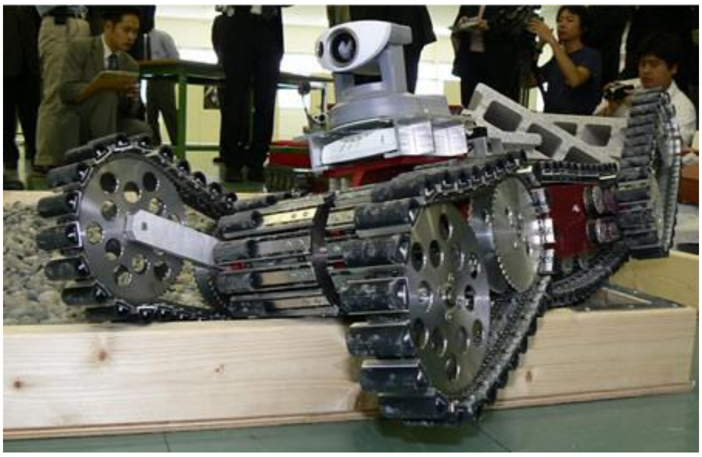


Figure 2.2: Hibiscus

Chiba Institute of Technology Japan has developed a new rescue robot named Hibiscus. This robot's main purpose is to look for survivors in case of disasters like earthquakes which are common in Japan. It has an infrared thermal camera which can detect trapped survivors in the rubble by their heat signature. With the max speed of 1.1 meters per second, this robot communicates to operator via Wi-Fi 802.11g and is using a SH-4 processor. Dimensions are 370 mm x 650 mm x 180 mm and weighs is 22.5 kg. It is powered by a 3700 mAh Lithium Polymer battery which lasts for 60 minutes. It has six independent crawlers and has two flipper arms which allow it to move over obstacles effortlessly.

2.2.3 Darmstadt Rescue Robot

Figure 2.3: Darmstadt Rescue Robot

The Team Hector Darmstadt established at the Technische Universität Darmstadt within the PhD program Cooperative, Adaptive and Responsive Monitoring in Mixed Mode Environments, funded by the German Research Foundation (DFG). This program addresses the exciting and challenging research areas of navigation and coordination of multiple autonomous vehicles as well as monitoring in mixed mode environments that are characterized by the heterogeneity resources, capabilities and connectivity.

The experience in hardware and software of autonomous robots has already been successfully applied to RoboCup soccer, and there have been studies in simulation on cooperative control. Different algorithms were developed from computer vision for people detection and object recognition which can now be applied to Search and Rescue scenarios. Finally, team members from mechanical engineering are focusing on the design and experimental evaluation of unmanned aerial and ground vehicles for environmental monitoring and surveillance applications.

The team's name was recently changed from "Darmstadt Rescue Robot Team" to "Hector Darmstadt", which stands for Heterogeneous Cooperating Teams of Robots.

2.2.4 Sandia Gemini-Scout Mine Rescue Robot

Figure 2.4: Sandia Gemini-Scout Mine Rescue Robot

Gemini-Scout robot, a product of Sandia Labs, can withstand explosions, crawl over boulders, find its way through 18 inches of water, and navigate through rubble piles. Gemini-Scout having a boot to deliver food, air packs, and medicine to miners trapped underground before human rescue teams can arrive. But while Gemini-Scout is impressive, it's not the only rescue robot that first responder teams have in their arsenal.

Gemini-Scout Mine Rescue Robot is less than 61cm (4 feet) long and 30.5cm (2 feet) tall, and it is nimble enough to navigate around tight corners and over safety. Sandia engineers had to build something intuitive for new operators who need to learn the system quickly, so they used an Xbox 360 game controller to direct the robot.

To ensure functionality in flooded tunnels, Gemini-Scout’s controls and equipment needed to be waterproof. It’s able to navigate through 45cm (18 inches) of water, crawl over boulders and rubble piles, and move in ahead of rescuers to evaluate potentially hazardous environments and help in rescue operations planning.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter discussed the complete development process of the rescue robot including the structure and mechanism, circuitry and also software.

3.2 Mechanical Design of Robot Structure

This section discusses the mechanical design of robot structure and modification of the original component.

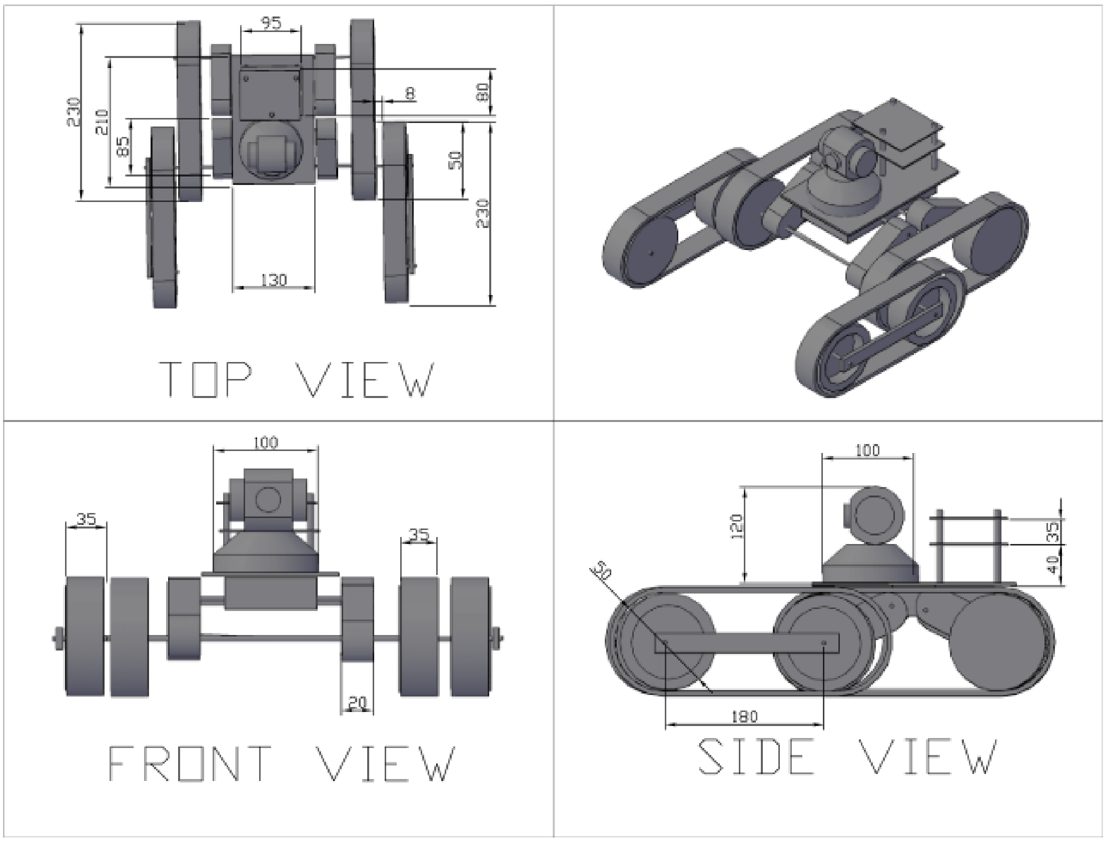


Figure 3.1: Three Dimensions Drawing of the Rescue Robot

3.2.1 Main Robot Structure (Tracked Wheel Design)

Figure 3.2: Rover 5 Tank Chassis Set

In order to travel on the racked uneven terrain, tracked wheel is the main component of the rescue robot. Several tracked wheel have been studied in order to choose the most suitable tracked wheel for this project. The design, shape, price, function, limitation of each tracked wheel have been considered. The tracked wheels was used in this project is Rover 5 Tank Chassis Set.

Rover 5 Tank Chassis Set was chose because there are several advantages of it. The clearance can be adjusted by rotating the gearboxes in five-degree increments. "Stretchy" rubber treads maintain tension as the clearance is raised. Besides, inside of the chassis are 4 noise suppression coils at the bottom and a battery holder that accepts 6x AA batteries.

Moreover, Rover 5 Tank Chassis Set consists of four motor spaces to install four motors in the robot structure. In this project, four motors have been installed in the robot structure. Two motors are used to control the robot motion and there are named as Tracked Wheel Motors. Another two motors is used to control the mechanism arms motion and there are named as Arm Motors.

3.2.2 Mechanism Arms Design

The applications of the rescue motor are the real situation may face a lot of obstacles or stair. In order to move over uneven terrain and up and down stairs, the robot structure was modified by adding two mechanism arms at the front of the tank chassis. The mechanism arms were made by removing two tracked wheel from another Rover 5 Tank Chassis Set. The mechanism arms are support a thin stainless steel beam. Figure show the modified mechanism arm.

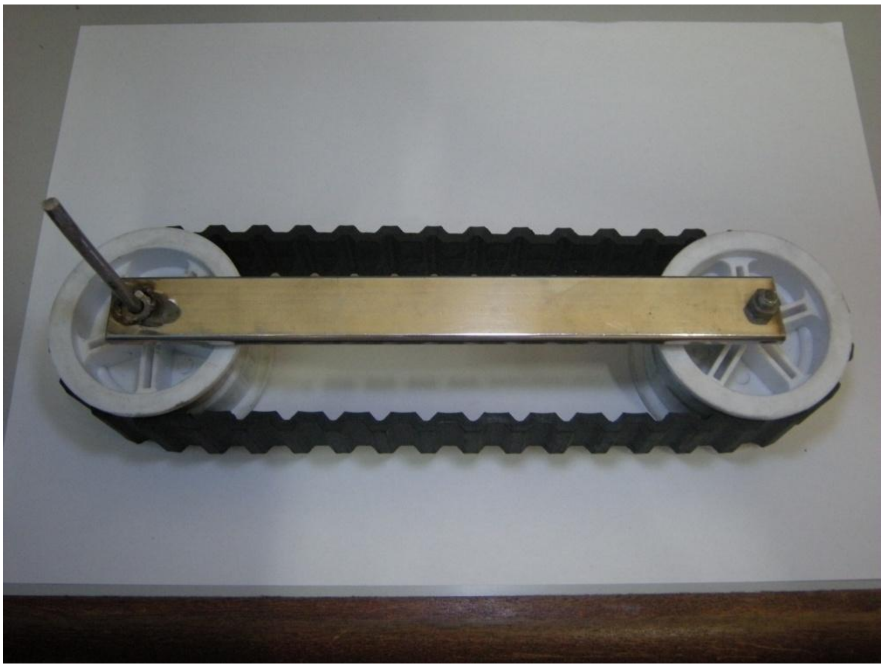


Figure 3.3: Mechanism Arm

Besides, the motor shaft for the Arms Motor has replaced by a longer steel shaft in order to attach the mechanism arms to the robot structure. Figure 3.4 show the original motor shaft and modified motor shaft. The above one is the modified motor shaft and the below one is the original motor shaft.

Figure 3.4: Original motor shaft and modified motor shaft

3.3.3 Track Wheel Motion Design

In the original design, six motors were expected for the whole robot motion and mechanism arms motion. Due to the limitation of robot structure space, it is very difficult to install six motors on the robot structure.

This problem has been overcome by adding a coupling between the tracked wheel and it is named as Tracked Wheel Coupling. The coupling couples together the two wheels so that the two tracked wheel on one side can be move by a single motor. Figure 3.5 show the wheel of the tracked wheel and the Tracked Wheel Coupling

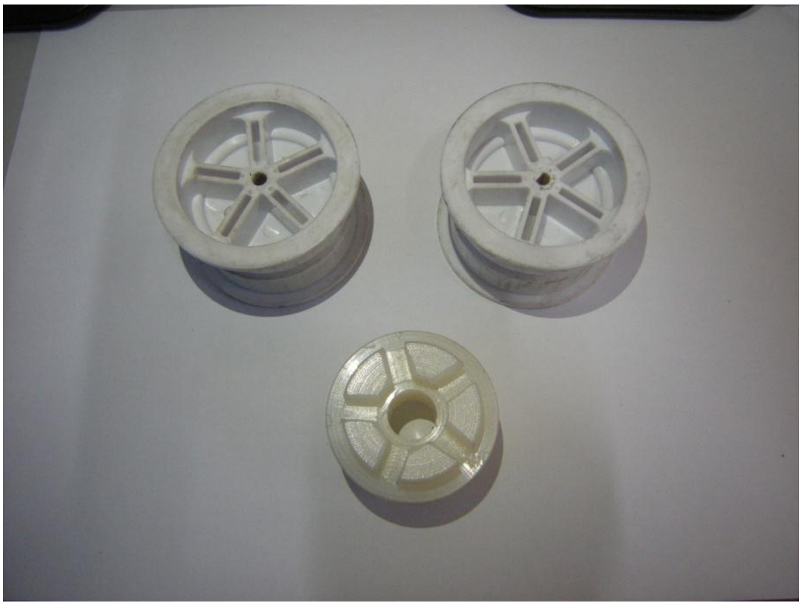


Figure 3.5: The Tracked Wheel and the Tracked Wheel Coupling

3.3 Components and Electrical Circuitry

This section discusses the electrical circuitry design and components used. The full circuit connection is show in Appendix B. Table shows the major components used in this project.

Table 3.1: Major Components Used In This Project

NO.	Components	Quantity
1	PIC16F877A	1
2	L298	2
3	PIC Starter Kits	1
4	PS2 wireless Controller	1
5	PS2 Starter Kit	1
6	Apexis Wireless IP Camera	1
7	Transistor BC547	2

3.3.1 PIC 16F877A Microcontroller

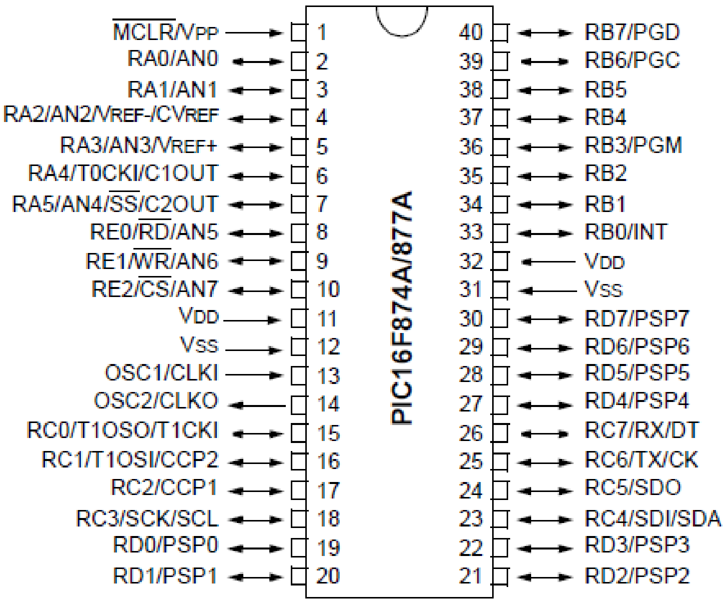


Figure 3.6: Pin Diagram of PIC16F877A

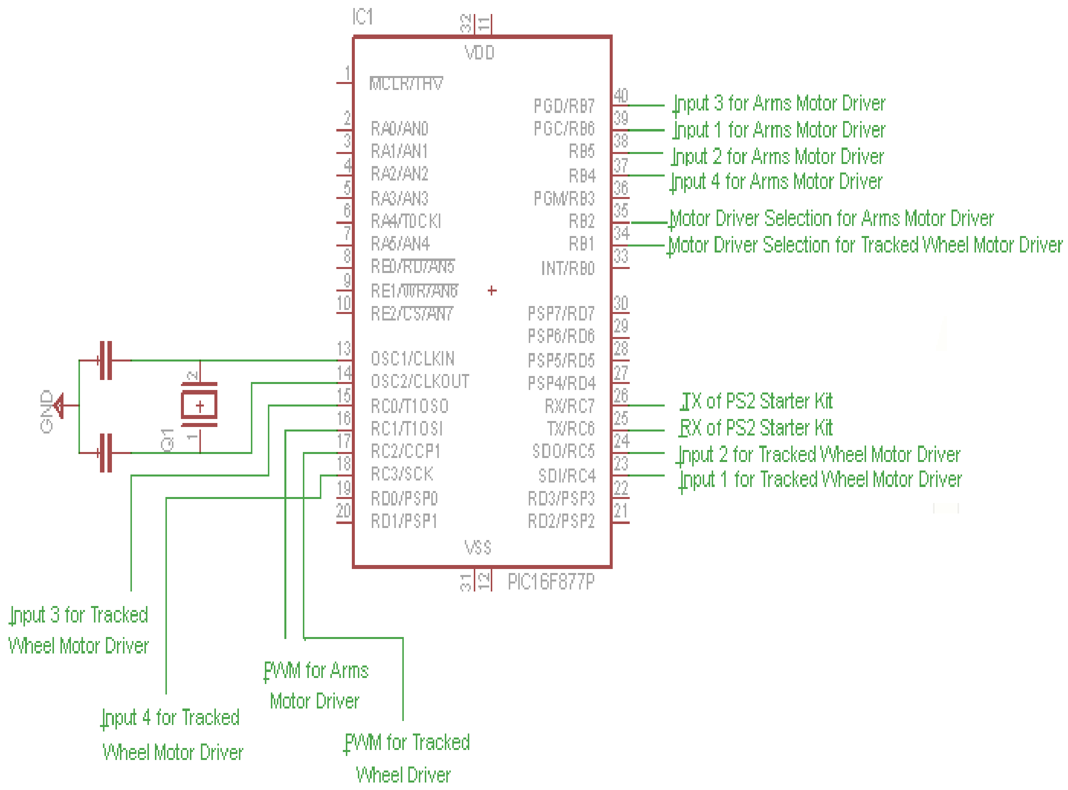


Figure 3.7: Circuit Connection of PIC16F877A

Figure 3.6 shows the architecture of PIC16F877A and Figure 3.7 shows the circuit connection of PIC16F877A. Microcontroller PIC16F877A is a 40 pins microcontroller which has five I/O ports. PIC16F877A is chosen to be used as the main processing unit for the rescue robot because it has high enough performance but with cheaper price, which is only cost about RM20. Besides, this microcontroller has 2 PWM modules with 10 bits resolutions.

The transmitter pin (TX) and receiver pin (RX) is used to communicate with PS2 Starter Kit. Eight pins of the PIC16F877A are used to control the direction of four motors. The two pins RC1 and RC2 are used to control the speed of the motors by Pulse Width Modulation (PWM). Due to the microcontroller only have two PWM outputs, it is impossible to control four motor speeds simultaneously.

The problem has overcome by control the enable pin of the motor diver L298 by two microcontroller pins RB1 and RB0 which connect to a transistor BC547. The connection is show as Figure. When the output logic of the microcontroller pins RB1 or RB2 is set to 1, the enable pin of the motor drivers L298 will be set to 1 to enable the motor driver or vice versa.

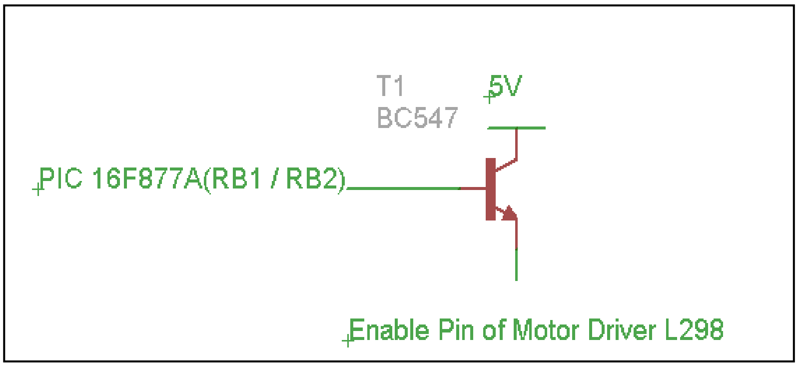


Figure 3.8: Motor Drivers Enable Pin Connection

By manipulate the programming, only one of the motor drivers will be enable its corresponding microcontroller pin is set to 1 and another motor driver will be disabling. As a result, the PWM value will be passing to one of the motor driver only so that the two different PWM value can be use by only two PWM output. The connection able the motor speed turning and motor speed control for four DC motors.

Beside, an external crystal of 20Mhz is connected to the PIC18F4550 at pin 15 and 16 as shown in Figure to establish oscillation. For 20Mhz crystal, two 15pF capacitors are used for oscillator stability purpose.

3.3.2 Motor Driver L298

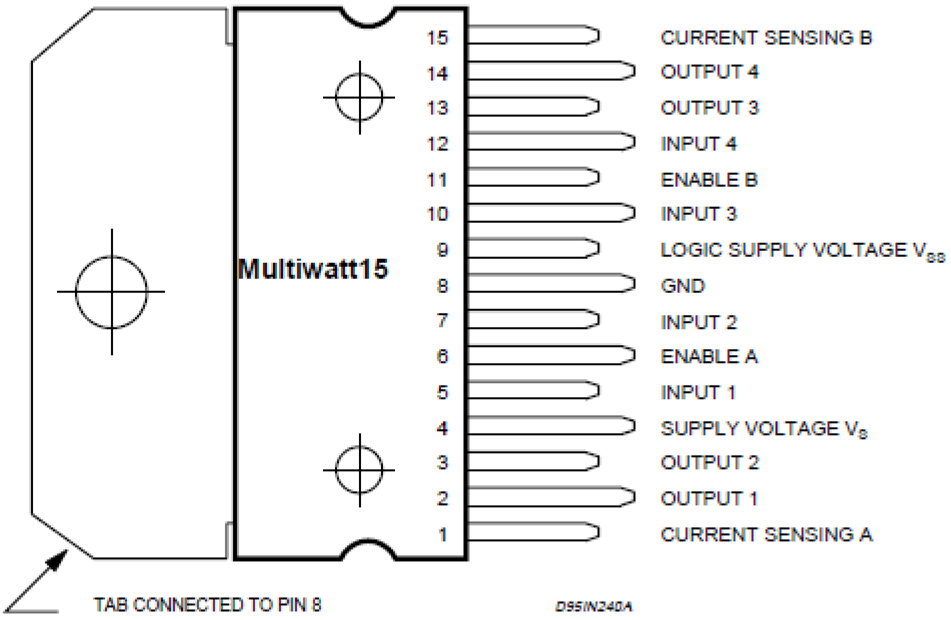


Figure 3.9: Motor Driver L298

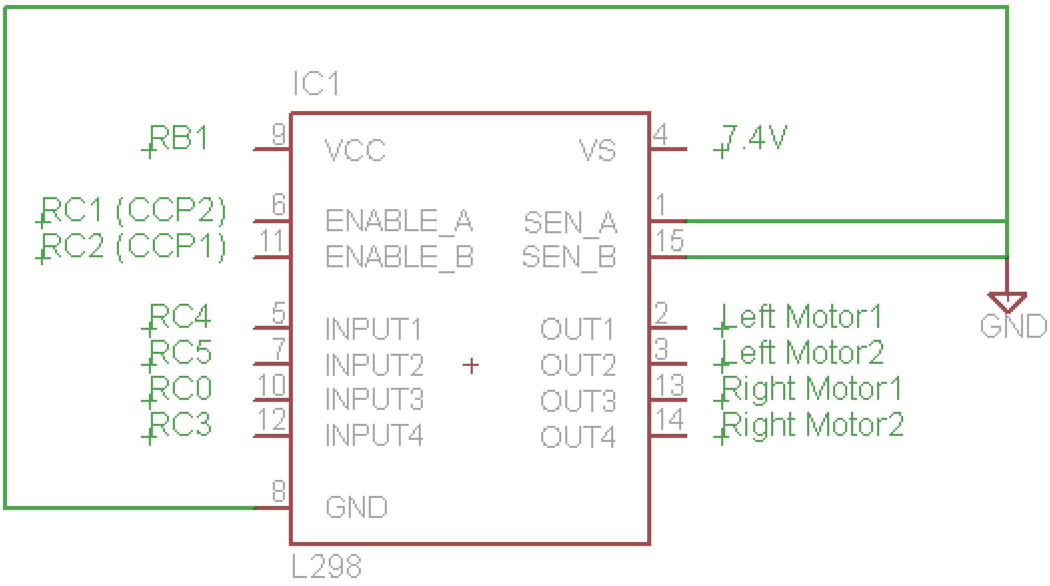


Figure 3.10: Tracked Wheel Motor Driver Circuit Connection

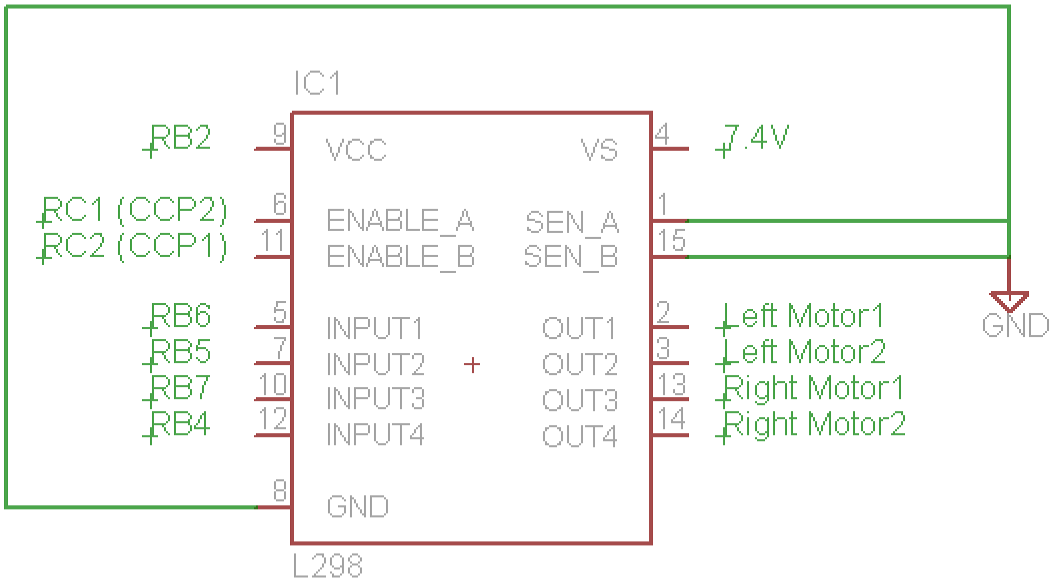


Figure 3.11: Arms Motor Driver Circuit Connection

Figure 3.9 show the architecture of Motor Driver IC L298 and Figure 3.10 and Figure 3.11 shows the circuit connection. L298 is a high current four channels driver which is suitable to used for controlling the two DC motors per motor driver for bidirectional. It is capable of delivering up to 2.5A current output per channel.

Each Motor Driver IC L298 consists of four inputs and four outputs. Four inputs are connecting to the microcontroller and four outputs are connecting to the four terminals of two motors. The logic power supply for Motor Driver IC L298 is 5V which is connected to the pin 9 of the IC, while motor power supply for the motor in this project is 7.4V connected to pin 4 of the IC. The PWM signal from PIC16F877A is connected to the two enable pin of L298, which are pin 6 and pin 11 in order to control the speed of the motor. Since the PWM signal used is 8 bits, hence the range of PWM signal used is 0 to 255, with 255 as the maximum speed.

Since the circuit does not require current sensing, pin 1 and pin 15 of Motor Driver IC L298 is connected to the ground. As mention in the previous part, the microcontroller only has two PWM outputs, thus it is impossible to control four motor speeds simultaneously. This problem has been solved by controlling the enable pin (pin 9) of the motor diver L298. The enable pin (pin 9) of the motor diver L298 is connected to a transistor of BC547 which to two microcontroller pins RB1 or RB0 and 5V. The connection is showed in the Figure 3.8.

3.3.3 Voltage Regulator LM7805

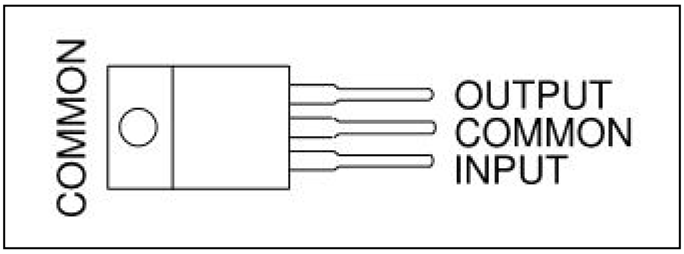


Figure 3.12: Voltage Regulator (LM7805)

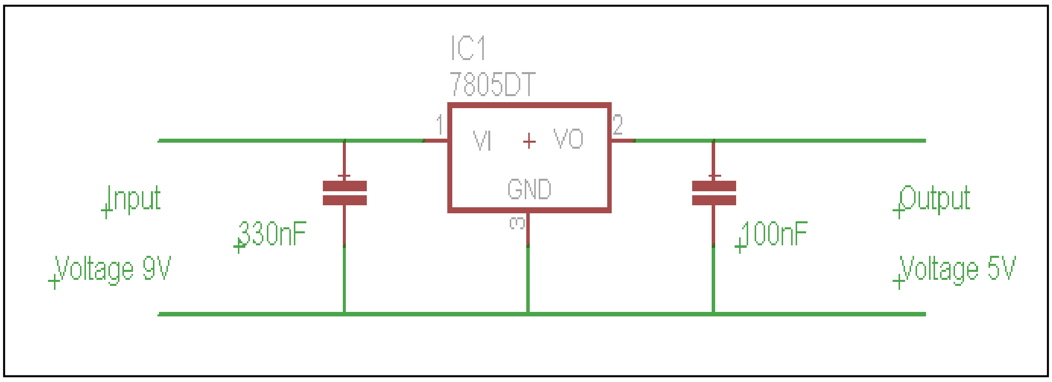


Figure 3.13: Circuit Connection of LM7805

Figure 3.12 shows LM7805 architecture and Figure 3.13shows the circuit connection of circuit connection for LM7805.

LM7805 is used to supply a stable output voltage 5V to microcontroller PIC18F4550, motor driver L298 as the logic power supply. LM7805 has internal current limiting, thermal shut down and safe operating area protection capability. The output current can goes up to 1A. A heat sinking has been attached to the IC LM7805 to protect the IC from overheat and damage.

3.3.4 PS2 Starter Kit and PS2 Wireless Controller

The situation around the rescue robot is unsafe and unpredictable. This is very difficult to program the rescue robot autonomously. The robot is design to operate manually by the PS2 controller.

Figure 3.14: Wireless PS2 Controller

Figure 3.14 show Wireless PS2 Controller. PS2 is abbreviation for Playstation2. Playstation2 wireless controller 2.4 GHz and Cytron PS2 Controller Starter Kit were utilized to remote control the rescue robot. Play Station 2 (PS2) controller has been chosen because it easy to obtain from any game store and it offers good human manual input for control system.

But the major problem to achieve this is the socket for PS2 and the protocol to communicate with it. PS2 socket is very unique and difficult to obtain. Besides, protocol to obtain the status (digital and analog) of each button and analog stick on PS2 controller is difficult.

This problem has overcome by using the Cytron PS2 Starter Kit, reading Joy-stick button's state will be easier. It offers a standard connector for Sony PS2 controller to plug-in.

Moreover, the Cytron PS2 Starter Kit is using serial communication over UART and only require four simply connection on it there are transmitter (TX), receiver (RX), voltage supply 5V and Ground. Indeed the TX and RX are cross connected to TX (pin 25) and RX (pin 26) on microcontroller 16F877A. Cross connection mean the transmitter (TX) of PS2 Starter Kit is connected to the receiver (RX) of microcontroller 16F877A while the receiver (RX) of PS2 Starter Kit is connected to the transmitter (TX) of microcontroller 16F877A. The connection enables the two devices to communicate and transfer data with each other.

Figure 3.15: PS2 Controller Starter Kit

3.3.5 Apexis Wireless IP CAmera

Figure 3.16: Apexis Wireless IP Camera

Figure 3.16 show Apexis Wireless IP Camera. As mention before the situation around the rescue robot is unsafe and unpredictable, Apexis wireless IP camera was used to monitor and send the captured image to the robot operator.

Apexis wireless IP camera was chose because it has built in servo motor to rotate camera view. The camera has maximum pitch angle 270° and maximum yaw angle 270°. Apexis Wireless IP Camera it has the moderate resolution and cheaper price compared to other wireless IP camera. The video provided by the camera is of a middle quality but good enough for this project.

The live video can be viewed by computer, laptop or smart phone. This makes the operator's life easier because the live video can view in many ways and more suitable for the usage of rescue robot. Normally the disaster area is always do not the electricity power supply, if the electricity power supply of the laptop ran out, the operator can use smart phone to access the wireless IP camera.

Moreover, the live video can be view simultaneously by computer, laptop and smart phone. This allows more than one operator to access the live video. The operation mechanism of Apexis wireless IP camera is creating a wireless network connection around it. The live video can be viewed by connecting the wireless network with laptop or smart phone. Besides, the Apexis wireless IP camera do not need software to operate, the wireless IP camera can use any web browser to view the live video.

3.4 Programming and Software Design

This section discusses the software development process. MPLAB IDE version 8.63 is used for writing program. C language is used to program the PIC microcontroller 16F877A. PICkit 2 programmer is used for burning the program into the microcontroller by using USB programmer.

Program flow chart is also included in the next section. Figure 3.17 shows the programming workplace of MPLAB IDE. Figure 3.18 shows the USB programmer used for burning program into microcontroller.

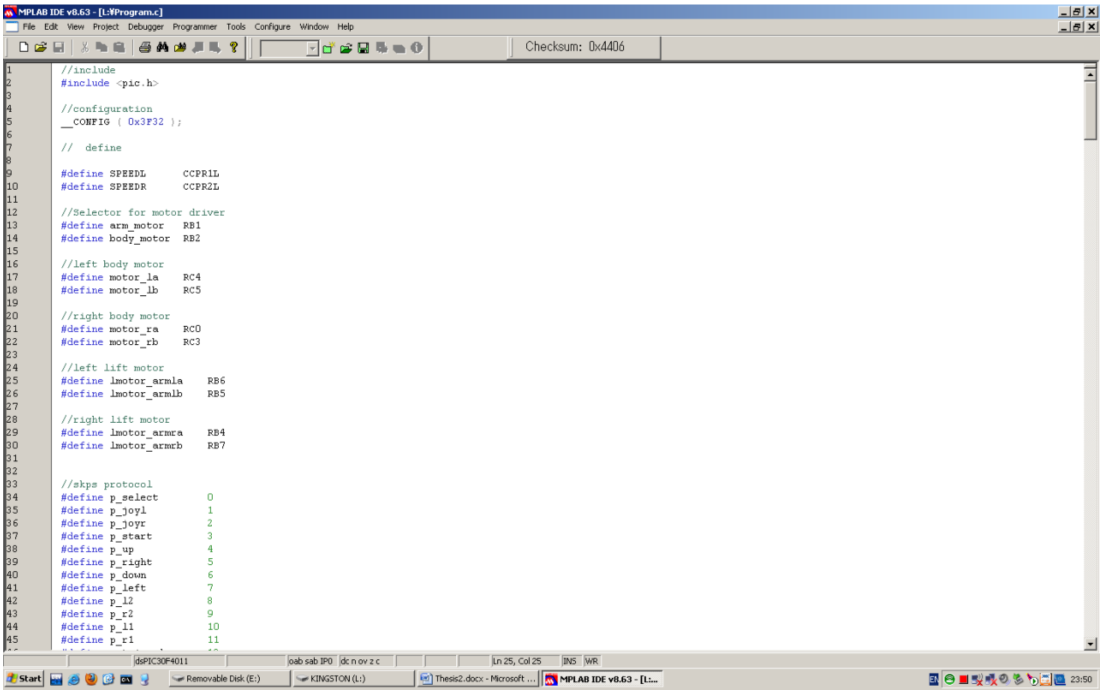
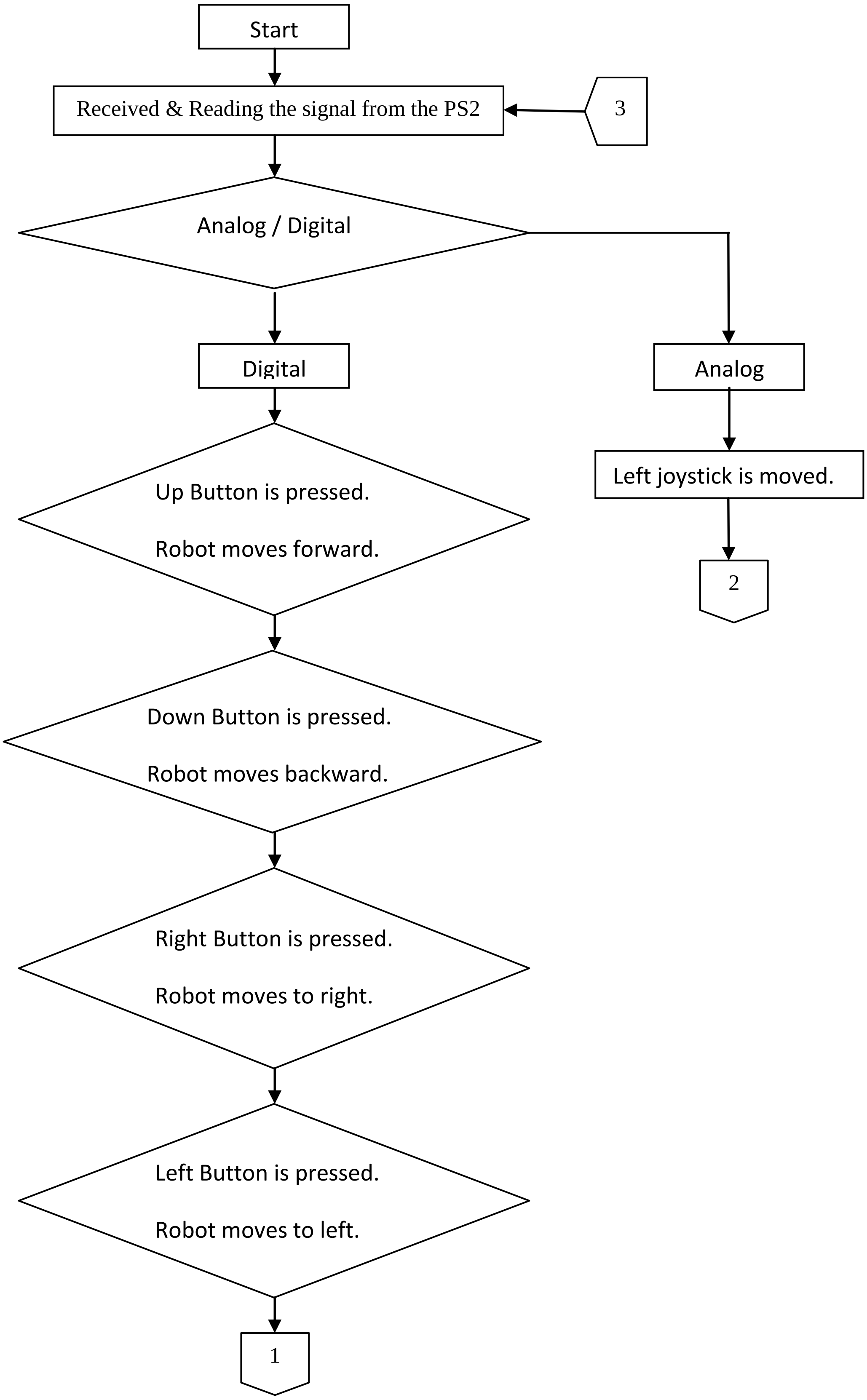


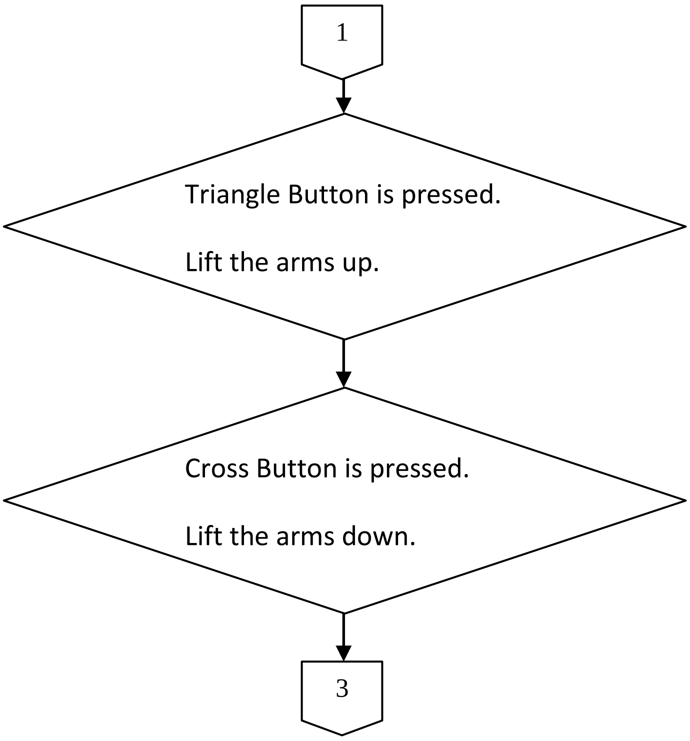
Figure 3.17: MPLAB IDE Work Place

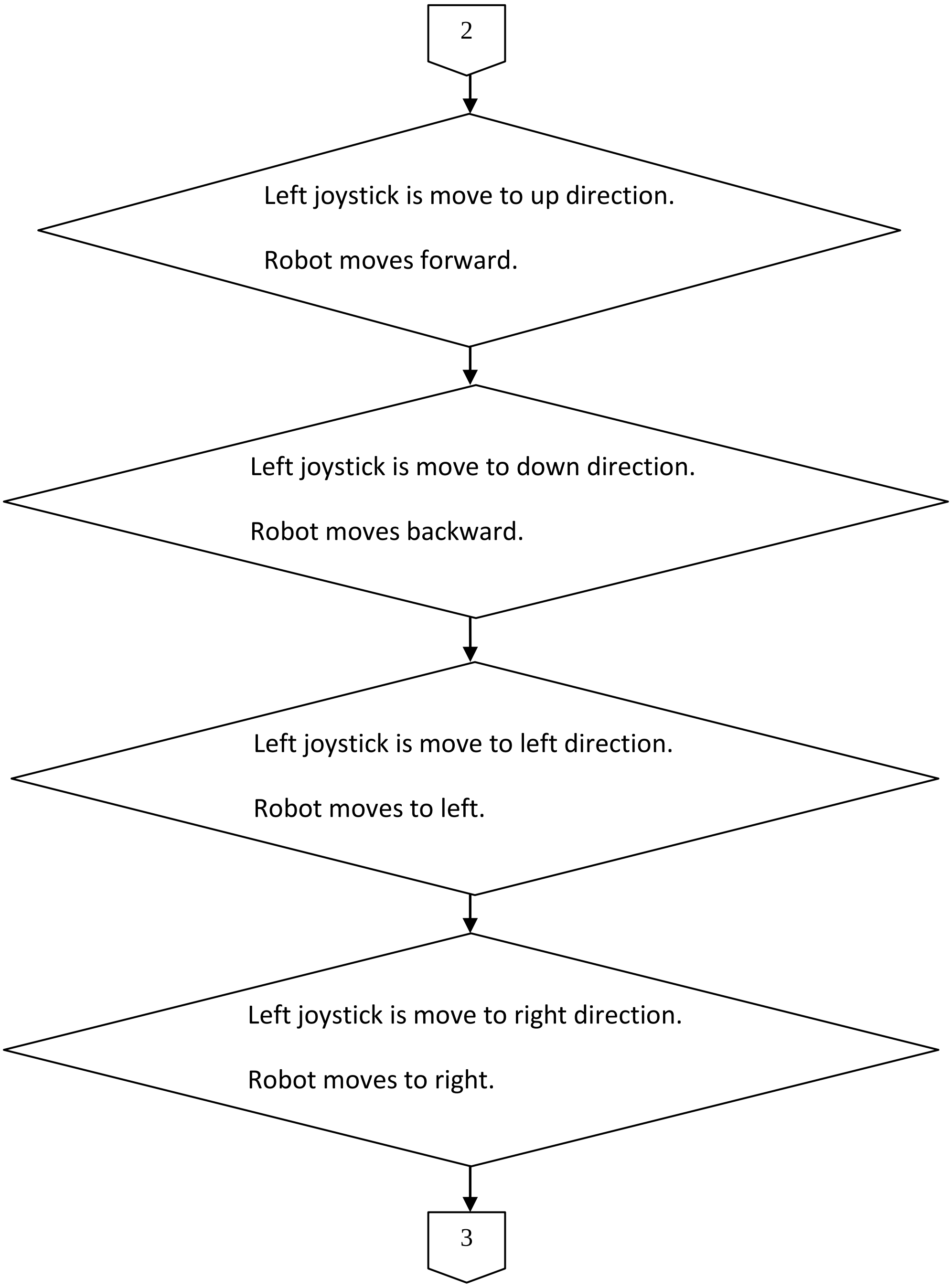
Figure 3.18: USB ICSP PIC Programmer V2010

3.4.1 Flow Chart

The rescue robot function mainly base on the signal received from the PS2 controller. The program flow chart is showed as below.




1
Triangle Button is pressed.
Lift the arms up.
Cross Button is pressed.
Lift the arms down.
3


2
Left joystick is move to up direction.
Robot moves forward.
Left joystick is move to down direction.
Robot moves backward.
Left joystick is move to left direction.
Robot moves to left.
Left joystick is move to right direction.
Robot moves to right.
3

3.4.2 Microcontroller P16F877A Configuration

The syntax for the configuration bits is __CONFIG (0x3F32). The hexadecimal code 3F32 is equivalent to the binary code 0011 1111 0011 0010. The configuration bits for the PIC microcontroller 16F877A consists of 14 bits only, the most significance two bits are ignored.

For bits 0 to 1 is 1o which refer to the HS oscillator. For bit 2 is set to 0 to disable the Watchdog Timer. For bit 3 is set to 0 to disable Power-up Timer Enable. For bit 6 is set to 0 to disable Brown-out Reset. Bit 7 is for Low-Voltage (Single-Supply) In-Circuit Serial Programming Enable bit was set to 0 so that RB3 is digital I/O, HV on MCLR must be used for programming.

Bit 8 is set to 1 to off Data EEPROM code protection. Bit 9 and 10 is set to 11 to off the write protection and all program memory may be written to by EECON control. Bit 11 is set to 1 to disable In-Circuit Debugger. Bit 13 is set 1 to off Code protection. Bits 4, 5 and 12 is Unimplemented and Read as ‘1’.

3.4.3 PS2 Starter Kit Protocol

PS2 wireless controller consist 30 buttons on it. In order to differentiate which button is pressed, PS2 starter Kit uses a unique protocol by defining each button with a particular number. The PS2 Starter Kit Protocol is showed as Figure 3.19.

```
#define p_select    0
#define p_joyl      1
#define p_joyr      2
#define p_start     3
#define p_up        4
#define p_right     5
#define p_down      6
#define p_left      7
#define p_l2        8
#define p_r2        9
#define p_l1        10
#define p_r1        11
```

```
#define p_triangle        12
#define p_circle          13
#define p_cross           14
#define p_square          15
#define p_joy_lx          16
#define p_joy_ly          17
#define p_joy_rx          18
#define p_joy_ry          19
#define p_joy_lu          20
#define p_joy_ld          21
#define p_joy_ll          22
#define p_joy_lr          23
#define p_joy_ru          24
#define p_joy_rd          25
#define p_joy_rl          26
#define p_joy_rr          27
#define p_con_status      28
#define p_motor1          29
#define p_motor2          30
```

Figure 3.19: PS2 Starter Kit Protocol

3.4.4 PS2 Starter Kit Signal Processing

This section discusses the signal processing of the PS2 Starter Kit. Initially, the logic of all buttons is 1. The button will be set to 0, when it has been pressed.

3.4.4.1 Button Control (Digital Control)

The button of the PS2 is used the Digital Logic to control it. When the button is pressed, the logic state of the up button is equal to 0. Then, the if loop condition become true, the if loop will be executed. The syntax for the PS2 controller up button signal processing is show in Figure 3.20.

```
if(skps(p_up)==0)
{
        body_motor = 1;                         // motor selection
        forward();                              //move forward
        SPEEDL=230;                             // PWM
        SPEEDR=230;                             // PWM
}
```

Figure 3.20: Syntax of PS2 Starter Kit (Digital Control)

3.4.4.2 Joystick Control (Analog Control)

The joystick of the PS2 is used the joystick angle (analog) to control it. The syntax is begin by declare four unsigned characters up_v, down_v, left_v and right_v to represent the four ordinary direction which are up, down, left and right as show in Figure 3.21. Then, equal the unsigned character to the four direction of the PS2 Starter Kit protocol.

```
up_v=skps(p_joy_ru);
down_v=skps(p_joy_rd);
left_v=skps(p_joy_ll);
right_v=skps(p_joy_lr);
```

Figure 3.21: The declaration of four unsigned character for analog control

Next, use the unsigned characters to determine the direction of the joystick. Besides, by using loop in the loop programming technique, the other four direction which are up-left, up-right, down- left and down-right can be determined.

```
else if(up_v>0)
		{
			forward();
			body_motor=1;
			if(left_v>0)
			{
				if(up_v>left_v)SPEEDL=up_v-left_v+140;
				else SPEEDL=140;
				SPEEDR=up_v+140;
			}
			else if(right_v>0)
			{
				if(up_v>right_v)SPEEDR=up_v-right_v+140;
				else SPEEDR=140;
				SPEEDL=up_v+140;
			}
			else
			{
				SPEEDL=up_v+140;
				SPEEDR=up_v+140;
			}
		}

		else if(down_v>0)
		{
			backward();
			body_motor=1;
			if(left_v>0)
			{
				if(down_v>left_v)SPEEDR=down_v-left_v+140;
				else SPEEDR=140;
				SPEEDL=down_v+140;
			}
			else if(right_v>0)
			{
				if(down_v>right_v)SPEEDL=down_v-right_v+140;
				else SPEEDL=140;
				SPEEDR=down_v+140;
			}
			else
			{
				SPEEDL=down_v+140;
				SPEEDR=down_v+140;
			}
		}

		else if(left_v>0)
		{
			left();
```

```
                    body_motor=1;
                    SPEEDL=left_v+120;
                    SPEEDR=left_v+120;
            }

            else if(right_v>0)
            {
                    right();
                    body_motor=1;
                    SPEEDL=right_v+120;
                    SPEEDR=right_v+120;
            }
```

Figure 3.22: Syntax of PS2 Starter Kit (Analog Control)

3.4.5 Pulse Width Modulation Module

In order to use the PWM of the microcontroller to control the motors speed, the registers CCP1CON and CCP2CON is set to 0b00001100 to enable the PWM mode of the microcontroller. The PR2 register is set to 255, which means that the period of the PWM is set to 255. T2CON is set to 4 that enables the timer2. Figure 3.23 shows the initialization code for PWM.

```
PR2 = 255;
T2CON = 0b00000100;
CCP1CON = 0b00001100;
CCP2CON = 0b00001100;
```

Figure 3.23: PWM Module Initialization

CHAPTER 4

RESULT AND DISCUSSION

4.1 Actual Robot

Figure 4.1 show the front view and the top view of the actual robot.

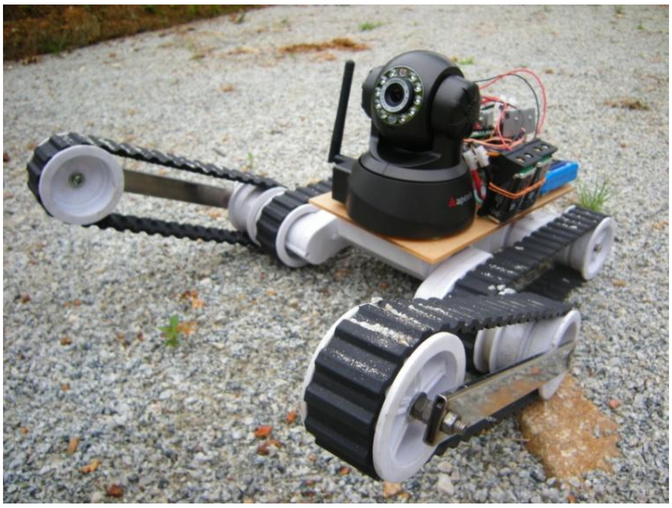


Figure 4.1: Front view of Rescue Robot

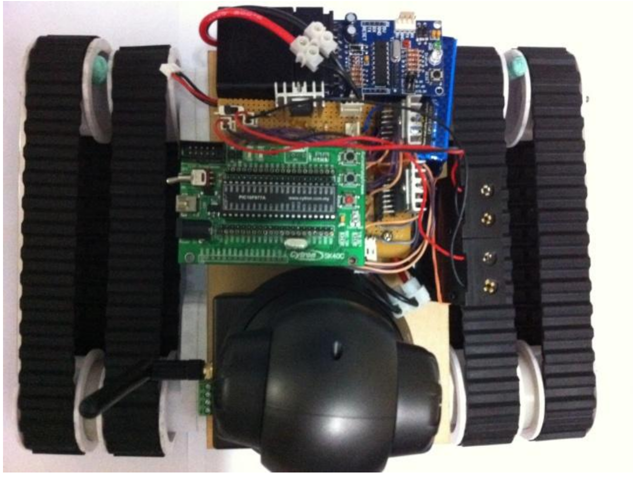


Figure 4.2: Top view of Rescue Robot

4.2 Applications

As mentioned in the early chapter, the rescue robot is used to monitoring the situation of the disaster area. The situation of the disaster area is unpredictable and unsafely. The rescue robot would have the ability to move in the several kind of surface. Figure 4.3 to Figure 4.6 show the robot move in the various surfaces.

Figure 4.3: Moving on the grass Surface

Figure 4.4: Moving on the rock surface

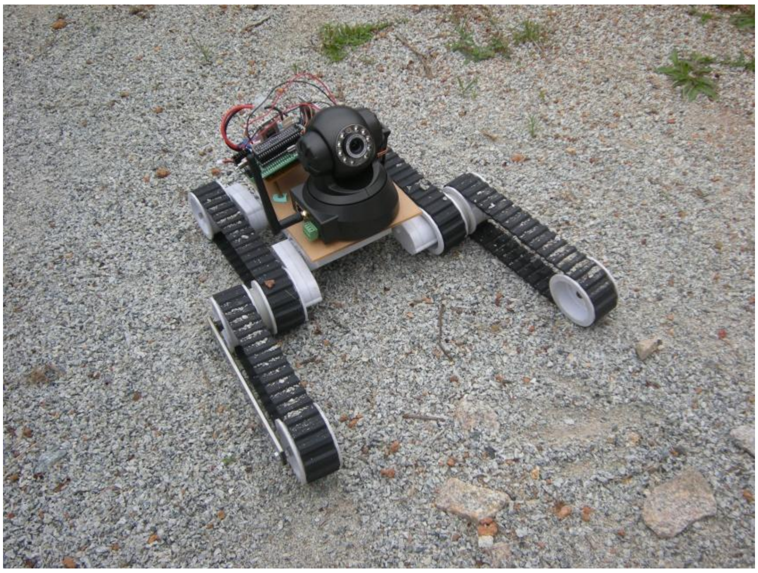


Figure 4.5: Moving on the sand surface

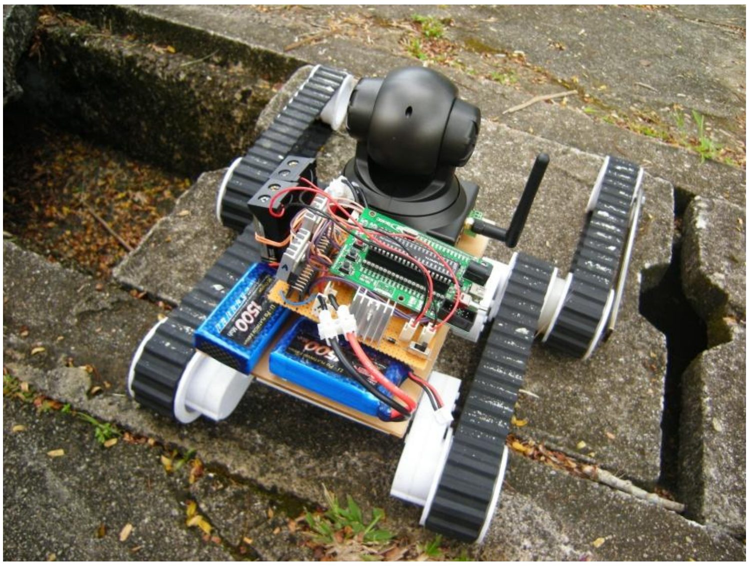


Figure 4.6: Moving on the unsafe condition

4.3 Live Video

Figures 4.7 and 4.8 show the live video received from Apexis Wireless IP Camera by laptop and smart phone. Although the resolution of the IP camera is moderate, the live video received is clear enough for the Rescue Robot applications.

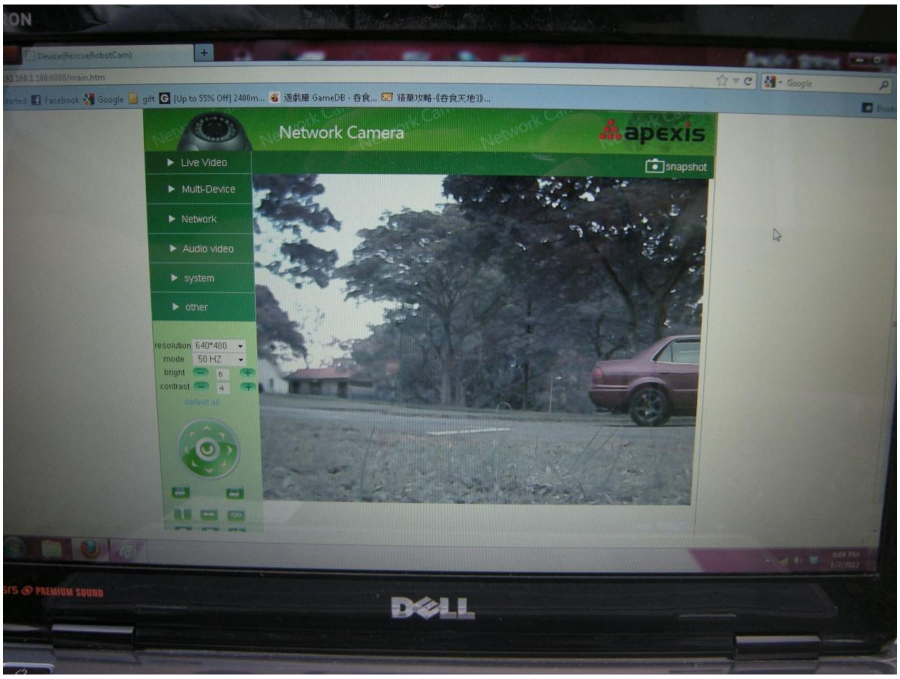


Figure 4.7: The live video received by laptop

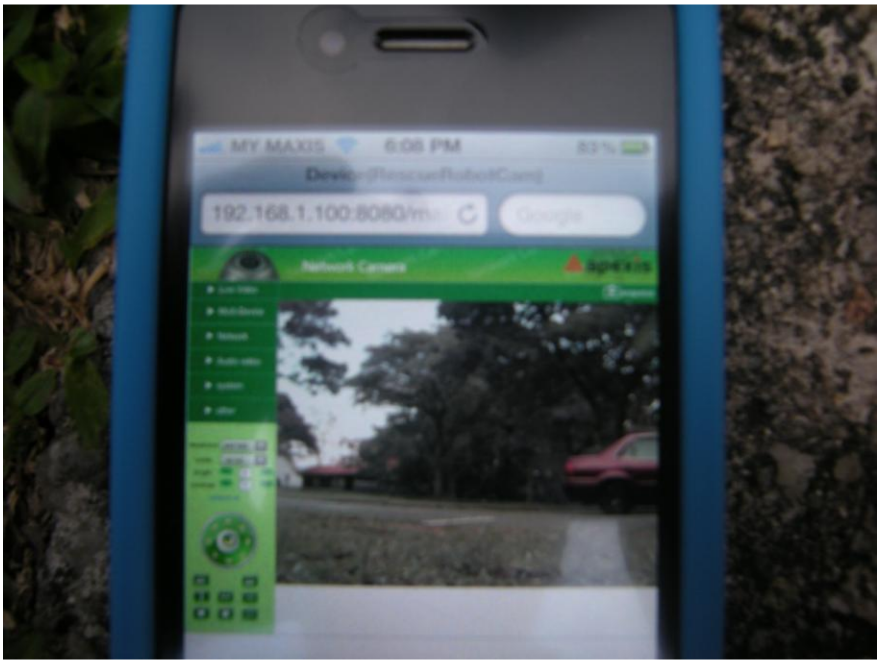


Figure 4.8: The live video received by smart phone

As mention in the previous chapter, the video from Apexis Wireless IP Camera can be view simultaneously by computer, laptop and smart phone. Figure 4.9 show the simultaneous video received by laptop and smart phone.

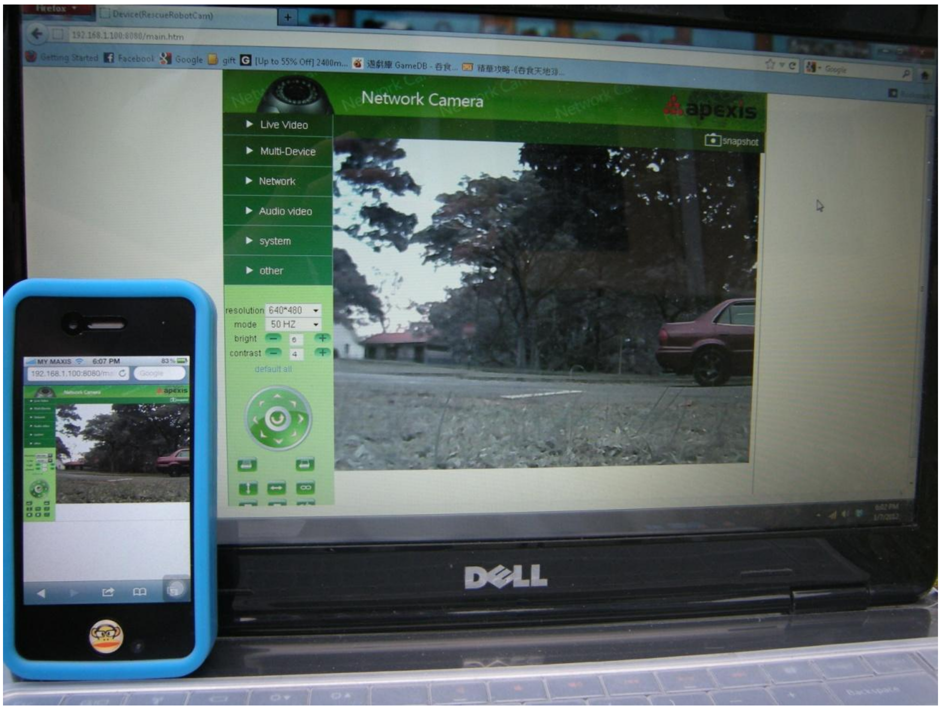


Figure 4.9: The live video received by Laptop and Smart Phone simultaneously

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the rescue robot is able to be remotely controlled by the robot operator. The live video around the rescue robot is able to feedback to the operator using the wireless IP camera. Since the operator is able to control the rescue robot and monitor the situation around the rescue robot, the rescue worker can away from the dangerous and harmful disaster area and reduce the risk of injury

Beside, the rescue robot is capable to travel on the several type of surface and avoid the specific obstacles using a modified tracked wheel structure and mechanism arms. Thus it enables the rescue robot to executes its duty smoothly and independently.

The objectives of the project are fulfilled.

5.2 Limitations

There are some limitations of this project, which are stated follows:

1. The robot structure is modified from original Rover 5 Tank Chassis Set which made from the plastic material. The plastic material is not strong enough and hard to modify by welding.
2. The PS2 controller is able to the rescue robot in the range of 2 m only.
3. The wireless IP camera is very high power consume device, a bid battery is need to operate the wireless IP camera.
4. The original motor of Rover 5 Tank Chassis Set is not enough torque to left the mechanism arms from flat position (0°).

5.3 Recommendation

For future development purpose, few suggestions are recommended as follows:

1. Do not modify the original Rover 5 Tank Chassis Set, but direct made a new tracked wheel platform with metal material.
2. Use other stronger wireless control device to replace the PS2 controller and PS2 Starter Kit in order to control the rescue robot in bigger range.
3. The Apexis wireless IP camera can be replace by a lower power consume camera or any live vision device.
4. A high torque DC motor or stepper can be use to replace the original motor of Rover 5 Tank Chassis Set.

REFERENCES

[1] Mary Bellis(2012). *The Definition of a Robot*. About.com Guide

[2] Engineering Seismology and Earthquake Engineering Research (e-SEER). (2009). Research Group: Retrived June, 28, 2012, from http://utm.simple.my/content.php?id=109&cid=81&lang=1

[3] Joseph Loh, and Rashvinjeet S. Bedi (2009, October 11). *Unshaken Complacency*. The Star. Retrieved October 11,2009, from http://thestar.com.my/news/story.asp?file=/2009/10/11/focus/4882460&sec=focus

[4] Lee, W., & Park, C. (2004). RoboCup2004 – US Open.

[5] Lee, W., Kang, S., Kim, M., & Park, M. (2004). *ROBHAZ-DT3 : Teleoperated Mobile Platform with Passively Adaptive Double-Track for Hazardous Environment Applications*, *1*, 33-38.

[6] Ohno, K., & Yoshida, T. (2009). RoboCupRescue 2009 - Robot League Team < *Pelican United (JAPAN)* > Rescue Robot League Pelican United (Japan).

[7] Germany, H. D., Graber, T., Kohlbrecher, S., Meyer, J., & Petersen, K. (2011). *RoboCupRescue 2011 - Robot League Team*, (1).

[8] Soltanzadeh, A. H., Chitsazan, A., Azizah, S., & Ghazali, S. A. (2010). RoboCupRescue 2010 - Robot League Team, *2009*.

[9] Azizah, S., & Ghazali, S. A. (2009). RoboCupRescue 2009 - Robot League Team.

[10] Soltanzadeh, A. H., Rajabi, A. H., Alizadeh, A., Eftekhari, G., & Soltanzadeh, M. (2011). RoboCupRescue 2011 - Robot League Team, *1*.

[11] Billah, M., Ahmed, M., & Farhana, S. (2008). Walking Hexapod Robot in Disaster Recovery : Developing Algorithm for Terrain Negotiation and Navigation, 328-333.

[12] Kadous, M. W., Sheh, R. K.-man, & Sammut, C. (2006). Effective User Interface Design for Rescue Robotics.

[13] M.Tandy, S.Winkvist, and K.Young(2010). Competing in the RoboCup Rescue Robot League. 1 – 15. None

[14] Mohd Syawal Bin Mohamed Abdul Fatah(2006). Tracked Wheel Development and Implementation for Mobile Robot. Bachelor Degree, Universiti Teknologi Malaysia, Skudai.

[15] Lim Choong Honn(2008). Development of A Wireless Mobile Robot. Bachelor Degree, Universiti Teknologi Malaysia, Skudai.

[16] Lee Wai Kun(2010), Wheeled Mobile Robot with Motion Control. Bachelor Degree, Universiti Teknologi Malaysia, Skudai.

[17] Singapore Robotic(2010). *Jaguar Platform User Manual*, Singapore: Singapore Robotic

[18] Cytron Technologies Sdn. Bhd(2008). *PS2 Controller Starter Kit.* Skudai, Johor: Cytron Technologies Sdn. Bhd.

[19] Microchip Technology Inc(2003). *PIC16F87XA Data Sheet*. U.S.A: Microchip Technology Inc.

[20] Fairchid Semiconductor(2001). MC78XX/LM78XX/MC78XXA 3-Terminal 1A Positive Voltage Gegulator. U.S.A: Fairchid Semiconductor

[21] STMicroelectronics(2000). Dual Full-Bridge Driver L298. U.S.A: STMicroelectronicsote

[22] Shenzhen Apexis Electronic Co.,Ltd(2011), IP Camera Remote Pan/Tilt Rotate User Manual. China: Shenzhen Apexis Electronic Co.,Ltd(2011)

Appendix A

```
//include
#include <pic.h>

//configuration
__CONFIG ( 0x3F32 );

//        define

#define SPEEDL              CCPR1L
#define SPEEDR              CCPR2L

//Selector for motor driver
#define arm_motor     RB1
#define body_motor    RB2

//left body motor
#define motor_la      RC4
#define motor_lb      RC5

//right body motor
#define motor_ra      RC0
#define motor_rb      RC3

//left lift motor
#definelmotor_armla  RB6
#definelmotor_armlb  RB5

//right lift motor
#define lmotor_armra RB4
#define lmotor_armrb RB7


//skps protocol
#definep_select            0
#define p_joyl             1
#define p_joyr             2
#define p_start            3
#define p_up               4
#define p_right            5
#define p_down             6
#define p_left             7
#definep_l2                8
#definep_r2                9
#define p_l1               10
#define p_r1               11
#define p_triangle         12
#define p_circle           13
```

```
#define p_cross            14
#definep_square            15
#define p_joy_lx           16
#definep_joy_ly            17
#define p_joy_rx           18
#define p_joy_ry           19
#define p_joy_lu           20
#define p_joy_ld           21
#define p_joy_ll           22
#define p_joy_lr           23
#define p_joy_ru           24
#define p_joy_rd           25
#define p_joy_rl           26
#define p_joy_rr           27

#definep_con_status        28
#define p_motor1           29
#define p_motor2           30


//      function prototype
//============================================================

void init(void);

void forward(void);
void stop (void);
void backward (void);
void reverse (void);
void left(void);
void right(void);

void uart_send(unsigned char data);
unsigned char uart_rec(void);
unsigned char skps(unsigned char data);
void skps_vibrate(unsigned char motor, unsigned char value);



//      main function
//============================================================

void main(void)
{
        unsigned char up_v, down_v, left_v, right_v;

        init();                 //initialize microcontroller
        stop();                 //stop all motor
```

```
	while(1)

	{

//read joy stick value process
//========================================================================

		up_v=skps(p_joy_ru);
		down_v=skps(p_joy_rd);
		left_v=skps(p_joy_ll);
		right_v=skps(p_joy_lr);


//button control for mobilility


		if(skps(p_up)==0)				//check "up" button

		{
			body_motor = 1;
			forward();				//move forward
			SPEEDL=230;
			SPEEDR=230;
		}

		else if(skps(p_down)==0)			//check "down" button
		{
			body_motor = 1;
			backward();				//move backward
			SPEEDL=230;
			SPEEDR=230;
		}

		else if(skps(p_left)==0)			//check "left" button
		{
			body_motor = 1;
			left();					//rotate left
			SPEEDL=230;
			SPEEDR=230;
		}

		else if(skps(p_right)==0)			//check "right" button
		{
			body_motor = 1;
			right();				//rotate right
			SPEEDL=230;
			SPEEDR=230;
		}

		else if(skps(p_triangle)==0)
```

```
{
arm_motor=1;

lmotor_armla=1;
lmotor_armlb=0;
lmotor_armra=1;
lmotor_armrb=0;

SPEEDL=230;
SPEEDR=230;
}

else if(skps(p_cross)==0)
{
arm_motor=1;

lmotor_armla=0;
lmotor_armlb=1;
lmotor_armra=0;
lmotor_armrb=1;

SPEEDL=230;
SPEEDR=230;
}


//analog control for mobility

else if(up_v>0)
{
	forward();
	body_motor=1;
	if(left_v>0)
	{
		if(up_v>left_v)SPEEDL=up_v-left_v+140;
		else SPEEDL=140;
		SPEEDR=up_v+140;
	}
	else if(right_v>0)
	{
		if(up_v>right_v)SPEEDR=up_v-right_v+140;
		else SPEEDR=140;
		SPEEDL=up_v+140;
	}
	else
	{
		SPEEDL=up_v+140;
		SPEEDR=up_v+140;
	}
}
```

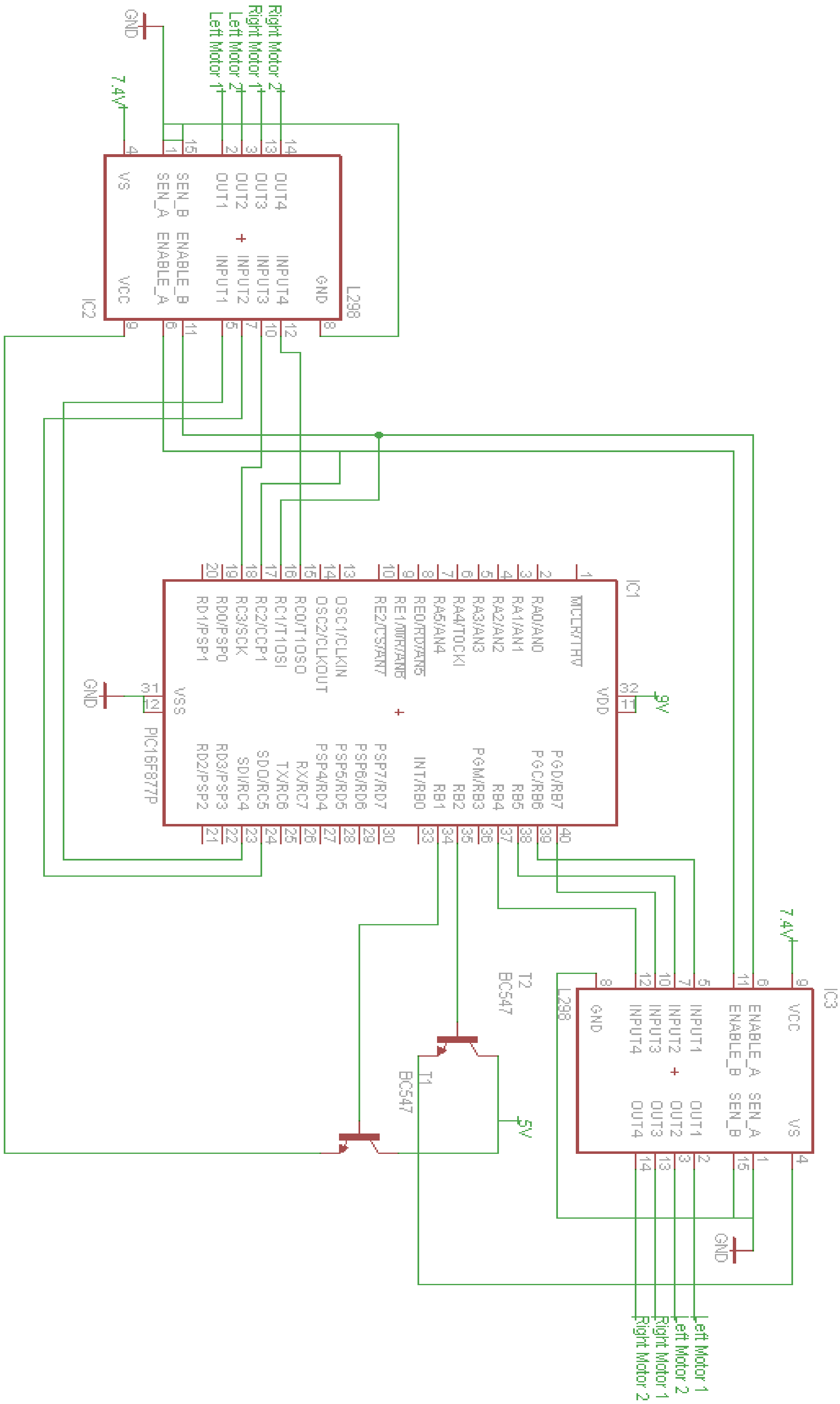
```
                else if(down_v>0)
                {
                        backward();
                        body_motor=1;
                        if(left_v>0)
                        {
                                if(down_v>left_v)SPEEDR=down_v-left_v+140;
                                else SPEEDR=140;
                                SPEEDL=down_v+140;
                        }
                        else if(right_v>0)
                        {
                                if(down_v>right_v)SPEEDL=down_v-right_v+140;
                                else SPEEDL=140;
                                SPEEDR=down_v+140;
                        }
                        else
                        {
                                SPEEDL=down_v+140;
                                SPEEDR=down_v+140;
                        }
                }

                else if(left_v>0)
                {
                        left();
                        body_motor=1;
                        SPEEDL=left_v+120;
                        SPEEDR=left_v+120;
                }

                else if(right_v>0)
                {
                        right();
                        body_motor=1;
                        SPEEDL=right_v+120;
                        SPEEDR=right_v+120;
                }

                else
                {
                        stop();
                        body_motor=0;
                        SPEEDL=255;
                        SPEEDR=255;
                }
        }

}
```

```
//============================================================

// initailization
//============================================================

void init()
{

	// motor PWM configuration

	PR2 = 255;					// set period register
	T2CON =		0b00000100;		//
	CCP1CON =	0b00001100;

// config for RC1 to generate PWM	( for more detail refer datasheet section
'capture/compare/pwm')

	CCP2CON =	0b00001100;

// config for RC2 to generate PWM

	// Tris configuration (input or output)

	TRISA = 0b00000011;		//set RA0 and RA2 pin as input,other as output
	TRISB = 0b00000000;		//set RB0-RB4 pin as input, other as output
	TRISC = 0b10000000;		//set PORTC pin as output
	TRISD = 0b00000000;		/set all PORTD pin as output
	TRISE = 0b00000000;


//setup USART

	SPBRG = 0x81;			//set baud rate to 9600 for 20Mhz
	BRGH = 1;				//baud rate high speed option
	TXEN = 1;				//enable transmission
	TX9 = 0;
	CREN = 1;				//enable reception
	SPEN = 1;				//enable serial port
	RX9 = 0;
	RCIE = 0;				//disable interrupt on eachdata received

// enable all unmasked interrupt
	GIE = 0;
	PEIE = 0;

}
```

```
//==========================================================
// uart function
//==========================================================

void uart_send(unsigned char data)   //function to send out a byte via uart
{
        while(TXIF==0);              //wait for previous data to finish send out
        TXREG=data;                  //send new data
}


unsigned char uart_rec(void)         //function to wait for a byte receive from uart
{
        unsigned char temp;
        while(RCIF==0);              //wait for data to received
        temp=RCREG;
        return temp;                 //return the received data
}


//==========================================================
// skps function
//==========================================================

unsigned char skps(unsigned char data)      //function to read button and joystick
{
        //information on ps controller
        uart_send(data);
        return uart_rec();
}

void skps_vibrate(unsigned char motor, unsigned char value)
{
        //function to control the vibrator motor
        uart_send(motor);                   //on ps controller
        uart_send(value);
}


//==========================================================
// motor control function
//==========================================================

void forward ()
{
        motor_ra = 0;
        motor_rb = 1;
        motor_la = 0;
        motor_lb = 1;
}
```

```
void backward ()
{
	motor_ra = 1;
	motor_rb = 0;
	motor_la = 1;
	motor_lb = 0;
}

void left()
{
	motor_la = 1;
	motor_lb = 0;
	motor_ra = 0;
	motor_rb = 1;
}

void right()
{
	motor_la = 0;
	motor_lb = 1;
	motor_ra = 1;
	motor_rb = 0;
}

void stop()
{
	motor_la = 0;
	motor_lb = 0;
	motor_ra = 0;
	motor_rb = 0;
	lmotor_armla = 0;
	lmotor_armlb = 0;
	lmotor_armra = 0;
	lmotor_armrb = 0;
	arm_motor = 0;
	body_motor = 0;

}
```

Appendix B


GND
7.4V
Right Motor 2
Right Motor 1
Left Motor 2
Left Motor 1
IC2
L298
IC1
PIC16F877P
9V
IC3
L298
T2
BC547
T1
BC547
5V
GND
7.4V
Left Motor 1
Left Motor 2
Right Motor 1
Right Motor 2