FIRE-FIGHTING ROBOT

by

TEH NAM KHOON

DISSERTATION

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan.

CERTIFICATION OF APPROVAL

FIRE-FIGHTING ROBOT

by

TEH NAM KHOON

A project dissertation submitted to the

Electrical and Electronics Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfillment of the requirement for the

BACHELOR of ENGINEERING (Hons)

(ELECTRICAL and ELECTRONICS ENGINEERING)

Approved by:

____

(Mr Patrick Sebastian)
Final Year Project's Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK DARUL RIDZUAN.
SEPTEMBER 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this report whereby the original work belongs to me except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(TEH NAM KHOON)

ACKNOWLEDGEMENTS

First and foremost, I would like to express my utmost gratitude and special thanks to Mr Patrick Sebastian, my Final Year Project's supervisor, for guiding me through the process in completing my final year project. He has given me lots of guidance and constructive advice on how to resolve all the problems, conundrum, and issues arise along the way in completing this project during the 8 months FYP period. Also, he has shared his precious knowledge and experience accumulated along the years in guiding through and supervising his students in all kind of projects that are related to the Robotic's field, ranging from circuit constructions, microcontroller C programming technique, and documentation work such as the technical paper and the final report. He is dedicated and committed towards his supervised students. He prefers to know my overall progress done on a weekly basis so that he can provide me some necessary and essential technical solutions, advice and guidance to aid me to overcome the issues faced.

Besides that, I would like to thank to all of my coursemates and friends, who have directly or indirectly contributed to my project. Their contributions really aid me a lot in order to complete the prototype as perfect as possible.

Additionally, I would like to extend my gratitude to FYP coordinators, Dr Zuhairi Baharudin, Dr Wong Peng Wen, Dr Nasreen, and Mr Abu Bakar Sayuti Saman for their effort in coordinating FYP proceedings. Last but not least, I would like to take this opportunity to thank to my family members, friends and lecturers for their continuous supports and encouragements given to me along the way in completing this project.

ABSTRACT

Along the way with the evolvement and advancement of science and technology, human beings tend to use robot to perform their daily routine works or some dangerous tasks such as rescuing victims from hazardous sites, whereby the rescuing tasks might pose certain level of risks to human beings. In conjunction of that reason, the ultimate goal, aim and objective of this project is to develop and implement an Autonomous Fire-Fighting Mobile Platform (AFFMP) that is equipped with the basic fire-fighting knowledge that can patrol through the hazardous sites with the aim of early detection for fire and extinguish it using the built-in fire extinguishing system on the platform itself. The AFFMP is capable to patrol the building continuously via the guiding track while at the same time, it attempts to locate for fire source by using the Flame Sensors as the primary detection. The detection for the occurrence of fire source in AFFMP is also assisted by the secondary detection sensors, which are the Heat/Temperature Sensor and the Smoke Sensor as well. Once the fire source is being identified, it will move directly towards the fire source and extinguish it in the shortest time by using the fire extinguisher that is attached to its platform. In short, the project can be considered as successful as it has achieved the expected goals and objectives.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

Fire detection and extinguishment are the hazardous job that invariably put the life of a fire fighter in danger. By putting a mobile robot to perform this task in a fire-prone area, it can aid to avoid untoward incidents or the loss of lives. This project is about the development of an Autonomous Fire Fighting Mobile Platform (AFFMP) that is equipped with the basic fire-fighting equipment that can patrol through the hazardous sites via a guiding track with the aim of early detection for fire. When the fire source is being identified, the flame will be promptly extinguished using the fire extinguishing system that is mounted on its platform. The patrolling movement is guided by a set of line with the use of a conventional line following algorithm but with the addition of a homing algorithm. The tasks for the AFFMP once it navigates out of the patrolling route include the obstacle avoidance, locating for more precise location of fire source using front flame sensor and extinguish the fire flame. To detect for fire source, the input from flame sensors were finely-tuned in relation to the surrounding area, external interference and the mobility of the AFFMP prior the deployment of the platform. The development work done to date on the platform has shown its feasibility of being an autonomous unit to monitor a prescribed area, detect for fire and extinguish the flame.

1.1 Background of Study

Fire-Fighting is an extremely dangerous task but still often being carried out by human operators, thus putting human life, invaluable as it is, in a very precarious situation. Therefore, it is highly desirable that the execution of routine and basic fire-fighting tasks to be replaced or at least partially assisted by AFFMP. There are several ways of implementation for AFFMP; however, most of them are being deployed based on the need-to-use basis. This project is quite unique in terms of its way of implementation wise, whereby the guiding track will be used to guide the AFFMP to navigate through an area for patrolling purposes and locate for fire source with its continuous monitoring feature for 24 hours per day, 7 days per week.

This report describes the work done to develop an AFFMP that monitors for occurrence of fire in a prescribed area and safely extinguish it promptly. Monitoring is done by patrolling within a guiding track while constantly scanning for fire via the flame sensors. If fire is detected, AFFMP will then attempt to locate for more precise position of the fire source. Once the location is determined, it will move out of its guiding track, approach the fire source and extinguish the flame by using the built-in fire extinguishing sub-system. When the flame is extinguished completely, it then returns to the guiding track to continue the patrolling task. All of the processes occur autonomously without any need of human controls since all processes are fully automated by using a microcontroller system, executing the fire-detection algorithm, the autonomous navigation algorithm, the line tracking algorithm and the fire extinguishing sub-system.

It is undeniably that through the utilization of robot in assisting human beings to carry out their daily routine and dangerous tasks can aid to minimize the level of risks. In another word, robot can be used as the human replacement for whatever hazardous jobs or tasks that require repetition, endurance, high efficiency and accuracy. Robot can be used in almost all fields or areas, ranging from manufacturing industry, assembly line for components and parts, agriculture, healthcare, doing house-chores to ease human lives or even entertainment as well. Time has proven the capabilities, performance, contributions and the role of robots to the people in the society.

1.2 Problem Statement

Fire-fighting task is one of the extreme and dangerous tasks to be carried out by human beings generally or specifically the firefighters. Theoretically, the execution of the routine and basic fire-fighting tasks can be assisted or partially replaced by robots. Hence, this embedded project owns the practicality of implementation in the real industry based. This project requires me to design and implement an Autonomous Fire-Fighting Mobile Platform that has the practicality of implementation in the real hazardous sites, attract my field of interests and attentions. Upon the completion of this project, the AFFMP, which is equipped with the basic fire-fighting knowledge is hoped to share out the burden of fire-fighters and reduce the risks associated with the fire-fighting tasks encountered by the fire-fighters tremendously.

1.3 Objectives and Scope of Study

The main objective of this project is to design and implement an Autonomous Fire Fighting Mobile Platform that is able to patrol and monitor a prescribed area, detect for the occurrence of fire, locate for exact location of fire source, extinguish the flame and safely return to continue with the patrolling of the area once the extinguishing task is completed. By employing the patrolling feature, flame detection feature and self fire extinguishing feature in the AFFMP, the burden of fire-fighters on fire-fighting tasks can be at least shared and assisted by AFFMP. The priority of this project is the fire detection capabilities and its accuracy. Overall, at the end of this project, it is aimed that the prototype is able to function accordingly to its initial design with minimum level of error.

1.4 Feasibility, Relevancy, and Significant of Project

According to a simple survey that has been conducted from 10/1/2012 to 23/2/2012 period by using the SurveyMonkey.com, it has proven that the Autonomous Fire-Fighting Mobile Platform is quite practical and possible to be implemented. The survey has shown that out of the total of 41 respondents, there are 30 respondents felt that the Autonomous Fire-Fighting Mobile Platform is essential and necessary in our daily lives to execute the dangerous fire-fighting tasks. For more details, please refer to Figure 1.

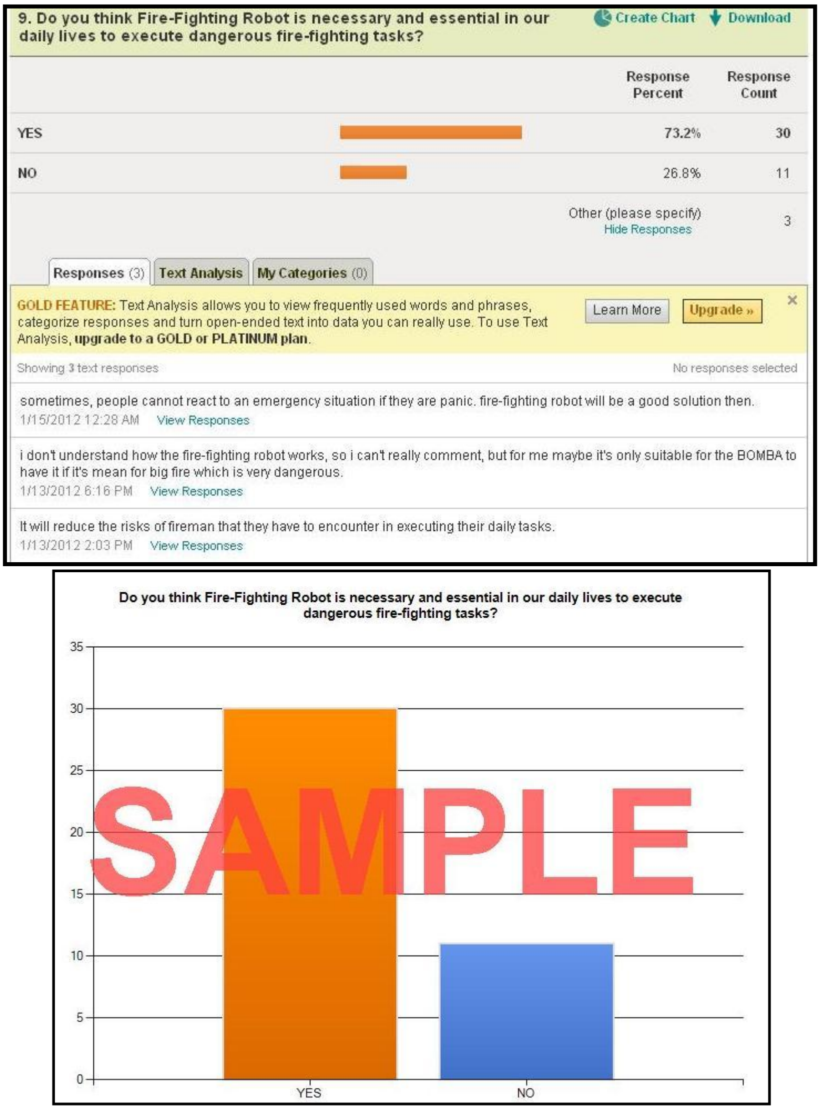
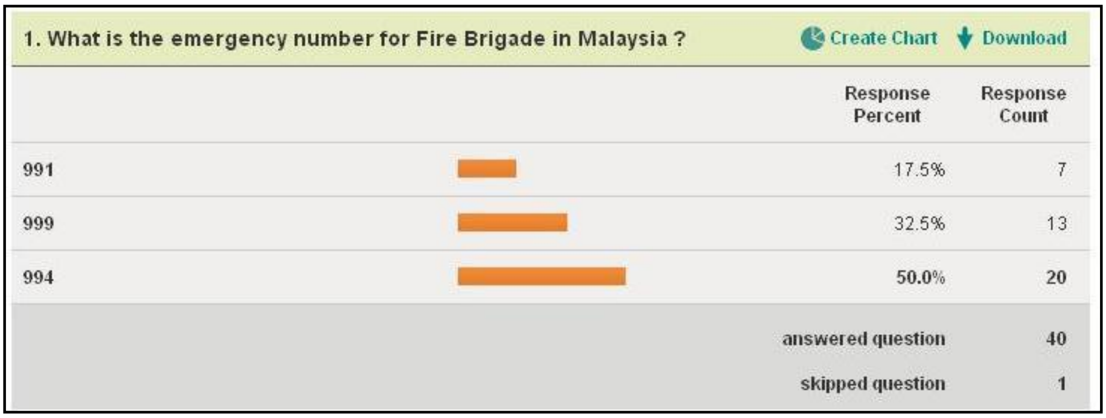


Figure 1 A survey to collect the respondent's responses on the need of having Autonomous Fire-Fighting Mobile Platform.

Also, according to the responses collected from the survey, it has proven that only 50% of the respondents know the most direct emergency number for Fire Brigade in Malaysia, which is 994. For further information, please refer to Figure 2. It is undeniably that the victims can call to 999 or 991 first and request for the operator to divert the call to fire brigade department. However, the timing does play a vital and crucial role in such an emergency situation. If the victims wish to request for help but do not channel it to the proper and correct department directly, then for sure there will be some delays in the rescuing process. During emergency cases, every single second counts since the timing becomes the key factor of success for rescuing work to be carried out immediately. Hence, it is quite obvious that it is necessary and essential of having the Autonomous Fire-Fighting Mobile Platform.



1. What is the emergency number for Fire Brigade in Malaysia ?	Response Percent	Response Count
991	17.5%	7
999	32.5%	13
994	50.0%	20
	answered question	40
	skipped question	1

Figure 2 A survey to collect the respondent's responses on the Direct Emergency Number for Fire Brigade.

Based on the study and research that have been conducted so far, it has shown that the scope of study and objectives of AFFMP are clear and concise. This project is quite feasible and able to be completed within the allocated time frame for FYP. The outcome of this project will be based on the objectives set during the initial planning stage.

*** Note: For more details about this survey, please refer to Appendix Q.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview of an Autonomous Mobile Platform

Basically, there are a variety of ideas and implementations of mobile robots that can operate in hazardous situations, which are introduced, enhanced and upgraded from time to time. An example is a mobile robot that can be used to rescue and evacuate people in disasters, such as from the on fire building, earthquake sites and others. Some of the works are described in the following sections.

Fire Searcher is a robot designed for usage in the extreme conditions such as high temperatures or poisonous gases. It monitors the internal situation of a fire site and victims and sends back crucial information to its operator at a remote site [1]. Meanwhile, Jet Fighter is a type of Autonomous Fire Fighting Mobile Platform that is introduced by Tokyo Fire Department. It can be operated and controlled by remote user and has the ability to extingusih flame after locating the source of fire. It is equipped with a monitoring system and operates through a wireless communication system. It is equipped with an obstacles avoidance system embedded into its autonomous navigation system [2].

Furthermore, there is another type of portable Autonomous Fire Fighting Mobile Platform that is specifically designed to be thrown into the fire site to collect data and information, search for victims and evacuate them from the fire site [3]. It can be controlled by the operator and the victims are able to communicate with the operator by using the built-in microphone and speaker system during emergency cases [3]. Also, this system contains the camera to capture the scene of fire site, sensors for temperature measurement, CO_2 and O_2 concentration measurement [3]. Since it is specially designed to be thrown into the fire site, it can withstand with high temperature, over 1500^0C, waterproofed and has impact resistance feature [3].

A mobile platform can also be built around a wireless sensor network for its intra-system communication, for example using zigbee wireless communication modules. It allows for relatively huge data transfer such as video and audio from the robot to a remote control centre. It also allows for tracking the robot's position through the signal strength of the wireless sensor network [4].

BEAR (Battlefield Extraction-Assist Robot) by Vecnarobotics is a type of rescuing robot built in form of a humanoid that can lift and carry victims for casualty extraction, unsafe building evacuation, and also searching and rescuing work. However, its cost is prohibitive [5]. Tehzeeb is another type of rescuing robot that uses laser scanner module, a manipulator and map generation algorithms for localisation and navigation in visually poor situation such as in dense smoke surrounding [3]. Table 1 summarizes all the key features for each of the previous related projects.

Related Projects/Works :

1. Daniel J. Pack; Robert Avanzato; David J. Ahlgren; Igor M. Verner; "**Fire-Fighting Mobile Robotics and Interdisciplinary Design-Comparative Perspectives**", IEEE Transactions on Education, 3 August, 2004, Volume 47, No. 3.
2. Hongke Xu; Hao Chen; Chao Cai; Xunzhao Guo; Jianwu Fang; Zhu Sun; "**Design and Implementation of Mobile Robot Remote Fire Alarm System**", Intelligence Science and Information Engineering, 2011 International Conference, Pages:43-47.
3. Jared Harwayne-Gidansky; Michael Sudano; "**A Low-Complexity Navigation Algorithm for a Scalable Autonomous Firefighting Vehicle**", Research and Development, the 5th Student Conference-SCOReD 2007, 11-12 December 2007.
4. Kashif Altaf; Aisha Akbar; Bilal Ijaz; "**Design and Construction of an Autonomous Fire Fighting Robot**", 2007 IEEE.
5. Kuo L. Su; "**Automatic Fire Detection System Using Adaptive Fusion Algorithm for Fire Fighting Robot**", Systems, Man, and Cybernetics, IEEE International Conference, 8-11 October 2006, Pages:966-971.
6. Scott Dearie; Kevin Fisher; Brian Rajala; Steven Wasson; "**Design and Construction of a Fully Autonomous Fire Fighting Robot**", 2004 IEEE, Pages:303-310.
7. Shuying Zhao; Wenjun Tan; Shiguang Wen; Chongshuang Guo; "**Research on Robotic Education Based on LEGO Bricks**", Computer Science and Software Engineering, 2008 International Conference, Pages:733-847.
8. Ting L. Chien; Jr H. Guo; Kuo L. Su; Sheng V. Shiau; "**Develop a Multiple Interface Based Fire Fighting Robot**", Proceedings of International Conference on Mechatronics on 8-10 May2007, Pages:1-6.
9. Young-Duk Kim; Yoon-Gu Kim; Seung-Hyun Lee;Jeong-Ho Kang; Jinung An; "**Portable Fire Evacuation Guide Robot System**", Intelligent Robots and Systems, IEEE/RSJ International Conference, 11-15 October 2009. Pages:2789-2794.

Related Projects/Works :

Features	1	2	3	4	5	6	7	8	9
Rigid Body Chassis Structure	√	√	√	√	√	√	√	√	√
Navigation System	√	√	√	√	√	√	√	√	√
Obstacle Avoidance System	√	√	√	√	√	X	√	√	X
Microcontroller Used	Motorola 68HC11	STC89C52	PIC18F452	ATMEGA 16	MCS-51	68HC12	LEGO Control Computer	Industry PC	Embedded OS
Flame Detection System	√	√	√	√	√	√	√	√	√
Remote Supervising System	X	X	X	X	√	X	X	X	√
Fire Extinguishing System	12V Fan	X	X	12V Fan	X	X	12V Fan	12V Fan	X
Photoelectric Line Sensors	X	√	X	X	X	X	√	X	X
Infrared Line Sensors	√	X	X	√	√	X	X	√	X
Ultrasonic Sensors	√	√	X	√	√	X	√	√	X
Smoke Sensors	X	√	X	X	X	X	X	X	X
Communication Module	X	√	X	X	√	X	X	√	√
Candle as fire source	√	√	√	√	√	√	√	√	√
		Far-infrared flame sensor	Phototransistors Sharp Range Finder	Infrared LED Emitter LDR Receiver		Phototransistors			High Temp. Waterproofing High impact resistance

Table 1 Comparison of features among all the previous projects.

Overall, the main approach used to develop the AFFMP was quite conventional and straight forward. Fundamentally, it was designed to detect for obstacles, the existence of walls and flames [2,4]. Thus, it must possesses a good wall-following algorithm, for instance, it depends on the brightness level of the colors on the wall, either black or white [8]. In order to improve the accuracy of the flame detection system, the AFFMP may need to move closer to the fire source (around 30cm from the fire source) and even closer to extinguish it [2, 4]. The AFFMP was designed to navigate through a specific designed maze that consists of many rooms and connecting paths, search for fire (usually simulated by a candle flame), extinguish the fire in the shortest time period and return back to the original position [2]. Some of the key features for AFFMP are summarized in the following section:

2.2 Line Following

4 sets of infrared (IR) sensors were used to implement the line following feature on the AFFMP. Each set of IR sensors were arranged side by side for both IR emitter and IR receiver [9]. The different level of IR reflection created by the black lines and white lines become the principle of working for the line detector [9]. Different voltage levels will be generated depending on the output from the IR receiver, whether there is any reflected light from the reflective lines [9]. Once the IR sensor detects the line, it will give logic '1' and vice versa [7]. The outputs from IR sensors are fed into the interrupt pin of the microcontroller so that the AFFMP can adjust itself to keep its body always within the line track automatically [11].

An IR sensor usually has an angle of 45^0 from the x-axis of the infrared radiation beam [7]. Normally, the IR Sensors is having the viewing angle of ±15º [6]. If the AFFMP is using 5 IR sensors, then the total coverage of IR Sensors are 150º ±75º [6]. Alternatively, IR phototransistors can also be used for flame detection purposes [6, 8, 9]. For optimum performance, stability and reliability of the line tracking system, the IR sensors should be placed on the centerline of the AFFMP's body chassis symmetrically [9].

There is another approach of utilizing 2 IR sensors to implement the line following feature as well [13]. Logic '0' is used to indicate that the AFFMP is out of the line while logic '1' signifies that the AFFMP is within the line, as summarized in Table 2 [13].

Left Sensor	Right Sensor	Conditions
0	0	Whole robot is outside the line track.
0	1	Left side of the robot is outside of the line track.
1	0	Right side of the robot is outside of the line track.
1	1	Whole robot is within the line track.

Table 2 The conditions/states of both IR Sensors [13].

2.3 Flame Detection

The flame detection module was built around flame sensors. The analog output from the flame sensors were fed into the analog to digital signal converter (ADC) input pin of the microcontroller. When the output from the flame sensor is greater than the minimum preset threshold value, it signifies that there is a fire source in front of the AFFMP. The minimum threshold was set based on the desired sensitivity, overall performance, reduced-interference and the mobility of the AFFMP.

If the minimum threshold value is set to high, then the sensitivity of the sensing mode will be reduced. Also, the stability and accuracy of the sensing mode will be compromised and traded off as well. The output value of the Flame Sensors will increase gradually when the AFFMP is moving closer to the fire source. By having a single flame sensor on the mobile platform, the region covered by the AFFMP might be quite limited. However, if the AFFMP is made to turn around for 360 degrees, the coverage of the AFFMP increases tremendously [6, 9].

The AFFMP was also designed to adapt to various kind of environments with different levels of light intensity by using the Dynamic Method to set the minimum threshold value as described below [9]:

1) The AFFMP will capture the intensity of any given environment for 10 times via the Flame Sensor’s readings without any fire source.

2) The data is then processed using the Median Average Filtering Method. The maximum and minimum data are eliminated as they are the outliers that will affect the accuracy for flame detection.
3) The remaining 8 values are used to calculate for the average value.
4) The average value is then added with an offset value, delta T = 4 so that the random interference is taken into account and considerations.

2.4 Obstacle Avoidance

Obstacle avoidance is the additional feature that can be embedded into the robotics system so that it will not collide or hit with any obstacles during the navigation process [2]. This measure is taken so that the AFFMP can move freely without any collisions with any obstacles [6]. It can be implemented by using ultrasonic sensors. Basically, there are two terms defined in the obstacles avoidance module, which are the "free space" and "obstacle" [7]. The safe distance between the AFFMP and the obstacle, D_s is updated from time to time while the AFFMP is navigating, which will keep the AFFMP not too close to any obstacles [7]. The relationship of the ultrasonic sensor and its distance is given by [7]:

$$D_{ultrasonic} = \{ \begin{matrix} 1, D_s \leq D_{safe} \\ \frac{D_{safe}}{D_s}, D_s \rangle D_{safe} \end{matrix} \qquad \text{(Eqn. 1)}$$

where D_{safe} is the preset threshold value (constant) for the distance between the Mobile Platform and the obstacle while D_s is the value that changes continuously when the Mobile Platform navigates around. If the Mobile Platform is not approaching to any obstacles, then its $D_{ultrasonic}$ value will be always equal to 1. When the Mobile Platform gets too closed with any obstacles, the D_s value will be greater than the D_{safe} value and thus yields a $D_{ultrasonic}$ value which is less than 1.

The obstacle avoidance module is implemented by converting the analog output from the ultrasonic sensor into digital form by using the 8 bits A/D converter inside the microcontroller and performs a comparison with the previously set threshold value to see whether the AFFMP is too closed with any obstacles [6, 10]. The obstacle bits will be set in another register if any obstacles are detected [6]. Alternatively, instead of using the ultrasonic sensor, the ranging sensor (Sharp GP2D120) can also be used for obstacle detection and avoidance purpose as well [6, 8, 10]. It has the detection range of 9cm to 80cm, whereby the voltage is inversely proportional to the distance of the AFFMP from the wall [10].

2.5 Fire Extinguishing

The fire extinguishing system is activated once the Flame Sensors detects that there is a fire source and the distance between the Autonomous Fire Fighting Mobile Platform and the fire source is closed enough [6]. The fire extinguishing system that is commonly used in the Autonomous Fire Fighting Mobile Platform is the DC Fan in order to blow off the candle flame [8, 11]. There are some other alternatives of fire extinguisher tools, for example, the robotic snuffers or computer controlled CO_2 streams that can be used as the fire extinguishing system [8]. Table 3 shows the different classes of fires caused by various materials while Table 4 shows the various types of fire extinguishers that can used to put off each class of fires.

Class of Fires	**Materials**
A	Solids (Paper, Wood, Plastic).
B	Liquids (Paraffin, Petrol, Oil).
C	Gases (Propane, Butane, Methane).
D	Metals (Sodium, Lithium, Manganese, Aluminium, Magnesium, Titanium in the form of swarf).
E	Electrical Apparatus.
F	Cooking oil & fat.

Table 3 Class of Fires [12].

Types of Fire Extinguisher	**Characteristics**
Water	-Cheapest and commonly used to put off Class A fire. -Not suitable for Class B fire.
Foam	-Slightly expensive than water type. -Used to put off Class A and B fires. -Not suitable for fire involves electricity.
Dry Powder	-Multipurpose Extinguisher. -Used for Class A, B, and C fires. -Best for running liquid fires (Class B). -Effectively extinguishes Class C Gas fire.
Carbon dioxide	-Ideal for fires involves electrical apparatus. -Disadvantages: Fire might re-ignite for Class B liquid fire.
Wet chemical	-Used to put off Class F fire.
Metal	-Used to put off Class D fire.

Table 4 Types of Fire Extinguishers [12].

CHAPTER 3
METHODOLOGY

3.1 Research Methodology

The implementation of this project involves the construction of the Autonomous Fire Fighting Mobile Platform (AFFMP), interfacing of hardware such as the motor driver circuitry, LDR sensors circuitry, Flame Sensors, Heat/Temperature Sensor, Smoke Sensor and the developed algorithm for the microcontroller to provide artificial intelligence to the Mobile Platform itself. The priority of this project is the fire detection capabilities and its accuracy for flame detection though the developed algorithm, preferably at the minimum level of error as possible. The overall flow of the whole project is shown in Figure 3.

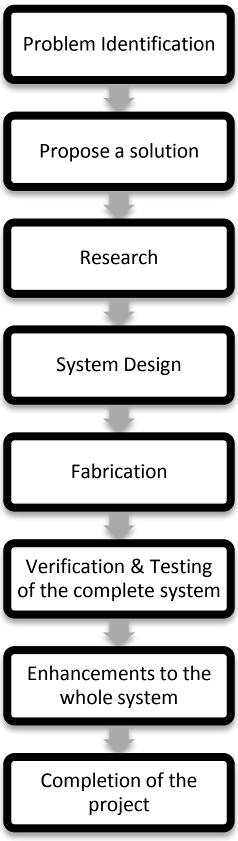


Figure 3 The flows of the project.

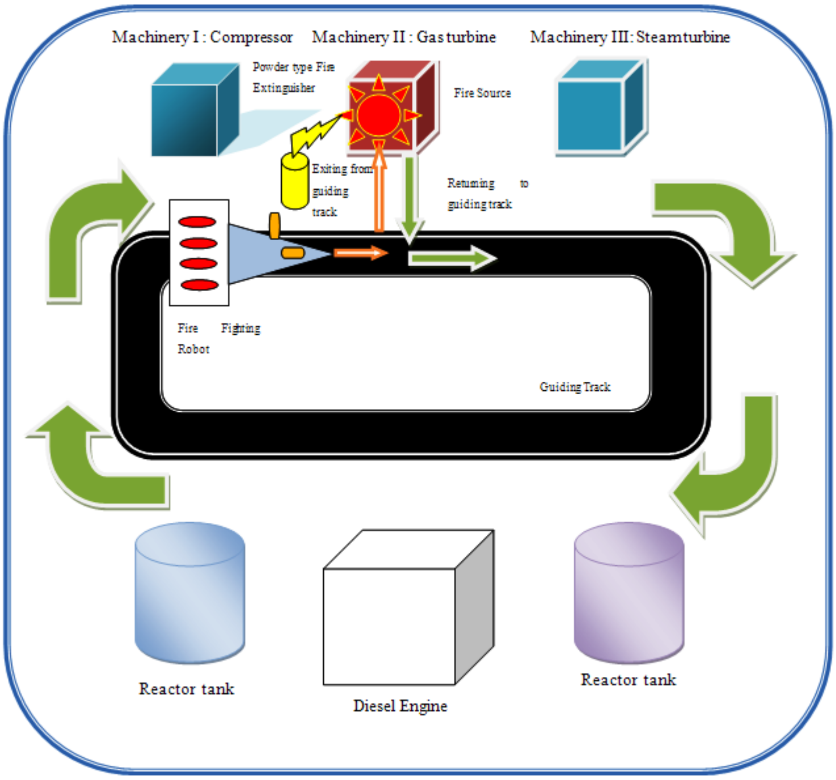


Figure 4 The working principle of AFFMP.

Figure 4 visually illustrates how the AFFMP works. The PIC16F877A microcontroller chip is plugged into the SK40C board. The MPLAB Integrated Development Environment (IDE) is the interface used to develop the C algorithm to provide the intelligence to the AFFMP. Each functional module will be developed in separate sub-functions and it will be called from the main module of the C algorithm. For verification purposes on the developed algorithm, the PIC16F Simulator Integrated Development Environment (IDE) is used to simulate the overall functionality of the coding to ensure its functionality is correct and accurate. Once the coding is verified to be working correctly, the algorithm will be compiled and loaded into the PIC microcontroller chip on SK40C board by using the JTAG Programmer Cable

.

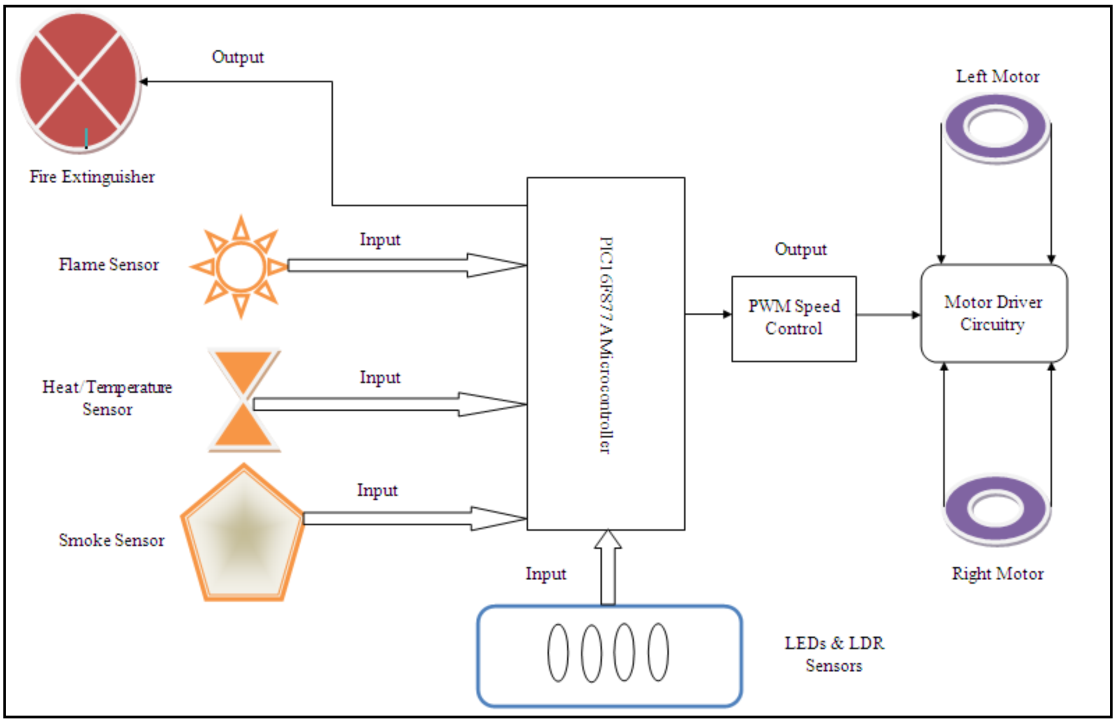
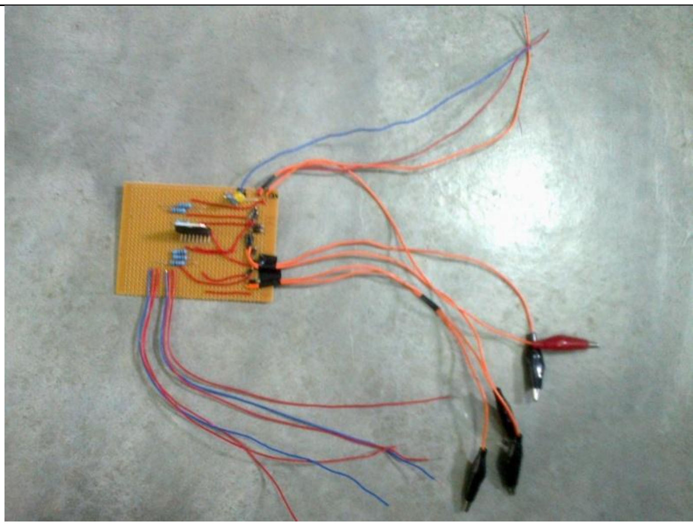
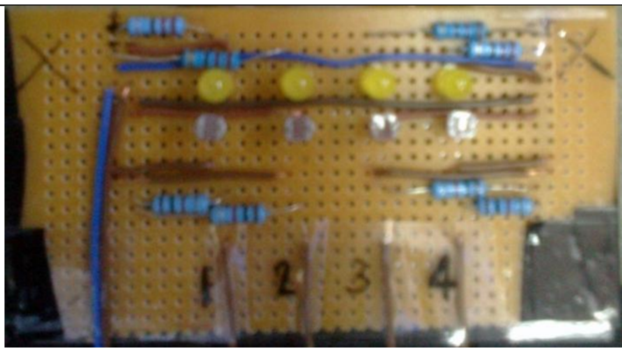
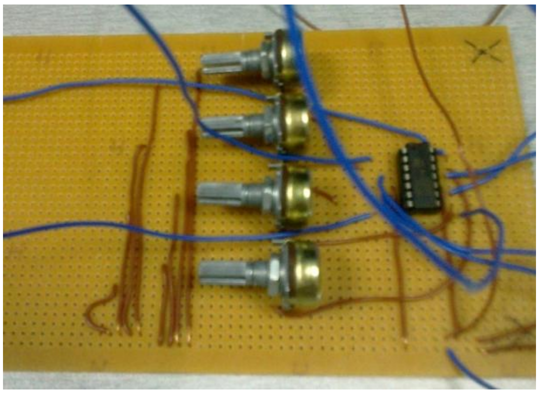


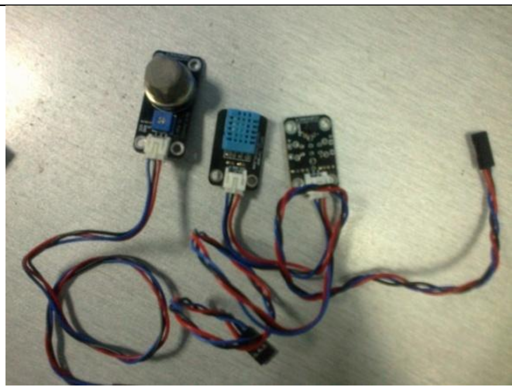
Figure 5 The block diagram for the complete AFFMP.

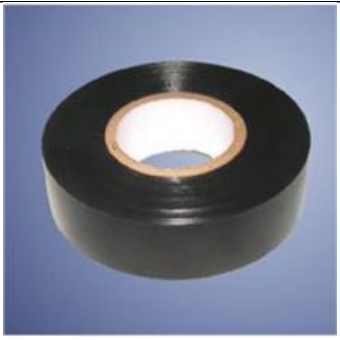
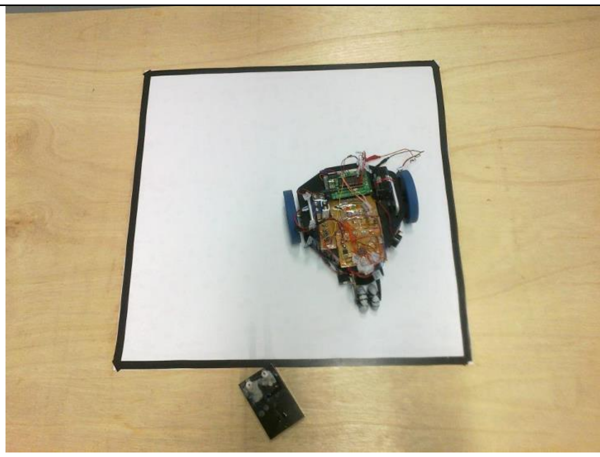
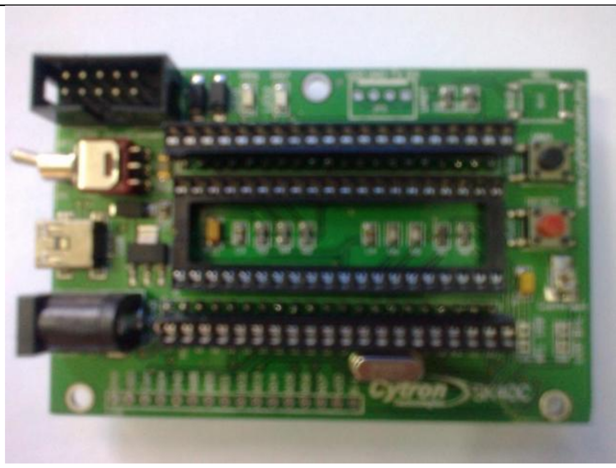
Figure 5 shows the block diagram of the developed AFFMP, which is capable to patrol the hazardous sites via the guiding track and perform real-time checking for fire source. The lightest 1kg powder type fire extinguisher can be used in the fire extinguishing system since it can put off almost all classes of fires. However, due to budget constraint and no collaboration with the fire extinguisher distributors for project development, the fire extinguishing system is being replaced with the 6V DC fan to blow off the candle flame. AFFMP has 5 different power supplies with common ground, each of them is used to power up motor driver circuitry (9V Alkaline battery), SK40C main board (9V Zinc Chloride battery via 7805 voltage regulator), LDR sensors circuitry (9V Alkaline battery via 7805 voltage regulator), Flame Sensors, Heat/Temperature Sensor, Smoke Sensor circuitry and DC fan (9V Alkaline battery via 7805 voltage regulator).

Four pairs of super bright white LEDs (Emitter) and LDRs sensors (Receiver), as shown in Appendix I, are being utilized for line following feature to ensure the AFFMP always aligns itself within the guiding track if no fire source is detected. The arrangement of the LDR Sensors are put side by side between the LED (Emitter) and LDR (Receiver), installed on the front part the AFFMP body chassis symmetrically, namely as left sensor, middle left sensor, middle right sensor, and right sensor. The analog outputs from LDR sensors are fed into a comparator and later on to the digital pins of the microcontroller.

Table 5 summarizes all the components and sub-modules that are integrated in the AFFMP.

No.	Hardware	Illustrations
1	**Motor Driver Circuitry**	 Function: **To drive the DC motors on the AFFMP.** Please refer to Appendix H for schematic.
2	**LEDs & LDRs Sensors Circuitry**	 **<u>LEDs(Emitter) & LDRs(Receiver) Circuitry.</u>**  **<u>Comparator Circuitry to adjust the sensitivity of LDR sensors.</u>**

		Function: **To implement the line following feature to keep the AFFMP always aligns within the black color guiding track.** Please refer to Appendix I for schematic.
3	**Fire Extinguishing System (6V DC Fan)**	 Function: **To extinguish the fire source (Candle flame). (Act as temporary Fire Extinguishing System).** Please refer to Appendix J for schematic.
4	**Flame Sensor**	 Function: **To detect for flame / fire source.** Please refer to Appendix K for datasheet.
5	**Heat / Temperature Sensor & Smoke Sensor**	 Function : **Smoke Sensor to detect for smoke. (Leftmost)** **Heat Sensor to measure for heat/temperature. (Middle)** Please refer to Appendix L & Appendix M for datasheet.

6	**Guiding Track (Black Insulation Tape)**	 Function: **Serves as the guiding track to the AFFMP.**
7	**Plywood Gamefield (4 inch X 8 inch)**	 Function: **Acts as a game field to the AFFMP. Black insulation tape will be pasted on it to define the track.**
8	**PIC16F877A Microcontroller**	 Function: **To provide intelligence to the AFFMP.**
9	**SK40C Board**	 Function**: To program the PIC chip and provide input pins and output pins interface to the AFFMP.** Please refer to Appendix F for schematic.

10	**JTAG CABLE**	 Function: **To load the C coding inside MPLAB interface into the PIC chip.**
11	**Power Supply to SK40C Board (9V)** **Normal Current (~19.46mA)**	 Function: **To provide Vcc (5V) and GND (0V) to the SK40C Board.**
12	**Power Supply to Motor Driver Circuitry** **(9V)** **Higher Current (~20.00mA)**	 Function: **To provide Vss (9V) and 0V (GND) to the Motor Driver Circuitry.**
13	**Fire Source Indicator – Candle Flame**	

Table 5 The main components / elements in AFFMP.

Figure 6 shows the implementation of the line following feature by using 4 LDR sensors while Table 6 provides the detailed descriptions of necessary movements to the AFFMP, depending on the states of each LDR sensors. By default, LDR sensors will yield logic ‘1’ since white background reflects back all the emitted lights and the sensor's output will be logic '0' if black strip line is detected as black line absorbs all the emitted lights.

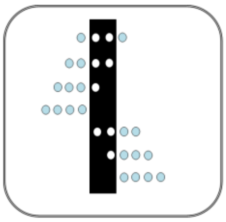


Figure 6 Implementation of the Line following feature by using LDR sensors to the AFFMP.

Case	Left Sensor	Middle Left Sensor	Middle Right Sensor	Right Sensor	Necessary Movements
1	1	0	0	1	Forward
2	1	1	0	0	Right (1 unit), Forward
3	1	1	1	0	Right (2 units), Forward
4	1	1	1	1	Based on most recently memory position, Right (3 units), Forward
5	0	0	1	1	Left (1 unit), Forward
6	0	1	1	1	Left (2 units), Forward
7	1	1	1	1	Based on most recently memory position, Right (3 units), Forward

Table 6 Case by case implementation for line following feature.

Since the light intensity in every environment is slightly different, during the initial startup of the platform, the Dynamic Method will be adapted to set the minimum threshold value for the side Flame Sensor in order to avoid for false positive detection of fire flame by tuning the adjustable resistor [2]. The false positive detection of flame can be avoided through pre-calibration or fined-tuned before AFFMP is set to execute the fire-fighting tasks. For instance, during the pre-deployment of AFFMP, the ambience of environment such as the light intensity will be collected by adapting the Dynamic Method, analyzed and filtered in order to increase the accuracy of the flame detection on AFFMP.

The flame sensor used in this project is capable to detect for flame's wavelength ranging from 760nm to 1100nm whereby it covers for visible spectrum and partially of the infrared spectrum, as shown in Appendix K [14, 15]. The primary inspection of fire source is done by Flame Sensor by feeding its analog output into a comparator to be compared with the preset threshold value and later on to digital pin of the microcontroller. Other than the primary inspection, the AFFMP is also equipped with secondary inspection for fire source, which are the Smoke Sensor and the Heat/Temperature Sensor. If any fire source is being detected, the AFFMP will stop from moving forward and turns perpendicular 90^0 out of the guiding track and heads towards the fire source.

Once the AFFMP exits from the guiding track, the mounted fire extinguishing system will start to extinguish the fire automatically. Once the fire is being extinguished, the AFFMP will reverse back the route and return back into the guiding track to continue the patrolling task.

Also, the obstacle avoidance feature can be implemented into the system as well to prevent the AFFMP from hitting or colliding with any objects-like obstacles by using the Ultrasonic Sensor if the timeframe for FYP permits. The distance between the AFFMP and the obstacle can be tuned or adjusted accordingly through experiments.

Appendix A, B, C, D, and Appendix E show the progress of constructing the AFFMP. For the interfacing of hardware and software, please refer to Appendix F, G, H, I, and Appendix J. For complete sourcecode of AFFMP, please refer to Appendix P. The flowchart in Figure 7 describes the overall implementation of algorithm for the Autonomous Fire Fighting Mobile Platform.

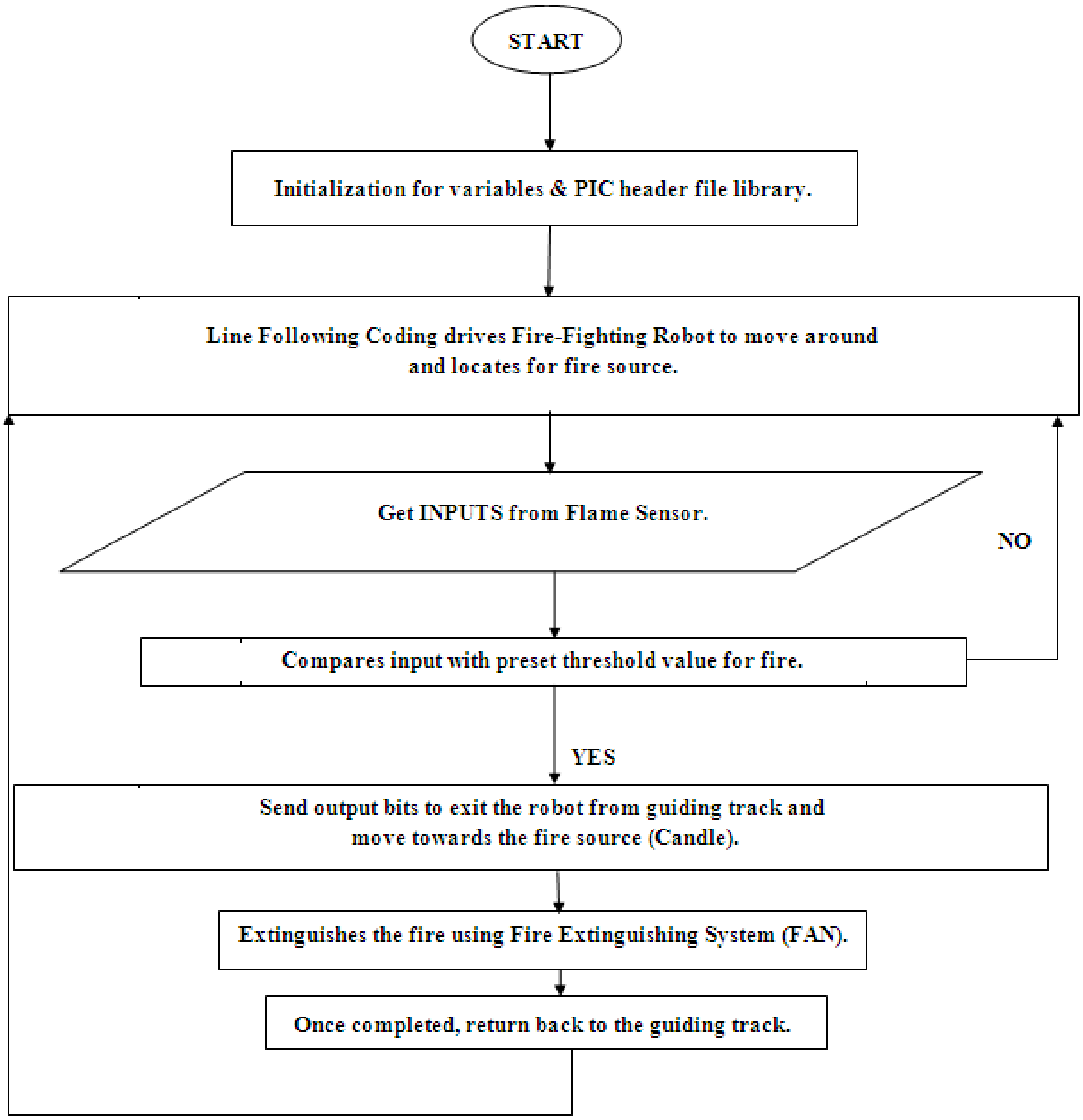


Figure 7 The overall flowchart for algorithm implementation.

For the software section, the development of the algorithm involves the stages of

i. Basic movements coding (Forward, Backward, Left, Right, and Stop) with speed control using PWM technique.
ii. Line following algorithm.
iii. Flame detection algorithm.
iv. Fire extinguishing system activation algorithm.
v. Return back to the guiding track algorithm once the flame is put off.

3.2 Project Activities

This project involves the following tasks:

i. Builds up the AFFMP's body, wheels and motors.
ii. Integrates all sorts of sub-systems, ranging from LDR Sensors Circuitry, Motor Driver Circuitry, Flame Sensors, Heat/Temperature Sensor, Smoke Sensor Circuitry and the SK40C Microcontroller Circuitry.
iii. Develops the C coding to provide intelligence to the AFFMP by using PIC 16F877A microcontroller.
iv. Performs full test run of the AFFMP and ensure for its stable performance.

3.3 Key Milestone

First Stage :	
1) Builds the AFFMP's body, wheels and motors.	Done
2) Purchasing of all components: Sensors, Rechargeable Battery& Charger, LDR Sensors, and etc.	Done
Second Stage :	
Hardware Section:	
1) Designs and constructs the Motor Driver Circuitry to drive the DC Motors.	Done
2) Designs and constructs the LDR Sensors Circuitry for line tracking purpose.	Done
3) Designs and constructs the Fire Extinguishing System with its holder.	Done
4) Integrates all working parts of circuitry including sensors to the AFFMP.	Done
Software Section:	
1) Develops the basic movements coding: Left, Right, Forward, Backward, and Stop. -Controls the speed of the AFFMP by using Pulse Width Modulation (PWM) technique inside the coding.	Done
2) Develops line following algorithm for the AFFMP to run on track.	Done

3)	Develops flame detection algorithm and respond towards the flame. Once extinguished the flame, return back to the guiding track and continue the patrolling feature.	Done
4)	Combines all the modules / codes as a complete system. Full test run of the AFFMP.	Done
Third Stage:		
1.	Troubleshooting and fine tuning to ensure the AFFMP functions properly. -Measurements for each subsystem module as results. -Video recording session as backup.	Done

Table 7 Key Milestone.

3.4 Gantt Chart

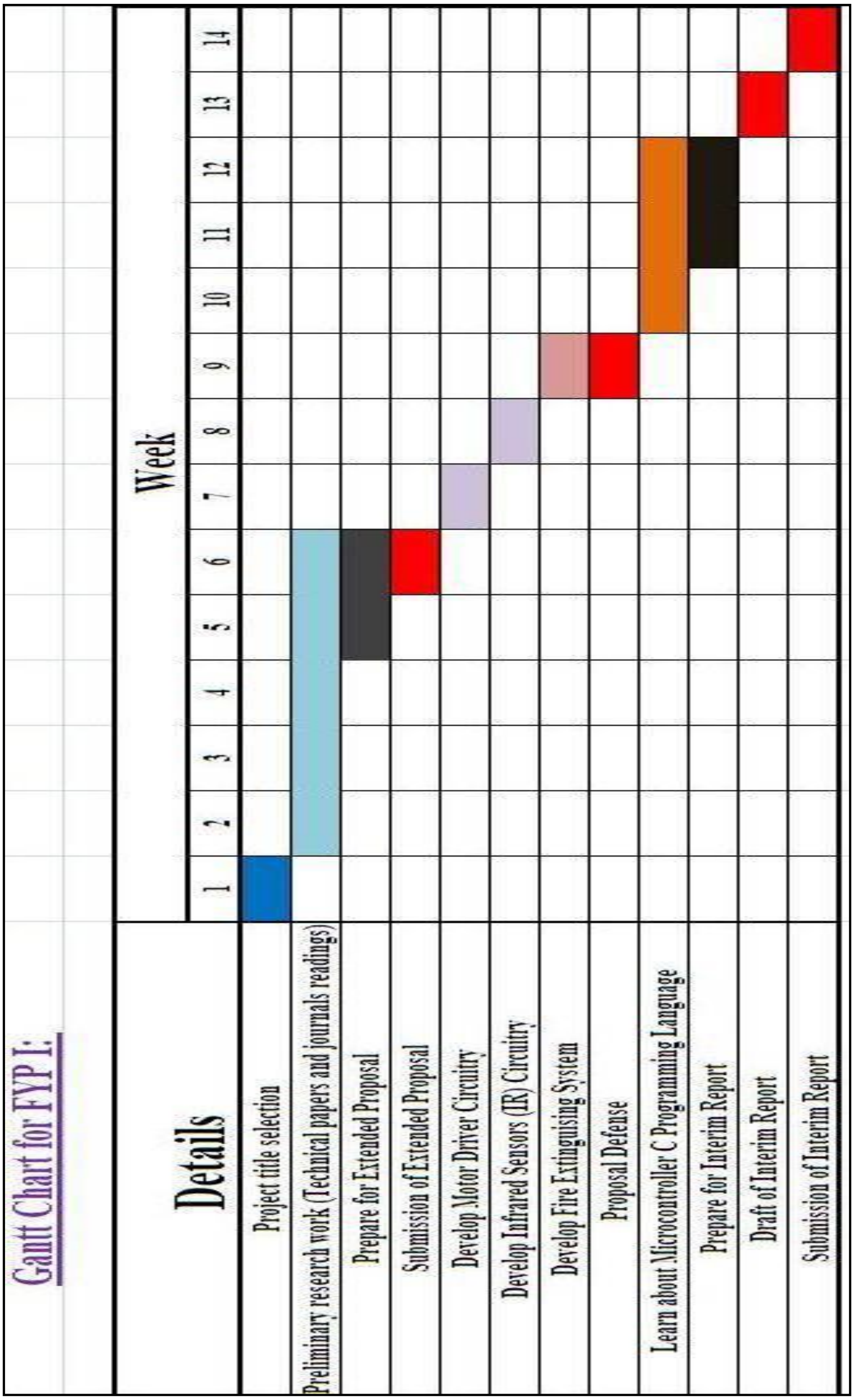


Figure 8 Gantt Chart for FYP I.

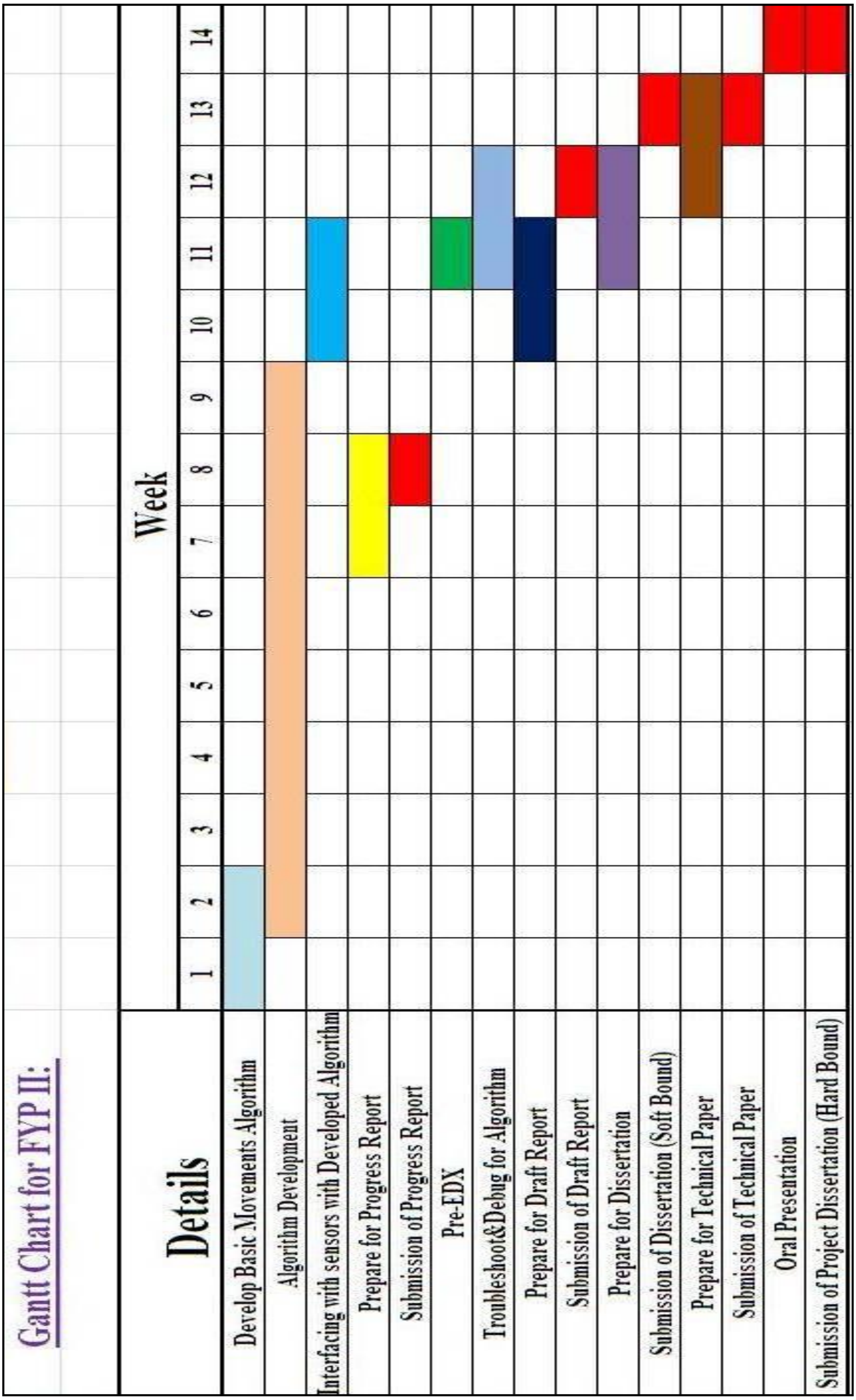


Figure 9 Gantt Chart for FYP II.

3.5 Tools and Hardware Required

Software	Hardware
PIC Simulator IDE	Parallax Robot Body Chassis
MPLAB IDE	Motor Driver Circuitry
PICkit2 v2.61	LEDs & LDRs Sensors Circuitry
	Fire Extinguishing System
	SK40C Start-up Kit
	PIC16F877A Microcontroller
	JTAG Programmer Cable
	Batteries / Power Supplies
	Flame Sensor
	Smoke Sensor
	Heat Sensor

Figure 10 Tools & Equipment required to develop the AFFMP.

CHAPTER 4
RESULT & DISCUSSION

4.1 Results & Measurements

This chapter discusses about the measurements and data gatherings for various type of sensors and circuitry used in the AFFMP. It is important to know the range of outputs so that it can be used as the reference data during the troubleshooting stages to determine whether there is any hardware failure or sensors failure when the integrated system does not work as designed.

4.1.1 Speed Control of DC Motors by using PWM technique

By assigning either clockwise or anti-clockwise rotations to both DC motors, it will produce different types of movements to the AFFMP, as summarized in Table 8.

Left Motor	Right Motor	Movements
Forward	Forward	Forward
Backward	Backward	Backward
Forward	Stop	Turn Right
Forward	Backward	Sharp Right Turning
Stop	Forward	Turn Left
Backward	Forward	Sharp Left Turning

Table 8 Configurations to produce different types of movements to the AFFMP.

Based on the configuration of this AFFMP prototype, the range of Pulse Width Modulation (PWM) value that can be used to control the speed of AFFMP falls within 160 to 255. By adjusting the duty cycle of the motor from minimum 62.75% to maximum 100%, we can set the desired speed to the AFFMP for its movements.

Table 9 illustrates the duty cycle set to the AFFMP for speed control during its navigation process.

PWM value	Duty Cycle in Percentage
175	68.63%
180	70.59%
185	72.55%
220	86.27%

Table 9 PWM value & Duty Cycle used in AFFMP.

The motor driver circuitry requires 2 inputs for each motor from the user, whereby A1 or B1 is the Most Significant Bit (MSB) while A0 or B0 is the Least Significant Bit (LSB). If we apply the same inputs for both inputs to the motor driver circuitry, no output will be produced by the motor driver circuitry. If MSB is applied to 1 and LSB is applied to 0, then the motor driver circuitry will yield clockwise rotation to the motor and vice-versa, which is the LSB is applied to 1 and MSB is applied to 0, then the motor driver circuitry will produce anti-clockwise rotation to the motor respectively.

If we wish to produce forward movements to the AFFMP, we apply forward movements to both motors and backward movements to both motors if we want to produce reverse movements to the AFFMP. When the left motor is applied backward movements and right motor is applied forward movements, the AFFMP will turn left. In order to produce right turning movements to the AFFMP, we need to apply forward movements to left motor and backward movements to right motor.

4.1.2 Flame Sensor

The approach used to measure the analog output values from sensor is by using a SK40C board. The DC input of 12V 1A is fed into the SK40C board and the 7805 voltage regulator steps the voltage down into 5V. The sensors have 3 wires, which are known as the Vcc terminal, Ground terminal and analog output terminal. The Vcc and GND are connected to the Vcc pin and GND pin of the SK40C board respectively. For the analog output terminal of the sensors, it is connected to a Digital Multimeter for voltage measurement. The Digital Multimeter's positive terminal is connected to the analog output while the negative terminal of the Digital Multimeter is connected to the GND of the SK40C board.

Table 10 shows the experiment conducted to determine the most suitable indicator as fire source by using the Flame Sensor. The candle is the most suitable indicator for fire source as the Flame Sensor reacts positively towards it.

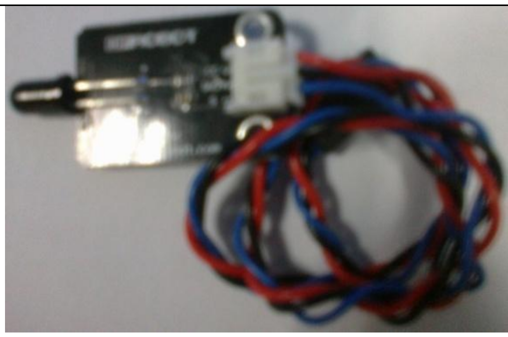
No.	Type of Sensors	Illustrations& Range of values when approaching fire source
1	Flame Sensor	 Detection Range : 20cm (4.8V) – 100cm (1V) Wavelength: 760nm to 1100nm, Angle : 60^0 **Using Candle:** Approx. 15cm distance : 3.6V to 4.1V (CHOSEN) **Using RED LED:** Touched surface between flame sensor &LED: 2.2V ~ 3.4V Approx. 20cm distance : 0.04V (FAILED) **Using YELLOW LED:** Touched surface : 0.14V Approx. 20cm distance : 0.00V (FAILED) **Using ORANGE LED:** Touched surface : 0.63V Approx. 20cm distance : 0.01V (FAILED) **Using GREEN LED:** Touched Surface between Flame Sensors & LED: 0.01V ~ 0.02V Approx. 20cm distance : 0.00V ~ 0.01V (FAILED)

Table 10 Initial raw data for Flame Sensor during FYP I.

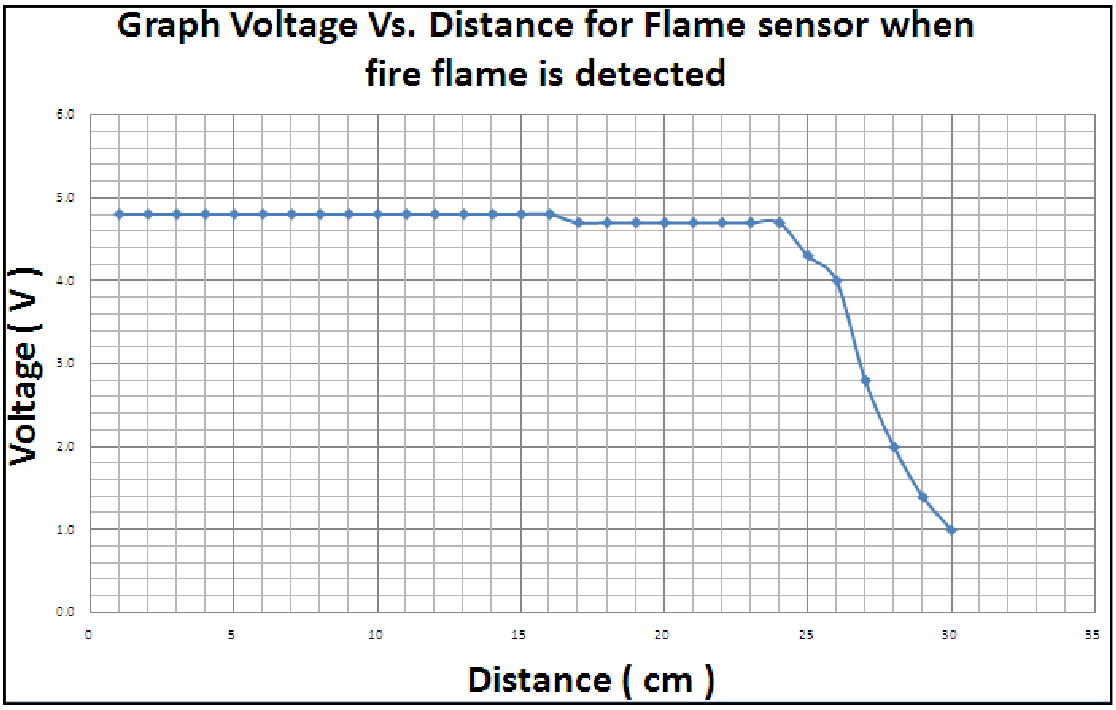


Figure 11 Characteristic of flame sensor.

As we can observe from Figure 11, the maximum detection range of flame sensor used is 26cm. The flame sensor can detects the wavelength of the flame that falls in between 760nm to 1100nm.

4.1.3 Smoke Sensor

Table 11 shows the experiment conducted to determine the response of the Smoke Sensor with thick smoke from joss sticks.

No.	**Type of Sensors**	**Illustrations& Range of values when approaching fire source**
1	Smoke Sensor	 Surrounding **without Smoke** : 0.6V ~ 0.7V Surrounding **with thick Smoke** : 2.4V ~ 3.8V

Table 11 Initial raw data for Smoke Sensor during FYP I.

4.1.4 Heat/Temperature Sensor

Table 12 shows the experiment to determine the response of heat /temperature sensor in room temperature.

No.	**Type of Sensors**	**Illustrations& Range of values when approaching fire source**
1	LM35 LINER TEMPERATURE SENSOR	 Digital Outputs: Logic ‘1’ for room temperature, Logic ‘0’ for temperature exceeds the default preset threshold value.

Table 12 Initial raw data for Heat/Temperature Sensor during FYP I.

4.1.5 LDR Sensor

Through experiment, it has been identified that the super bright white LEDs and LDR sensors are more suitable to be used to implement the line following feature due to its higher sensitivity and stable performance as compared to the IR sensor, as shown in Table 13.

	Infrared (IR) Sensor (Emitter & Receiver)	Bright White LED (Emitter) & Light Dependent Resistors (LDR) (Receiver)
Colour of Emitter	Transparent	White
Colour of Receiver	Black	Light brown
Colour of Background Surface	Black	White
Colour of Line / Track	White	Black
Detection strategies	Logic '1' to detect for track. Logic '0' to detect for background surface.	Logic '0' to detect for track. Logic '1' to detect for background surface.
Theories / Concepts behind the detection strategies	White colour reflects back all the light and produce logic '1'. By default: Logic '0'	Black colour absorbs all the lights from emitter and produce logic '0'. By default: Logic '1'
Detection Range	**<1cm**	**<2cm**
Sensitivity	**Low** & not consistent performance for detection.	**High** & quite consistent performance for detection.

Table 13 Characteristics of IR sensor and LDR sensor.

Figure 12 shows the readings for each of the LDR sensors during white surface and black surface while Table 14 illustrates that by using the super bright white LEDs and yellow LEDs as the emitter will slightly influence the overall reading of voltage from the LDR sensors as well.

LDR Sensors with super bright white LED emitter for line following purpose : * At a height of about 1.2cm between LDR sensors and the surface:	
Voltage level of sensors during **white surface:**	Voltage level of sensors during **black surface:**
Right : **3.41V** Middle Right : **3.39V** Middle Left : **3.37V** Left : **3.36V** (With slight variations from time to time)	Right : **0.00V** Middle Right : **0.00V** Middle Left : **0.00V** Left : **0.00V**

Figure 12 Voltage levels for LDR sensors on black surface and white surface.

Types of Sensors	Detection Range
LDR Sensors (With super bright white LEDs) (More stable)	At a height of about 1.2cm between LDR sensors and the surface, when the line track is not detected, the voltage level are Right : 3.41V Middle Right : 3.39 V Middle Left : 3.37V Left : 3.36V (With slight variations from time to time) When **black line track** is detected, the voltage level will be **ZERO**.
LDR Sensors (With yellow LEDs) **(Unstable)**	At a height of about 1.2cm between LDR sensors and the surface, when the line track is not detected, the voltage level are Right : 3.08V Middle Right : 3.09V Middle Left : 3.06V Left : 3.08V (With slight variations from time to time) When **black line track** is detected, the voltage level will be **ZERO**.

Table 14 Comparison of voltage levels for LDR sensors with super bright white and yellow LEDs.

As shown in Table 14, the LDR sensors (receiver) can operate more reliably and stable if super bright white LEDs (emitter) are being used to implement the line following feature to AFFMP as compared to Yellow LEDs (emitter).

CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The developed Autonomous Fire Fighting Mobile Platform has shown to be a feasible project. Based on the findings, after integrating all the hardware such as flame sensors, motor driver circuitry, LDR sensors, the expected patrolling and fire extinguishing tasks are possible to be carried out and executed with minimum level of error. By deploying the AFFMP to monitor for hazardous site via patrolling process, it aids to share out the burden of fire-fighters in fire fighting tasks as the fire-fighters can safely delegate the fire fighting tasks to AFFMP.

Throughout the implementation of AFFMP, there are several huge issues being encountered. One of the most notably issue is the power supplies for the whole system. Due to the insufficiency level of voltage in shared power supply, it causes the Pulse Width Modulation (PWM) failed to work for speed control of AFFMP. In order to overcome this issue, there are 5 separate power supplies been used to power up separate circuitry by common ground all the power supplies.

Other than that, the failure / inconsistency performance of the yellow LEDs (Emitter) and LDR sensors circuitry become another challenges in this project. During the design testing on the breadboard, the combination of yellow LEDs and LDR sensors works well but once the design has been transferred and soldered on top of verobod, the circuitry failed to work. The solution to overcome this problem is by changing the yellow LEDs (Emitter) to super bright white LEDs and fine tune the comparator with respect to white surface and black surface for line following purposes.

5.2 Recommendations

For future enhancements to the current project, additional features can be integrated onto the system, namely the wireless communication module, so that it can communicate between the operator and the victims within the fire site; image processing technique to analyze for fire source instead of using the flame sensors; utilization of renewable source of energy such as solar power to drive the main circuitry on the AFFMP's platform; ability to navigate on uneven surfaces; and ability to climb staircases.

REFERENCES

[1] P.H. Chang and Y.H. Kang, et al., "Control Architecture Design for Fire Searching Robot using Task Oriented Design Methodology", SICE-ICASE 2006, Oct. 2006.

[2] Daniel J. Pack; Robert Avanzato; David J. Ahlgren; Igor M. Verner; "Fire-Fighting Mobile Robotics and Interdisciplinary Design-Comparative Perspectives", IEEE Transactions on Education, 3 August, 2004, Volume 47, No. 3.

[3] Young-Duk Kim; Yoon-Gu Kim; Seung-Hyun Lee;Jeong-Ho Kang; Jinung An; "Portable Fire Evacuation Guide Robot System", Intelligent Robots and Systems, IEEE/RSJ International Conference, 11-15 October 2009. Pages:2789-2794.

[4] Kuo L. Su; "Automatic Fire Detection System Using Adaptive Fusion Algorithm for Fire Fighting Robot", Systems, Man, and Cybernetics, IEEE International Conference, 8-11 October 2006, Pages:966-971.

[5] Vecna Robotics Co.; "Battlefield Extraction-Assist Robot (BEAR)", Available:http://www.vecnarobotics.com/robotics/product-services/bear-robot/ [Accessed : June 27, 2012]

[6] Jared Harwayne-Gidansky; Michael Sudano; "A Low-Complexity Navigation Algorithm for a Scalable Autonomous Firefighting Vehicle", Research and Development, the 5th Student Conference-SCOReD 2007, 11-12 December 2007.

[7] Ting L. Chien; Jr H. Guo; Kuo L. Su; Sheng V. Shiau; "Develop a Multiple Interface Based Fire Fighting Robot", Proceedings of International Conference on Mechatronics on 8-10 May2007, Pages:1-6.

[8] Igor M. Verner; David J. Ahlgren; "Education Design Experiments in Robotics", World Automation Congress (WAC), 24-26 July 2006.

[9] Hongke Xu; Hao Chen; Chao Cai; Xunzhao Guo; Jianwu Fang; Zhu Sun; "Design and Implementation of Mobile Robot Remote Fire Alarm System", Intelligence Science and Information Engineering, 2011 International Conference, Pages:43-47.

[10] Scott Dearie; Kevin Fisher; Brian Rajala; Steven Wasson; "Design and Construction of a Fully Autonomous Fire Fighting Robot", 2004 IEEE, Pages:303-310.

[11] Kashif Altaf; Aisha Akbar; Bilal Ijaz; "Design and Construction of an Autonomous Fire Fighting Robot", 2007 IEEE.

[12] "Fire Extinguishers: The Different Types"[Online]. Available:http://www.mfs-fire-extinguishers.co.uk/types [Accessed : May 20, 2012]

[13] Shuying Zhao; Wenjun Tan; Shiguang Wen; Chongshuang Guo; "Research on Robotic Education Based on LEGO Bricks", Computer Science and Software Engineering, 2008 International Conference, Pages:733-847.

[14] DFRobot Co. ; "Flame Sensor", Available:http://www.dfrobot.com/index.php?route=product/product&filter_name=flame&product_id=195 [Accessed : June 27, 2012]

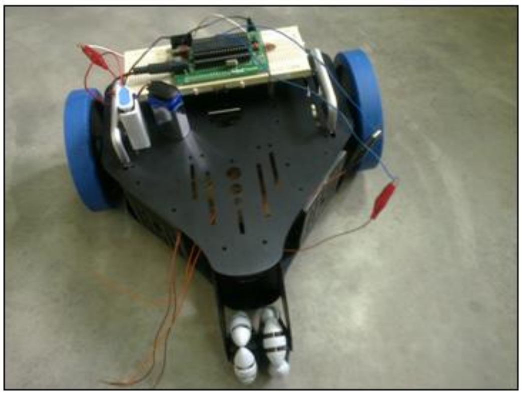
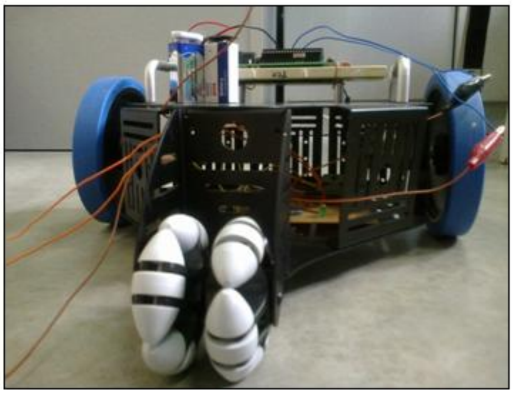
[15] DFRobot Co. ; DFRobot Flame Sensor Technical Datasheet. [Accessed : June 27, 2012]

APPENDIX A

PARALLAX ROBOT BODY CHASSIS PLATFORM

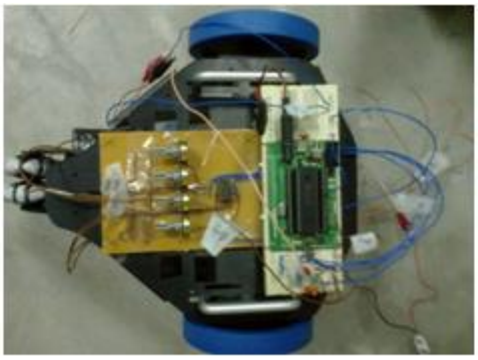
APPENDIX B

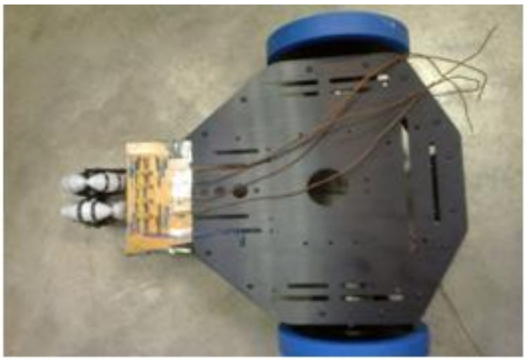
AFFMP WITH MOTOR DRIVER CIRCUITRY

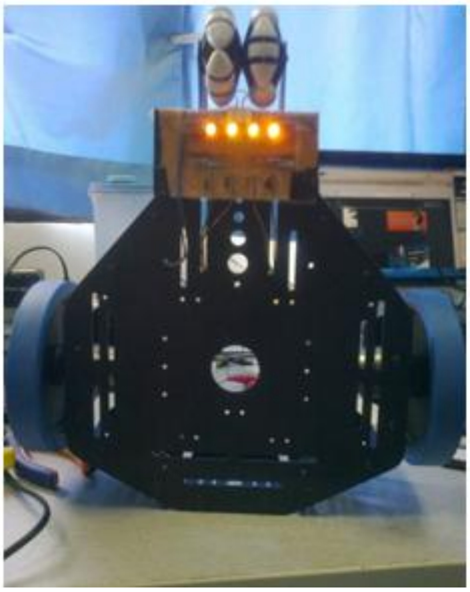
 

APPENDIX C

AFFMP WITH LEDS & LDRS SENSORS SYSTEM

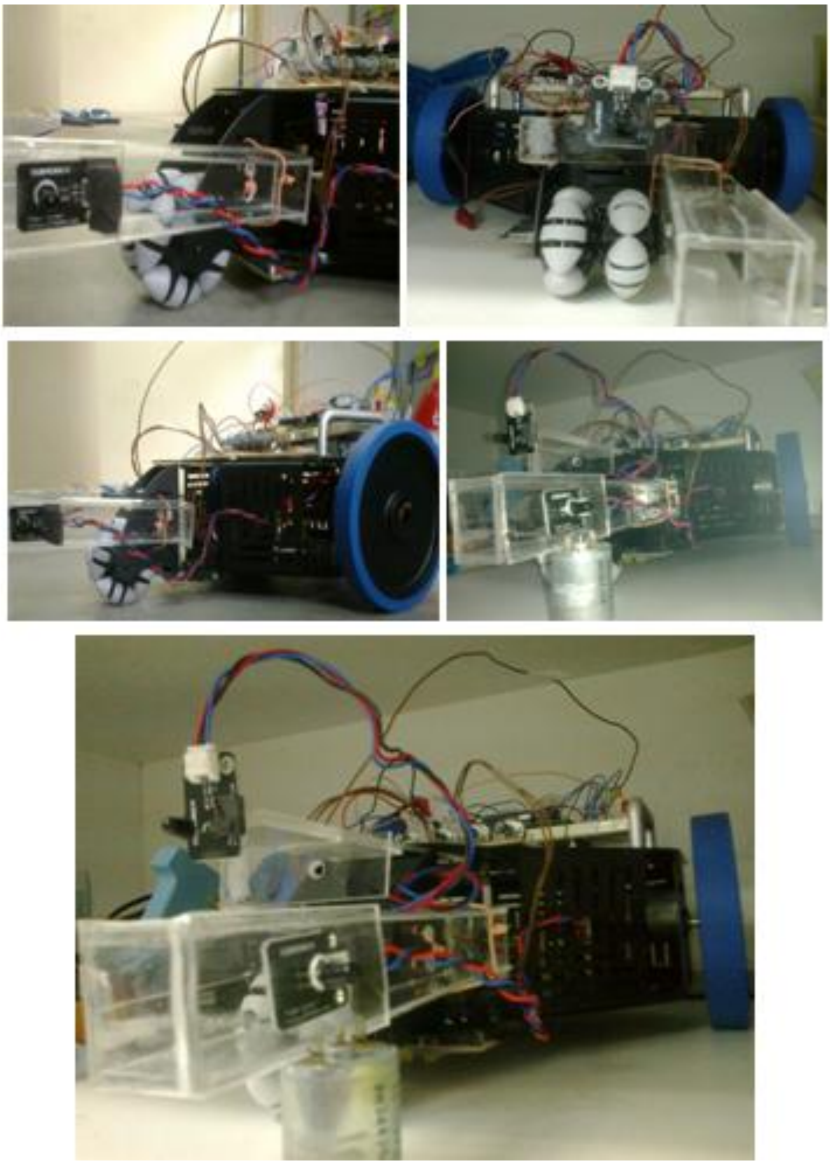






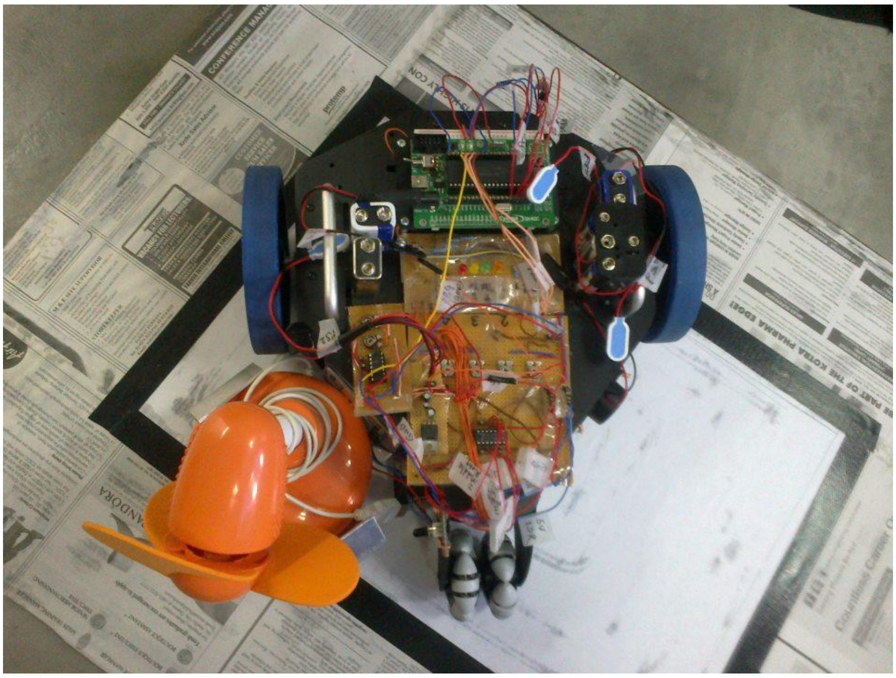
APPENDIX D

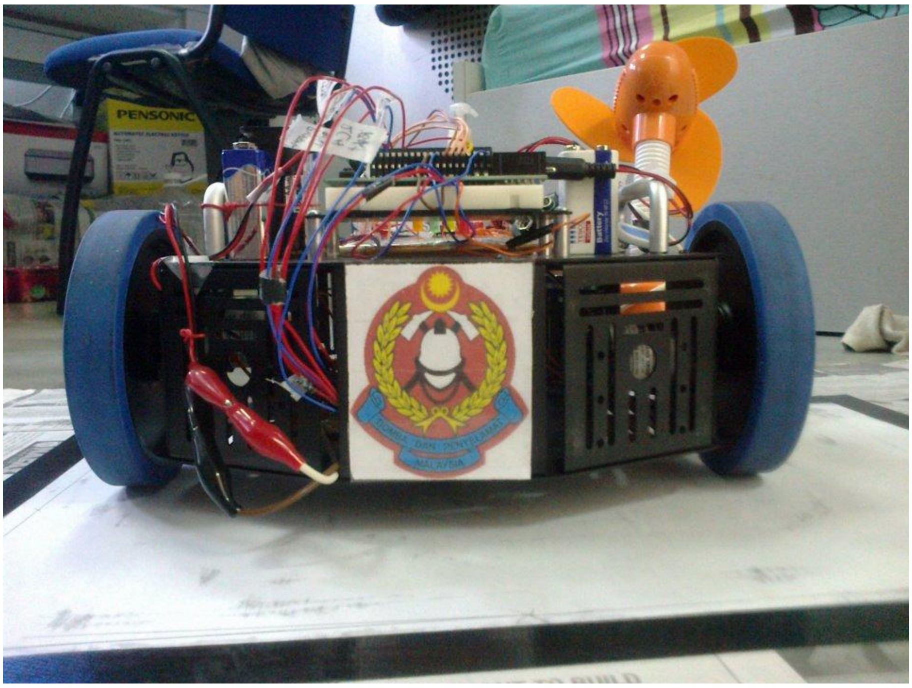
AFFMP WITH FLAME SENSORS.

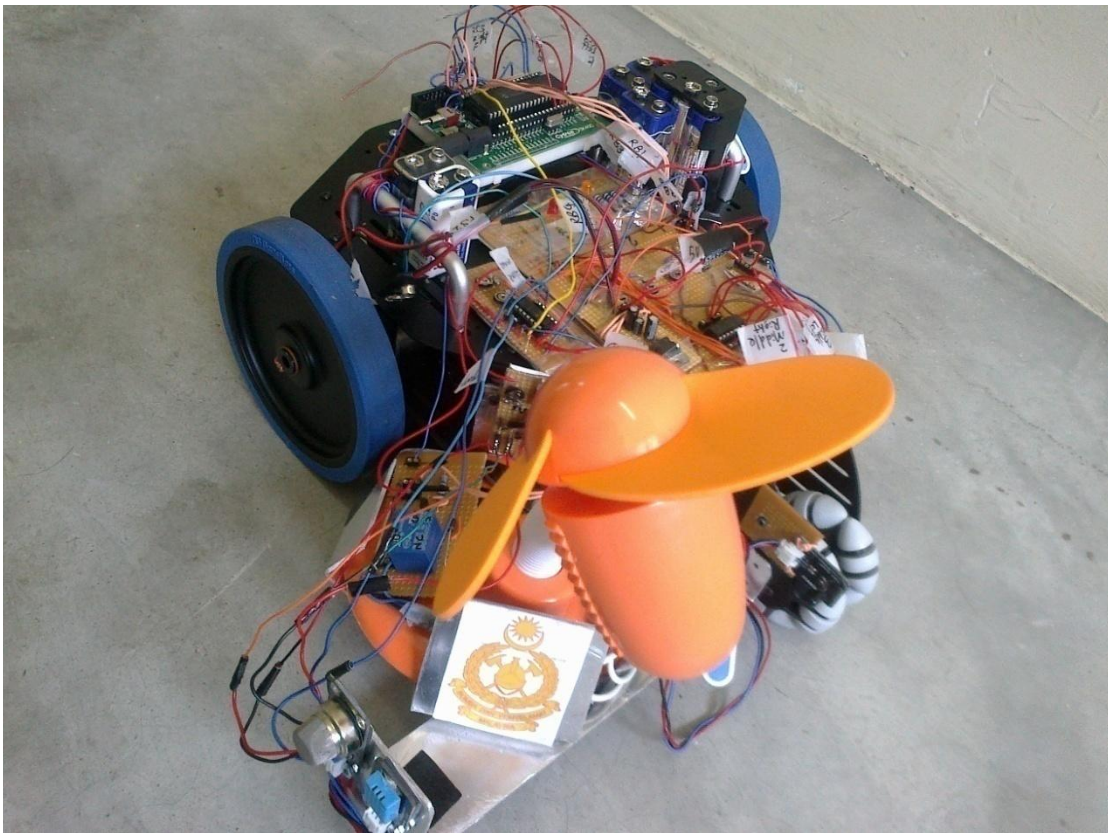


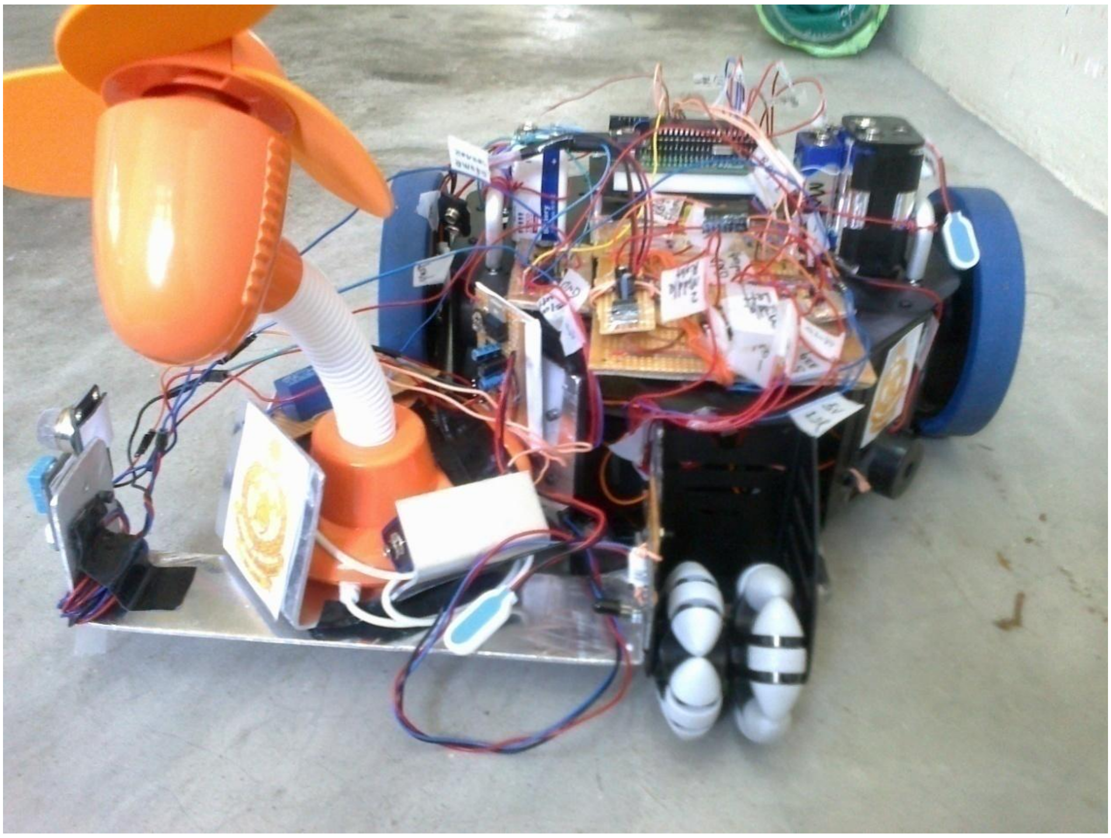
APPENDIX E

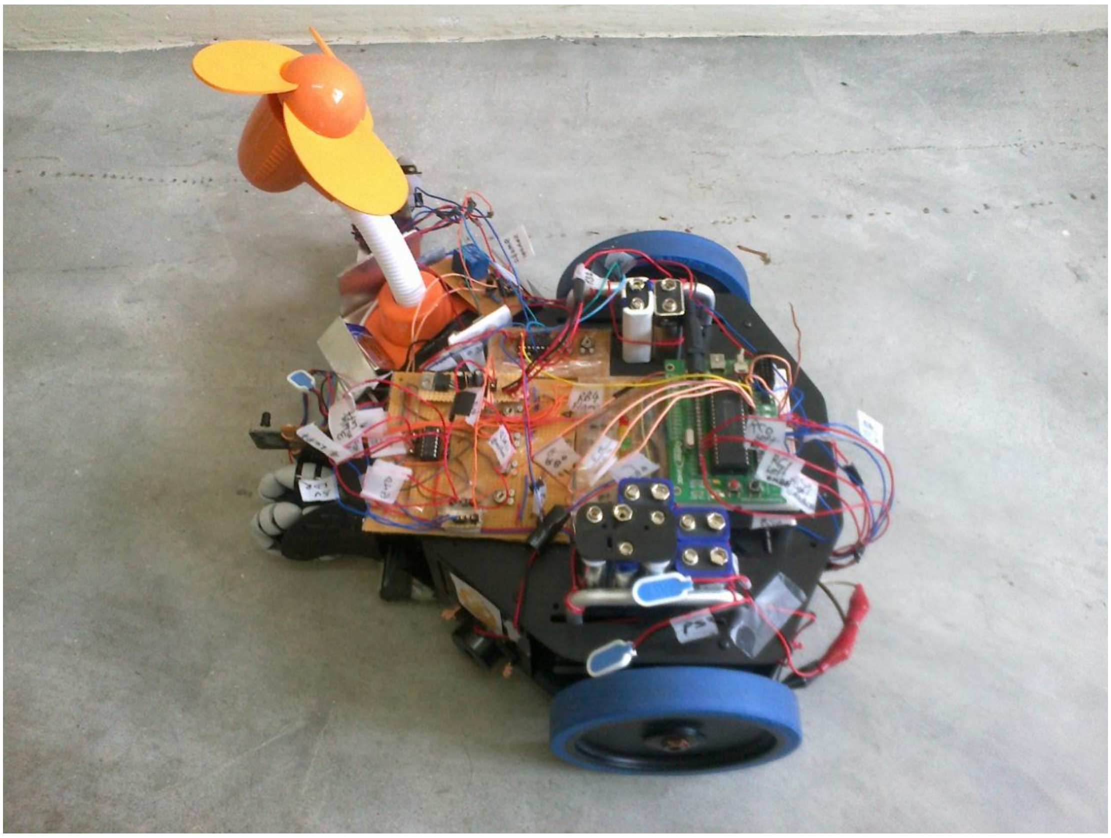
COMPLETED AFFMP

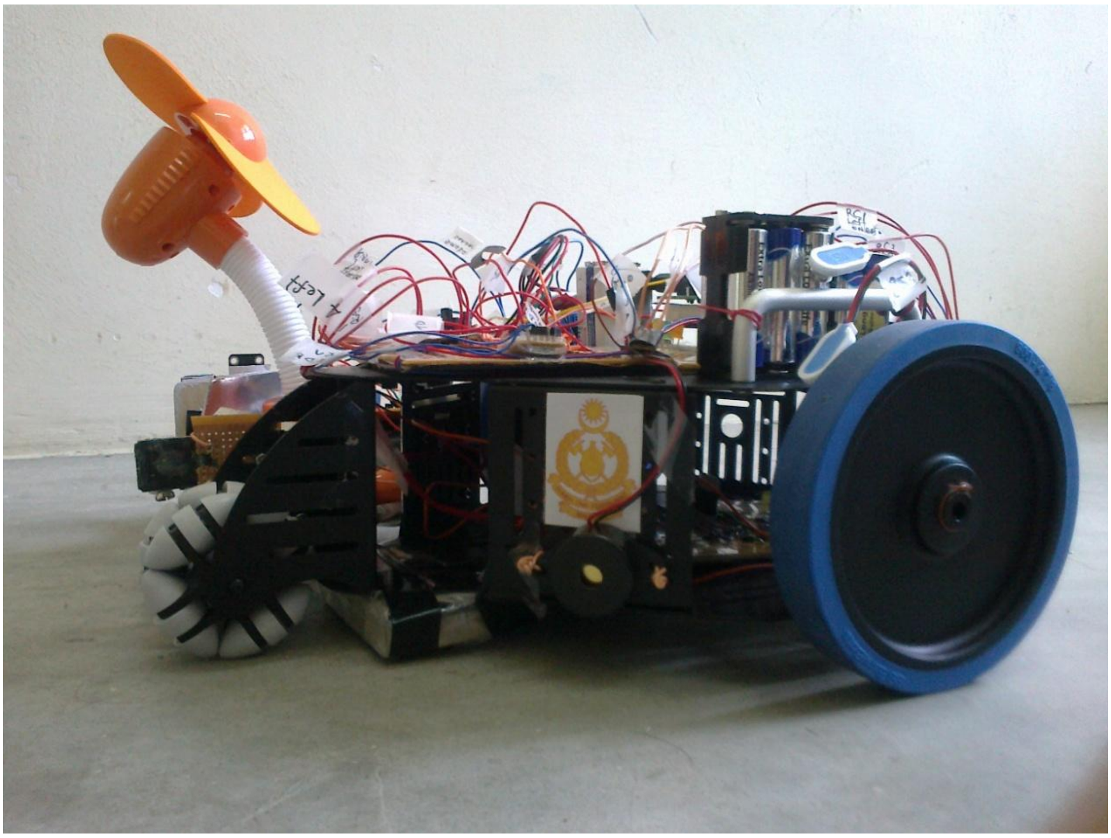


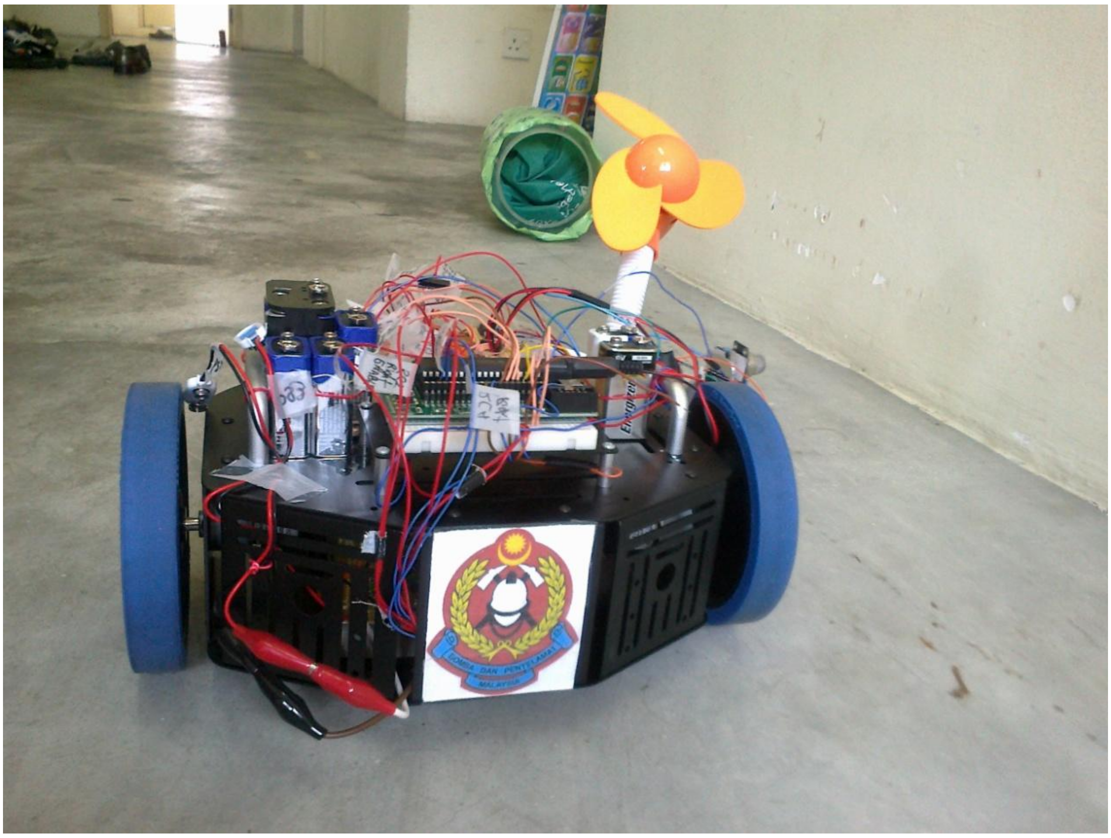






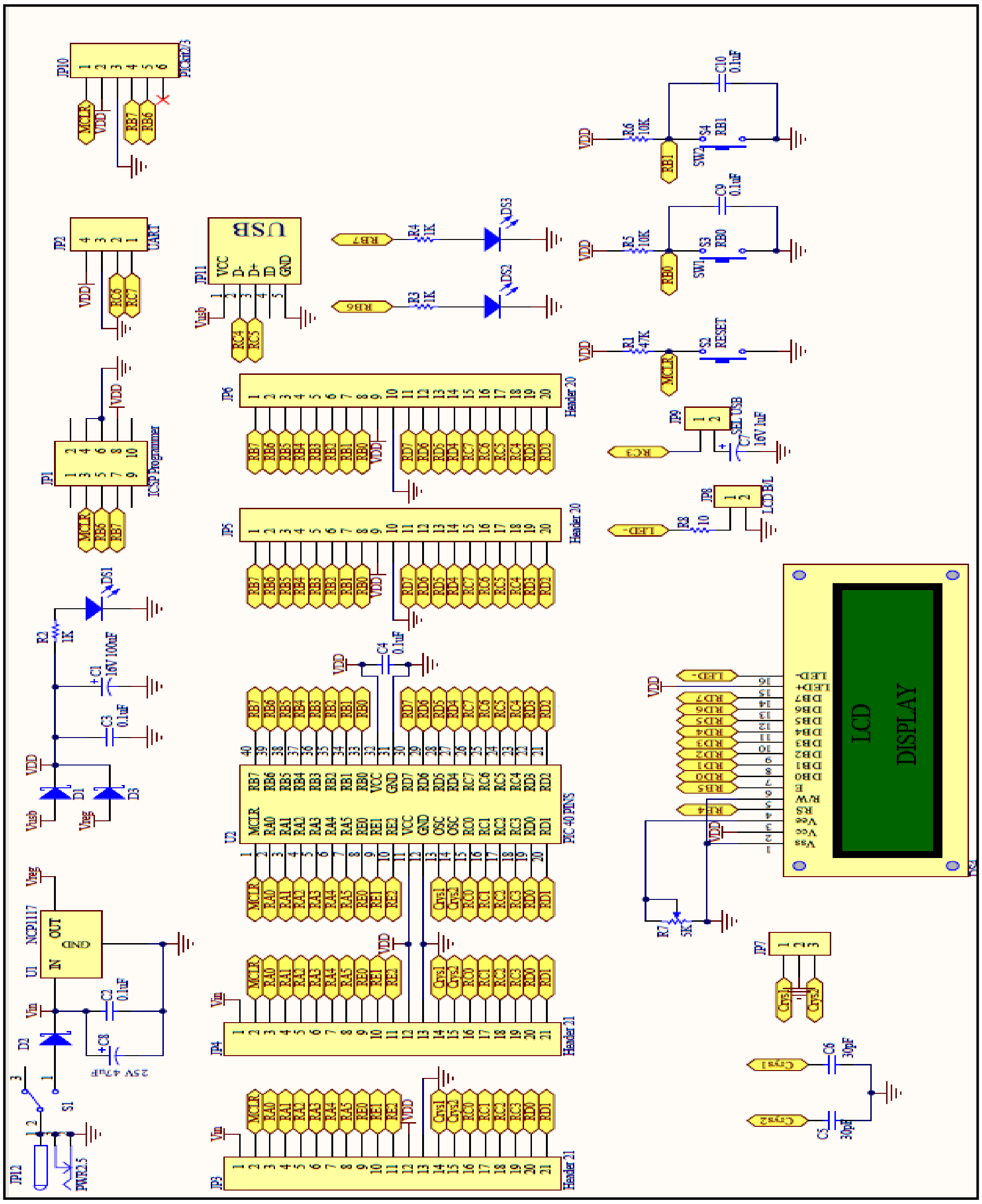






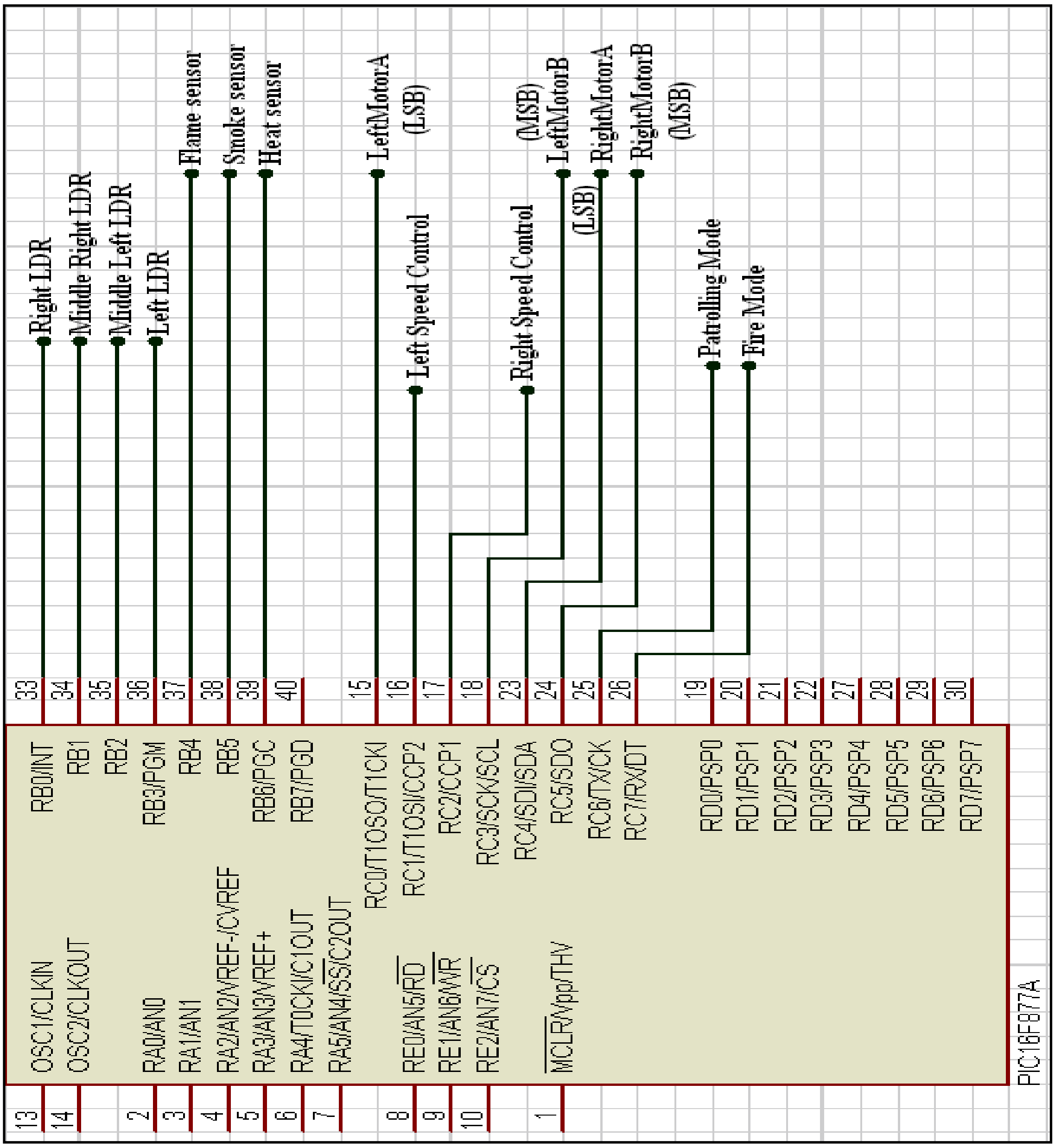
APPENDIX F

SCHEMATIC FOR SK40C BOARD



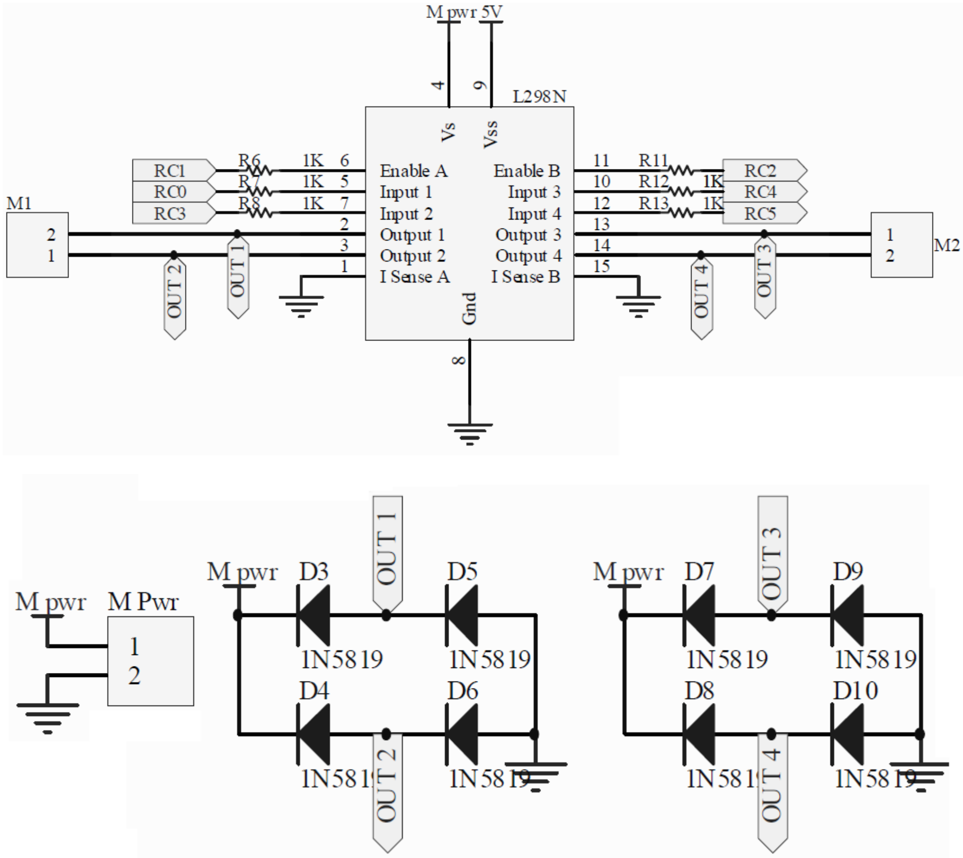
APPENDIX G

PIN CONFIGURATIONS FOR PIC16F877A MICROCONTROLLER



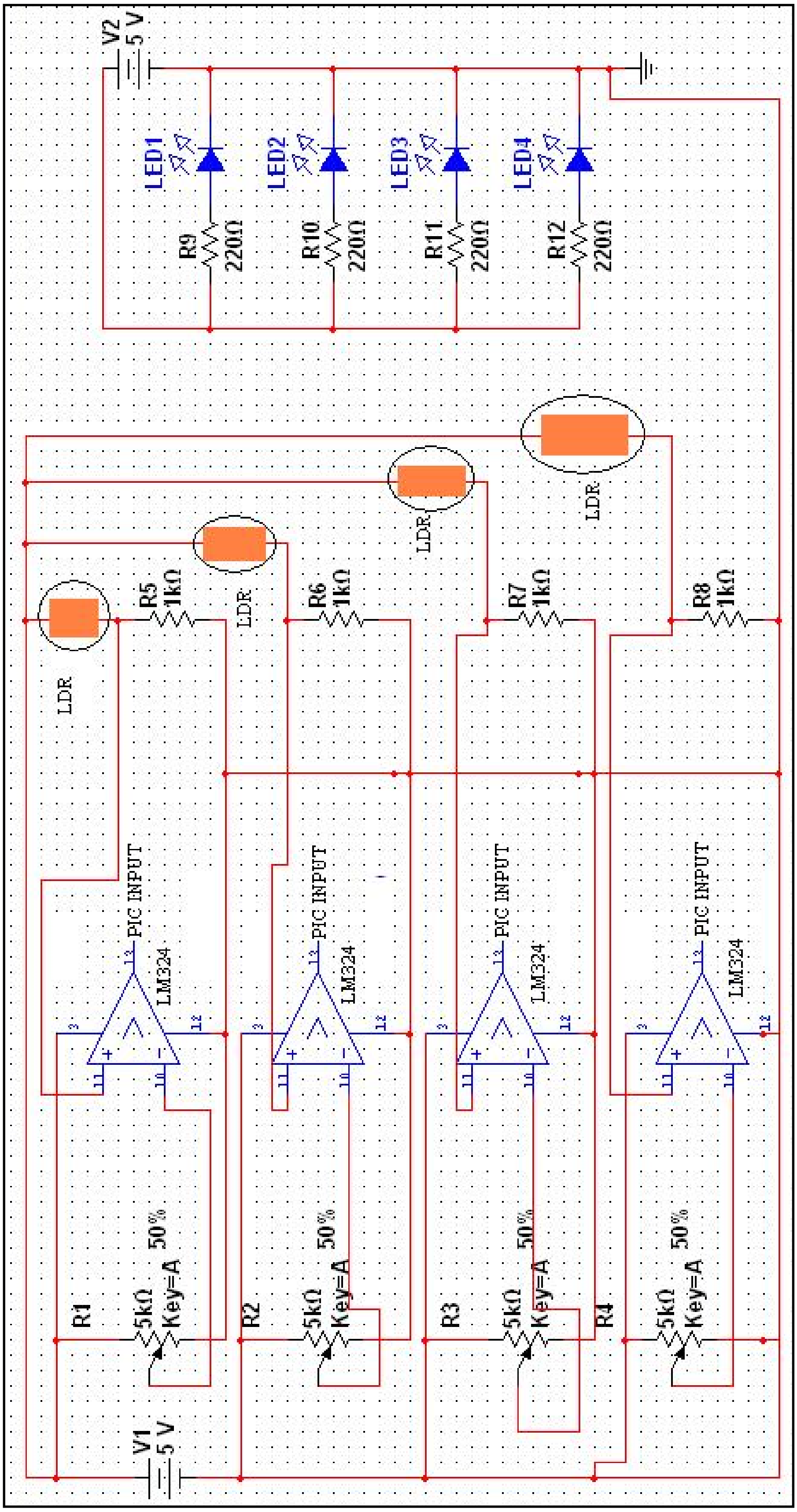
APPENDIX H

SCHEMATIC FOR MOTOR DRIVER CIRCUITRY



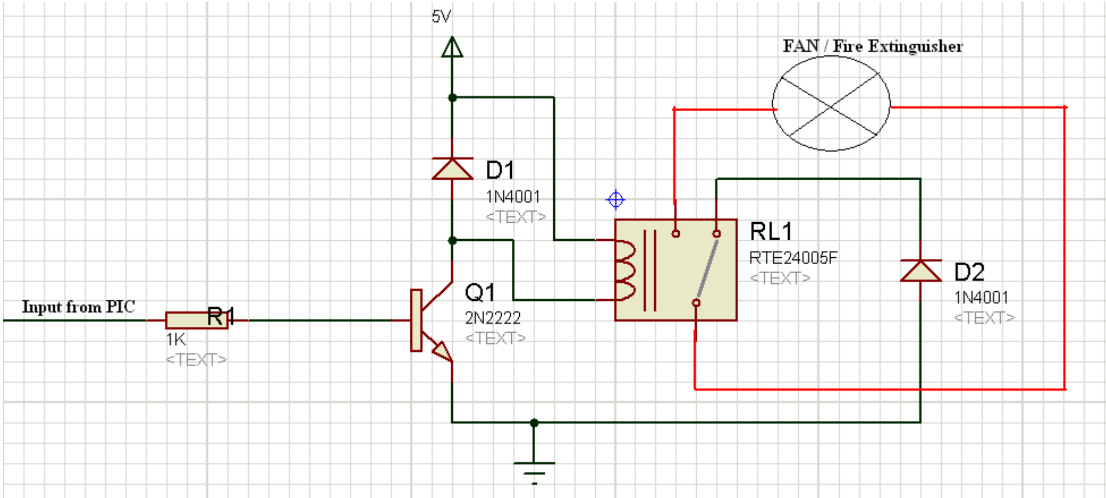
APPENDIX I

SCHEMATIC FOR LDR SENSORS CIRCUITRY



APPENDIX J

SCHEMATIC FOR FAN/FIRE EXTINGUISHER ACTIVATION



APPENDIX K

DATASHEET FOR FLAME SENSOR

FLAME SENSOR

Click to enlarge

Price: RM13.00
Availability: 8
Model: SS-DFR76

Qty: 1 Add to Cart

Description | **Additional Images (0)** | **Related Products (4)**

The flame sensor can be used to detect fire or other wavelength at 760 nm ~ 1100 nm light. In the fire-fighting robot game, the flame plays an important role in the probe, which can be used as the robot's eyes to find fire source or football. It can make use of fire-fighting robots, soccer robots.

Flame sensor probe angle of 60 degrees, the special sensitivity of the flame spectrum, two M3 mounting holes to stabilize the module will not spin.

The flame sensor's operating temperature is -25 degrees Celsius to 85 degrees Celsius, in the course of the flame it should be noted that the probe distance from the flame should not be too close inorder to avoid damage.

Specification:

- Interface:Analog
- Supply Voltage: +5 V
- Detection range: 20cm (4.8V) ~ 100cm (1V)

Technical Data Sheet

Features

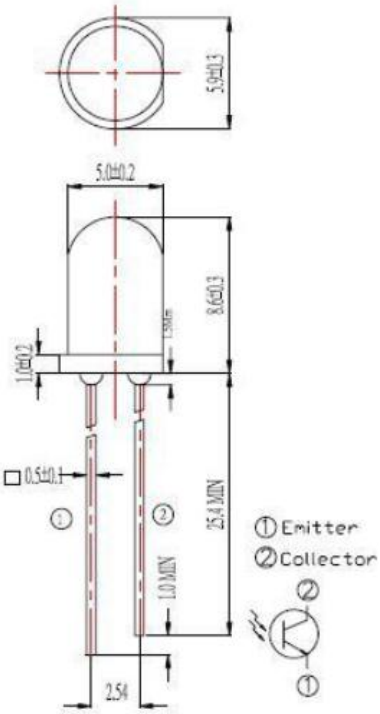
- Fast response tine
- High photo sensitivity
- Pb free
- This product itself will remain within RoHS conpliant version.

Descriptions

- YG1006 is a high speed and high sensitive NPNsiicon phototransistor in a standard5mm package.

Dueto its black epoxy the device is sensitive to infrared radiation.

Package Dimensions



APPENDIX L

DATASHEET FOR SMOKE SENSOR

Analog Gas Sensor User Manual

Thursday, 18 August 2011 11:23 Sensor - Other Sensor / Module

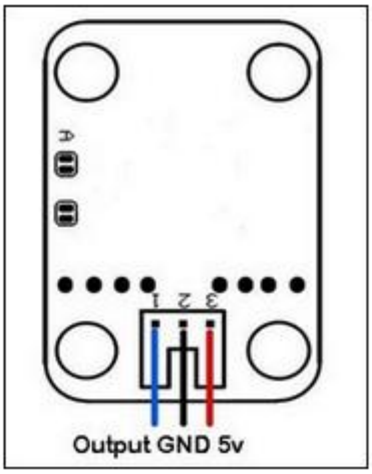
INTRODUCTION

The gas sensor detects smoke, methane, carbon dioxide and other gases. It is able to give alarms when the smoke/gas leaks. You can adjust the sensitivity with the potentiometer.

PIN DEFINITION

The definition of gas sensor pin is

1. Signal Output
2. GND
3. Power



APPENDIX M

DATASHEET FOR HEAT/TEMPERATURE SENSOR

Digital-output relative humidity & temperature sensor/module – DHT11

Resisitive-type humidity and temperature module/sensor

1. Feature & Application:

* Full range temperature compensated * Relative humidity and temperature measurement
* Calibrated digital signal *Outstanding long-term stability *Extra components not needed
* Long transmission distance * Low power consumption *4 pins packaged and fully interchangeable

2. Description:

DHT11 output calibrated digital signal. It utilizes exclusive digital-signal-collecting-technique and humidity sensing technology, assuring its reliability and stability. Its sensing elements is connected with 8-bit single-chip computer.

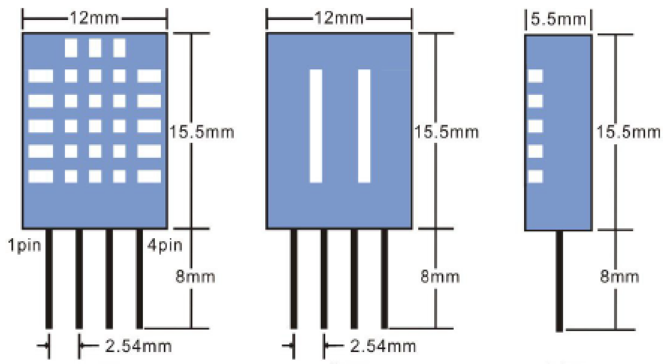
Every sensor of this model is temperature compensated and calibrated in accurate calibration chamber and the calibration-coefficient is saved in OTP memory.

Small size & low consumption & long transmission distance(20m) enable DHT11 to be suited in all kinds of harsh application occasions. Single-row packaged with four pins, making the connection very convenient.

3. **Technical Specification:**

Model	DHT11
Power supply	3-5.5V DC
Output signal	digital signal via single-bus
Sensing element	Polymer resistor
Measuring range	humidity 20-90%RH; temperature 0-50 Celsius
Accuracy	humidity +-4%RH (Max +-5%RH); temperature +-2.0Celsius
Resolution or sensitivity	humidity 1%RH; temperature 0.1Celsius
Repeatability	humidity +-1%RH; temperature +-1Celsius
Humidity hysteresis	+-1%RH
Long-term Stability	+-0.5%RH/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	size 12*15.5*5.5mm

4. Dimensions: (unit----mm)



3Pin-NULL, MCU=Microcomputer or single-chip computer

6. Operating specifications:

(1) Power and Pins

Power's voltage should be 3-5.5V DC. When power is supplied to sensor, don't send any instruction to the sensor within one second to pass unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

(2) Communication and signal

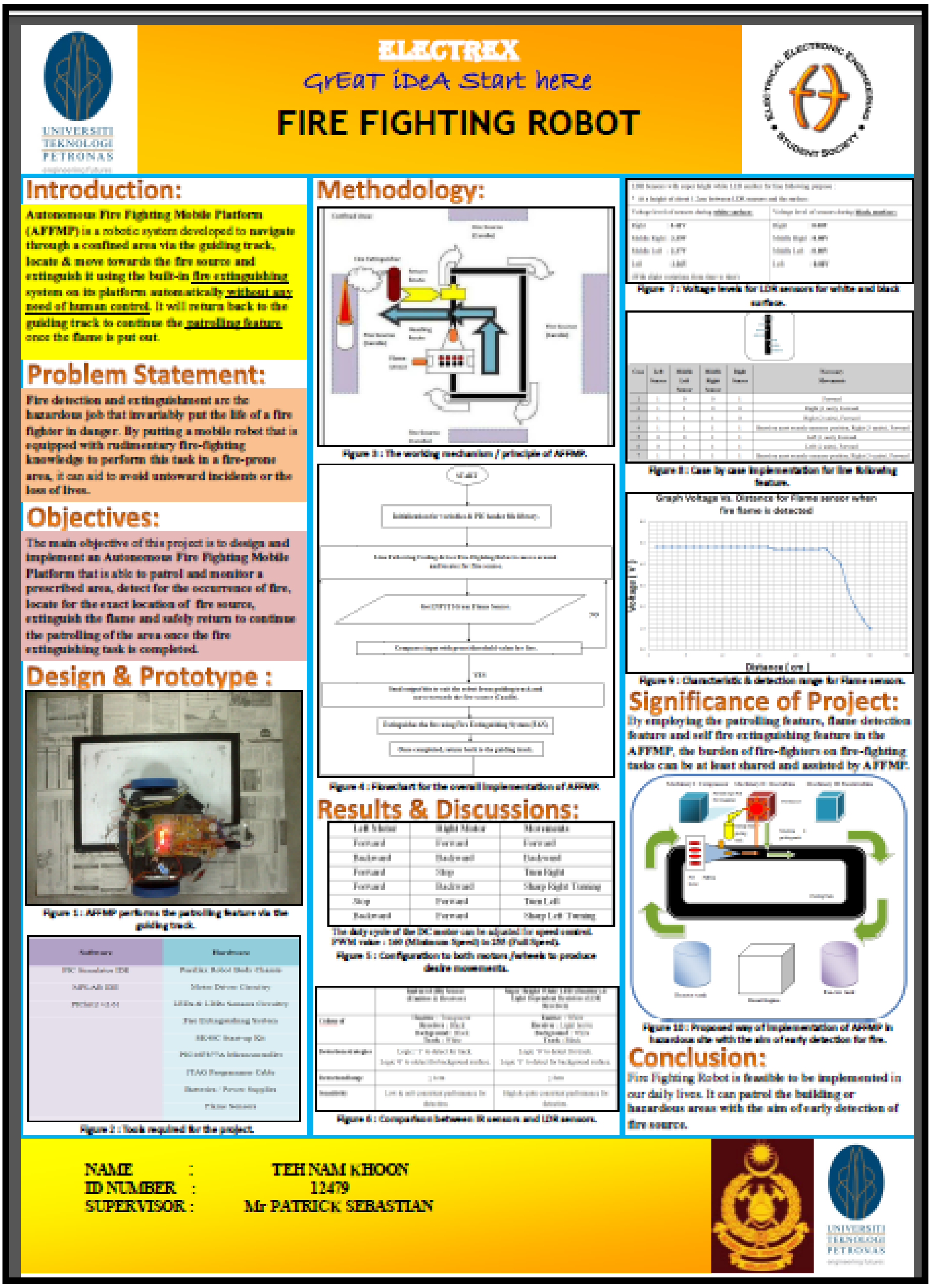
Single-bus data is used for communication between MCU and DHT11.

7. Electrical Characteristics:

Item	Condition	Min	Typical	Max	Unit
Power supply	DC	3	5	5.5	V
Current supply	Measuring	0.5		2.5	mA
	Stand-by	100	Null	150	uA
	Average	0.2	Null	1	mA

APPENDIX N

ELECTREX POSTER



APPENDIX O

NOTIFICATION OF PAPER ACCEPTANCE BY IRIS 2012 CONFERENCE

Gmail by Google

NK TEH <nkteh89@gmail.com>

[IRIS2012] Review Result (Autonomous Fire Fighting Mobile Platform)

IRIS2012 Secretariat <iris2012secretariat@gmail.com> Mon, Jun 25, 2012 at 5:18 AM
To: NK TEH <nkteh89@gmail.com>

Dear Mr. Teh Nam Khoon:

Your paper #1569629109 "Autonomous Fire Fighting Mobile Platform" for IRIS2012 has been accepted, but requires major revisions and will be presented in IRIS2012.
Please see the attached reviewer comments.

[Mandatory Action for Final Camera-Ready Paper submission (for late submission paper)]

1) All Camera-Ready paper must be submit to iris2012secretariat@gmail.com within one week after the review result was received. Paper that submitted after 30th June 2012 will not be publish in the Journal of Procedia Engineering and the conference proceedings.
2) Submission of Camera-Ready paper must comply with the latest Elsevier format as available in the IRIS2012 website.
3) Correspondence author is responsible to make sure all comments by the reviewers have been considered and necessary corrections have been made before submitting the final paper.
4) Please submit both PDF and MsWords/LaTeX files of the paper.
5) At least one author must register and completed the payment before 31st July 2012.
6) The IRIS2012 organizer and Elsevier have the right to reject any papers that does not comply with the above requirements.
7) Please fill up the attached manual registration form and submit together with your Camera-Ready paper.

[Copyright Transfer]
Copyright transfer process will be handle by the publisher (Elsevier). The publisher will contact the correspondence author directly to fill up online Copyright Transfer form.

Thank you.

--

Dr. Hanafiah Yussof
Chairman IRIS2012
COE Humanoid Robots and Bio-Sensing (HuRoBs)
Faculty of Mechanical Engineering
Universiti Teknologi MARA
40450 Shah Alam
Selangor Malaysia
Tel: +603-5543 6455
Fax: +603-5543 5160
Email: iris2012secretariat@gmail.com
Website: http://www.iris2012.org

Authors' Rights
Help | Print

PROCEDIA EXCLUSIVE LICENCE AGREEMENT

Elsevier Ltd

YOUR ARTICLE DETAILS

Article:	Autonomous Fire Fighting Mobile Platform
Corresponding author:	Dr. Teh Nam Khoon
E-mail address:	patrick_sebastian@petronas.com.my;nkteh89@gmail.com
Journal:	Procedia Engineering
Our reference	PROENG9237
PII:	S1877-7058(12)02694-X
DOI:	10.1016/j.proeng.2012.07.294

YOUR STATUS

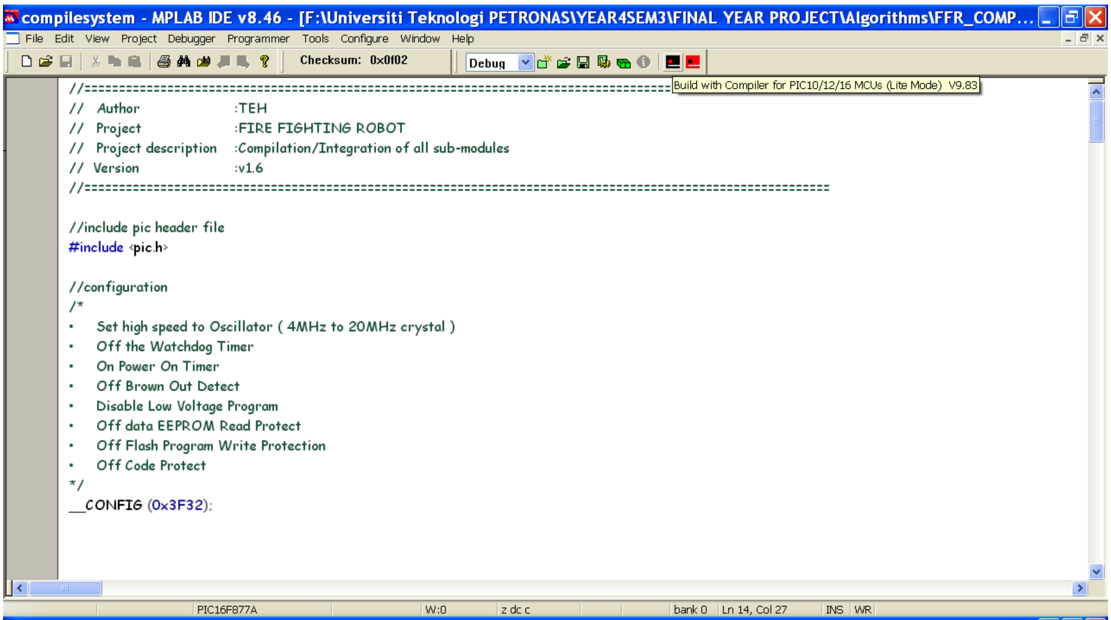
» I am one author signing on behalf of all co-authors of the manuscript

DATA PROTECTION & PRIVACY

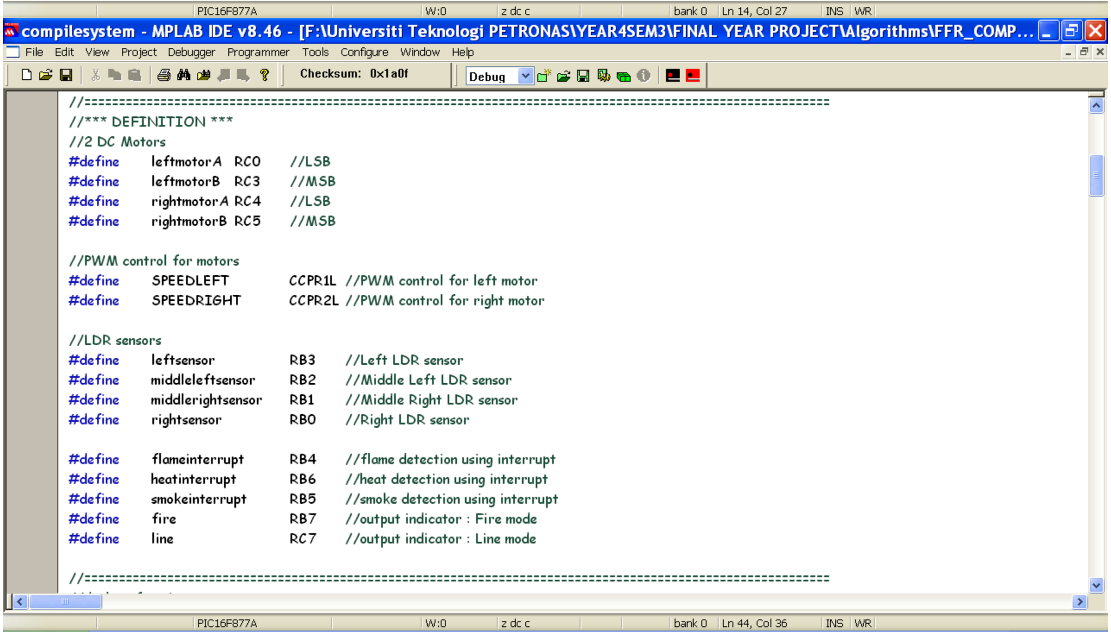
» I do wish to receive news, promotions and special offers about products and services from Elsevier Ltd and its affiliated companies worldwide.

APPENDIX P

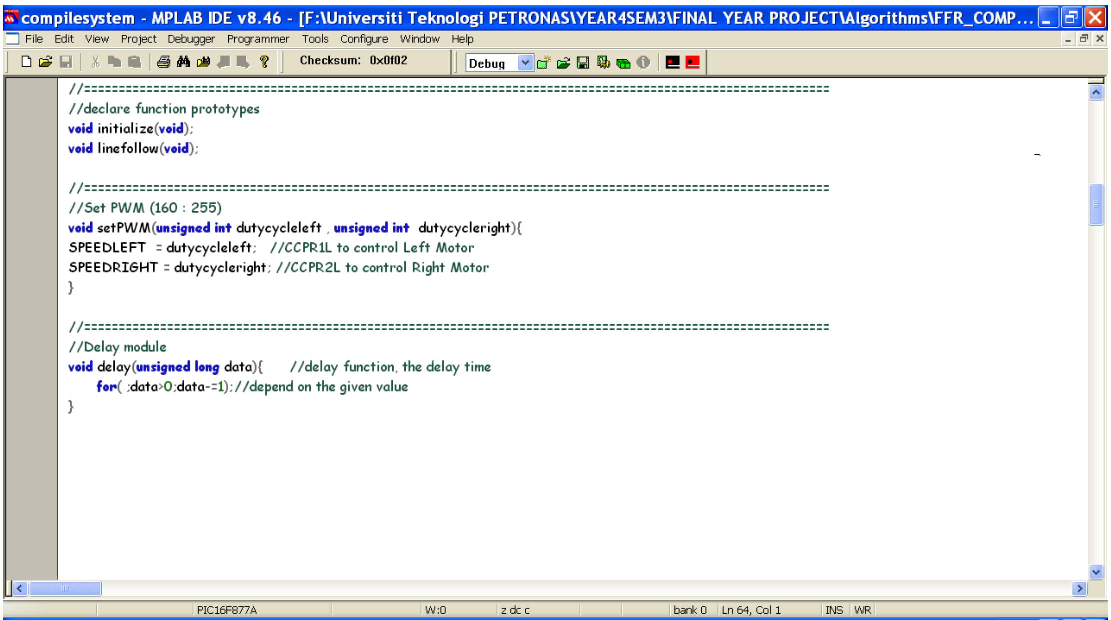
SOURCECODE



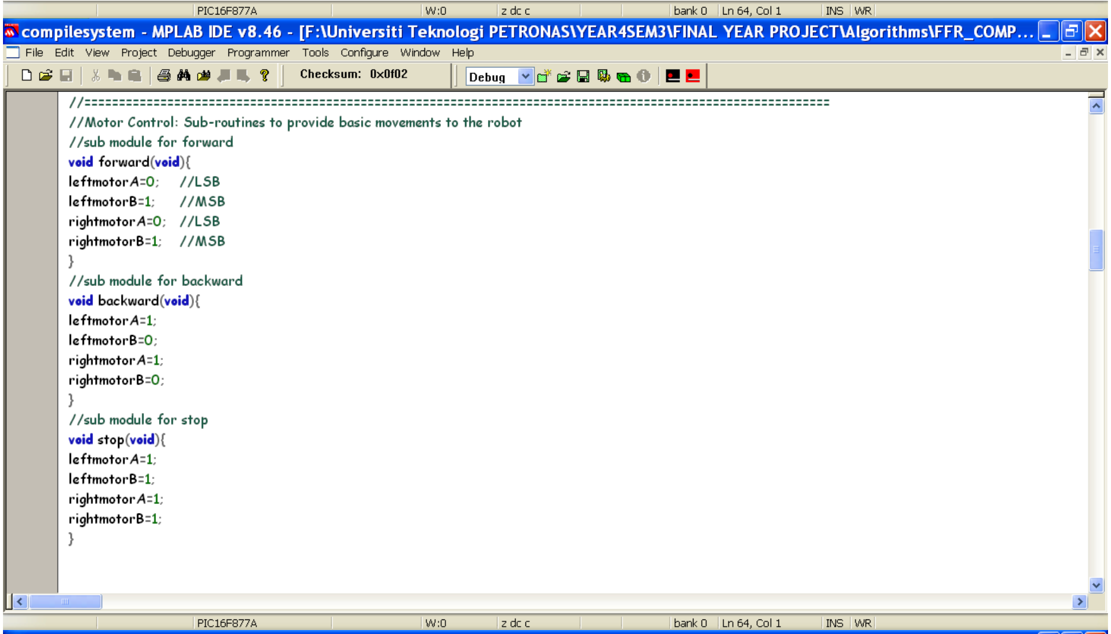

```c
//==================================================================================================
// Author               :TEH
// Project              :FIRE FIGHTING ROBOT
// Project description  :Compilation/Integration of all sub-modules
// Version              :v1.6
//==================================================================================================

//include pic header file
#include <pic.h>

//configuration
/*
•   Set high speed to Oscillator ( 4MHz to 20MHz crystal )
•   Off the Watchdog Timer
•   On Power On Timer
•   Off Brown Out Detect
•   Disable Low Voltage Program
•   Off data EEPROM Read Protect
•   Off Flash Program Write Protection
•   Off Code Protect
*/
__CONFIG (0x3F32);
```



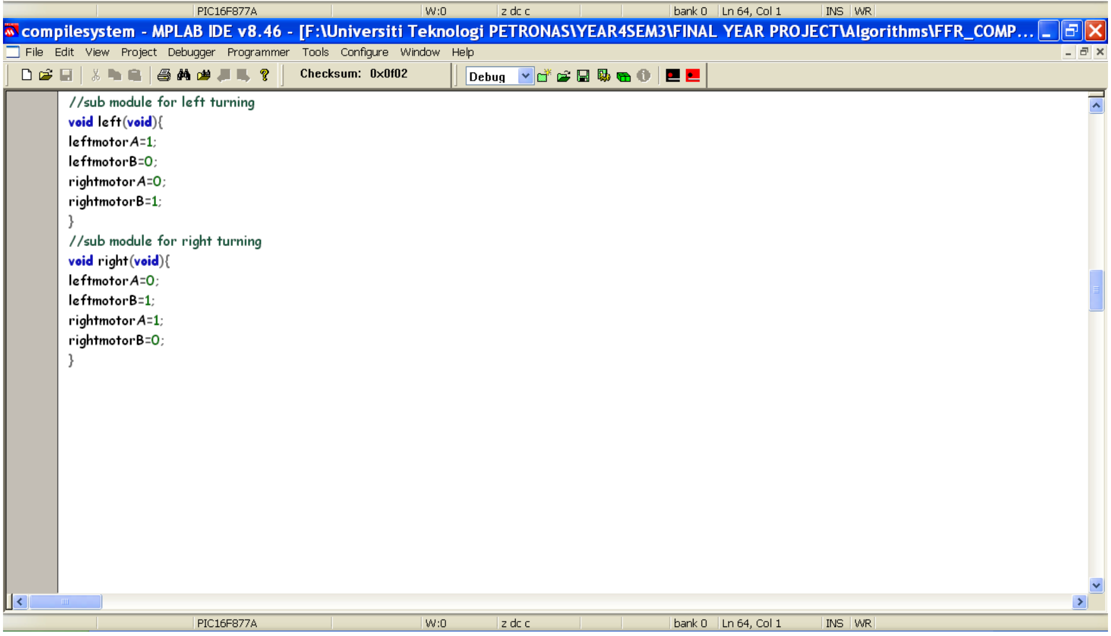

```c
//==================================================================================================
//*** DEFINITION ***
//2 DC Motors
#define     leftmotorA  RC0     //LSB
#define     leftmotorB  RC3     //MSB
#define     rightmotorA RC4     //LSB
#define     rightmotorB RC5     //MSB

//PWM control for motors
#define     SPEEDLEFT           CCPR1L  //PWM control for left motor
#define     SPEEDRIGHT          CCPR2L  //PWM control for right motor

//LDR sensors
#define     leftsensor          RB3     //Left LDR sensor
#define     middleleftsensor    RB2     //Middle Left LDR sensor
#define     middlerightsensor   RB1     //Middle Right LDR sensor
#define     rightsensor         RB0     //Right LDR sensor

#define     flameinterrupt      RB4     //flame detection using interrupt
#define     heatinterrupt       RB6     //heat detection using interrupt
#define     smokeinterrupt      RB5     //smoke detection using interrupt
#define     fire                RB7     //output indicator : Fire mode
#define     line                RC7     //output indicator : Line mode

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




```
//==========================================================================================================
//declare function prototypes
void initialize(void);
void linefollow(void);

//==========================================================================================================
//Set PWM (160 : 255)
void setPWM(unsigned int dutycycleleft , unsigned int  dutycycleright){
SPEEDLEFT  = dutycycleleft;  //CCPR1L to control Left Motor
SPEEDRIGHT = dutycycleright; //CCPR2L to control Right Motor
}

//==========================================================================================================
//Delay module
void delay(unsigned long data){      //delay function, the delay time
     for( ;data>0;data-=1);//depend on the given value
}
```




```
//==========================================================================================================
//Motor Control: Sub-routines to provide basic movements to the robot
//sub module for forward
void forward(void){
leftmotorA=0;   //LSB
leftmotorB=1;   //MSB
rightmotorA=0;  //LSB
rightmotorB=1;  //MSB
}
//sub module for backward
void backward(void){
leftmotorA=1;
leftmotorB=0;
rightmotorA=1;
rightmotorB=0;
}
//sub module for stop
void stop(void){
leftmotorA=1;
leftmotorB=1;
rightmotorA=1;
rightmotorB=1;
}
```




```
//sub module for left turning
void left(void){
leftmotorA=1;
leftmotorB=0;
rightmotorA=0;
rightmotorB=1;
}
//sub module for right turning
void right(void){
leftmotorA=0;
leftmotorB=1;
rightmotorA=1;
rightmotorB=0;
}
```

```
//==============================================================================================================
//Initialization for PIC16F877A microcontroller
void initialize(){

//Configure Ports (Inputs/Outputs) : Tris Configurations
TRISA=0b00000001;          //set RA0 as input
TRISB=0b01111111;          //set RB3,RB2,RB1,RB0 as LDR sensors inputs; RB4,RB5,RB6 as interrupt pin, RB7 as output
TRISC=0b00000000;          //set all pins in Port C as outputs
TRISD=0b00000000;          //set all pins in Port D as outputs
TRISE=0b00000011;          //set RE0 & RE1 as inputs,the rest as outputs

//PWM configurations
RBIE=1;                    //setup to capture PWM (Enable Interrupt on Port B)
PR2=255;                   //Set PWM Period through Period Register 2 (PR2)
CCPR1L = 0;                //Set Duty cycle = 0
T2CON =0b00000100;         //Enable timer 2, TMR2ON = 1
SPEEDLEFT=0;               //Set initial PWM for Left Motor = 0
SPEEDRIGHT=0;              //Set initial PWM for Right Motor = 0
CCP1CON=0b00001100;        //Configure RC1 to generate PWM for DC motor speed control (Enable CCP1M2 & CCP1M3)
CCP2CON=0b00001100;        //Configure RC2 to generate PWM for DC motor speed control (Enable CCP2M2 & CCP2M3)

//Initial reset to stop the motors
 stop();
//Cant set PWM(0,0) here else the robot wont work
```

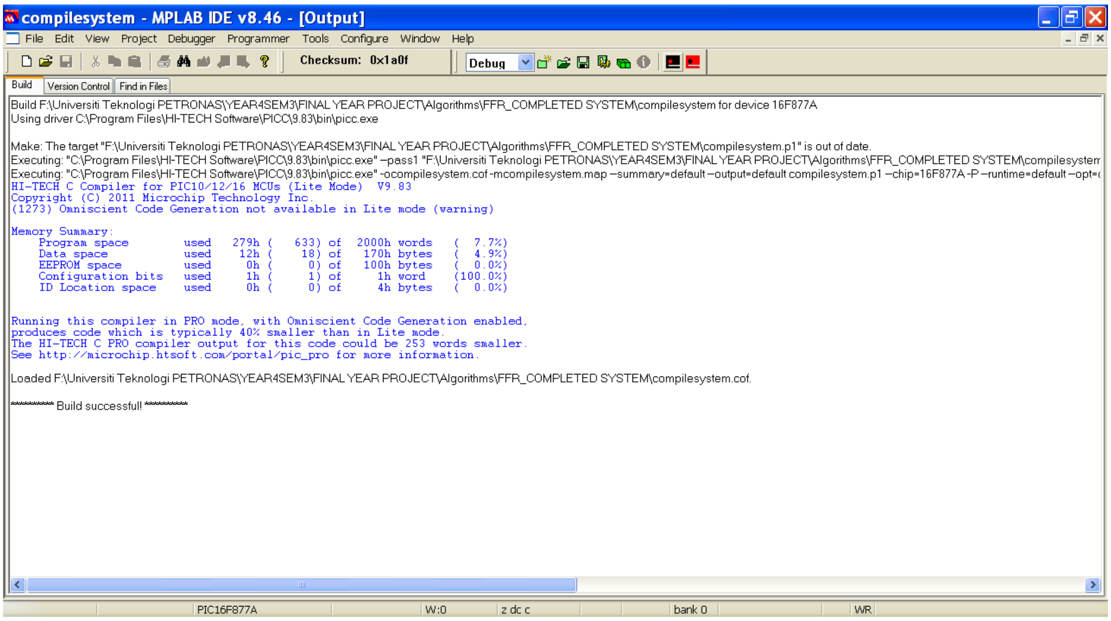
```
PEIE=1;                    // Activate/Enable Peripheral Interrupt ( Enable all unmasked peripheral interrupts)
GIE=1;                     // Enable Global Interrupt
}

//==============================================================================================================
void linefollow(){

while(1) {
line = 1;
fire=0; //off alarm

//Middle Left and Middle Right sensors detect guiding track >>> Forward
 if ((leftsensor==1) && (middleleftsensor==0) && (middlerightsensor==0) && (rightsensor==1)) {
forward();
setPWM(175,175); //forward
}

//Middle Right and Right sensors detect guiding track >>> Sharp right turning
else if ((leftsensor==1) && (middleleftsensor==1) && (middlerightsensor==0) && (rightsensor==0)) {
right();
setPWM(220,185); //sharp right
}
```

```
//Only Right sensor detects guiding track  >>> Slight right turning
else if ((leftsensor==1) && (middleleftsensor==1) && (middlerightsensor==1) && (rightsensor==0)) {
right();
setPWM(180,0); //slight right
}

//Left and Middle Left sensors detect guiding track >>> Sharp left turning
else if ((leftsensor==0) && (middleleftsensor==0) && (middlerightsensor==1) && (rightsensor==1)) {
left();
setPWM(185,220);//sharp left
}

//Left and Middle Left sensors detect guiding track >>> Slight left turning
else if ((leftsensor==0) && (middleleftsensor==1) && (middlerightsensor==1) && (rightsensor==1)){
left();
setPWM(0,180);//slight left
}

//none of the sensors detect guiding track
else if ((leftsensor==1) && (middleleftsensor==1) && (middlerightsensor==1) && (rightsensor==1)) {
forward();
setPWM(175,175); //forward
}
}//end while
}//end linefollow
```

```
//==============================================================================================================
//interrupt service routine
void interrupt isr(void)
{

//activate alarm
fire=1;
delay(5500);
fire=0;
delay(5500);

fire=1;
delay(5500);
fire=0;
delay(5500);

fire=1;
delay(5500);
fire=0;
delay(5500);

fire=1;
```

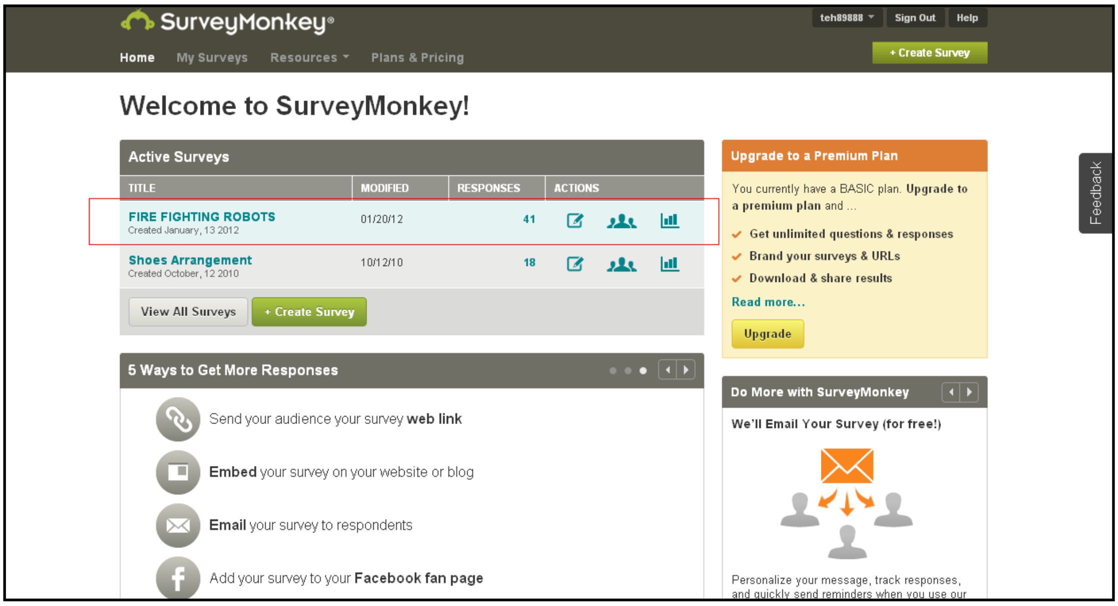
```
if(RBIF) {
    RBIF=0; //reset RBIF register

    // If RB4/RB5/RB6 pins experience changes of logic, from 0 to 1 >>> Execute Interrupt Service Routine (ISR)
    if (flameinterrupt || heatinterrupt || smokeinterrupt)
            {
            flameinterrupt=0;     // reset
            heatinterrupt=0;      // reset
            smokeinterrupt=0;     // reset

            setPWM(0,255); //lock left to turn right 90 degree perpendicular from the guiding track
            right();//turn right
            delay(58000);

            stop(); //stop for extinguishing
            delay(300000);

            setPWM(255,255); //return back to the guiding track
            backward();
            delay(65000);
            }
        }
    }
```

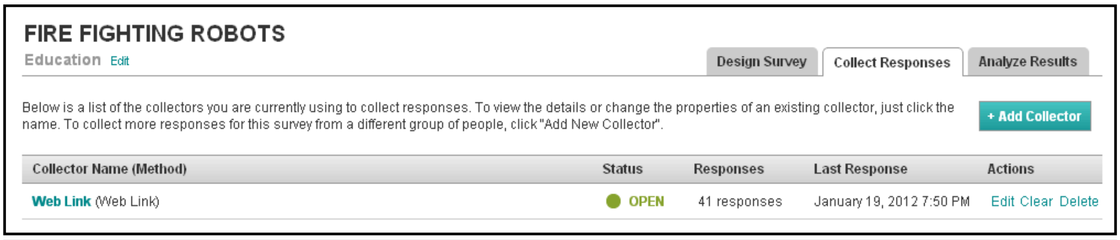
```
//main module
void main(void)
{
    initialize(); // initialization for microcontroller before the robot starts to perform the tasks

    flameinterrupt=0;     // reset interrupt for flame sensor
    heatinterrupt=0;      // reset interrupt for heat sensor
    smokeinterrupt=0;     // reset interrupt for smoke sensor

    line = 0 ;          // indicator for Patrolling Mode
    fire = 0 ;          // indicator for Flame Detection Mode

    linefollow();       //patrolling feature
}
```

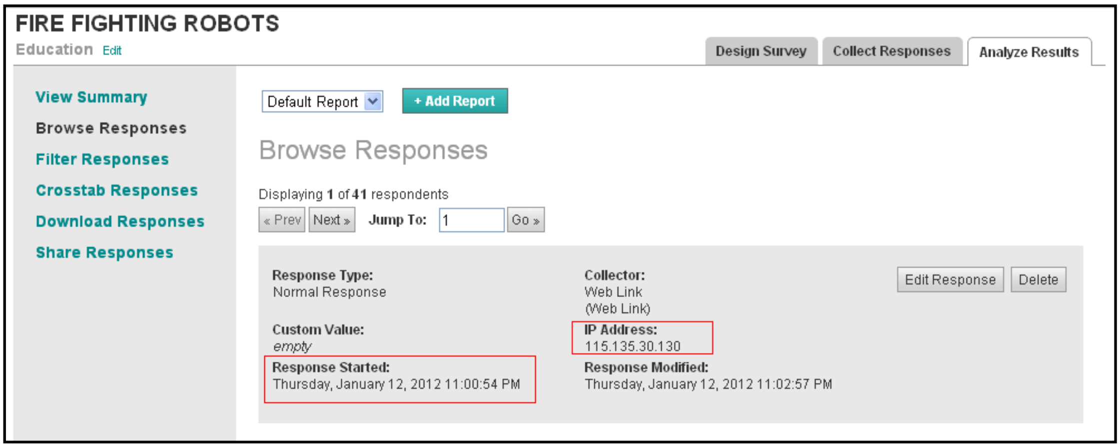

compilesystem - MPLAB IDE v8.46 - [Output]
File Edit View Project Debugger Programmer Tools Configure Window Help
Checksum: 0x1a0f
Debug
Build
Version Control
Find in Files
Build F:\Universiti Teknologi PETRONAS\YEAR4SEM3\FINAL YEAR PROJECT\Algorithms\FFR_COMPLETED SYSTEM\compilesystem for device 16F877A
Using driver C:\Program Files\HI-TECH Software\PICC\9.83\bin\picc.exe
Make: The target "F:\Universiti Teknologi PETRONAS\YEAR4SEM3\FINAL YEAR PROJECT\Algorithms\FFR_COMPLETED SYSTEM\compilesystem.p1" is out of date.
HI-TECH C Compiler for PIC10/12/16 MCUs (Lite Mode) V9.83
Copyright (C) 2011 Microchip Technology Inc.
(1273) Omniscient Code Generation not available in Lite mode (warning)
Memory Summary:
Program space used 279h (633) of 2000h words (7.7%)
Data space used 12h (18) of 170h bytes (4.9%)
EEPROM space used 0h (0) of 100h bytes (0.0%)
Configuration bits used 1h (1) of 1h word (100.0%)
ID Location space used 0h (0) of 4h bytes (0.0%)
Running this compiler in PRO mode, with Omniscient Code Generation enabled,
produces code which is typically 40% smaller than in Lite mode.
The HI-TECH C PRO compiler output for this code could be 253 words smaller.
See http://microchip.htsoft.com/portal/pic_pro for more information.
Loaded F:\Universiti Teknologi PETRONAS\YEAR4SEM3\FINAL YEAR PROJECT\Algorithms\FFR_COMPLETED SYSTEM\compilesystem.cof.
********** Build successful! **********
PIC16F877A
W:0
z dc c
bank 0
WR

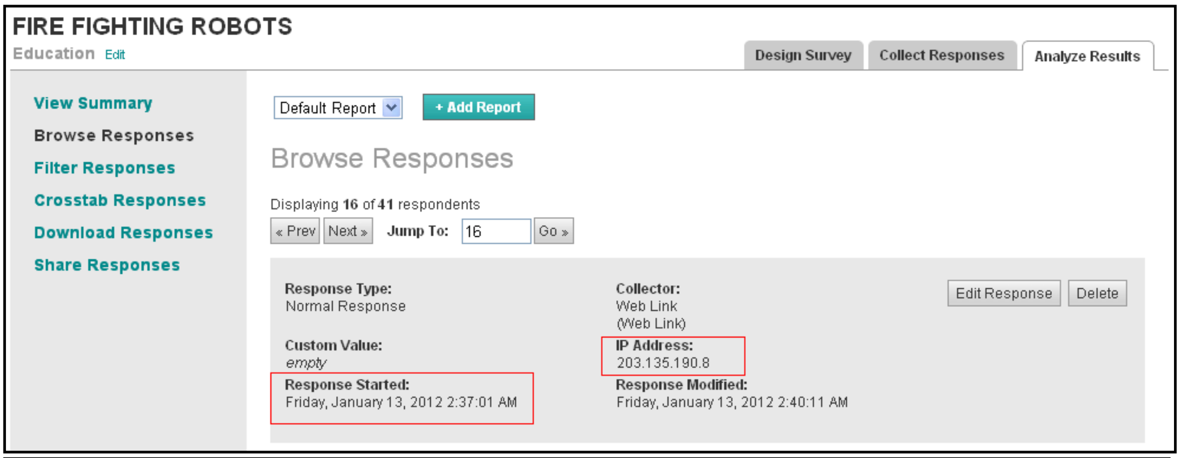
APPENDIX Q

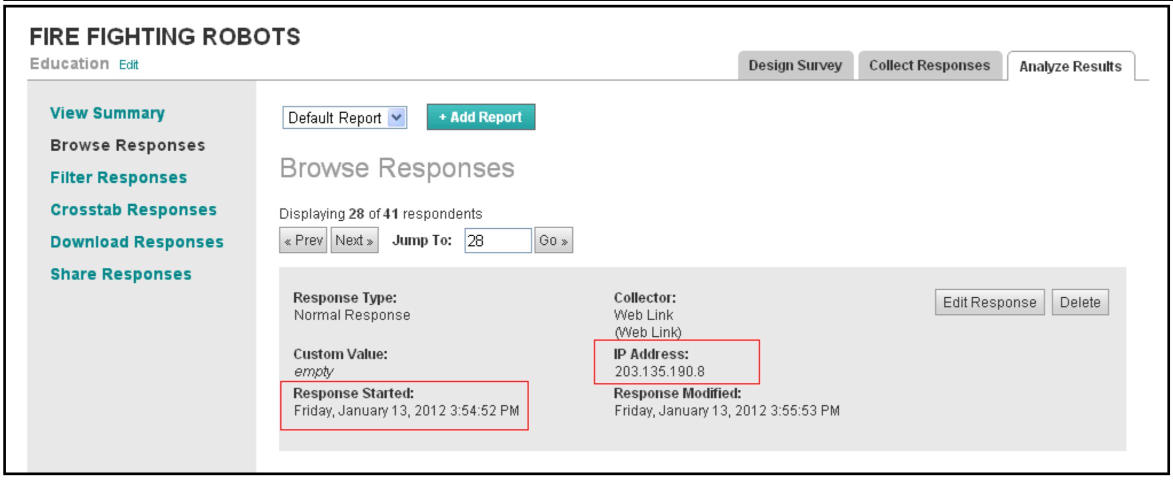
SURVEY CONDUCTED AT WWW.SURVEYMONKEY.COM

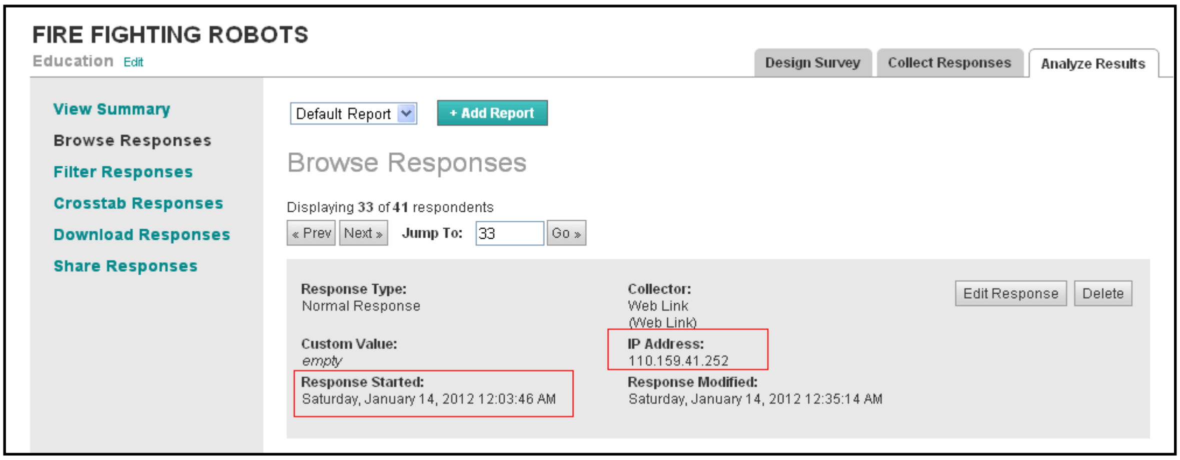


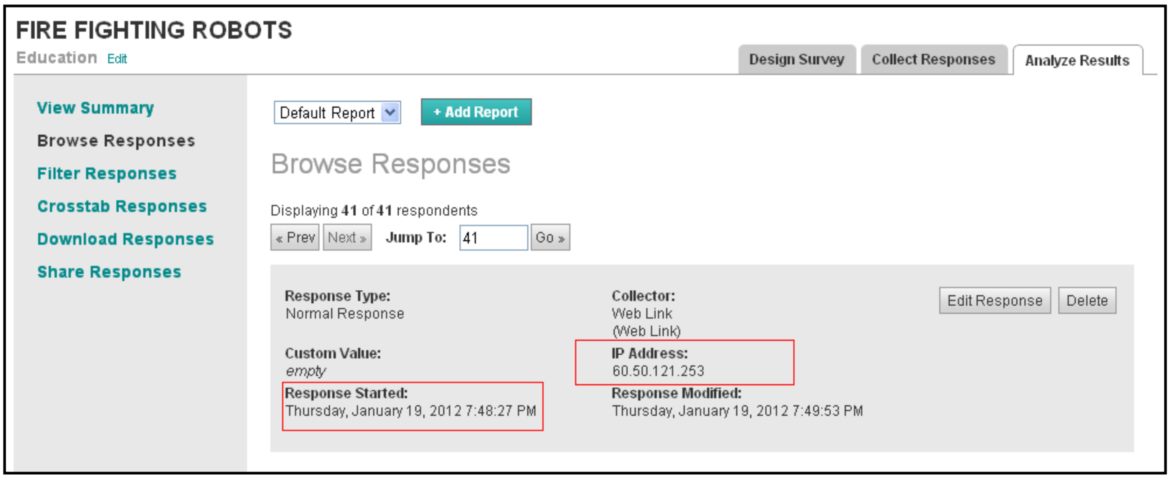





FIRE FIGHTING ROBOTS
Education Edit
Design Survey
Collect Responses
Analyze Results
View Summary
Browse Responses
Filter Responses
Crosstab Responses
Download Responses
Share Responses
Default Report
+ Add Report
Browse Responses
Displaying 16 of 41 respondents
« Prev Next »
Jump To: 16 Go »
Response Type:
Normal Response
Collector:
Web Link
(Web Link)
Edit Response
Delete
Custom Value:
empty
IP Address:
203.135.190.8
Response Started:
Friday, January 13, 2012 2:37:01 AM
Response Modified:
Friday, January 13, 2012 2:40:11 AM


FIRE FIGHTING ROBOTS
Education Edit
Design Survey
Collect Responses
Analyze Results
View Summary
Browse Responses
Filter Responses
Crosstab Responses
Download Responses
Share Responses
Default Report
+ Add Report
Browse Responses
Displaying 28 of 41 respondents
« Prev Next »
Jump To: 28 Go »
Response Type:
Normal Response
Collector:
Web Link
(Web Link)
Edit Response
Delete
Custom Value:
empty
IP Address:
203.135.190.8
Response Started:
Friday, January 13, 2012 3:54:52 PM
Response Modified:
Friday, January 13, 2012 3:55:53 PM


FIRE FIGHTING ROBOTS
Education Edit
Design Survey
Collect Responses
Analyze Results
View Summary
Browse Responses
Filter Responses
Crosstab Responses
Download Responses
Share Responses
Default Report
+ Add Report
Browse Responses
Displaying 33 of 41 respondents
« Prev Next »
Jump To: 33 Go »
Response Type:
Normal Response
Collector:
Web Link
(Web Link)
Edit Response
Delete
Custom Value:
empty
IP Address:
110.159.41.252
Response Started:
Saturday, January 14, 2012 12:03:46 AM
Response Modified:
Saturday, January 14, 2012 12:35:14 AM


FIRE FIGHTING ROBOTS
Education Edit
Design Survey
Collect Responses
Analyze Results
View Summary
Browse Responses
Filter Responses
Crosstab Responses
Download Responses
Share Responses
Default Report
+ Add Report
Browse Responses
Displaying 41 of 41 respondents
« Prev Next »
Jump To: 41 Go »
Response Type:
Normal Response
Collector:
Web Link
(Web Link)
Edit Response
Delete
Custom Value:
empty
IP Address:
60.50.121.253
Response Started:
Thursday, January 19, 2012 7:48:27 PM
Response Modified:
Thursday, January 19, 2012 7:49:53 PM