AUTOMATED GUIDED VEHICLE (AGC)

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ABSTRACT

This project is focused on development of the control system for Automated Guided Conveyor (AGC) by using PIC 18F4550. Two approaches are proposed for this project; hardware approach where involves the development and design of AGC prototype, line follower, sensor circuit and controller circuit and software approach when the system of AGC are write by using microcode studio programmed. This project concentrates on developing the automatic system for AGC which about how the AGC will operate, involve of the movement mechanism. This prototype takes into account when AGC travel and also tries to travel in order by following the line follower. This thesis also includes the test automatic system involving test program and test circuit for the AGC before proceed to the prototype AGC control system.

ABSTRAK

Projek ini difokuskan pada pembangunan sistem kawalan automatik dipandu Konveyor (AGC) dengan menggunakan PIC 18F4550. Dua pendekatan yang dicadangkan untuk projek ini; pendekatan hardware di mana melibatkan pembangunan dan rekabentuk prototaip AGC, pengikut garis, rangkaian sensor dan rangkaian kawalan dan pendekatan perisian apabila sistem AGC yang menulis dengan menggunakan microcode studio diprogramkan. Projek ini menumpukan pada pembangunan sistem automatik untuk AGC yang tentang bagaimana AGC akan beroperasi, melibatkan mekanisme gerakan. Model ini digunakan untuk saat perjalanan AGC dan juga cuba untuk melakukan perjalanan dalam rangka dengan mengikuti pengikut garis. Tesis ini juga merangkumi sistem ujian automatik melibatkan program ujian dan rangkaian uji untuk AGC sebelum meneruskan ke sistem kawalan prototaip AGC.

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LIST OF ABBREVIATIONS

AGC	Automated Guided Conveyor
AGV	Automated Guided Vehicle
MHE	Material Handling Equipment
JIT	Just In Time
AS	Automatic Storage
RS	Retrieval System
IC	Integrated Circuit
AI	Artificial Intelligent
GND	Ground
CW	Clockwise
CCW	Counter-Clockwise
PWM	Pulse Width Modulation

LIST OF SYMBOL

V_{ss}	Logic Supply Voltage
V_s	Power Supply Voltage
V_{ref}	Voltage Reference
V_{en}	Enable Voltage
V_i	Voltage Input
R	Resistor
R_{SA}	External Resistor A
R_{SB}	External Resistor B
P_1	Input 1
P_2	Input 2
P_3	Input 3
M	Motor
I_o	Peak Output Current

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The purpose of this project is to on create and develop an Automated Guided Conveyor (AGC) and it focus move on this project intended to continue and upgrade the previous AGV prototype based on two main parts: hardware approaches which are designed and developed of an AGC prototype, control circuit and line follower; and software approach that implement Microcode basic studio to program the PIC 18F4550.

1.2 PROBLEM STATEMENT

This AGC is designed to operate in the UMP FKM labs. This is to reduce the human power by applying robot to work. This AGC are functions to collect small components such as bolts and nuts.Futhermore, based on the previous project, there are also a few weakness regarding on the development. One of the weakness is when applying wiring system that limit the movement of AGC . Another weakness when it only can move forward and backward.

1.3 OBJECTIVES

I. Develop an automatic AGC by using PIC18F4550.
II. Develop controller and programming.
III. Integrate and customizing the whole system.

1.4 SCOPE OF PROJECT

The works undertaken in this project are limited to the following aspects:

1.4.1 Hardware system

I. Develop a controller circuit to ensure the AGC are run and meet the requirement.
II. Develop a line follower
III. Develop a prototype of AGC
IV. Develop sensor circuit

1.4.2 Write MICROCODE STUDIO program

I. Create the body program for whole operation easily
II. Easy connection automatic controller
III. Easily to handle

CHAPTER 2

OVERVIEW OF AUTOMATED GUIDED CONVEYOR

2.1 INTRODUCTION

The aim of this chapter is to give the overview information about the Automatic Guided Conveyor (AGC) which is part of the Material Handling Equipment (MHE) in the subject of its control system. In this chapter, the explanations will focus more on MHE and AGV from the previous research and findings, the theories are included. Combination reference from various sources as journal, thesis, references book, literature review has been carried out to collect information related to this project.

2.2 MATERIAL HANDLING EQUIPMENT (MHE)

Material handling is defined by the Materials Handling Institute as the movement of bulk packaged and individual goods, as well as their in process and post process storage, by means of manual labor or machines within the boundaries of a facility. Although this field of study includes the handling of bulk (solid- or liquid-phase) material and individual goods, this chapter will only focus on the latter (i.e., ‘‘unit loads’’), with a primary emphasis on material handling equipment, as opposed to facility planning and movement control. Material handling does not add value to the product but only cost. Thus the objective of material handling is the efficient movement of goods for the on-time delivery of correct parts in exact quantities to desired locations in order to minimize associated handling costs. It is not uncommon to have parts/subassemblies moving around a plant several kilometers prior to their shipment. Manufacturing plants must therefore eliminate all unnecessary part movements, as well as in process inventories, for just-in-time (JIT) production. Material handling equipment can be classified according to the movement mode: above-floor transportation (e.g., belt conveyors, trucks, etc.), on-floor transportation (e.g., chain conveyors), and overhead transportation (e.g., cranes). In the following sections, we will review industrial trucks (including automated guided vehicles), conveyors, and industrial robots as the primary mechanized/automated material handling equipment. We will also briefly review the automated storage and retrieval of goods in high density warehouses, as well as the important issue of automatic part identification (including bar codes). The chapter will be concluded with a discussion on automobile assembly.

2.3 REVIEW OF AUTOMATED GUIDED VEHICLE (AGV)

Material handling is an important aspect of any production system. Material handling system have been prevalent since the beginning of mass production, either as manual system, mechanical system (forklifts, conveyors), or in more recent years as fully automated system (automated guided vehicle, (AGV), automatic storage and retrieval system (AS/ RS) etc). Technological advances and the need for flexibility and reliability have increased focused on automated material handling systems. The use of AS/RS and AGV systems are becoming commonplace in today’s industries. AGVs have become increasingly popular as a means of horizontal material handling transportation system. They are used wherever there is a need for an autonomous transportation system. AGVs are particularly useful where products need to be handled carefully or the environment is potentially dangerous to humans. Examples include handling of telecommunication products, IC chips, voltage cables and radioactive materials. In the automotive manufacturing industry, AGVs have been combined with robots to perform welding and painting operations.

2.3.1 Description of an AGV system

An AGV system is an advanced material handling system that involves one or more driverless vehicles each following a guide path and controlled by an off-board computer or microprocessor. AGV are typically used to carry unit loads in production and assembly operations. The advantages of AGVs include reliable, automatic operation, flexibility in adapting to changes in material flow, improved positioning accuracy, reduced handling damage, easily expandable layout and system capacity, and automated interfaces with other system. An AGV system allows automation of a certain portion of material handling and thereby, a reduction in the labor force. It also results in an increase in the efficiency of the material handling operation, resulting in better utilization of the work force and processing equipment. An AGV based material handling system also supports various tires of production systems and improves productivity.

The efficient material handling system also helps in reducing mistakes and improving quality. The improved system results in increased worker satisfaction as it is possible to change the material arrival rate to suit the workers pace. The main advantage that a discrete material handling system such as an AGV system offers is real-time control of material handling. This helps in identification of the parts, the routes they travel and the vehicles they travel in, resulting in a lower WIP inventory, reduced tardiness, lower inventory costs and better response to demands (Hammond (1986)). An AGV system also offers other benefits such as reduction in space requirements. Unlike conveyors or other material handling systems, AGVs are small in size and only move along the aisles. They minimize product damage and help in housekeeping. Changes in the layout and relocation of the material handling system are also much easier to accomplish when using AGVs. They also are combined with other existing material handling systems and offer flexibility.

The main disadvantage of an AGV based material handling system is its expense. The high cost of the control software used and the number of vehicles required in a system curtail the wide usage of AGVs as material handling systems. A trade-off analysis between the initial setup cost of an AGV system and the savings involved is necessary before installation. Other limitations of an AGV include necessity for polished floor surfaces for smooth operation of the AGVs, guide path bed stability problems and restrictions such as height of metal floors that must be crossed and weather conditions that it can operate under when used outside the manufacturing plant. Obstructions in the facility layout and ramp gradients are other obstacles that need to be overcome when designing the guide path for the AGVs. Other issues that need to be considered when installing an AGV system are management support, worker attitudes towards the new system, maintenance problems and requirements. It can be seen from above that though the AGV has a number of benefits it also has its share of disadvantages and may not be applicable in all cases.

2.3.2 Component for an AGV

The different components of an AGV system are listed as below:

2.3.2.1 Vehicles – The vehicle or the AGV consists of the frame, batteries, on-board charging unit, and electrical system, drive unit, steering, precision stop unit, communication unit, safety system and work platform. The components mentioned above can each be further classified into different categories based on their capabilities and features. The application for which the AGV is used dictates the type of component that is to be used.

2.3.2.2 Guide path and guidance systems – Most AGVs need a guide path to follow. The guide path techniques used are known as passive or active tracking. Passive tracking occurs when optical or metal detection principles (wireless) are used for vehicle guidance whereas active tracking involves inductive principles (for example, guide wire is used to help tracking).

2.3.2.3 Floor and system controls – The controller is the brain of the whole system, tying the vehicle and the guide path together and integrating the system. The AGVs contains three levels of control architecture: vehicle control system, floor control unit and vehicle on-board processor. These control systems take care of the different tasks such as lane selection, carrier selection, guide path frequency generation, blocking between vehicles, automatic routing, controlling speeds, displaying job information, monitoring floor equipment status, tracking loads and so on.

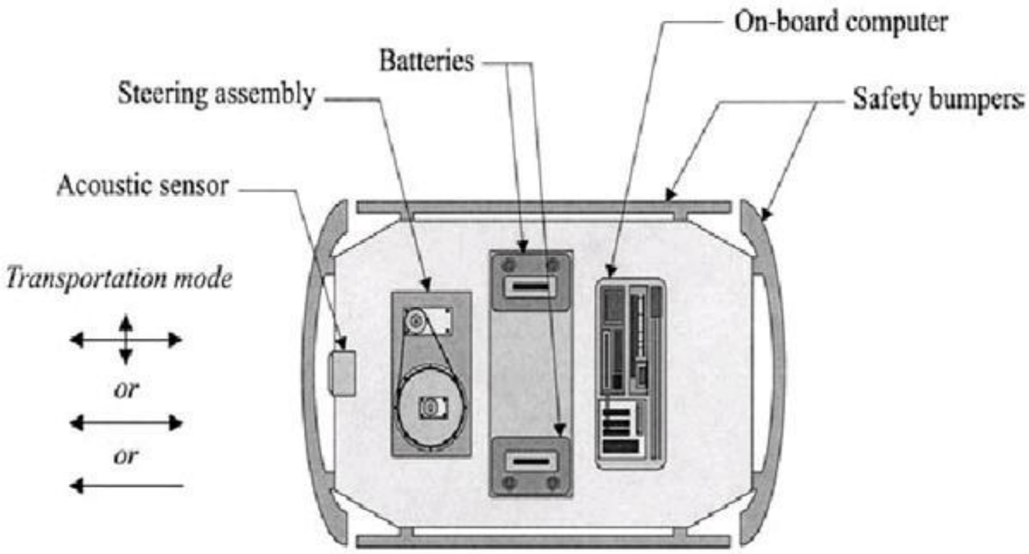


Figure 2.1: AGV Basic Components

2.3.3 AGV system design

The only current literature review on the Automated Guided Vehicle (AGV) flow path design problem is by Sinriech (1995). The general network design models for discrete material flow systems are reviewed. It concentrates more on the aspects of AGV flow path and reviewed individual papers very briefly. It also does not offer a classification scheme for the AGV flow path literature. However, the paper discusses various parameters involved in a material handling flow system and the different approaches that have been used to solve this problem. Peter, et al (1995) presents a control classification scheme for AGVs. They present a nice classification scheme for an AGV system in general, but concentrate more on the control aspects of the problem. They present the classification scheme with 3 basic level namely – guide path determination, vehicle capacity and vehicle addressing mechanism.

The paper does not concentrate as much on each of the individual levels, but gives a brief overview of each level and sublevel. It presents a cubic structure (based on the levels and sub levels) which partitions the AGV system into 12 different classes. Depending on the functionality requirement and the sublevel chosen, this structure helps identify the relative complexity involved in designing the required AGV system.

Vosniakos and Mamalis (1990) discussed the issues involved in an AGV system design with respect to flexible manufacturing system applications. An overview of the different aspects of an AGV is presented with emphasis on route control and collision avoidance. Docking, load transfer, traffic control, communication between the controller and the vehicle, AGV management policies, evaluation of the control policies and various other aspects that have to be considered before setting up an AGV based system are also discussed.

One of the more important areas in an AGV design is the guide path and guidance system. The area of interest in the guidance system and guide path is the guide path layout. There has been little research in the area of guide path layout. The research done in area of guide path layout in AGV systems can be explained better using the classification scheme presented in Rajagopalan and Heragu (1997).

2.3.4 Flow path type

The type of flow path in an AGV system is its most important characteristic. The flow path for any AGV system dictates how the AGV will travel between the different pickup/drop-off (p/d) points. The classification is based on the type of flow path used.

2.3.4.1 Traditional Layout

Maxwell and Muckstadt (1982) first recognized the importance of AGV based material handling system design. They developed a model that determines the maximum number of AGVs needed to efficiently transfer material from one facility to another. The problem was solved assuming the guide path was already installed and the best route had to be determined. The objective under consideration was to minimize total travel time. Figure 2.2 shows a traditional AGV flow path design.

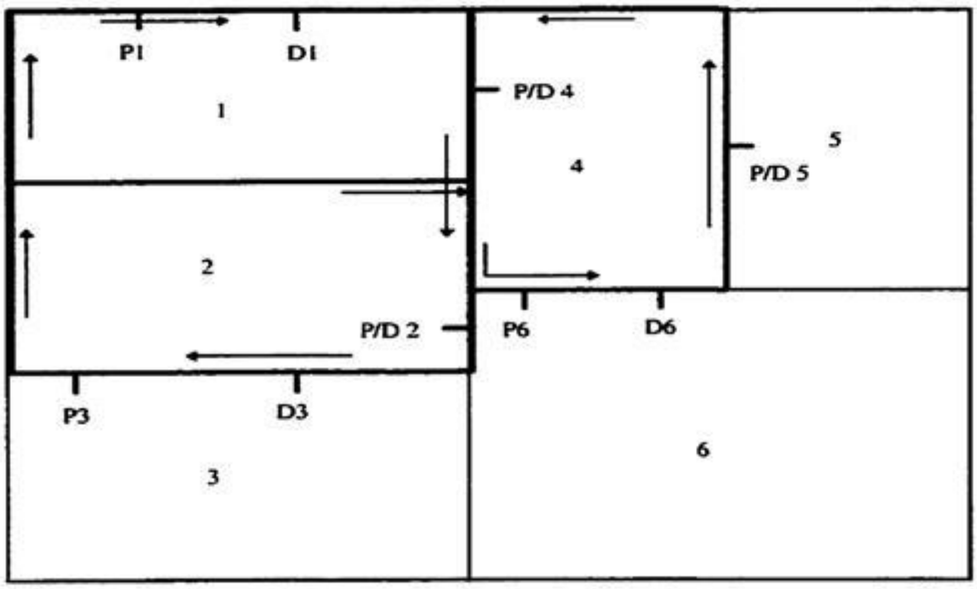


Figure 2.2: Traditional AGV flow path design

Maxwell and Wilson (1981) had developed a dynamic network flow model earlier to analyze the effects of blocking in a fixed path system. A traditional flow path design involved determining the best path that connected all the given p/d points.

Gaskin and Tanchoco (1987) presented a binary integer model to determine the optimal flow path for an AGV system. They only considered the movement of loaded vehicles unlike Maxwell and Muckstadt (1982). They did not make any assumptions about the flow path except that movement was restricted to certain areas (such as the aisles), nor did they discuss any generic solution method to the model. An example is solved to illustrate the approach used, but this approach cannot be generalized.

Kaspi and Tanchoco (1990) considered a unidirectional AGV system and solved the optimal flow path design problem using a branch and bound technique. The formulation is the same as that presented by Gaskins and Tanchoco (1987). They formulate the problem as a graph network (node – arc network) with the pick-up/drop-off points as nodes and feasible guide paths as arcs. They also addressed the reach ability problem which tackles the situation where a group of nodes might end up as sink nodes.

Sinriech and Tanchoco (1991) developed a formulation to solve the traditional AGV flow path problem using a graph theory approach. They use the same node – arc formulation as Kaspi and Tanchoco (1990) and use the model to give directions to the undirected graph network. They then use an improved branch and bound technique to solve the problem. They consider both loaded and unloaded travel time in this formulation. Gaskins and Tanchoco (1989) developed a model to solve the virtual flow path problem. The virtual flow path arises in cases where the AGV guide path does not exist in reality. The AGV is guided by the controller without the need for a physical guide path. They formulate the problem as a multi commodity flow problem where the material to be transferred is substituted for people and unit loads. This results in an integer model based on the multi-commodity flow problem. Instead of Euclidean or rectilinear distance, they consider a path distance which takes into account the fact that rectilinear distances and Euclidean distances may not always be applicable when considering distance between two facilities.

A path distance is the actual distance taken by an AGV to travel from one point to another. Goetz and Tanchoco (1989) and came up with an algorithm to solve layout design problem. The objective of this model is to minimize the total distance traveled. They reduce the problem size to be solved using a heuristic and the new reduced problem is used to determine the p/d points. Their heuristic determines the major flows into and out of each department and uses this as a base to prioritize the departments. It assumes that the flow data between departments is already known. Rectilinear distances are used and the flow is assumed to be between the departments centroids. It also uses the fact that in case of unidirectional AGV flow path design only four paths need be examined when considering the route between any pick up and drop off point. A linear programming model obtained after simplifying certain nonlinear terms is presented in this paper. For larger problem sizes this model may be difficult to solve.

2.3.5 Language

The language provided for the control of the bus master (and therefore the robot) is quite unusual as it provides low, high and very high level commands. The language definition itself only commons the low and high level commands while the very high level commands have to be added to the language by means of include and import files. When a module is acquired or constructed these files must be proved as well, containing all the commands that the module understands in the form of a command-code list for the include files and in the form of a procedure (probably containing bus access commands) written in the language in the case of import files. This feature of the language will allow its command set to increase as new developments are made and also provide ease of use for a purchased module as the operator will only have to know the command list the module understands rather than any complex codes that it needs to be passed. Therefore to use a module on a new system it would only be necessary to plug it in and add the relevant commands to any program at the standard input/output terminal.

2.4 Conveyor

Conveyors are a broad class of material handling (conveying) equipment capable of transporting goods along fixed paths. Although conveyors are the least flexible material handling equipment (owing to their path inflexibility), they provide manufactures with a cost effective and reliable alternative. Conveying equipment is generally classified as above floor conveyors versus on-floor or overhead tow-line conveyors. Both classes allow horizontal and inclined conveying, while tow-line conveyors. Both classes allow vertical conveying (e.g, bucket elevators). In the following subsections, several examples of conveyors will be discussed with the emphasis being on conveying for manufacturing (Asfahl, Ray C.(1992)).

2.4.1 Above Floor Conveyors

Above-floor conveyors have been also classified as package handling conveyors owing to their primary application of transporting cartons, pallets, and totes. On the factory floor, they are utilized to transport (palletized/fixture) work pieces (e.g, engine blocks, gearboxes, household items) from one assembly station to another. Networked environment, where branching occurs, automatic identification devices must be utilized to route parts correctly to their destination along the shortest possible path.

2.4.2 Roller Conveyors

Powered roller conveyors are line-restricted conveying devices comprising a set of space roller mounted between two side frame members and elevated from the floor by a necessary distance. Rolling power can be achieved by a moving flat belt underneath the rollers or a set of drive belts rotating the rollers individually, yielding speeds of up to 30 to 40 m/min.

2.4.3 Belt Conveyors

The early use of belt conveyors can be traced back to late 1800s in the mining industry. Today, the flat-belt version of such conveyors (versus the one used in bulk-material transfer with side inclined rollers-“troughing” idlers) are commonly used in the manufacturing industry for the transfer individual (unpalletized) work pieces, as well as cartons/bins/etc. the highly durable, endless belt is placed in tension between two pulleys and normally operated in unidirectional motion.

The belt is the most important and expensive component of a belt conveyor. A carcass, enclosed between top and bottom covers provides the tensile strength necessary for conveying and absorbs the impact forces by work pieces being loaded onto the belt. The top cover protects the carcass against tear and wear and against high temperatures when needed (up to 200°C). Steel is commonly used in the construction of the carcass for high tension applications.

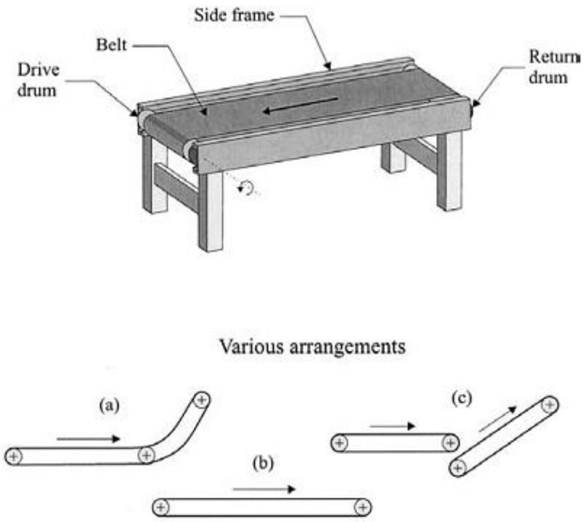


Figure 2.3: Belt Conveyors

Belt conveyors can be inclined up to 30 to 40° and operate at speeds of 10 to 40 m/min, over lengths of 20 to 30m, while carrying loads of up to 800kg/m.

2.4.4 On Floor and Overhead Conveyors

On-floor towline conveyors provide manufacturers with versatile transportation systems for conveying goods unsuitable (large, irregular geometry, etc) for above-floor conveyors. They normally comprise one, two or multiple chains running in parallel tracks (in shallow trenches). Goods can be directly placed on the chains or on pallets. Towline carts on a variety of sizes and shapes have also been used in on-floor conveying using chain conveyors. Traditionally, chain conveyors have been configured to operate along straight lines, horizontally and at low speeds (typically, 1 to 5 m/min for larger loads and less than 25 to 30m/min for small loads).

Overhead conveyors maximize utilization of three-dimensional work spaces. Although most are configured for the point to point transportation of unit loads directly mounted on the conveyor via hooks (e.g, automobile doors) or placed on suspension pallets, they can also provide a favorable environment for certain manufacturing applications such as the on-the-fly spray-painting of work pieces. Overhead conveyors can operate horizontally or in inclined nodes. The drive mechanism employs chains or worm-screws. Occasionally, these conveyors also employ individually powered carriers capable of moving along monorails.

Overhead conveyors can reach speeds up to 80 to 100m/min; through typically they operate in range of 10 to 20m/min.

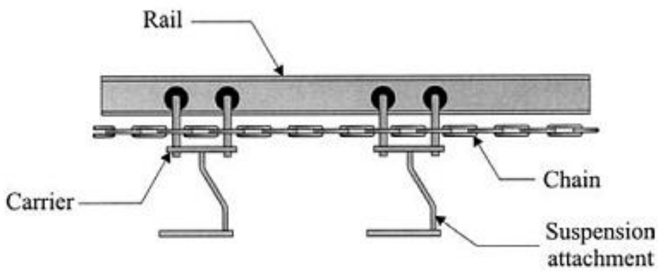


Figure 2.4: Overhead Conveyor

2.5 CONCLUSION

In this project AGV involving conveyor is called AGC. Automated Guided Conveyor (AGC) is one type of Material Handling Equipment (MHE) like conveyors, cranes & hoist, elevator & lifts, automatic storage and retrieval system and other which are focuses in process of transmitting goods from one place to another. These applications are used especially in industrial sector or industrial warehouse. The goals are to improve good working condition, improve productivity, promote safety and main target is to saving time and cost of production.

AGC is monitoring vehicle that move along the predetermined paths and performing certain describe duties. Moreover it’s relatively non-intelligent which direction can go and where they are sent and perform very limited and simple activities.

CHAPTER 3

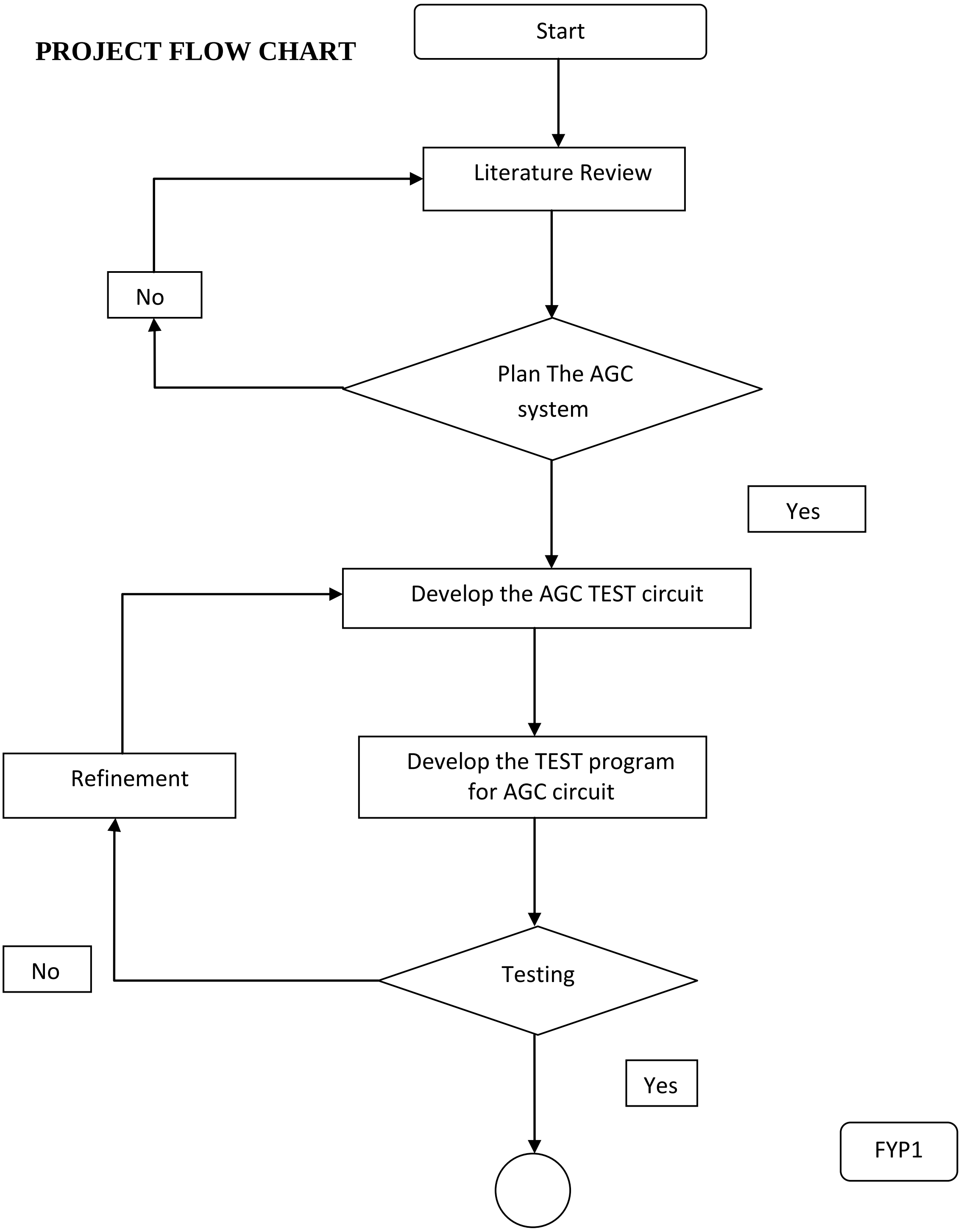
METHODOLOGY

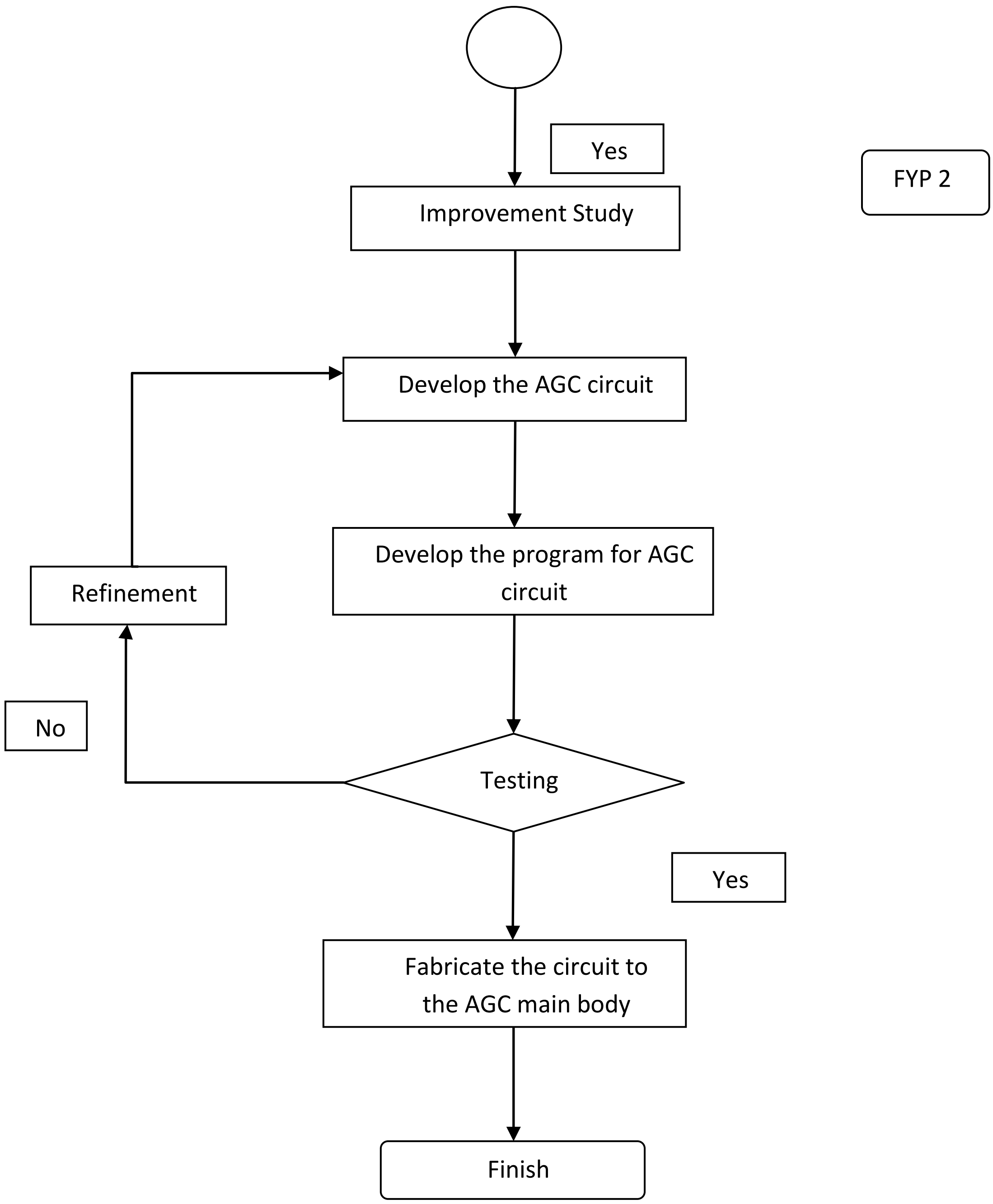
3.1 INTRODUCTION

Generally, this project involves a development of the program, creating the circuit for AGC where the main target to ensure the AGC work accordingly. This chapter will explain the overall flow of this project involves flow for AGC operation. To achieve the objectives of this project, methodology were constructed base on the scopes of projects as guiding principle to formulate this project successfully. A terminology of works and plans show in the flow chart. This is very important to make sure the goal and purpose of this project can be achieved. Literature review is the first things that need to be develop before plan the AGC system. If the system were plan accordingly, AGC test circuit and program for AGC circuit can be building. Finally is testing the AGC circuit if there are problems regarding to the circuit, refinement will be made.

3.2 FLOW CHART

PROJECT FLOW CHART




Yes
FYP 2
Improvement Study
Develop the AGC circuit
Develop the program for AGC circuit
Refinement
No
Testing
Yes
Fabricate the circuit to the AGC main body
Finish

3.3 DEVELOPMENT OF CONTROL SYSTEM

This project is to develop automatic controller. The method technical strategies implied is the most important disciplined to look at. Therefore some simplified phase by phase method was proposed. By using this method, problems can be detected at the early stage to avoid hectic failure. There is always a target to reach either short term or long term goals. It is more organized to do the job one by one according to their respective phases. Thus, the development of the robot is divided into three phases. They include; hardware development, electronic control system and software development process.

3.3.1 Phase 1-Chassis Development Process

The chassis of this project are constructed in this phase. The purpose of the chassis is to provide a place to mount all the electronics for the AGC, the platform also included space for micro controller, batteries and motors. Other mechanical parts include wheels and batteries 12V.The back design is attached with two drivers less tires, shown in Figure 3.2 below.

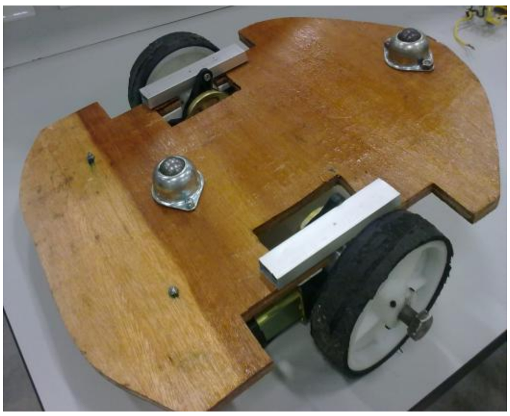


Figure 3.1: Back design of the base

The tires are connecting with an aluminum shaft, so the shaft can also been attached with power window motor. It showed in Fig 3.3 and 3.4.

Figure 3.2: Attachment between shaft and tire.

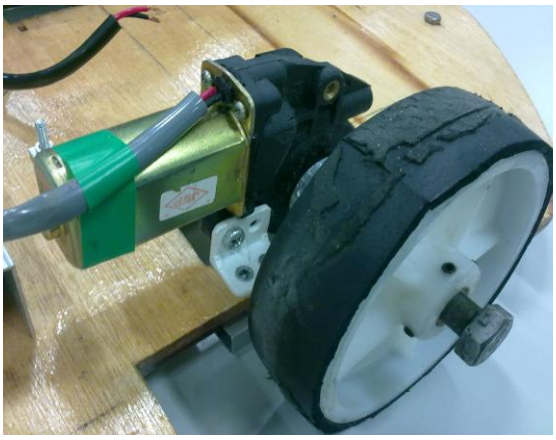


Figure 3.3: Attachment between tires and power windows motor.

3.3.2 Phase 2- Electronic Control Development Process

Electronic Control Development Process is one of the more complex phases as it cover many task which all need specific attention. The second phase of the AGC development involves the circuit connection of each module. The circuit connection of each module is explained elaborately which include the operations, functionality and features of each device. This chapter focus on the circuit diagram of micro controller PIC 18F4550, Enhanced 40 pins PIC Start-up Kit, DC gear Motor, controller circuit, wireless interface circuit and motor control circuit. Subsequently, numerous tests on the designed circuit are performed on a prototyping board. Once the circuit works effectively, the circuit designed then is transferred on the striped board.

3.3.2.1 Introduction to PIC 18F4550

Programmable Interface Controller (PIC) are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability. PIC has a set of registers that function as general purpose RAM. Special purpose control registers for on-chip hardware resources are also mapped into the data space. The addressability of memory varies depending on device series, and all PIC devices have some banking mechanism to extend the addressing to additional memory. Later series of devices feature move instructions which can cover the whole addressable space, independent of the selected bank.

Many of these architectural decisions are directed at the maximization of top-end speed, or more precisely of speed-to-cost ratio. The PIC architecture was among the first scalar CPU designs, and is still among the simplest and cheapest. The Harvard architecture - in which instructions and data come from conveniently separate sources - simplifies timing and microcircuit design greatly, and this pays benefits in areas like clock speed, price, and power consumption.

The simplicity of the PIC, and its scalar nature, also serve to greatly simplify the construction of real-time code. It is typically possible to multiply the line count of a PIC assembler listing by the instruction cycle time to determine execution time. On other CPUs (even the Atmel, with its MUL instruction), such quick methods are just not possible. In low-level development, precise timing is often critical to the success of the application, and the real-time features of the PIC can save crucial engineering time.

PIC18F4550 is the micro controller will be used in this project. It has 35 I/O pins with individual direction control in 40 DIP pins package. It function is to process all data from input and control the output process. PIC18F4550 micro controller is a high performance RISC CPU. Its operating speed is about 20MHz clock per input. It has 100,000 Erase/Write Cycle Enhanced Flash Program Memory typical, 368 Byte RAM Data Memory and 256 Byte EEPROM Data Memory. Figure 4 show PIC18F4550 Block Diagram.

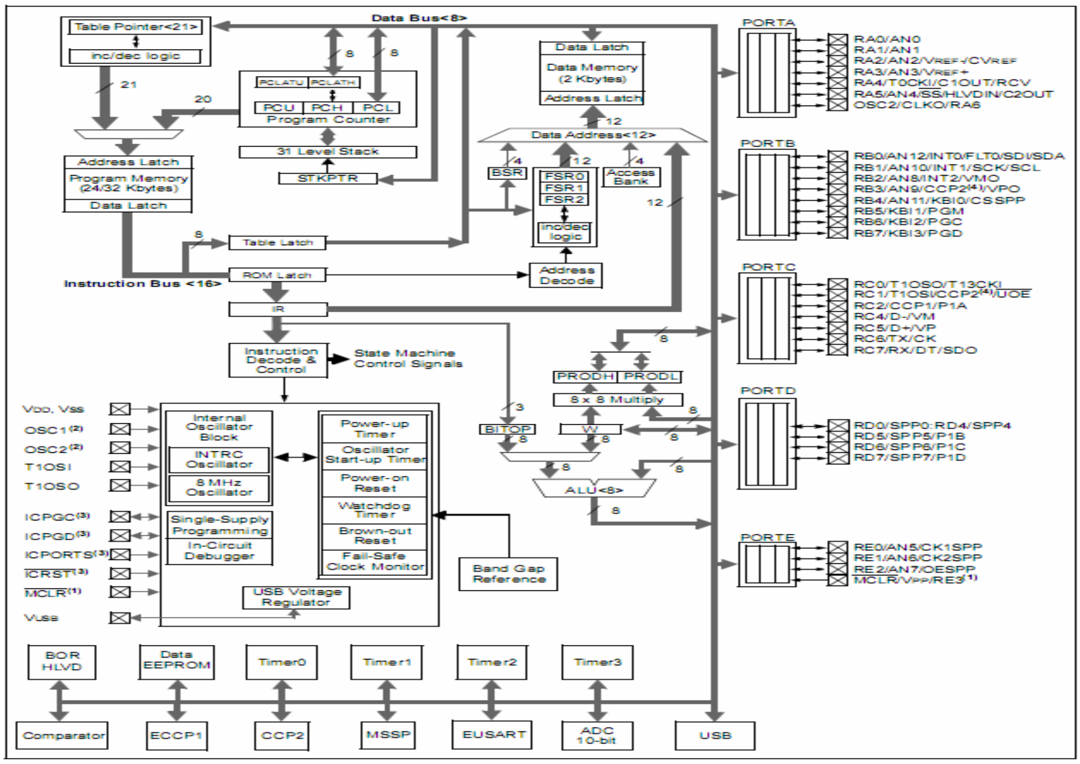


Figure 3.4: PIC18F4550 Block Diagram Special Micro controller Features

1. C Compiler Optimized Architecture with optional Extended Instruction Set
2. 100,000 Erase/Write Cycle Enhanced Flash Program Memory typical
3. 1,000,000 Erase/Write Cycle Data EEPROM Memory typical
4. Flash/Data EEPROM Retention: > 40 years
5. Self-Programmable under Software Control
6. Priority Levels for Interrupts
7. 8 x 8 Single-Cycle Hardware Multiplier
8. Extended Watchdog Timer (WDT):
   - Programmable period from 41 ms to 131s
9. Single-Supply 5V In-Circuit Serial

10. Programming™ (ICSP™) via two pins
11. In-Circuit Debug (ICD) via two pins
12. Optional dedicated ICD/ICSP port (44-pin devices only)
13. Wide Operating Voltage Range (2.0V to 5.5V)

40-Pin PDIP

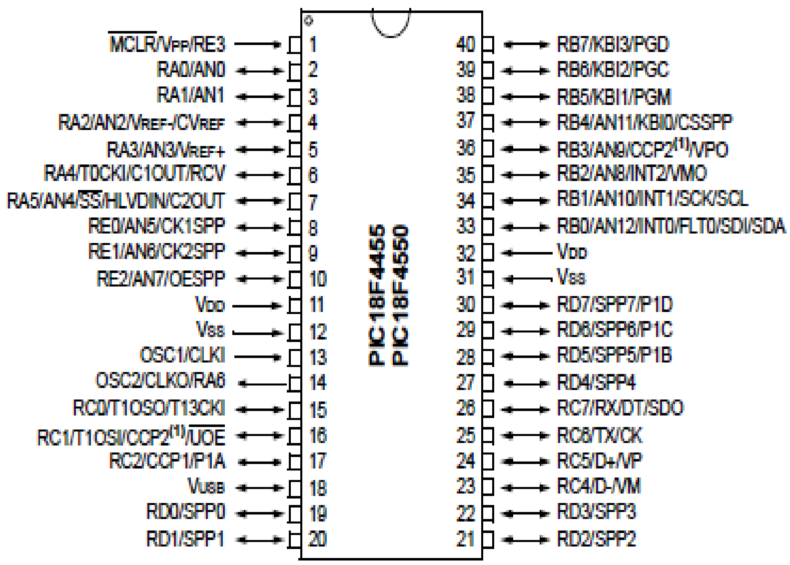


Figure 3.5: Pin Layout

This micro controller has two 8-bit timer/counter (TMR0, TMR2) with 8-bit programmable pre-scale, one for 16 bit timer/counter (TMR1) and two for capture, compare and PWM module. These microchips have 40 pins with operating voltage range from 2V to 5.5V as show in figure 2 and pin description at figure 3.

Pin	Function	TRIS Setting	I/O	I/O Type	Description
RA0/AN0	RA0	0	OUT	DIG	LATA<0> data output; not affected by analog input.
		1	IN	TTL	PORTA<0> data input; disabled when analog input enabled.
	AN0	1	IN	ANA	A/D input channel 0 and Comparator C1- input. Default configuration on POR; does not affect digital output.
RA1/AN1	RA1	0	OUT	DIG	LATA<1> data output; not affected by analog input.
		1	IN	TTL	PORTA<1> data input; reads '0' on POR.
	AN1	1	IN	ANA	A/D input channel 1 and Comparator C2- input. Default configuration on POR; does not affect digital output.
RA2/AN2/ VREF-/CVREF	RA2	0	OUT	DIG	LATA<2> data output; not affected by analog input. Disabled when CVREF output enabled.
		1	IN	TTL	PORTA<2> data input. Disabled when analog functions enabled; disabled when CVREF output enabled.
	AN2	1	IN	ANA	A/D input channel 2 and Comparator C2+ input. Default configuration on POR; not affected by analog output.
	VREF-	1	IN	ANA	A/D and comparator voltage reference low input.
	CVREF	x	OUT	ANA	Comparator voltage reference output. Enabling this feature disables digital I/O.
RA3/AN3/ VREF+	RA3	0	OUT	DIG	LATA<3> data output; not affected by analog input.
		1	IN	TTL	PORTA<3> data input; disabled when analog input enabled.
	AN3	1	IN	ANA	A/D input channel 3 and Comparator C1+ input. Default configuration on POR.
	VREF+	1	IN	ANA	A/D and comparator voltage reference high input.
RA4/T0CKI/ C1OUT/RCV	RA4	0	OUT	DIG	LATA<4> data output; not affected by analog input.
		1	IN	ST	PORTA<4> data input; disabled when analog input enabled.
	T0CKI	1	IN	ST	Timer0 clock input.
	C1OUT	0	OUT	DIG	Comparator 1 output; takes priority over port data.
	RCV	x	IN	TTL	External USB transceiver RCV input.
RA5/AN4/$\overline{SS}$/ HLVDIN/C2OUT	RA5	0	OUT	DIG	LATA<5> data output; not affected by analog input.
		1	IN	TTL	PORTA<5> data input; disabled when analog input enabled.
	AN4	1	IN	ANA	A/D input channel 4. Default configuration on POR.
	$\overline{SS}$	1	IN	TTL	Slave select input for SSP (MSSP module).
	HLVDIN	1	IN	ANA	High/Low-Voltage Detect external trip point input.
	C2OUT	0	OUT	DIG	Comparator 2 output; takes priority over port data.
OSC2/CLKO/ RA6	OSC2	x	OUT	ANA	Main oscillator feedback output connection (all XT and HS modes).
	CLKO	x	OUT	DIG	System cycle clock output (FOSC/4); available in EC, ECPLL and INTCKO modes.
	RA6	0	OUT	DIG	LATA<6> data output. Available only in ECIO, ECPIO and INTIO modes; otherwise, reads as '0'.
		1	IN	TTL	PORTA<6> data input. Available only in ECIO, ECPIO and INTIO modes; otherwise, reads as '0'.

Legend: OUT = Output, IN = Input, ANA = Analog Signal, DIG = Digital Output, ST = Schmitt Buffer Input,
TTL = TTL Buffer Input, x = Don't care (TRIS bit does not affect port direction or is overridden for this option)

Figure 3.6: Pin Description

3.3.2.2 Power Circuit

To ensure the micro controller and other integrated circuits are supplied with 5V dc voltage, a regulator is used to regulate the output voltage at 5V to prevent any damage on the components especially micro controller. In this project, voltage regulator 7805 is used to regulate 5V voltage. Figure 4 shows the schematic diagram for the power circuit.

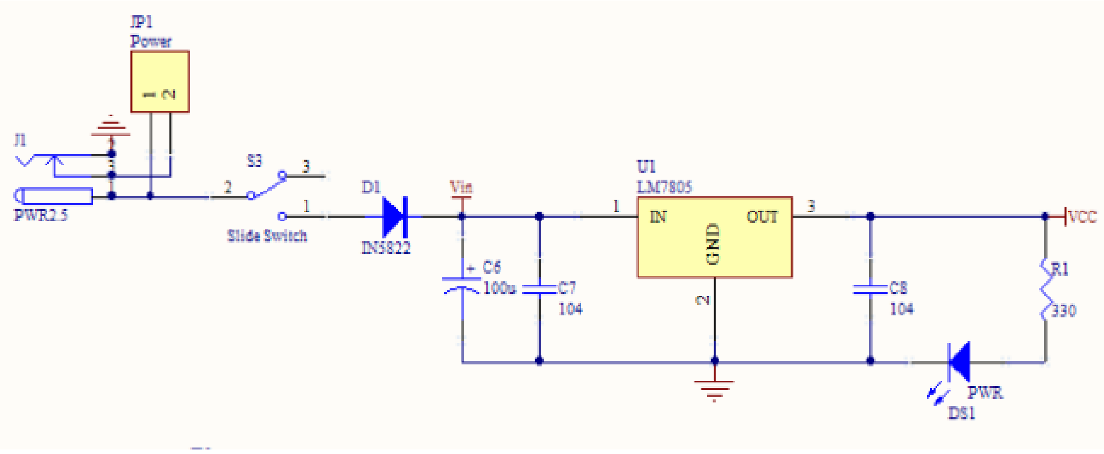


Figure 3.7: Power Circuit

3.3.2.3 Clock Circuit

In order to provide clock to the microcontroller system, a 20MHz crystal is used to produce 5MHz output clock cycle. The rate of the clock is determined by a crystal that is connected to the pin CLKIN and CLKOUT at the microcontroller. Figure 8 shows the schematic diagram of clock circuit.

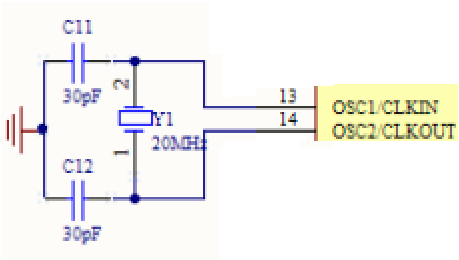


Figure 3.8: Clock Circuit

3.3.2.4 Reset Circuit

Figure 3.13 shows the schematic diagram of the reset circuit. This circuit is used to reset the microcontroller process. Pressing the push button causes the signal to be pulled low, thus forcing a reset. The value of RC must be chosen properly.

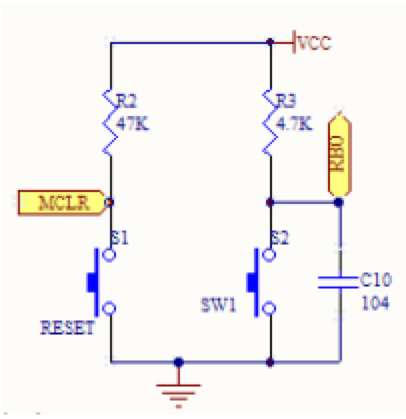


Figure 3.9: Reset Circuit

3.3.2.5 Enhanced 40 pins PIC Start-up Kit

Figure 3.10: Enhanced 40 pins PIC Start-up Kit

This board compatible with 5V voltage regulator, 20MHz crystal oscillator, reset button, RS232 hardware for serial communication to PC, connector for UIC00A, and On/Off switch for main power. The input supply should be ranged from 7 to 15 V. This board offers a compact, powerful, flexible and robust start-up platform.

3.3.2.6 IR Sensor

IR LED emits infrared radiation. This radiation illuminates the surface in front of LED. Surface reflects the infrared light. Depending on reflectivity of the surface, amount of light reflected varies. This reflected light is made incident on reverse biased IR sensor. When photons are incident on reverse biased junction of this diode, electron-hole pairs are generated, which results in reverse leakage current. Amount of electron-hole pairs generated depends on intensity of incident IR radiation. More intense radiation results in more reverse leakage current. This current can be passed through a resistor so as to get proportional voltage. Thus as intensity of incident rays varies, voltage across resistor will vary accordingly.

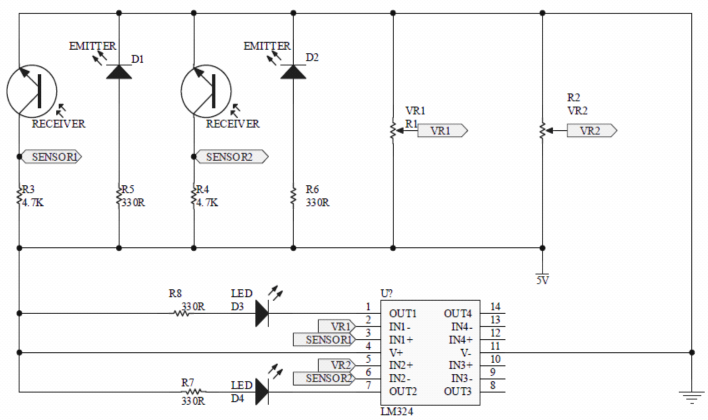


Figure 3.11: IR Circuit

This voltage can then be given to OPAMP based comparator. Output of the comparator can be read by µC. Alternatively, you can use on-chip ADC in AVR micro controller to measure this voltage and perform comparison in software.

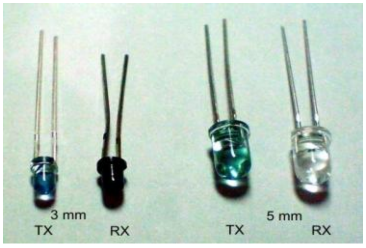


Figure 3.12: Sensors

IR LED is used as a source of infrared rays. It comes in two packages 3mm or 5mm. 3mm is better as it is requires less space. IR sensor is nothing but a diode, which is sensitive for infrared radiation.

This infrared transmitter and receiver are called as IR TX-RX pair. It can be obtained from any decent electronics component shop and costs less than 10Rs. Following snap shows 3mm and 5mm IR pairs. Color of IR transmitter and receiver is different. However you may come across pairs which appear exactly same or even has opposite colors than shown in above figure 3.9 and it is not possible to distinguish between TX and RX visually. In case you will have to take help of multimeter to distinguish between them.

3.3.2.7 Enhanced 30 Amp DC Motor Drivers

Figure 3.13: Enhanced 30 Amp DC Motor Driver

Figure 3.13 is a low cost and easy to use brush motor driver capable of driving up to 30-Ampere peak motor current. The board was added with extra LED status indicators and better protection.

This board has a heat sink with fan for fast thermal release, onboard PWM generation, linear current limiter, thermal shut down, and protection against wrong polarity of input voltage. With these features, make the board become more users friendly and more reliable. Table 3.2 below is the truth table in normal operating condition.

CW	CCW	MOTOR(+)	MOTOR(-)	COMMENT
1	1	H	H	Brake in Vin
1	0	H	L	Clockwise
0	1	L	H	Counterclockwise
0	0	L	L	Brake to Ground

Table 3.1: T truth table in normal operating condition

The Motor driver will be connected according to figure below; the pin's configuration is shown in table 3.3.

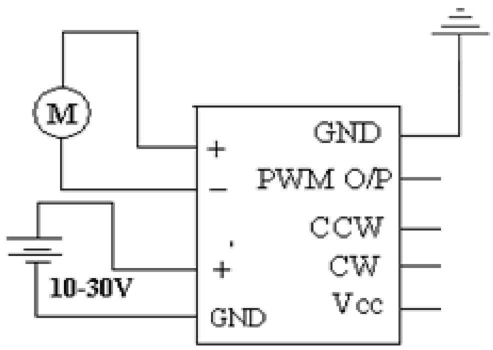


Figure 3.14: Schematic diagram of motor driver

MOTOR DRIVER'S PIN	LEFT	RIGHT
GND	GROUND	GROUND
PWM O/P	RC1	RC2
CCW	RD6	RD5
CW	RD7	RD4
Vcc	5-12V	5-12V

Table 3.2: Pin configuration between motor driver and PIC

3.3.3 Phase 3-Software Development Process

The first step in this stage is to select an appropriate type of micro controller, or in other words to recognize the appropriate PIC micro controller language for the AGC programming through MICROCODE STUDIO VERSION 2.2.1.1 software.

3.3.3.1 Introduction to Microcode Studio

The reason to choose microcode studio programmed because it easy to understand the language and easy to use because the interface are user friendly. The main editor provides full syntax highlighting of code with context sensitive keyword help and syntax hints. The code explorer allows to automatically jump to include files, defines, constants, variables, aliases and modifiers, symbols and labels, that are contained within source code. Full cut, copy, paste and undo are provided, together with search and replace features. It's easy to set up compiler, assembler and programmer options or feature. Compilation and assembler errors can easily be identified and corrected using the error results window. Just click on a compilation error and MICROCODE STUDIO will automatically take to the error line. MICROCODE STUDIO even comes with a serial communications window, allowing debugging and viewing serial output from your microcontroller. This software also helps to set the programmed into HEX files automatically.

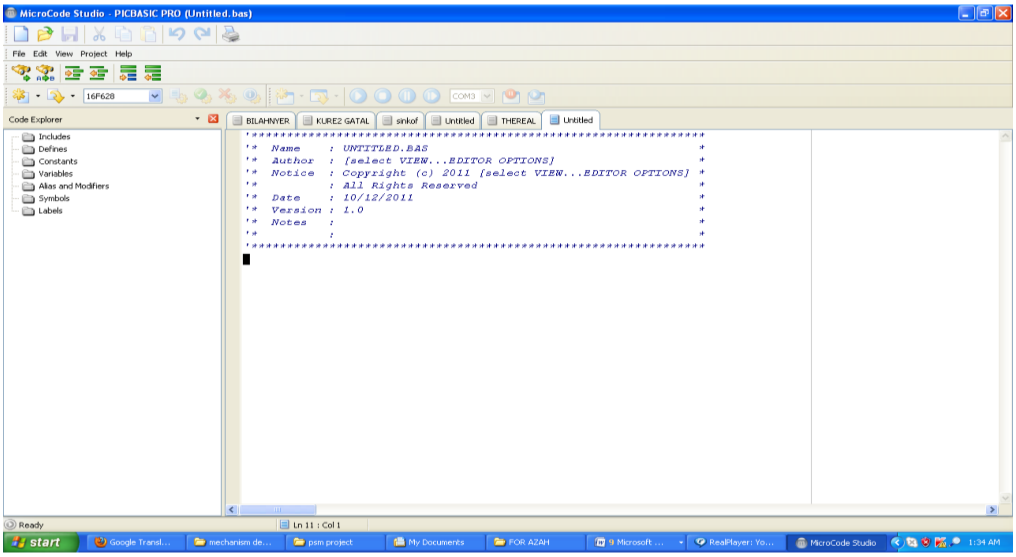


Figure 3.15: Microcode Studio

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter discusses about the overall result from the project which contains about Automated Guided Conveyor (AGC) circuit development, program development and testing for control system of the AGC. From this project, the circuit development consists of PIC18F4550 with motor driver to ensure the AGC can operate smoothly.

4.2 AGC CHASIS DESIGN

4.2.1 Weight

It is important to consider the overall AGC weight. The base of the AGC chassis design depending on the material used. Wood are used because it cheap and also can support the mounting of power window motor and other component that will be place on the upper chassis. The weight of the AGC base is 4.5 kg.

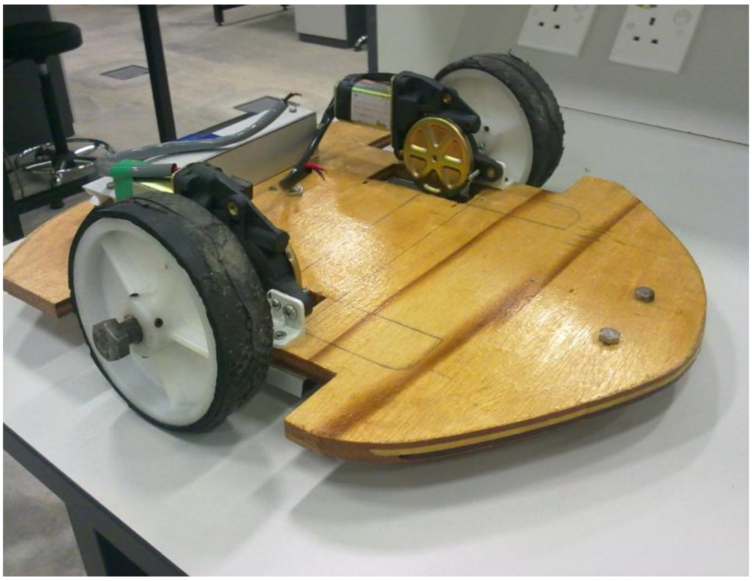


Figure 4.1: Base of AGC

Calculation for AGC

1) Weight calculations

Total Mass = Mbs + Mbatt + Mt + Mm + Mcomp

Mtotal = 3kg + 0.6kg + 0.3kg + 0.5kg + 0.1kg

= 4.5kg

Mbs =Mass of base structure

Mbatt =Mass of battery

Mt = Mass of tire coupling

Mm =Mass of motors

Mcomp =Mass of components

2) Speed requirements

By testing, the speed requirement is 1m/s.

In RPM;

$S1 = 2\pi \frac{D^{o}}{2}$ --------------------(1rev)

Do – Outer diameter = 0.16m

$2\pi \frac{0.16}{2} = 0.5184m$

No of revolutions to get the desired speed, Nr

$Nr = \frac{Sv}{S1}$= 1/0.5184

= $1.929s^{-1}$ x 60

= 115.74rpm

3) Required torque motor has to overcome

1. Frictional resistance due to self weight of structure.
2. Inertial resistance offered by the tires.

a) Inertia of the wheel

$\rho = 1kg/m^3$

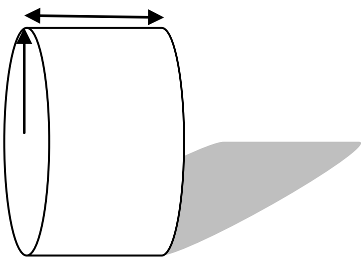
Dtire = 0.16m

r = 0.08m

dh = 0.04m

$d\theta = 1^{\circ}$

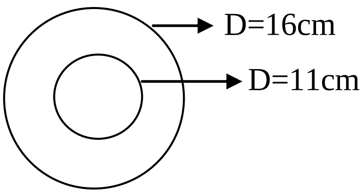
dr = 0.08m



From the equation;

$$J = \frac{\pi\rho(r)^4 h}{2}$$

Diameter of the tire;



Initial torque;

Nr = 115.74rpm

Nmotor = 78rpm

Tfloor = (Nmotor/Nr) +1

= (78/115.74) +1

= 1.67Nm

Force required overcoming self weight; Coefficient of static friction between rubber and concrete $0.6<\mu<0.9$,

Assume;

μ = 0.7(choose middle value)

Estimation mass of the vehicle :- 4.5kg

Force friction : Ff

:- Ff = μMg

= (0.7)(4.5)(9.81)

= 30.90N

Therefore the torque required to be supplied at the end of the wheel to overcome the static friction is;-

Tf = FfR2

= (30.90)x(0.08)

= 2.472Nm

4.3 AGC CIRCUIT

4.3.1 AGC main circuit

The main AGC circuit are build to place the PIC 18F4550. There are few component needed in developing this circuit. This circuit only allowed 5V of voltage to flow. However the input voltage are supply directly from 12V direct battery, to overcome this problem two regulators of L7805 are use and supported by 1uF of capacitor at input and output legs, so the main board are not easily get burned.

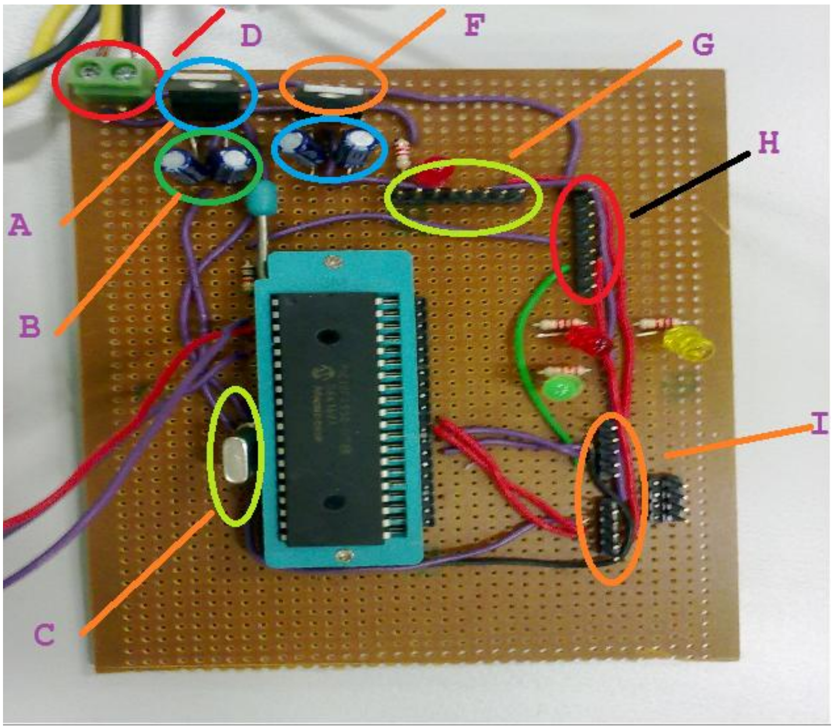


Figure 4.2: PIC 18F4550 circuit

Description from **Figure 4.20** can be seen in **Table 4.3**

	NAME	DESCRIPTIONS
A	REGULATOR 7805	Drop the voltage from power supply to some point
B	CAPACITOR 1uF	Blocking direct current, while allowing alternate current.
C	CRYSTAL 8MHz	Provide stable clock source for microcontroller
D	CONNECTOR	Connect with 12volts battery
F	REGULATOR 7805	Function similarly with A, but at interface
G	PORT GND	Connect ro ground
H	PORT Vcc	Connect from the regulator of output 5 volts
I	HEADER	Use for connector of main circuit with motor driver

Table 4.1: Descriptions of components

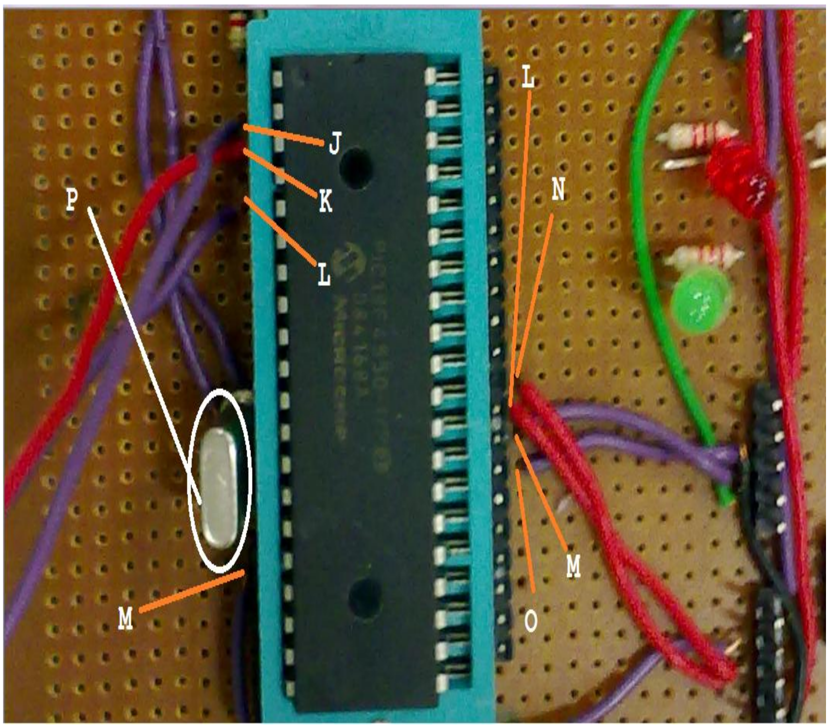


Figure 4.3: Port connecting with PIC18F4550

	NAME	DESCRIPTIONS
J	A0	Analog data transfer to high input voltage as signal from sensor 1
K	A1	Analog data transfer to high input voltage as signal from sensor 2
L	A3	Analog data transfer to high input voltage as signal from sensor 3
M	PORT D17	Consist of CCP1 timer that are used to create clock that makes the PWM signals
N	PORT D7	Port that are connect to motor driver
O	PORT D4	Port that are connect to motor driver
P	PORT 13,14	For oscillator 1 and2 that connect with crystal

Table 4.2: Descriptions of ports

4.3.2 IR sensor circuit

IR emitter and IR phototransistor an infrared emitter is an LED made from gallium arsenide, which emits near-infrared energy at about 880nm. The infrared phototransistor acts as a transistor with the base voltage determined by the amount of light hitting the transistor. Hence it acts as a variable current source. Greater amount of IR light cause greater currents to flow through the collector-emitter leads. As shown in the Fig 4.3 below, the photo-transistor is wired in a similar configuration to the voltage divider. The variable current traveling through the resistor causes a voltage drop in the pull-up resistor. This voltage is measured as the output of the device.

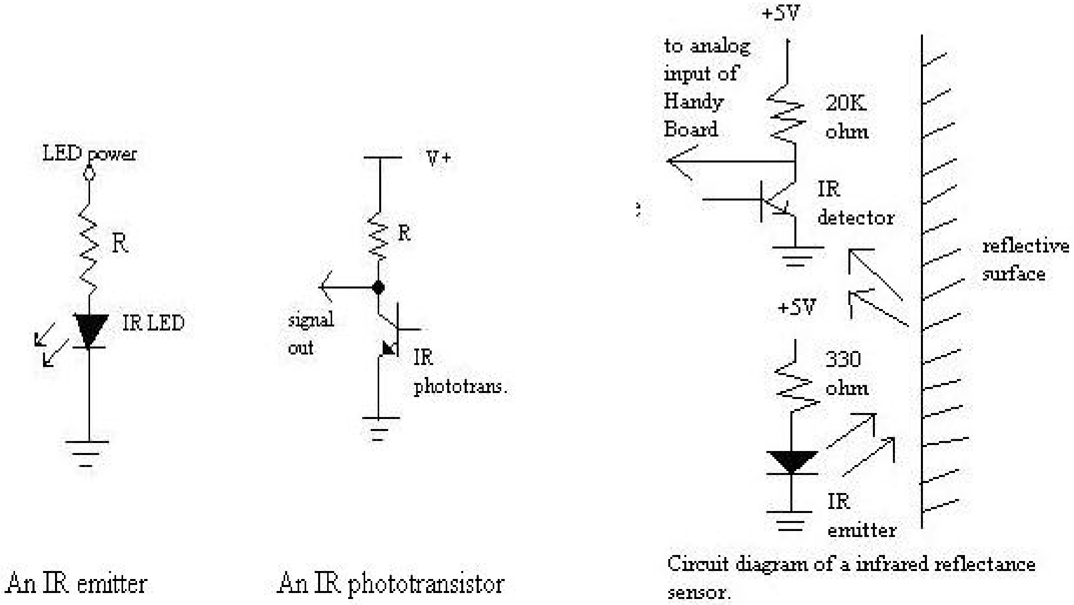


Figure 4.4: IR sensor circuit diagram

IR reflectance sensors contain a matched infrared receiver

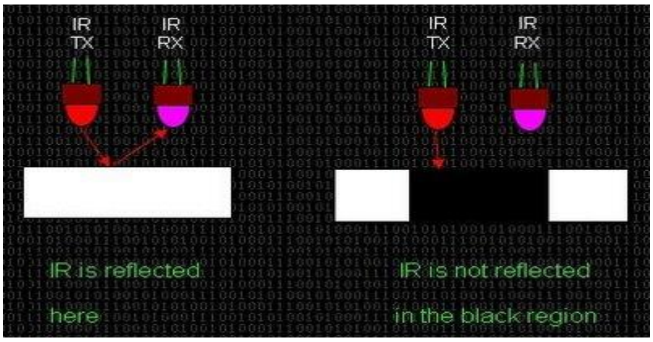


Figure 4.5 IR sensor

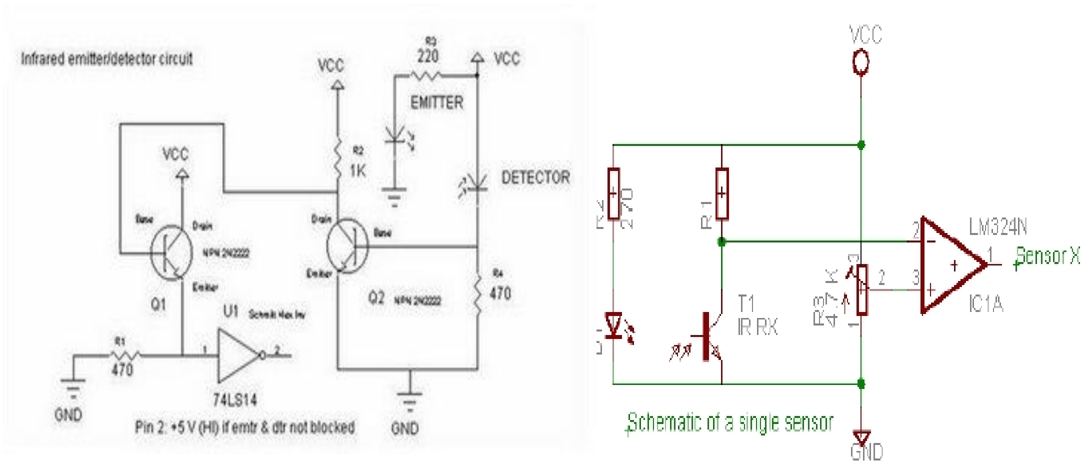


Figure 4.6: Schematic Diagram for single sensor

To get a good voltage swing, the value R1 must be carefully chosen. R_{sensor}= a when no light falls on it and R_{sensor}=b when light falls on it. The difference in the two potentials is

$$V_{cc} \text{ x } \{a/(a+R1)-b/(b+R1)\}, \qquad (4.1)$$

The resistance of the sensor decreases when IR light falls on it. A good sensor will have near zero resistance in presence of light and a very large resistance in absence of light. We have used this property of the sensor to form a potential divider. The potential at point ‘2’ is R_{sensor} / (R_{sensor} + R1). Again, a good sensor circuit should give maximum change in potential at point ‘2’ for no-light and bright-light conditions. This is especially important if you plan to use an ADC in place of the comparatorto get a good voltage swing, the value of R1 must be carefully chosen. If R_{sensor} = a when no light falls on it and R_{sensor} = b when light falls on it. The difference in the two potentials is:

$$V_{cc} \text{ x } \{a/(a+R1)-b/(b+R1)\}, \qquad (4.2)$$

Relative voltage swing= Actual Voltage Swing / Vcc,

= Vcc*{a/(a+R1)-b/(b+R1)}/Vcc,

= a/(a+R1) – b/(b+R1)

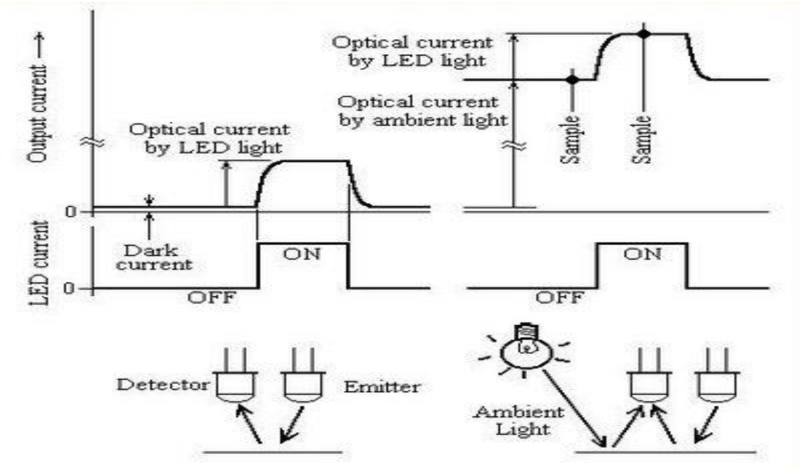


Figure 4.7: Graphically output current produce for single sensor

If the emitter and detector (phototransistor) are not blocked, then the output on pin 2 of the74LS14 will be high (apx.5Volts).When they are blocked, then the output will be low (apx.0Volts).The 74LS14 is a Schmitt triggered hex inverter. A Schmitt trigger is a signal conditioner. It ensures that above a threshold value, will always get "clean" HIGH and LOW signals. Not Blocked Case: Pin 2 High Current from V_{cc} flows through the detector. The current continues of low through the base of Q2.Current from V_{cc} also flows through R2, and Q2's Drain and Emitter to ground. As a result of this current path, there will be no current flowing through Q1's base. The signal at U1's pin 1 will be low, and so pin 2 will be high. Blocked Case: Pin2 Low Current "stops" at the detector. Q2's base is not turned on. The current is re-routed passing through R2 and into the base of Q1.This allows current to flow from Q1's detector and exiting out Q1's emitter. Pin 1 is thus high and pin2 will below. To detect a line to be followed, we are using two or more number of photo-reflectors .Its output current that proportional to reflection rate of the floor is converted to voltage with a resister and tested it if the line is detected or not. However the threshold voltage cannot be fixed to any level because optical current by ambient light is added to the output current. Most photo-detecting modules are using modulated light to avoid interference by the ambient light. The detected signal is filtered with a band pass filter and disused signals are filtered out. Therefore only the modulated signal from the light emitter can be detected. Of course the detector must not be saturated by ambient light, this is effective when the detector is working in linear region.

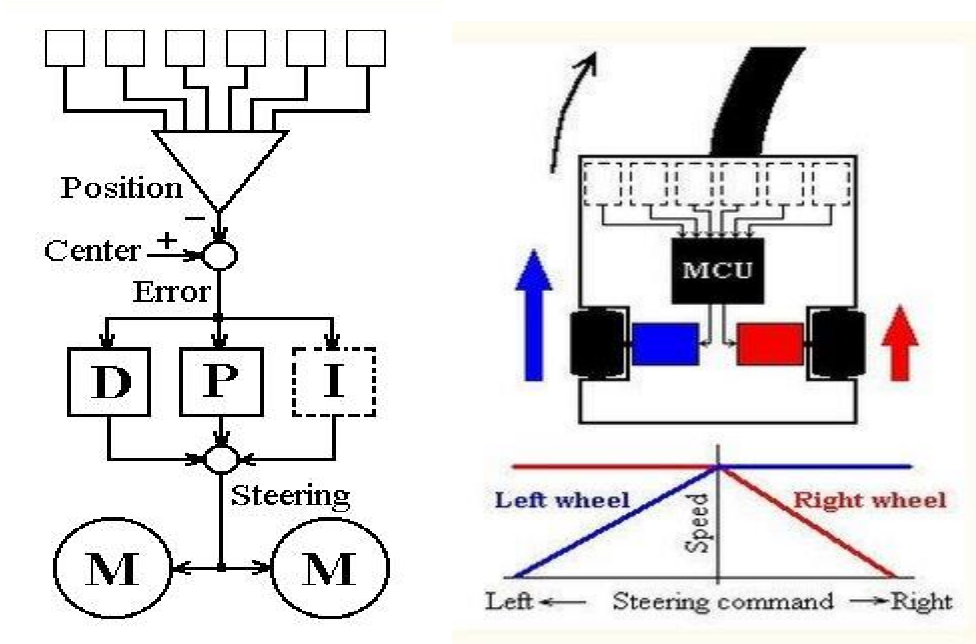


Figure 4.8: Position of sensor applies to system.

The line position is compared to the center value to be tracked; the position error is processed with Proportional/Integral/Difference filters to generate steering command. The line following robot tracks the line in PID control that the most popular algorithm for servo control. The proportional term is the common process in the servo system. It is only a gain amplifier without time dependent process. The differential term is applied in order to improve the response to disturbance, and it also compensate phase lag at the controlled object. The D term will be required in most case to stabilize tracking motion. The I term that boosts DC gain is applied in order to remove left offset error, however, it often decrease servo stability due to it space lag. When any line sensing error has occurred for a time due to getting out of line or end of line, the motors are stopped and the microcontroller enters sleep state of zero power consumption.

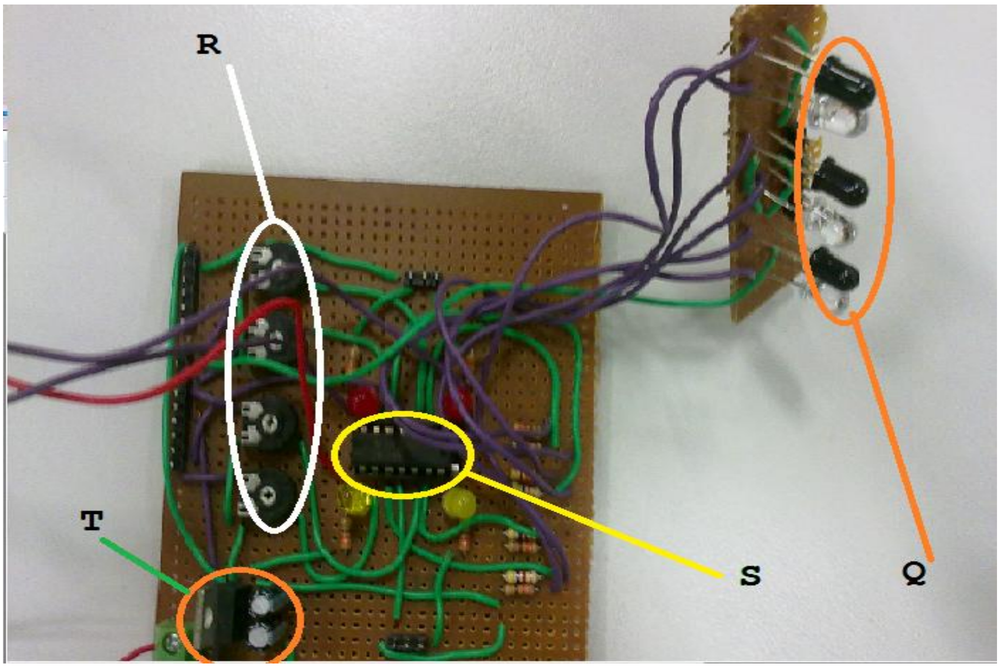


Figure 4.9: IR sensor circuit

	NAMES	DESCRIPTIONS
Q	LED	Led that functions as emitter and receiver
R	Potentiometer	Control the voltage allowes to LM324 by signaling to LED
S	LM324	Operations from split power supplies is also possible and lower current drain is independent of the magnitude of the power supply voltage
T	Regulator and Capacitor	Control the input voltage

Table 4.3: Descriptions for IR circuit

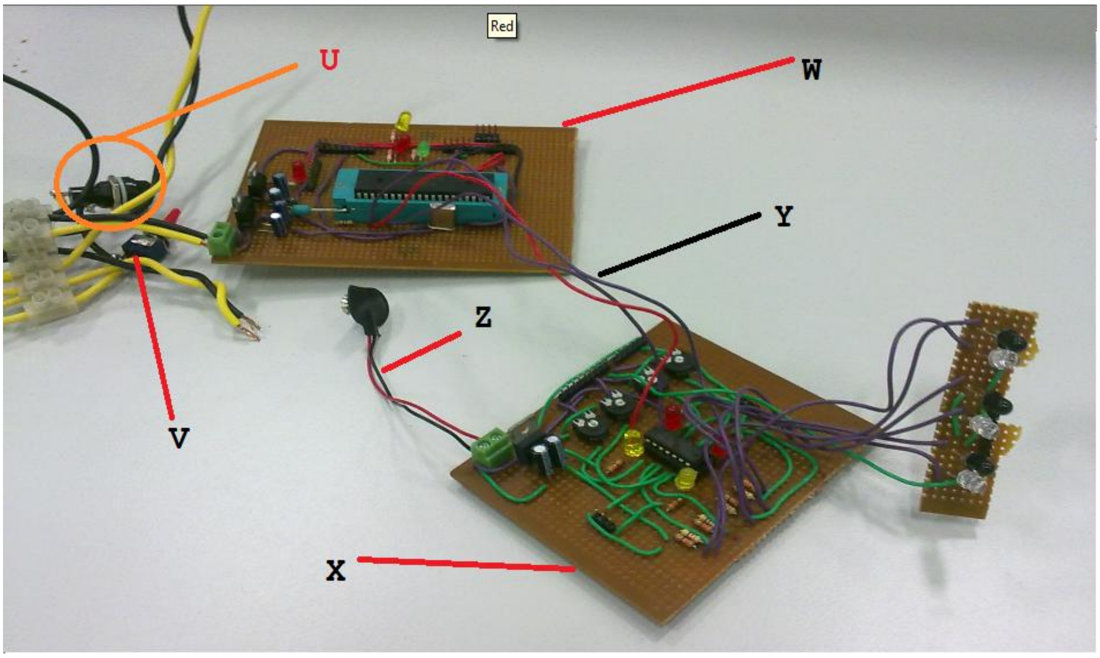


Figure 4.10: Connection between main circuit and IR sensor circuit

	NAME	DESCRIPTIONS
U	FUSE	Types of sacrificial over current protection device.
V	SWITCH	To off or on the current flow
W	CIRCUIT	PIC 18F4550 circuit
X	CIRCUIT	IR sensor circuit
Y	JUMPER	Connector
Z	CONNECTOR	Connector with battery

Table 4.4: Description of main circuit and sensor circuit

4.2.3 Line follower

The line follower is build up by using white tape and black rubber cloth as black surface. Line follower are build up to test the IR sensor circuit and to ensure the AGC is run smoothly and accurately. The line follower made up based few criteria which suitable with AGC programmed. The criteria of the line follower are consisting with straight line, 45 degree line, 90 degree line and etc.

Figure 4.11: Line follower

4.3 PROGRAMMING

MICROCODE STUDIO version 2.2.1.1 will help to in constructs instruction for PIC 18F4550 and also for IR sensor. The coding for this project is placed at Appendix 1.

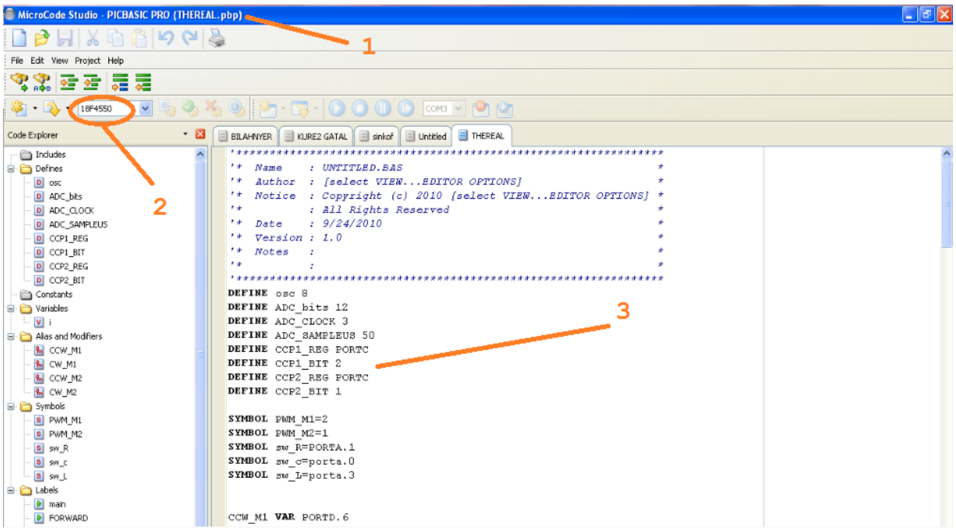


Figure 4.12: Interface of Micro Code Studio

Based on the figure 4.30 above shows at point 1 is the title of this program file. Point 2 indicates the type of PIC that been used while at point 3 the site for coding to be written.

4.4 LIMITATIONS

There are few limitations; main problem is battery is needed to take time while charging this became the main challenging when AGC only can work for 5 hours with battery 12volts. The second problem when line follower need to build up accurately to ensure the sensor can detect the line and also can run accurately. Thirdly when the electrical components are very sensitive with high temperature (higher than room temperature) and easily damage while crashing. The fourth problems when the sensors only detect white and black color as command. Lastly the line follower need to build up using black surface that are not reflecting any radiance

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In this project, the description of this AGC project, already been discussed accordingly based from previous chapters. This project flow and development are also discussed in more details in chapter 3 while in the chapter 4, the further discussion and final result are been focus as the important determinant to fulfill all the objective of this project.

In order to develop this AGC system, the AGC are been developed based on objective of this project. These developments of AGC contribute to describe more detail of interface and customizing AGC whole system. This project also achieved the other objective, one of the objective was to development prototype of AGC by using PIC 18F4550 are accomplished. Furthermore development for automatic movement for this AGC are been implement by applying Microcode studio software for PIC 18F4550. To achieve more accurateness for AGC movement last objective are also done by develop of line follower, and with all objective are striking accomplish, allowed to understand more about the limitations and can contribute to discovering a few improvements for further research.

However, these project still need to develop in model so it can clearly works and contribute for application at FKM Lab's. There are few recommendation will be discussed in section 5.2.

5.2 FURTHER STUDY AND RECOMMENDATIONS

After several improvement study and analysis in this project, there were some recommendation and further development listed below to improve this AGC control system to give better performance. The recommendations are:

5.2.1 Use solar energy as alternatively supply as back up for DC battery.

Solar robot is characterized by the ability to move using solar power with some speed with battery to support. The basic idea for a solar robot is drive the wheels using dc gear motor that get sources from battery that charger by solar energy. The robot needed to be able to be self contained, that is all charging from the sun, The Chicago robots combine a Miller solar engine (such as on Appetizer) with a comparator-chip line-following circuit (such as on Sandwich).

5.2.2 Use wireless camera to supervise AGC movement and also acoustic sensor to detect any incoming vibration on the surface.

A video connection is established using cameras which are able to be remotely controlled by a distant viewer. A local radio link is established between a telephony devices such as a cellular telephone or other wireless transmit/ receive unit (WTRU). A distant viewer connected through a telephone link can use a video image screen to viewer connected through a telephone link can use a video image screen to view the camera image and can use the telephone link to control the operation of the camera.

An acoustic vibration sensor, also referred to as a speech sensing device, is provided. The acoustic vibration sensor receives signals of a vibration and, in response, generates electrical signals representative of human speech. The acoustic vibration sensor includes at least one diaphragm positioned adjacent to a front port and at least one coupler. The coupler couples a first set of signals to the diaphragm while isolating the diaphragm from the second set of signals. The coupler includes at least one material with acoustic impedance matched to the acoustic impedance of human skin.

5.2.3 Use better material of electronics components to avoid any sensitivity.

The behavior of a component subjected to pulsed laser radiation is measured. The polarization value, frequency, and temperature (or other operating conditions) to which the component is sensitive are determined by detecting a temporary or permanent fault in the operation of the component. If necessary, the parasitic currents generated are prevented from destroying the tested component at the time of testing. A susceptibility of the component to energetic interactions and the preferred operating conditions for the component are deduced.

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APPENDIX A

PROJECT GANTT CHART

Appendix A1: Gantt chart for FYP 1

Project Activities	Week														
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Identify title	■														
Identify Objectives and scopes		■	■												
Literature review		■	■	■	■	■									
Methodology planning				■	■	■	■	■							
Concept development					■	■	■	■							
System level design								■	■	■	■				
Development of circuit									■	■	■	■			
Development of program										■	■	■			
Testing & Refinement											■	■	■		
Preparation of PSM 1 presentation													■	■	

Appendix A2: Gantt chart for FYP 2

Project Activities	**Week**														
	W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**	**W15**
Improvement Study	■	■													
Develop the AGC circuit		■	■	■	■	■									
Develop the AGC program					■	■	■	■	■	■					
Testing 1									■	■					
Fabricate the circuit to AGC											■	■			
Testing 2												■	■		
Refinement Stage													■	■	
Finalize Project													■	■	
Preparation of PSM 2 presentation														■	■

Coding for PIC 18F4550

```
define osc 8

define ADC_bits 12

define ADC_CLOCK 3

DEFINE ADC_SAMPLEUS 50

DEFINE CCP1_REG PORTC

DEFINE CCP1_BIT 2

DEFINE CCP2_REG PORTC

DEFINE CCP2_BIT 1

SYMBOL PWM_M1=2

SYMBOL PWM_M2=1

SYMBOL sw_R=PORTA.1

symbol sw_c=porta.0

symbol sw_L=porta.3

CCW_M1 VAR PORTD.6

CW_M1 VAR PORTD.7

CCW_M2 VAR PORTD.5

CW_M2 VAR  PORTD.4

i var byte

TRISC = 0
```

```
trisd = 0
PORTC = 0
portD = 0
TRISA = %11111111
PORTC = %00000000
portD = %00000000
adcon1= %00001111
HPWM PWM_M1, 100, 1000
HPWM PWM_M2, 100, 1000
main:
    if (sw_C=1 and sw_R=1) then
    gosub left1
    else
    if (sw_l=1 and sw_c=1)then
    gosub right1
    else
    if (sw_c=1)  then
    GOSUB FORWARD
    else
    if (sw_c=1)  then
```

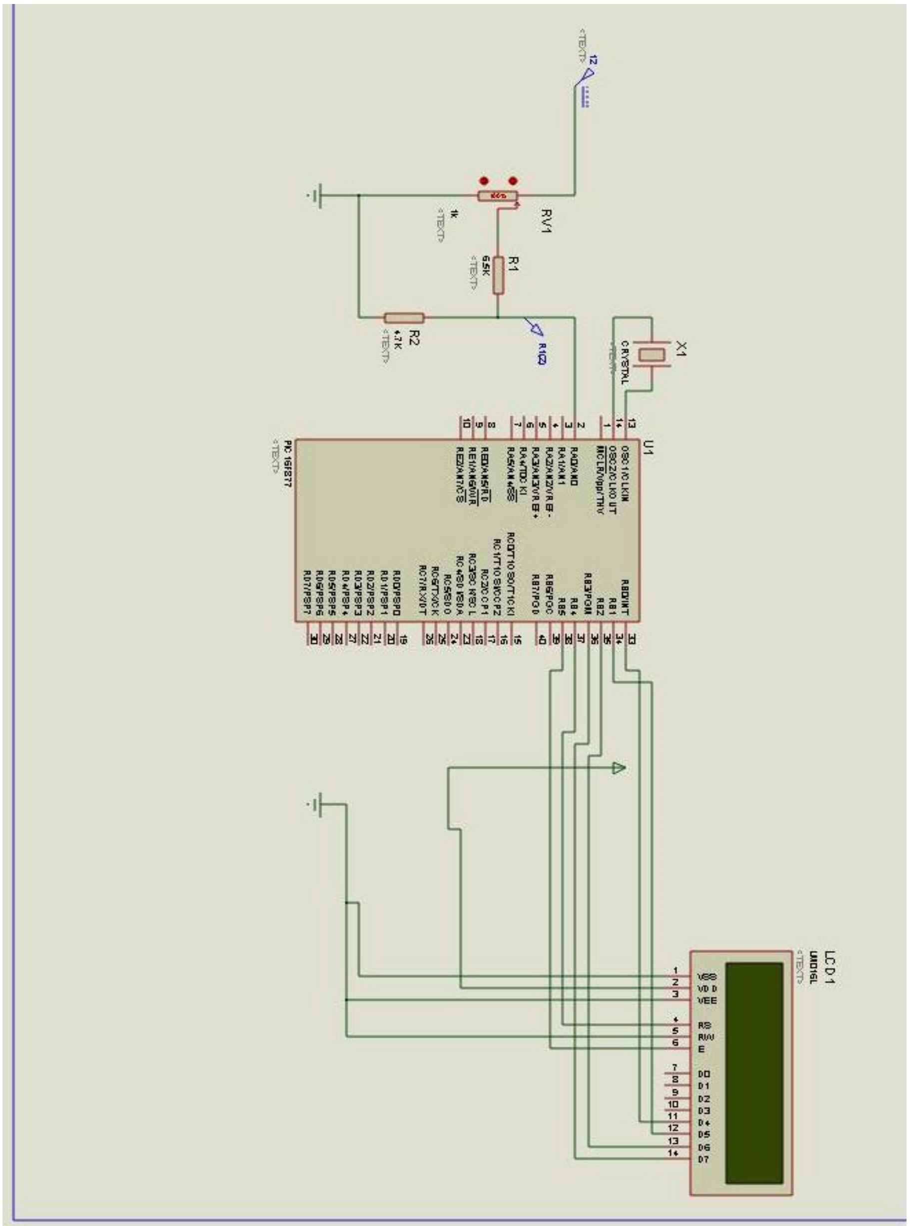
```
    GOSUB FORWARD
    else
    if (sw_l=1 ) then
    gosub right
    else
    if (sw_r=1) then
    gosub left
    else
    gosub stop1
    endif
    endif
    endif
    endif
    endif
    endif
    GOTO MAIN
FORWARD:
     CW_M1 = 1
     CCW_M1 = 0
     CW_M2 = 0
```

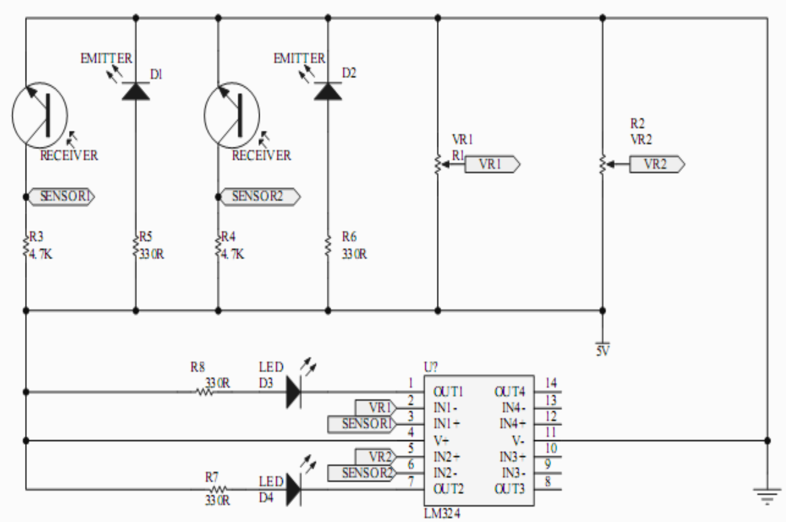
```
    CCW_M2 = 1
    HPWM PWM_M1, 70, 1000 'kiri   asal 120
    HPWM PWM_M2, 40, 1000 'kanan
RETURN
STOP1:
    CCW_M1 = 0
    CW_M1 = 0
    CCW_M2 = 0
    CW_M2 = 0
    HPWM PWM_M1, 0, 500 'kiri   asal 120
    HPWM PWM_M2, 0, 1000 'kanan
RETURN
reverse1:
    CCW_M1 = 1
    CW_M1 = 0
    CCW_M2 = 0
    CW_M2 = 1
    HPWM PWM_M1, 100, 500 'kiri   asal 120
    HPWM PWM_M2, 100, 1000 'kanan
RETURN
```

```
left:
    CCW_M1 = 0
    CW_M1 = 1
    CCW_M2 = 0
    CW_M2 = 0
    HPWM PWM_M1, 60, 500 'kiri   asal 120
    HPWM PWM_M2, 30, 500 'kanan
RETURN
right:
    CCW_M1 = 0
    CW_M1 = 0
    CCW_M2 = 1
    CW_M2 = 0
    HPWM PWM_M1, 30, 500 'kiri   asal 120
    HPWM PWM_M2, 60, 500 'kanan
RETURN
right1:
    CCW_M1 = 0
    CW_M1 = 0
    CCW_M2 = 1
```

```
    CW_M2 = 0
    HPWM PWM_M1, 30, 500 'kiri   asal 120
    HPWM PWM_M2, 60, 500 'kanan
RETURN
left1:
    CCW_M1 = 0
    CW_M1 = 1
    CCW_M2 = 0
    CW_M2 = 0
    HPWM PWM_M1, 60, 500 'kiri   asal 120
    HPWM PWM_M2, 30, 500 'kanan
RETURN
END
```

Circuit Diagram PIC 18F4550 and IR sensor




EMITTER
D1
EMITTER
D2
RECEIVER
RECEIVER
SENSOR1
SENSOR2
R3
4.7K
R5
330R
R4
4.7K
R6
330R
VR1
R1
VR1
R2
VR2
VR2
5V
R8
330R
LED
D3
R7
330R
LED
D4
U?
OUT1
IN1-
IN1+
V+
IN2+
IN2-
OUT2
OUT4
IN4-
IN4+
V-
IN3+
IN3-
OUT3
LM324