DEVELOPMENT OF AUTONOMOUS UNDERWATER VEHICLE

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A thesis submitted in fulfillment of the requirements for the award of the
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To my beloved mother and father,

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ABSTRACT

In the new era of technology, unmanned vehicles was created to help human explore the area that are can't reached by human kind. Robotic can be related to the most of invention which can reduce human's work using specialized equipment and devices that control and perform the particular tasks. For Underwater exploration, Underwater Vehicle without human are created to help human do research. Most of installation pipeline underwater can be dangerous area. The purpose invention of Autonomous Underwater Vehicle (AUV) can bring human to reach the dangerous areas. AUV stands for Autonomous Underwater Vehicle. Autonomous Underwater Vehicle (AUV) is unmanned or robotic vehicles that are using some technology to bring new capabilities to work in the subsea environment. Nowadays, this technology of Autonomous Underwater Vehicle (AUV) has upgrade their abilities which are can explore into deep seas. To reach that, a lot of investments are needed. This project will be focus on development of Autonomous Underwater Vehicles which are performing limited capabilities. AUV uses propellers to move the vehicle along vertical and horizontal axis that automatic operate based on the programming coding. The main objectives of the construction of the AUV are to replace human to do tasks underwater. In this project, the scope of the study focused on the mechanical design that water prove and design of the thruster using the DC motor and propeller.

ABSTRAK

Dalam era baru teknologi, kenderaan tanpa manusia dihasilkan untuk membantu manusia bagi membolehkan kita meneroka ke kawasan yang tidak mampu dicapai oleh manusia.Robotik boleh dikaitkan dengan penghasilan alat-alat yang mampu meringankan beban manusia dengan menggunakan peralatan yang istimewa dan juga peranti yang boleh mengawal kerja. Untuk eksplorasi di dalam air,kenderaan bawah air (AUV) dihasilkan bagi membantu manusia menjalankan kajian.Kebanyakkan pemasangan paip di dalam air terdedah kepada bahaya.Oleh itu,penciptaan kenderaan bawah air (AUV) membolehkan manusia melakukan kerja di kawasan yang terdedah kepada bahaya.Kenderaan bawah air adalah kenderaan tanpa manusia yang menggunakan teknologi untuk memberi kebolehan yang baru dalam melakukan kerja-kerja di dalam laut.Sekarang ini,teknologi kenderaan dalam air telah diubahsuai akan kebolehannya untuk melakukan eksplorasi di laut dalam.Untuk merealisasikan impian itu,banyak modal perlu dilaburkan.Projek ini memfokuskan kepada penghasilan kenderaan dalam air yang beroperasi secara terhad.Kenderaan dalam air menggunakan sepenuhnya daya tolakan dan daya angkat yang membolehkan ia bergerak ke hadapan,belakang,pusing arah jam dan juga pusingan lawan jam.Objektif utama penghasilan kenderaan dalam air adalah untuk menggantikan tempat manusia untuk melakukan kerja-kerja di dalam air.Projek ini menerangkan lakaran mekanikal,penghasilan motor yang kalis air dengan menggunakan DC motor dan bilah kipas bot.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Human capabilities are limited into deep sea. To overcome this problem, many inventor have create a thousand creation to discover the underwater world. Besides, under deep sea are dangerous and sometimes can cause death. Due to the limitation, human are difficult to explore under deep sea which is the untouchable area. Thus, unmanned underwater vehicle have created.With unmanned task, this underwater vehicle can explore and discover the underwater world and reduce the capability of human. This underwater vehicle generally can be divided into two major field, Autonomous Underwater Vehicles (AUV) and Remotely Operate Vehicle (ROV). Recently, underwater vehicle have been used in limited number of task. With further research and development, underwater vehicle can reduces the limitation and increase the capability to do more tasks. Today, most of Autonomous Underwater Vehicles (AUV) can been seen in military field, oiled and gas industry and some of the expedition to explorer under the deep sea. However, this project will be focus on Autonomous Underwater Vehicles (AUV).

1.2 PROJECT OBJECTIVE

The objectives of the project are:

a) To develop underwater vehicle that able to move underwater.
b) To develop underwater vehicle that able to float, submerge, rotate left and right in the water.
c) To design the physical structure, electronic circuit and control of the vehicle.

1.3 PROJECT SCOPE

The scopes of the project are as follow:

a) Literature study on the general characteristic of AUV.
b) In depth study of mechanical design and electronic circuit.
c) Design the waterproof propeller.
d) Increase the downward force acting to reduce the buoyancy force.
e) In depth study on Buoyancy principle.
f) Performance of the propeller underwater through water pressure.

1.4 PROBLEM STATEMENT

Deep underwater exploration is one of dangerous task due to limited of human capabilities. If human can discover the underwater, many discoveries could get and learned with it. So, the underwater vehicle has been designed to overcome that problem.

1.5 EXPECTED OUTCOMED

The expected outcomes are as follow:

a) In the end of this project, AUV can operate underwater with forward and backward movements rotate left and right with basic 3D design that is develop using computer software called Google Sketch Up.

b) It will stabilized floating in water and smooth submerging underwater.

CHAPTER 2

Literature Review

2.1 HULL DESIGN

An Autonomous Underwater Vehicle (AUV) hull must be able to protect its components in dry, watertight environment. The hull must allow components to be easily accessible and maintainable, as well as allowing for modularity in case of future changes or additions [1]. Being under the water are the major problems through AUV. Thus,designing the hull, it must be consider that there is no leak in each part of the body of AUV. The electrical part must be place properly to avoid changing the component once it wet and being short circuit. To make sure the AUV movement underwater flow in smooth, the Hydrodynamic concept must be design. Hydrodynamic is the concept of the dynamic fluids in motion. However, the hull design helps the AUV smooth in the water besides support by the propeller.

2.1.1 Material Body

The Material Body are the important part of design.The material must choose wisely in order to make the body of Autonomous Underwater Vehicle (AUV) in high durablelity, strong and light. In this project, the body of the Autonomous Underwater(AUV) is build base on those criteria. Polyvinyl chloride (PVC) are the best match for those criteria. The principal goals of AUV design effort is to produce a vehicle that is small, inexpensive, easy to deploy, and yet fully functional [2].

2.1.1.1 Polyvinyl chloride (PVC)

PVC is a widely used thermoplastic polymer. In terms of revenue generated, it is one of the most valuable products of the chemical industry. Overall, over 50% of PVC manufactured is used in construction. As a building material, PVC is cheap, durable, and easy to assemble. Regardless of claims that PVC production negatively affects the natural environment and human health, it is still widely used.

The same criteria as hard plastic, it is used as vinyl siding, , piping, plumbing and conduit fixtures. The material is often used in Plastic Pressure Pipe Systems for pipelines in the water and sewer industries because of its inexpensive nature and flexibility. PVC pipe plumbing is typically white, which is commonly available in grey as well as white. In this form, it is used in clothing and upholstery, and to make flexible hoses and tubing, flooring, to roofing membranes, and electrical cable insulation.

2.1.2 Hydrodynamic

Hydrodynamic is the concept of the dynamic fluids in motion. Basically ,the theory are same as aerodynamic theory. The motion of the Autonomous Underwater Vehicle gives rise to a pressure distribution over its surfaces, which should be integrated to obtain the hydrodynamic effect of the interaction with the water. The movement of AUV in the water must be smooth in order to make perfect path of the AUV to its destination.The smoothly of AUV across its path the better efficient to the propulsion system.Figure show the water flow through AUV body.

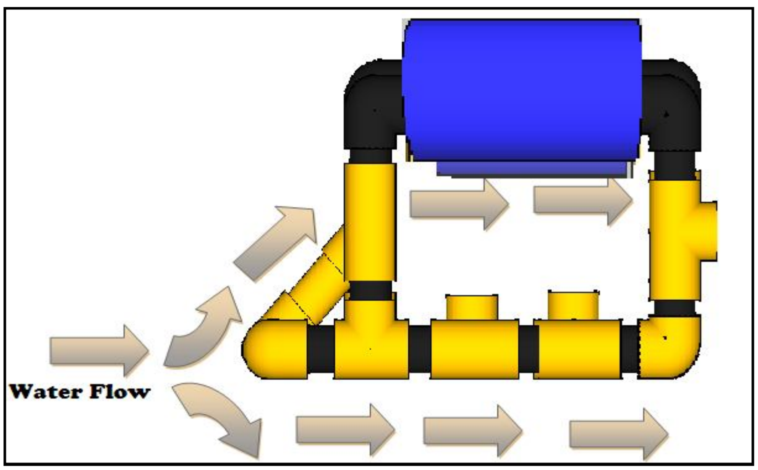


Figure 2.0 : Water flow through AUV body.

2.2 Propulsion

All Autonomous Underwater Vehicles (AUV) required some sort of propulsion and is usually one of the main sources of power consumption. Most of AUV use motors for propulsion due to the scarcity and cost of alternative systems [2].The location of the motor affect which degrees of freedom can be controlled [3]. In this project, two motors are required to do the forward and backward motion and the other two for submerging. To make sure AUV travels in smooth underwater and have limited energy supply, it must travel at a speed that does not draw to much power. At a same time, this AUV does not take too long to complete its mission. Hence, obtaining the ideal speed becomes are the best solution for this problems.

2.2.1 Thruster design

Thruster of Autonomous Underwater Vehicle (AUV) are currently related to the propulsion system.Propulsion is define as movement caused by a force[3].The force acting by the truster can make the AUV forward ,backward rotate left and right position.The waterproof truster design can be devided into several part.Thruster consist DC motor, coupling shaft and propeller.The body of the thruster is made by PVC.Thruster are need to be waterproof to avoid short circuit to the main controller board of AUV.

2.2.1.1 DC Motor

In this project,propulsion system use two DC motor. DC motor is define as simple electric motor that uses electricity and a magnetic field to produce torque,.In other word it has ability to turns the motor.

2.2.1.2 Principle operation of DC Motor

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field. When this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.Figure 2.1 indicate the operation inside the DC motor.

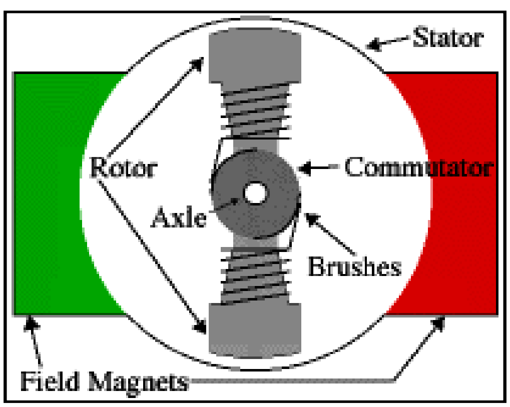


Figure 2.1 : Operation inside the DC motor.

Every DC motor has six basic parts which are axle, rotor ,stator, commutator, field magnet(s), and brushes. In most common DC motors, the external magnetic field is produced by high-strength permanent magnets. The stator is the stationary part of the motor. This includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor rotate with respect to the stator. The rotor consists of windings, the windings being electrically connected to the commutator.

The geometry of the brushes, commutator contacts, and rotor windings are such that when power is applied, the polarities of the energized winding and the stator magnets are misaligned, and the rotor will rotate until it is almost aligned with the stator's field magnets. As the rotor reaches alignment, the brushes move to the next commutator contacts, and energize the next winding. In real life, though, DC motors will always have more than two poles (three is a very common number). In particular, this avoids "dead spots" in the commutator. Meanwhile, with a two-pole motor, there is a moment where the commutator shorts out the power supply. This would be bad for the power supply, waste energy, and damage motor components as well.

2.2.1.3 12 volt DC Motor

AUV used 12 volt DC Motor and it was produce in China.This 12 volt DC motor arer use in many application such as in household appliances, including hair cutter machines, massagers, toy models, electrical toys, remote controllers, DVD and VCD players, and printers.Figure 3 show the specification of DC motor.

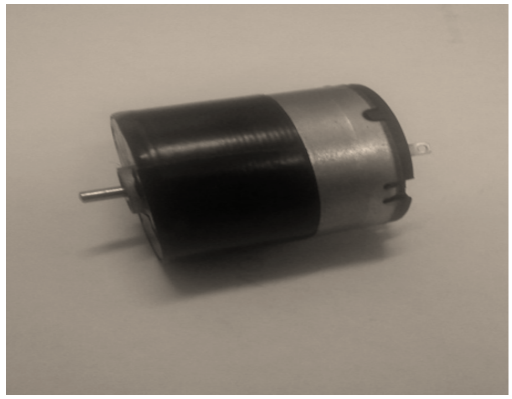


Figure 2.2: Specification of DC motor.

Table 1: 12 Volt DC Motor

Product Name	DC Motor
Model Number	260, 360, 500, BL00 series motor
Place of Origin	China
Power	1.5 - 12V DC
Free load	a) Speed: 6,000 - 20,000rpm b) Current: 0.12 - 0.3A
At max. efficiency	a) Speed: 5,000 - 18,000rpm b) Current: 0.2 - 0.6A c) Torque: 15 - 50gf-cm d) Power: 1.0 - 5.0 watts

2.2.2 Propeller

A propeller is a device consisting of a set of two or more twisted, airfoil-shaped blades mounted around a shaft and spun to provide propulsion of a vehicle through water or air, or to cause fluid flow, as in a pump. The lift generated by the spinning blades provides the force that propels the vehicle or the fluidthe lift does not have to result in an actual upward force.Its direction is simply parallel to the rotating shaft.Figure 2.3 show the propeller that mount to coupling shaft.

Figure 2.3: Propeller mounting to coupling shaft.

2.2.2.1 Marine Propeller Terminology

There are a variety of terms used to describe propeller characteristics as well as performance attributes. It is important that to learn and have a good understanding of them, as detailed here. In this thesis,several of marine propeller terminology will be discuss which are diameter, pitch and the number of blades.

2.2.2.1.1 Diameter

Diameter is the distance across the circle made by the blade tips as the propeller rotates. Diameter is determined primarily by the RPM at which the propeller will be turning and the amount of power that will be delivered to the propeller through the shafts and gears. The degree to which the propeller may operate in a partially surfaced condition, as well as the intended forward velocity, will also play a role in determining the most desirable diameter.

Within a given propeller line, the diameter usually increases for propellers used on slower boats and decreases for faster boats. If all other variables remain constant, diameter will increases as power increases, diameter will increase as propeller RPM decreases, and diameter should increases as propeller surfacing increases.

2.2.2.1.2 Pitch

Pitch is the distance that a propeller would move in one revolution if it were moving through a soft solid, like a screw in wood. Pitch is measured on the face of the blade.A number of factors can cause the actual pitch of a propeller to vary from the advertised pitch stamped on it. Minor distortion may have occurred during the casting and cooling process. Adjustments or modifications may have been made by propeller repair stations. And finally, undetected damage may have altered the pitch.

There are two common types of pitch which areconstant (flat pitch) and progressive pitch. Constant pitch means the pitch is the same at all points from the leading edge to the trailing edge. Progressive pitch starts low at the leading edge and progressively increases to the trailing edge. The pitch number assigned is the average pitch over the entire blade. Progressive pitch improves performance when forward and rotational speed are high and the propeller is operating high enough to break the water surface. It is commonly used on mid- to high-horsepower Mercury propellers.

Pitch is rather like another set of gears. For a given engine that wants to run at a given RPM, the faster the boat can go, the higher the pitch you need. If you select too low a pitch, the engine RPM will run too high, putting an undesirable higher stress on many moving parts. It may have a great acceleration butthe top speed will probably suffer and propeller efficiency will definitely suffer. Selecting too high a pitch will force the engine to lug at a low RPM which is generally at a higher torque level and can be very damaging to the engine. Top speed may not suffer too much, but acceleration will be seriously reduced.

2.2.2.1.3 Number Of Blades

A single-blade propellerwould be the most efficient - if the vibration could be tolerated. So, to get an acceptable level of balance with much less vibration, a two-bladed propeller, practically speaking, is the most efficient. As blades are added, efficiency decreases, but so does the vibration level. Most propellers are made with three blades as a compromise for vibration, convenient size, efficiency, and cost.

The efficiency difference between a two- and a three-bladed propeller is considered less significant than the vibrational difference. Nearly all racing propellers are presently either three- or four-bladed. In recent years, with the growing frequency of propellers being run at an increased height four- and five- bladed props havebecome more popular. They suppress the higher level of vibration and improve acceleration by putting more blade area into the water. They can also help to make the rake more effective in lifting the bow of the boat for added speed.

2.2.3 Coupling Shaft

Coupling shaft are use to make the distance between propeller and the motor became far.It because when assemble the DC motor to the thruster body,the distance to the propeller became short and when the motor run it cannot operate very smoothly and can cause inefficentcy to the motor current.Figure 2.4 show the 3D design of coupling using google sketchUp.

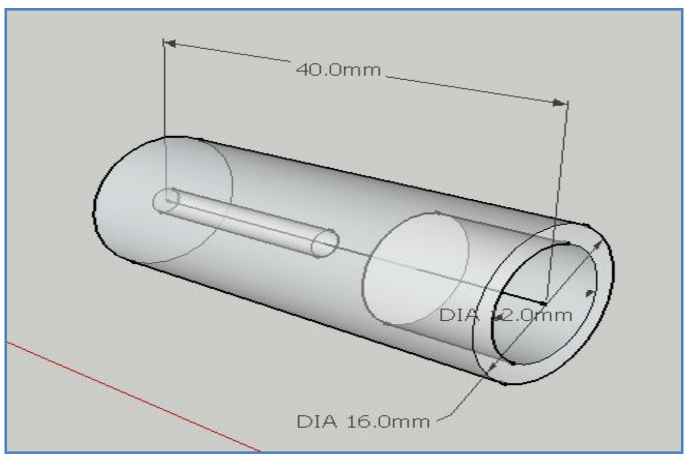


Figure 2.4: 3D design of coupling using google sketchUp.

2.2.4 Waterproof Thruster

In the water, the thruster must be design and follow to its waterproof criteria.To make sure there are no water leakage,thruster of this Autonomous Underwater

Vehicle(AUV) are been design using PVC material. The reason choosing PVC have been discuss early because it light and easy to assemble. Mechanical parts are important when designing any robot or vehicle or something else. If there have problems at mechanical parts, the problems will be carried on to the next parts. To design this part, all factors must be considered including the stability, movement of the robot and also the material that have been used [4]. Figure 2.5 show the 3D thruster design and figure 2.6 indicate complete thruster design.

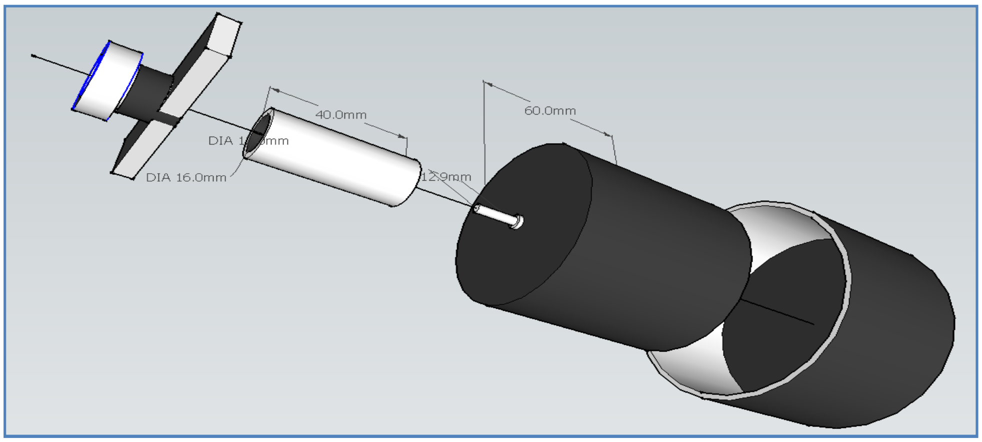


Figure 2.5: 3D thruster design

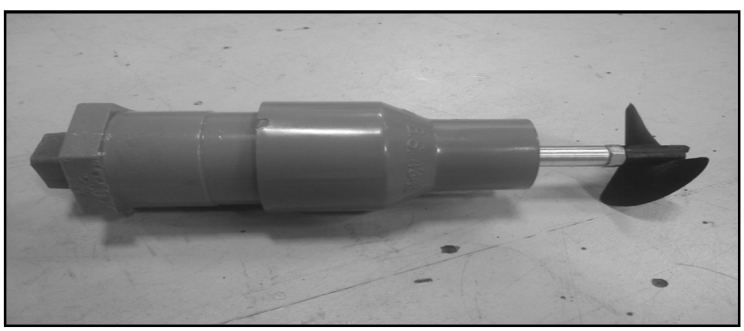


Figure 2.6: Complete thruster design.

2.3 Submerging

In the case of submerging the vehicle, since the volume of the vehicle remains constant, in order to dive deeper, it must increase the downward force acting upon it to counteract the buoyant force [5]. It can accomplish this either by increasing its mass via the use of ballast tanks or by using external thrusters [6]. In this project, there will be two thrusters that point downwards. This application is much simpler, but is quite inefficient in terms of power consumption and limited to submerge into great depth water.

2.3.1 Force acting Downward

For submerging system, the Autonomous Underwater Vehicle(AUV) use two thruster in the middle body that force the body goes to downward direction. In initial condition,the all the motor have been sink.When the downward motor is on, it will force the body of AUV goes downward.It depend of the speed of the motor.The more speed the long distance that Autonomous Underwater Vehicle(AUV) forcing downward.

2.4 Buoyancy Theory

In this project, the divergence theorem to show that the immerse a body in a fluid the net effect of fluid pressure acting on the surface of the body is a vertical force that also known as the buoyant force whose magnitude equals the weight of fluid displaced by the body. This force enables the object to float or at least to seem lighter. This known as Archimedes' principle. The buoyant force acts through the centre of buoyancy which is the centre of mass of the liquid displaced by the body. The design of self righting AUV exploits the fact that the centre of buoyancy and the centre of gravity, where gravity acts, need not be the same. The problem of this architecture is the instability in the water column when the AUV carries equipment externally mounted on hull because the center of gravity and center of buoyancy are too close [7]. Buoyancy is important for many vehicles such as boats, ships, balloons, and airships, and plays a role in diverse natural phenomena such as sedimentation.

Buoyancy = Weight of displaced fluid .... Equation 1

When an object is placed in a fluid a force, called the buoyant force, acts to push the object upwards. The strength of the force is equal to the weight of the volume of fluid displaced by the object. It is the objects volume, not its weight that determines the buoyant force.Take a submarine, for example, the buoyant force acts to push it to the surface while the weight of the submarine acts to push it to the bottom. The strength of these two opposing forces determines if the sub rises or sinks in the water.

A submarine however, can only control its weight, since the buoyant force can only be adjusted by a change in volume. This is unlikely to happen since the hull is inflexible and designed to withstand high water pressure that would crush it at great depths.A submarine sinks if it takes in water to increase its weight (force acting downward). It will rise if it expells water from its tanks, therefore making itself lighter.As it rises, the buoyant force is greater than the force acting to push it down (weight).As it sinks the force pushing it down (weight) is greater than the buoyant force pushing it up.

2.4.1 Archimedes' Principle

It is important to note that the buoyant force does not depend on the weight or shape of the submerged object, only on the weight of the displaced fluid. Archimedes's principle applies to object of all densities. If the density of the object is greater than that of the fluid, the object will sink. If the density of the object is equal to that of the fluid, the object will either sink or float. If the density of the object is less than that of the fluid, the object will float.

2. 4.2 Stability

A floating object is stable if it tends to restore itself to an equilibrium position after a small displacement. For example, floating objects will generally have vertical stability, as if the object is pushed down slightly, this will create a greater buoyancy force, which, unbalanced by the weight force, will push the object back up. Rotational stability is of great importance to floating vessels. Given a small angular displacement, the vessel may return to its initial position (stable), move away from its initial position, or remain where it is (neutral). Hydrodynamic modeling is a key element in the design of control systems for autonomous vehicles [8].

Rotational stability depends on the relative lines of action of forces on an object. The upward buoyancy force on an object acts through the center of buoyancy, being the centre of the displaced volume of fluid. The weight force on the object acts through its center of gravity. A buoyant object will be stable if the center of gravity is beneath the center of buoyancy because any angular displacement will then produce a ‘righting moment'.

2.5 Microcontroller

A microcontroller is a small computer on a single integrated circuit containing a memory, processor core, and programmable input and output. Microcontrollers are used in automatically controlled products and devices.

2.5.1 PIC18F4550

In this project, the AUV will use microcontroller 18F4550. The PIC18F4550 has its own specification and it has 40 pin configuration.The more detail about the specification of this PIC18F4550 are shown in appendix.

2.5.2 Motor Driver (L293D)

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays,solenoids,dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications.

2.6 Power Source

To operate an Autonomopus Underwater Vehicle, 9V and 11.1V supply are needed. 9 V is for PIC circuit and 11.1V for running the 12V DC motor.Figure 2.7 indicate the power supply to operate 12V DC motor.

(a) (b)

Figure 2.7: Power supply (a) 11.1V and (b) 9V

CHAPTER 3

Methodology

3.1 Working Plan

To develop the Autonomous Underwater Vehicle need a systematic working plan. Without proper planning the process to developing the AUV wouldn't success. The method that used must be clear and easily understand. Good working plan help the flow to developing the project become smooth and reduce the problem

3.2 Ideas and Concept

The ideas and concept are the first step to develop the project. Make some research are the better way in order to get the new ideas and concept. After achieving the ideas and concept the next step can be done.

3.3 Project Flow

This project starting with briefing and meeting with the supervisor to discuss and choosing project title. When the project title is achieved, the next step is to gain project description. Understanding the project, indentify project objective, scope of study and methodology of the project are need to be achieve.Figure 3.0 indicate the work progress during constructing the Autonomous Underwater Vehicle.

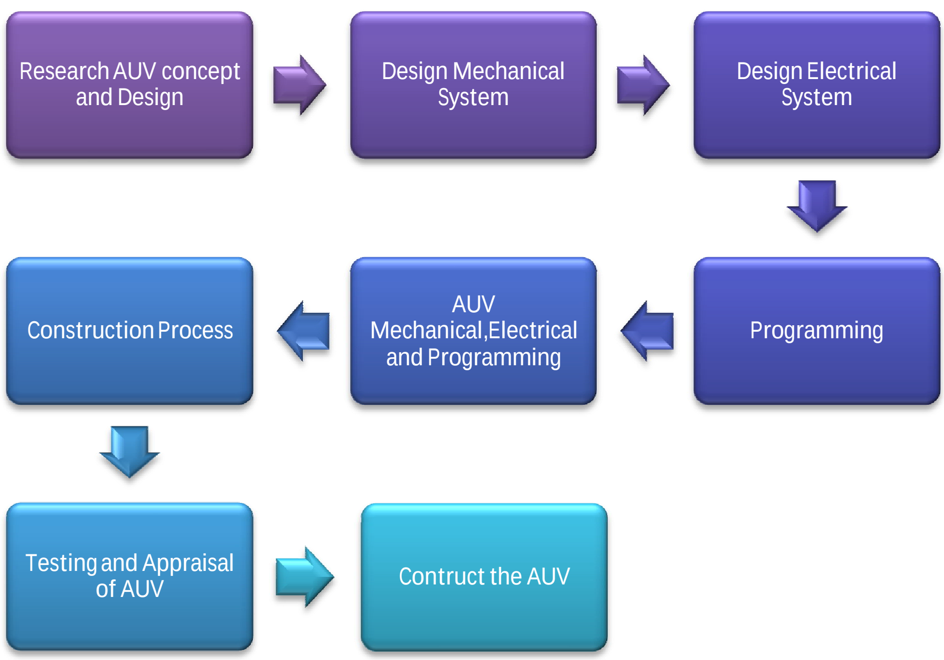


Figure 3.0 : Work progress

3.4 GANTT CHART

To develop an Autonomous Underwater Vehicle,every task must be state in order to make the task easy to do.Gantt chart is the best technique to show the progress of the project that has complete.Table 2 and 3 show the gantt chart during implementing the project.

3.4.1 Gantt Chart PSM 1

Table 2 : Gantt Chart PSM 1

Task	WEEK													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Briefing		■												
Meeting with Supervisor		■	■	■	■	■	■	■	■	■	■	■	■	■
Discussing and choosing project title			■											
Gain project description			■	■	■									
Understanding the project, identify project objective, scope of study, methodology				■	■	■								
Identify problem statement and way to overcome						■	■							
Submission proposal to coordinator							■							
Preparation to PSM 1 Seminar								■	■	■				
PSM 1 Seminar											■			
Finish the PSM 1 Report												■	■	
Submission PSM 1 Report														■

3.4.2 Gantt Chart PSM 2

Table 3:Gantt Chart PSM 2

Task	WEEK														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Building the circuit		■	■	■	■	■	■	■	■						
Build the mechanical part		■	■	■	■	■	■	■	■						
Assemble mechanical and electronic part						■	■	■	■	■	■				
programming			■	■	■	■	■	■	■	■					
testing								■	■	■	■				
Tuning and Modification								■	■	■	■				
Report and Thesis Writing			■	■	■	■	■	■	■	■	■				
Preparation to PSM 2 Seminar												■	■		
PSM 2 Seminar												■	■		
Finish the PSM 2 Report												■	■		
Compile Thesis													■	■	■

3.5 Mechanical Design

In Mechanical design,the Autonomous Underwater Vehicle can be divided into four step which are the body part,Thruster, Buoyancy and coupling shaft.

3.5.1 AUV design

Autonomous Underwater Vehicle use four unit thruster to make forward, backward, upward, downward ,rotate left and rotate right.Two thruster in the middle of the body are function to make the AUV submerge and floating in the water.The other two thruster at the back are use to make the AUV doing forward, backward, rotate left and right movement.

3.5.2 Body design

The AUV body design are 100% made of PVC. Because of the light criteria,it was choose to became the body of AUV.The joining PVC pipe was connected by the ‘L’ connector (90 degree connector) and the ‘T’ connector.In this design,eight unit (8)‘L’ connector and fourteen unit(14) ‘T’ connector are been used to make the complete of AUV body.Figure 10 show the design of AUV body from 3D perspective.

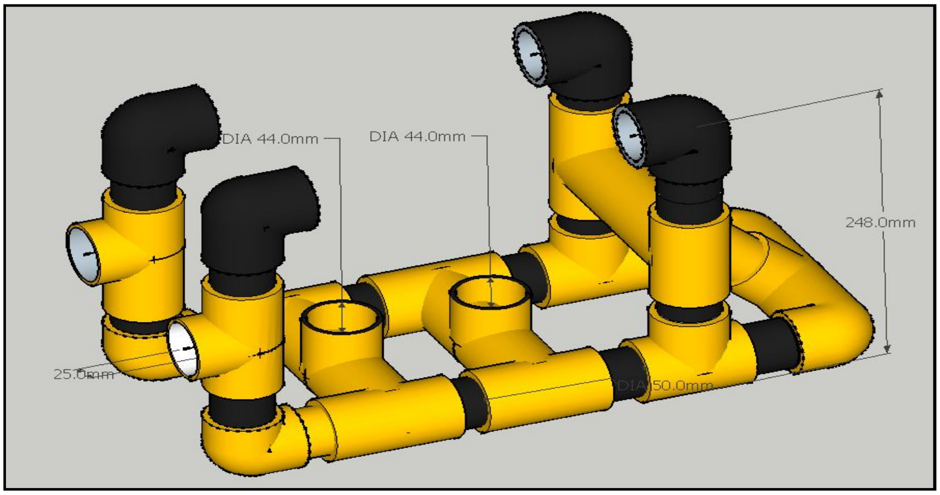
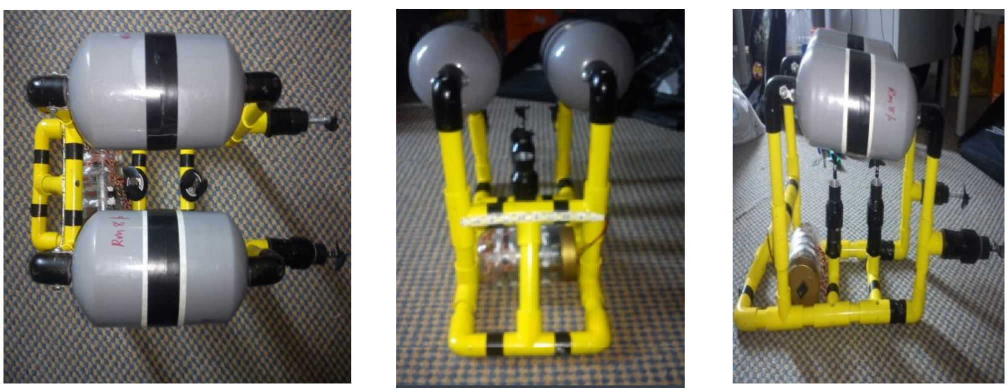


Figure 3.1: Design of AUV body

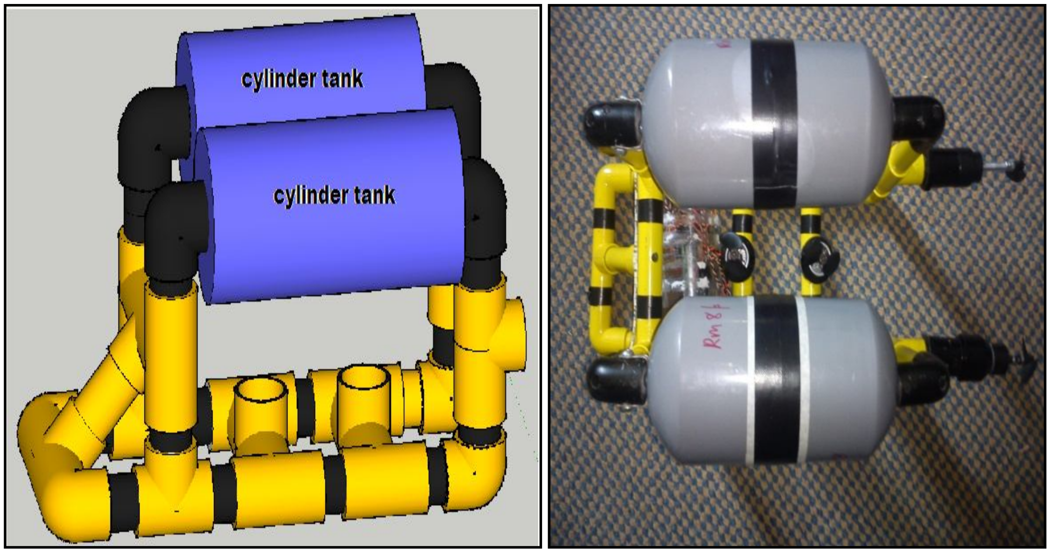


(a) (b) (c)

Figure 3.2: a) Top view ,b) front view ,c)side view

3.5.3 Buoyancy design

For floating in the water,AUV consist 2 cylinder like a balast tank.This two cylinder act as the buoyancy medium to make the AUV auto floating in the water.The Buoyancy cylinder tank was only the end of cap of PVC pipe that has been combine.By referring figure 3.3, this tank there is an air and to make sure the force acting to the buoyancy is equal to the weight of AUV.



(a) (b)

Figure 3.3: a) 3D view and b) real tank

3.5.4 Thruster Design

The main success for AUV movement is based on thruster design.Waterproof thruster design design have been made using PVC material. Designing the thruster can be divided into several step which are sealing the DC Motor and thruster's body.Firstly, the 12 Volt DC motor ahas been seal using the Electrical tape.Next, placing the DC motor to the cap of PVC pipe(thruster body). Figure 3.4 to figure 3.6 show the step to assemble the thruster.

3.5.4.1 Assembling the thruster part

These are the step to make the complete waterproof thruster.

1. Sealing the DC Motor with the Electrical tape.

Figure 3.4 : 12V DC motor

2. Body of thruster using PVC material.

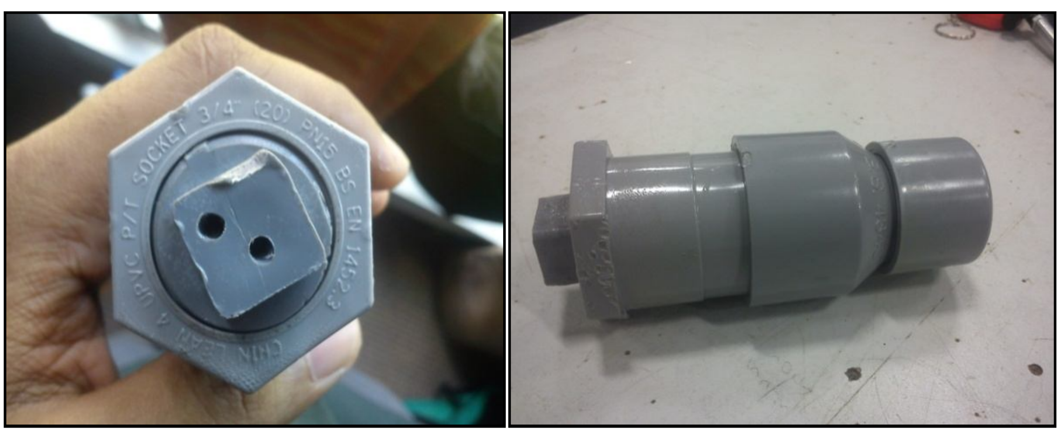
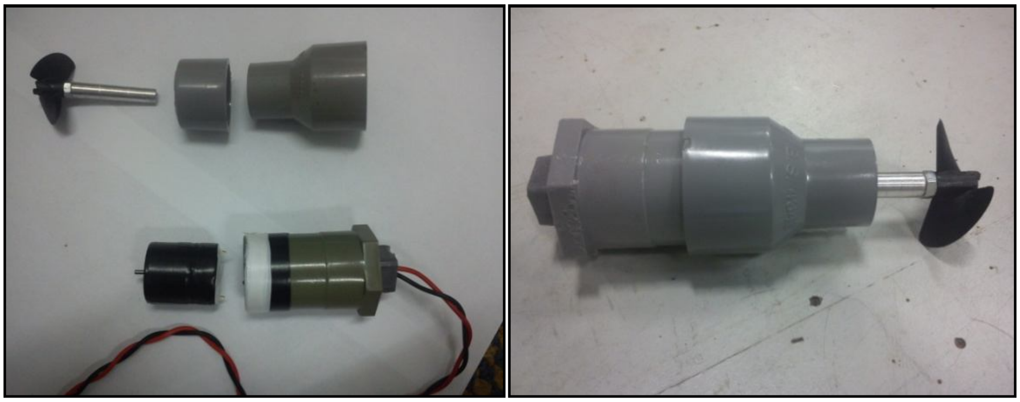


Figure 3.5 : Thruster body

3. Assemble the thruster part

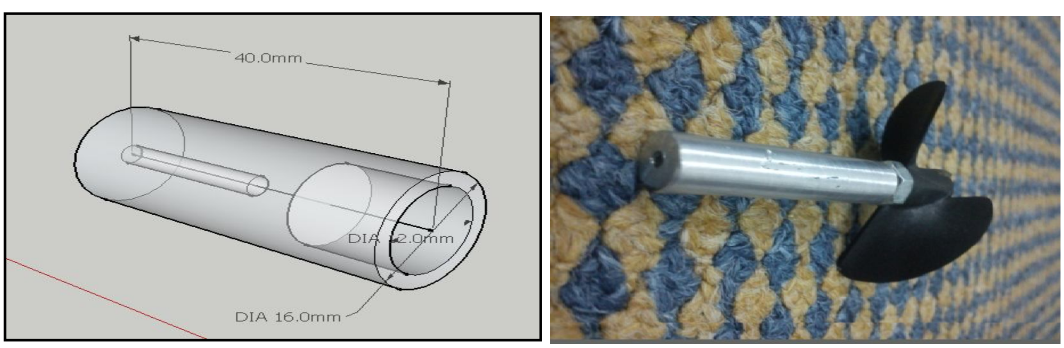


(a) (b)

Figure 3.6: a) Thruster part and b) Complete thruster

3.5.5 Coupling shaft

Coupling shaft are used to make the distance between propeller and the motor became far.It because when assemble the DC motor to the thruster body,the distance to the propeller became short and when the motor run it cannot operate very smoothly and can cause inefficentcy to the motor current. Coupling size are exactly same to the figure 3.7 and figure 3.8.

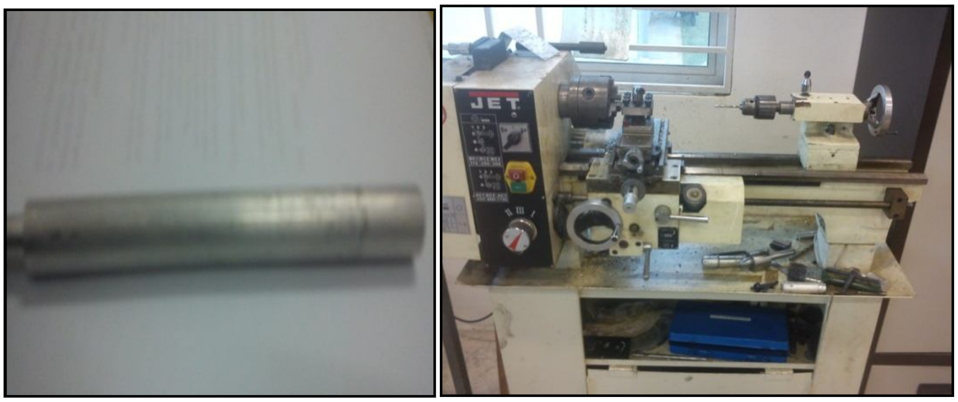


(a) (b)

Figure 3.7: a) Coupling design and b) Coupling with propeller

3.5.5.1 Step to make Coupling

1. Aluminium rod are cutting and adjusted using machine.



(a) (b)

Figure 3.9 a) Coupling shaft and b) Drilling machine

2. Make a screw hole.

(a) (b)

Figure 3.10 : a) Drilling process and b) the complete coupling

3.6 Electronic Design

Electronic design consist two main part, Microcontroller circuit and motor driver circuit.This two circuit are design using computer simulation software, PROTEUS.Figure 3.11 indicate the simulation software using PROTEUS version 7.8.

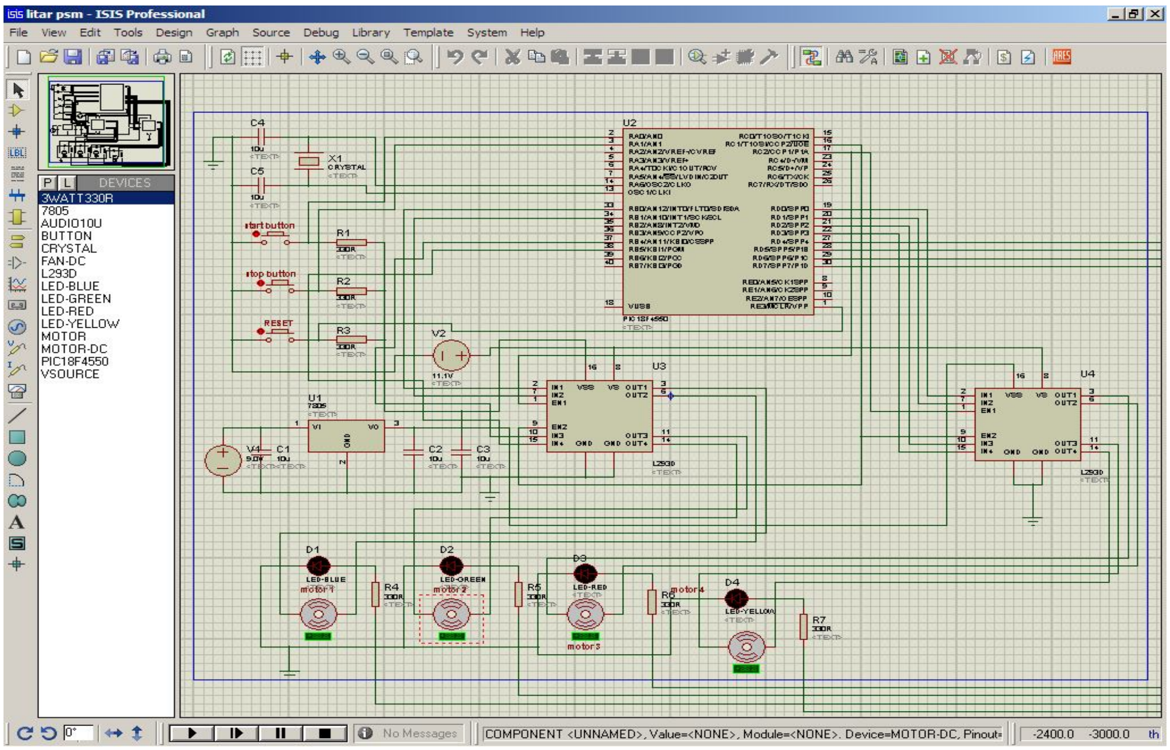


Figure 3.11 : PROTEUS version 7.8

3.6.1 Main circuit

Microcontroller circuit contain PIC18F4550 ,Reset Button ,Start and Stop button and voltage regulator circuit.Figure 3.12 indicate Microcontroller circuit using Cytron circuit.

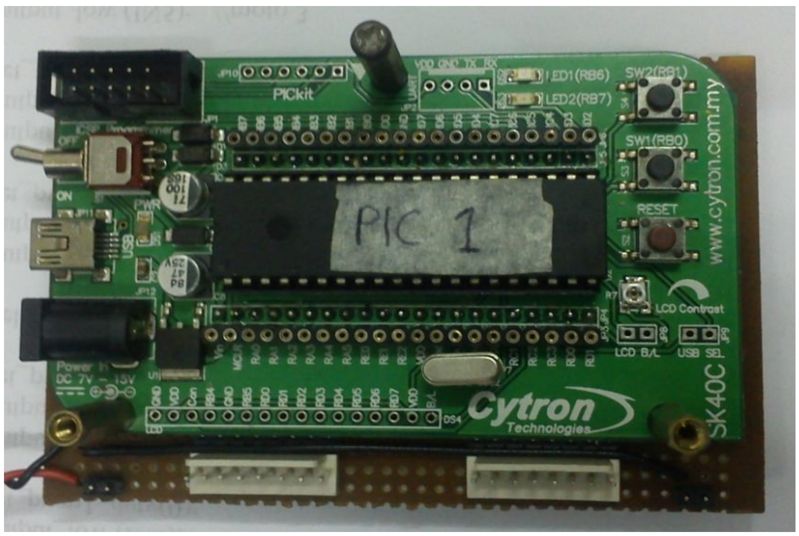


Figure 3.12 : Microcontroller circuit using Cytron circuit.

3.6.1.1 Main Circuit Description

In this electronic circuit,the main circuit are functioning as abrain of all thruster movement and 12 Volt LED.The analogy of main controller circuit is very simple.When, the input from start button are send, all the output port A,C and D are active.In this case,the output are determine by programming code which is either set as a high or low.Next,the output flow to the Motor Driver(L293D) circuit.From the main controller circuit,the port C1 and C2 are act as a Pulse Width Modulation(PWM) .When enable pin1 and 2 are active at L293D circuit, the PWM will ocsilate the pulse that have been determine in programming code.

The Pulse Width Modulation in this PIC controller circuit have range between 0 to 255.In this project,the PWM are set to 250 to all thruster because in the water,the propulsion system is not enough if pulse width modulation are set low.In other word,the speed of the motr are ow that is not to make movement of Autonomous Underwater Vehicle (AUV).

3.6.2 Placing the Main Circuit in AUV Body

The main circuit are place in front of the AUV body. The cover made of plastic in square shape as show in figure 3.13. The start switch button is place at the side of the square box. The box is seal with gum so that is no water leakage that can make the short circuit to the main circuit.

Figure 3.13 : Main circuit box

3.7 Software

In software part,The PIC microcontroller has been program using CCS C Compiler (figure 3.14) that is use High Level Language,C language.Then, using PIC Kit (figure 3.15) software to transfer the program to the PIC18F4550 using ICSP (burn the programming code).

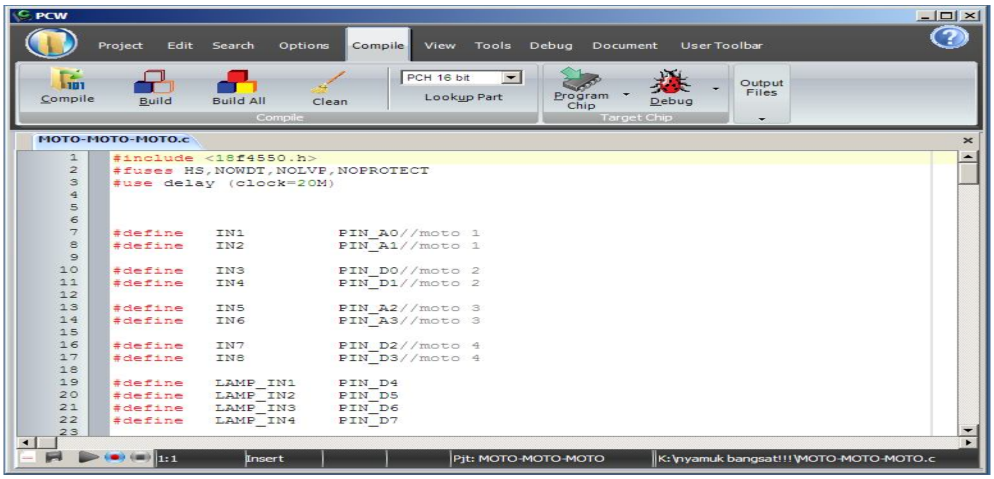


Figure 3.14 : CCS C Compiler

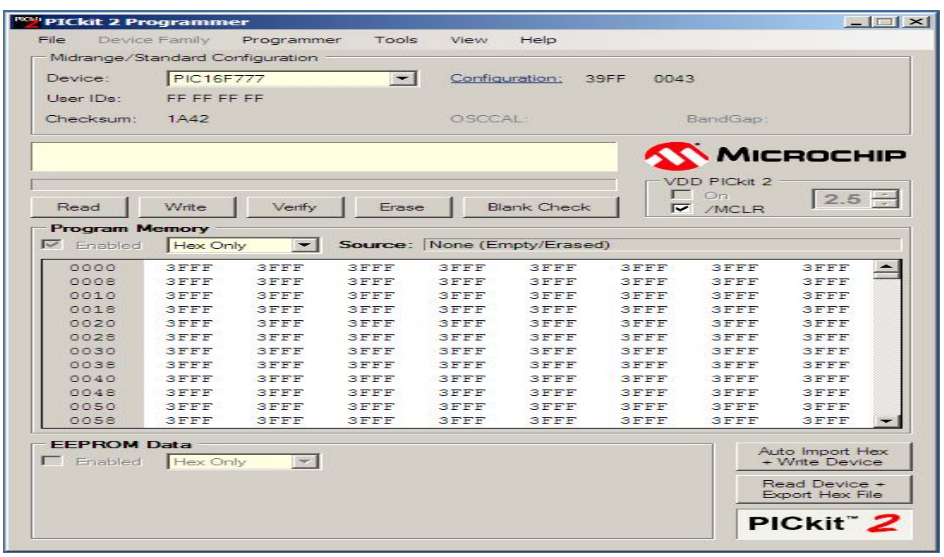
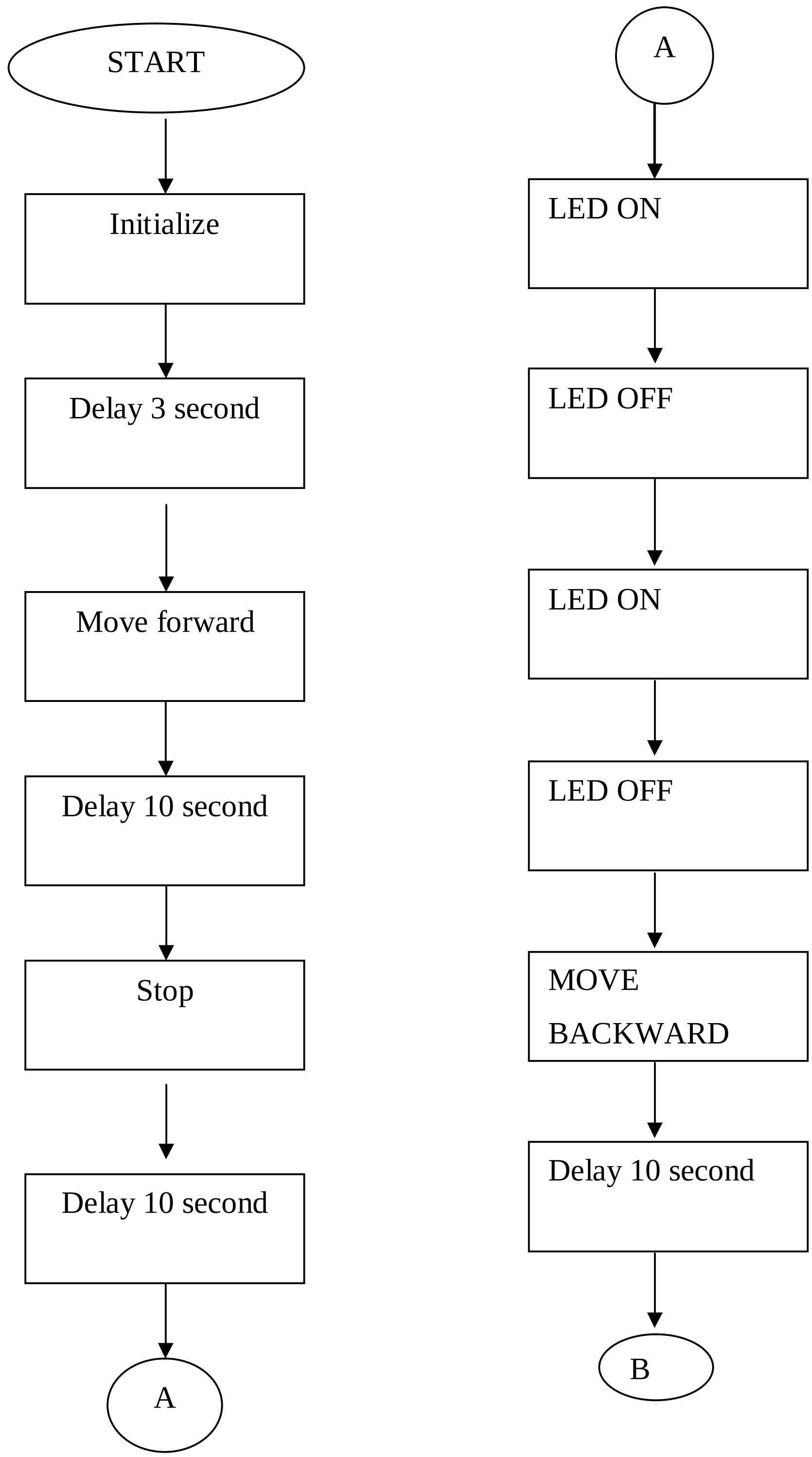
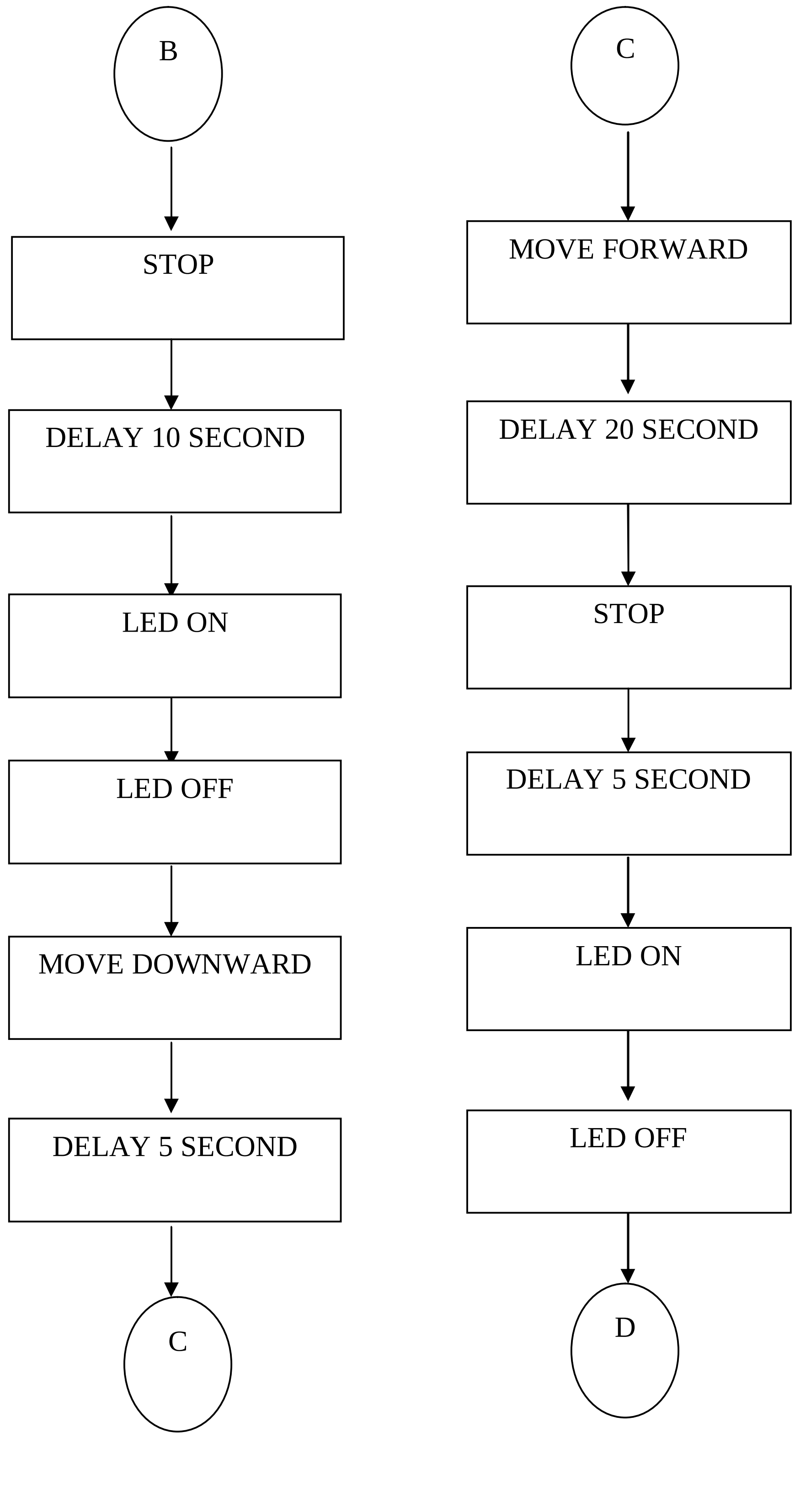


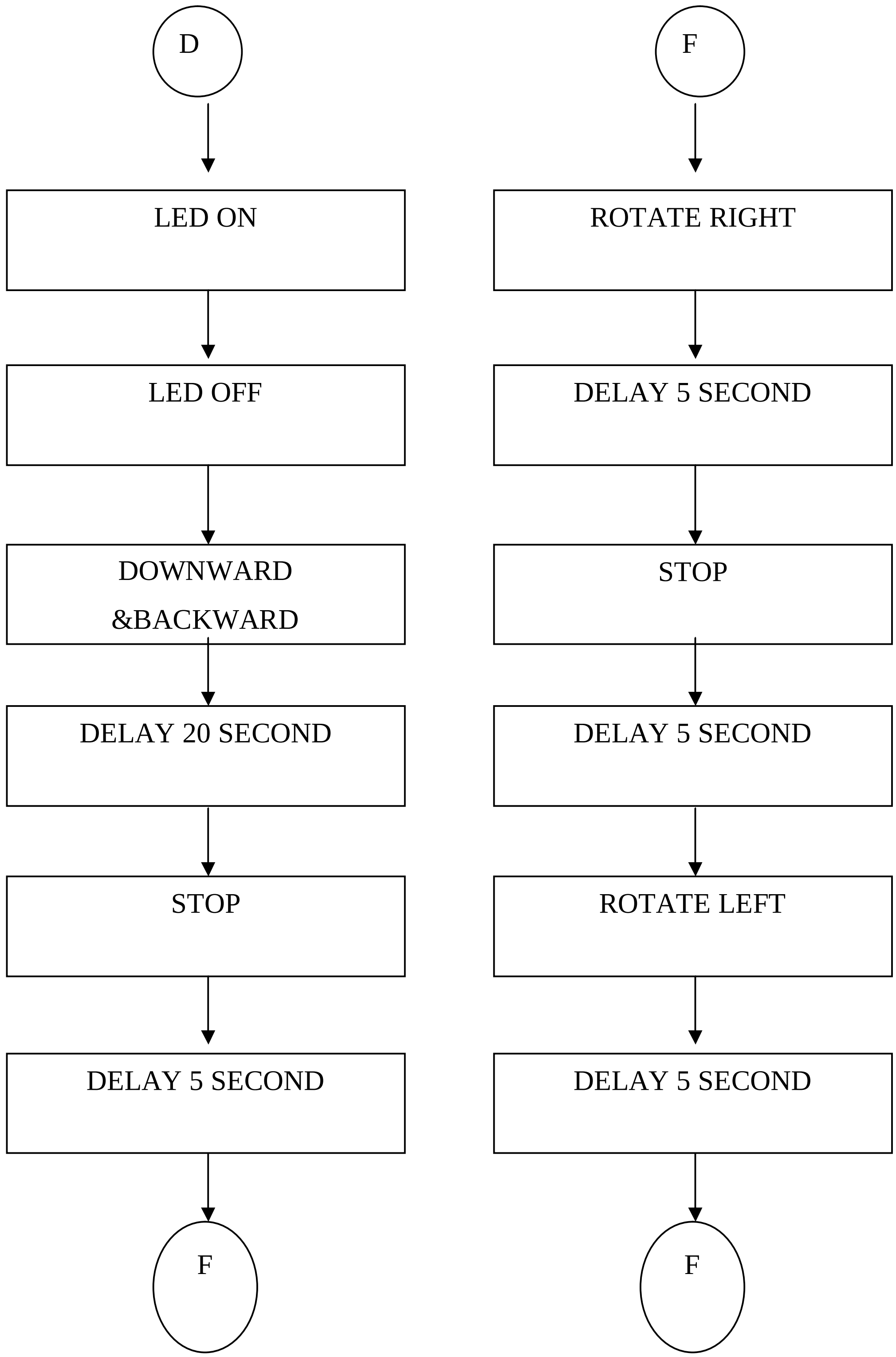
Figure 3.15 : PIC Kit

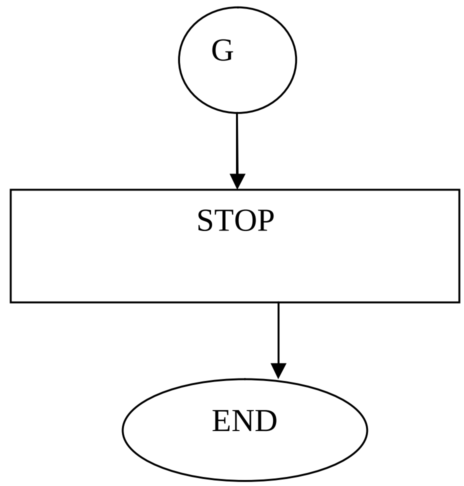
3.7.1 Program Flow Chart

Programming flow chart are important for making movement of the DC motor.The programmming flow give the guidance to make sure the output follow as needed.Flow chart above show overall process of Autonomous Underwater Vehicle.




B
STOP
DELAY 10 SECOND
LED ON
LED OFF
MOVE DOWNWARD
DELAY 5 SECOND
C
C
MOVE FORWARD
DELAY 20 SECOND
STOP
DELAY 5 SECOND
LED ON
LED OFF
D


D
F
LED ON
ROTATE RIGHT
LED OFF
DELAY 5 SECOND
DOWNWARD &BACKWARD
STOP
DELAY 20 SECOND
DELAY 5 SECOND
STOP
ROTATE LEFT
DELAY 5 SECOND
DELAY 5 SECOND
F
F


G
STOP
END

CHAPTER 4

RESULT AND DISCUSSION

In this chapter, it will be discuss about result of the Development of Anutonomous Underwater Vehicle project. The topic that will discussed which are the movement of AUV, AUV design and bouyancy.

4.1 Movement of AUV

When running the Autonomous Underwater Vehicle,for the forward and backward movement are very smootly, this is because the motor spin at the full speed.For downward movement,the thruster of Autonomous Underwater Vehicle has low speed.it because the setting of PWM in programming mode.Figure 4.0 show the AUV moment in the water.

Figure 4.0 : AUV movement in the water

4.2 AUV Design

The AUV design has the perfect shape.PVC material is the best choice because it light and easy to assemble.The AUV body are not much stable in the water and need to be improve for the next time.

4.3 Bouyancy

For floating in the water,AUV consist 2 cylinder like a balast tank.This two cylinder act as the buoyancy medium to make the AUV auto floating in the water.The Buoyancy cylinder tank was only the end of cap of PVC pipe that has been combine.In this tank,there is an air according to the buoyancy principle.Figure 4.1 show the bouyancy using cylinder tank.

Figure 4.1 : AUV stable in the water

CHAPTER 5

CONCLUSION AND RECOMMENDATION

This chapter will discuss about the conclusion of this project and recommendation by developing an Autonomous Underwater Vehicle.This chapter also will discuss about future recommendation of develeping AUV.

5.1 Conclusion

By developing an Autonomous Underwater Vehicle,the expected outcome finally success.This AUV use 4 thruster as a motor to operate in the water.The design and the prototype was succescfully design.Using PIC18F4550 as a microcontroller,the electronic part are successfully design and apply in the real time.Programming using high level language which is C language,the AUV can make movement according to itself.The objectives was successfully reach at the end of this project.From generating the ideas,develope the hardware and software part,it is not an easy part to develop the project.

For the conclusion,I hereby said that this project as name as Development Of An Autonomous Underwater Vehicle was successfully design,implemented and tested.

5.2 Recommmendation

This project was succesfully design and met the objective.During develope of Autonomous Underwater Vehicle,I have founf some way to improve this project for the next research.In the water,the AUV can float automatically by using bouyancy tank.For a recommendation,should have the system that can automatically floating and submerge the AUV.Although the AUV was only use a middle thruster that act as submerging system.I recommend that it should not the submerge only and it should floating too.Some other part should be take a way look too which is the thruster design,circuit main board and the body of AUV.

References

1. M. Shahrieel M. Aras, H A Kasridin, M Herman Jamaluddin,M Farriz Basar. Design and Development of an Autonomous Underwater Vehicle ,Faculty Electrical Engineering, UTeM.2009

2. L.A Gonzalez. Design,Modelling and Control of an Autonomous Vehicle, Bachelor of Engineering Honours Thesis, The University of Western Australia,2004.

3. Mohd Zaidi Bin Mohd Tumari.The development of low cost underwater vehicle,University Teknologi Mara,2008.

4. D.R. Yoerger, J.-J.E.Slotine, M. Grosenbaugh, D.M. DeLonga . Dynamics and Controlof Autonomous Vehicles .Deep Submergence Laboratory Woods Hole Oceanographic Institution Woods Hole, MA02543.

5. Dr. Richard Blidberg " Autonomous Undersea System institute", Lee New Hampshire, USA

6. A. Cadena. Design and Construction of an Autonomous Underwater Vehicle for the launch of a small UAV. ESPOL, Km 30.5 Perimentral Av, Guayaquil, Ecuador,2007

7. Aditya S. Gadre, Jared J. Mach, Daniel J. Stilwell ,Carl E. Wick. Design of a Prototype Miniature Autonomous Underwater Vehicle. The Bradley Department of Electrical and Computer Engineering Systems Engineering Department Virginia Polytechnic Institute and State University United States Naval Academy Blacksburg, VA 24061 Annapolis, MD 21402.2003

8. Ismadi Bin Ibrahim. Remotely Operated Underwater Vehicle (ROV). Faculty of Electrical Engineering Universiti Teknologi Malaysia.MAY 2010

APPENDIX A

PIC18F4550 DATA SHEET

MICROCHIP

PIC18F2455/2550/4455/4550 Data Sheet

28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology

MICROCHIP PIC18F2455/2550/4455/4550

28/40/44-Pin, High-Performance, Enhanced Flash, USB Microcontrollers with nanoWatt Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Low Speed (1.5 Mb/s) and Full Speed (12 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 Endpoints (16 bidirectional)
- 1-Kbyte Dual Access RAM for USB
- On-Chip USB Transceiver with On-Chip Voltage Regulator
- Interface for Off-Chip USB Transceiver
- Streaming Parallel Port (SPP) for USB streaming transfers (40/44-pin devices only)

Power-Managed Modes:

- Run: CPU on, peripherals on
- Idle: CPU off, peripherals on
- Sleep: CPU off, peripherals off
- Idle mode currents down to 5.8 μA typical
- Sleep mode currents down to 0.1 μA typical
- Timer1 Oscillator: 1.1 μA typical, 32 kHz, 2V
- Watchdog Timer: 2.1 μA typical
- Two-Speed Oscillator Start-up

Flexible Oscillator Structure:

- Four Crystal modes, including High Precision PLL for USB
- Two External Clock modes, up to 48 MHz
- Internal Oscillator Block:
  - 8 user-selectable frequencies, from 31 kHz to 8 MHz
  - User-tunable to compensate for frequency drift
- Secondary Oscillator using Timer1 @ 32 kHz
- Dual Oscillator options allow microcontroller and USB module to run at different clock speeds
- Fail-Safe Clock Monitor:
  - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- High-Current Sink/Source: 25 mA/25 mA
- Three External Interrupts
- Four Timer modules (Timer0 to Timer3)
- Up to 2 Capture/Compare/PWM (CCP) modules:
  - Capture is 16-bit, max. resolution 5.2 ns ($T_{CY}/16$)
  - Compare is 16-bit, max. resolution 83.3 ns (T_{CY})
  - PWM output: PWM resolution is 1 to 10-bit
- Enhanced Capture/Compare/PWM (ECCP) module:
  - Multiple output modes
  - Selectable polarity
  - Programmable dead time
  - Auto-shutdown and auto-restart
- Enhanced USART module:
  - LIN bus support
- Master Synchronous Serial Port (MSSP) module supporting 3-wire SPI (all 4 modes) and I²C™ Master and Slave modes
- 10-bit, up to 13-channel Analog-to-Digital Converter module (A/D) with Programmable Acquisition Time
- Dual Analog Comparators with Input Multiplexing

Special Microcontroller Features:

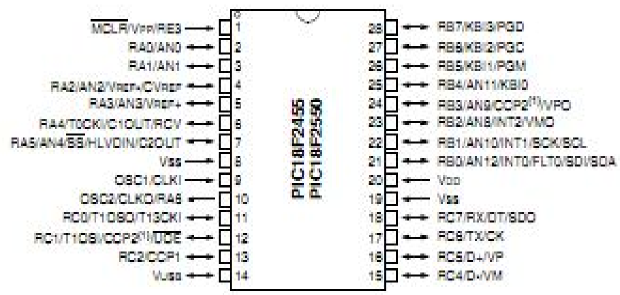
- C Compiler Optimized Architecture with optional Extended Instruction Set
- 100,000 Erase/Write Cycle Enhanced Flash Program Memory typical
- 1,000,000 Erase/Write Cycle Data EEPROM Memory typical
- Flash/Data EEPROM Retention: > 40 years
- Self-Programmable under Software Control
- Priority Levels for Interrupts
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
  - Programmable period from 41 ms to 131s
- Programmable Code Protection
- Single-Supply 5V In-Circuit Serial Programming™ (ICSP™) via two pins
- In-Circuit Debug (ICD) via two pins
- Optional dedicated ICD/ICSP port (44-pin devices only)
- Wide Operating Voltage Range (2.0V to 5.5V)

Device	Program Memory		Data Memory		I/O	10-Bit A/D (ch)	CCP/ECCP (PWM)	SPP	MSSP		EAUSART	Comparators	Timers 8/16-Bit
	Flash (bytes)	# Single-Word Instructions	SRAM (bytes)	EEPROM (bytes)					SPI	Master I²C™			
PIC18F2455	24K	12288	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F2550	32K	16384	2048	256	24	10	2/0	No	Y	Y	1	2	1/3
PIC18F4455	24K	12288	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3
PIC18F4550	32K	16384	2048	256	35	13	1/1	Yes	Y	Y	1	2	1/3

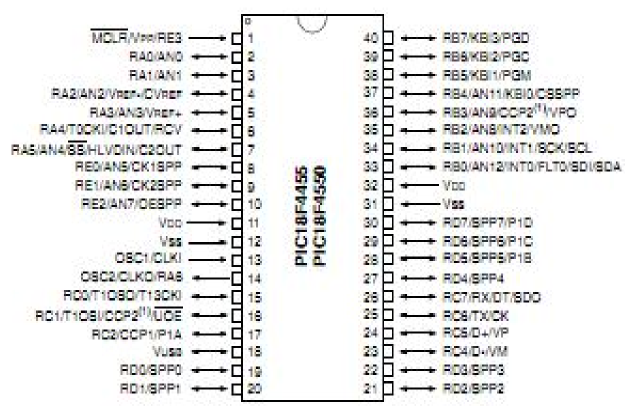
PIC18F2455/2550/4455/4550

Pin Diagrams

28-Pin PDIP, SOIC



40-Pin PDIP



Note 1: RB3 is the alternate pin for CCP2 multiplexing.

 Preliminary

1.0 DEVICE OVERVIEW

This document contains device-specific information for the following devices:

- PIC18F2455
- PIC18F2550
- PIC18F4455
- PIC18F4550
- PIC18LF2455
- PIC18LF2550
- PIC18LF4455
- PIC18LF4550

This family of devices offers the advantages of all PIC18 microcontrollers – namely, high computational performance at an economical price – with the addition of high endurance, Enhanced Flash program memory. In addition to these features, the PIC18F2455/2550/4455/4550 family introduces design enhancements that make these microcontrollers a logical choice for many high-performance, power sensitive applications.

1.1 New Core Features

1.1.1 nanoWatt TECHNOLOGY

All of the devices in the PIC18F2455/2550/4455/4550 family incorporate a range of features that can significantly reduce power consumption during operation. Key items include:

- **Alternate Run Modes:** By clocking the controller from the Timer1 source or the internal oscillator block, power consumption during code execution can be reduced by as much as 90%.
- **Multiple Idle Modes:** The controller can also run with its CPU core disabled but the peripherals still active. In these states, power consumption can be reduced even further, to as little as 4% of normal operation requirements.
- **On-the-Fly Mode Switching:** The power-managed modes are invoked by user code during operation, allowing the user to incorporate power-saving ideas into their application's software design.
- **Low Consumption in Key Modules:** The power requirements for both Timer1 and the Watchdog Timer are minimized. See **Section 28.0 "Electrical Characteristics"** for values.

1.1.2 UNIVERSAL SERIAL BUS (USB)

Devices in the PIC18F2455/2550/4455/4550 family incorporate a fully featured Universal Serial Bus communications module that is compliant with the USB Specification Revision 2.0. The module supports both low-speed and full-speed communication for all supported data transfer types. It also incorporates its own on-chip transceiver and 3.3V regulator and supports the use of external transceivers and voltage regulators.

1.1.3 MULTIPLE OSCILLATOR OPTIONS AND FEATURES

All of the devices in the PIC18F2455/2550/4455/4550 family offer twelve different oscillator options, allowing users a wide range of choices in developing application hardware. These include:

- Four Crystal modes using crystals or ceramic resonators.
- Four External Clock modes, offering the option of using two pins (oscillator input and a divide-by-4 clock output) or one pin (oscillator input, with the second pin reassigned as general I/O).
- An internal oscillator block which provides an 8 MHz clock (±2% accuracy) and an INTRC source (approximately 31 kHz, stable over temperature and VDD), as well as a range of 6 user-selectable clock frequencies, between 125 kHz to 4 MHz, for a total of 8 clock frequencies. This option frees an oscillator pin for use as an additional general purpose I/O.
- A Phase Lock Loop (PLL) frequency multiplier, available to both the High-Speed Crystal and External Oscillator modes, which allows a wide range of clock speeds from 4 MHz to 48 MHz.
- Asynchronous dual clock operation, allowing the USB module to run from a high-frequency oscillator while the rest of the microcontroller is clocked from an internal low-power oscillator.

Besides its availability as a clock source, the internal oscillator block provides a stable reference source that gives the family additional features for robust operation:

- **Fail-Safe Clock Monitor:** This option constantly monitors the main clock source against a reference signal provided by the internal oscillator. If a clock failure occurs, the controller is switched to the internal oscillator block, allowing for continued low-speed operation or a safe application shutdown.
- **Two-Speed Start-up:** This option allows the internal oscillator to serve as the clock source from Power-on Reset, or wake-up from Sleep mode, until the primary clock source is available.

PIC18F2455/2550/4455/4550

1.2 Other Special Features

- **Memory Endurance:** The Enhanced Flash cells for both program memory and data EEPROM are rated to last for many thousands of erase/write cycles – up to 100,000 for program memory and 1,000,000 for EEPROM. Data retention without refresh is conservatively estimated to be greater than 40 years.
- **Self-Programmability:** These devices can write to their own program memory spaces under internal software control. By using a bootloader routine, located in the protected Boot Block at the top of program memory, it becomes possible to create an application that can update itself in the field.
- **Extended Instruction Set:** The PIC18F2455/2550/4455/4550 family introduces an optional extension to the PIC18 instruction set, which adds 8 new instructions and an Indexed Literal Offset Addressing mode. This extension, enabled as a device configuration option, has been specifically designed to optimize re-entrant application code originally developed in high-level languages such as C.
- **Enhanced CCP Module:** In PWM mode, this module provides 1, 2 or 4 modulated outputs for controlling half-bridge and full-bridge drivers. Other features include auto-shutdown for disabling PWM outputs on interrupt or other select conditions and auto-restart to reactivate outputs once the condition has cleared.
- **Enhanced Addressable USART:** This serial communication module is capable of standard RS-232 operation and provides support for the LIN bus protocol. Other enhancements include Automatic Baud Rate Detection and a 16-bit Baud Rate Generator for improved resolution. When the microcontroller is using the internal oscillator block, the EUSART provides stable operation for applications that talk to the outside world without using an external crystal (or its accompanying power requirement).
- **10-Bit A/D Converter:** This module incorporates programmable acquisition time, allowing for a channel to be selected and a conversion to be initiated, without waiting for a sampling period and thus, reducing code overhead.
- **Dedicated ICD/ICSP Port:** These devices introduce the use of debugger and programming pins that are not multiplexed with other microcontroller features. Offered as an option in select packages, this feature allows users to develop I/O intensive applications while retaining the ability to program and debug in the circuit.

1.3 Details on Individual Family Members

Devices in the PIC18F2455/2550/4455/4550 family are available in 28-pin and 40/44-pin packages. Block diagrams for the two groups are shown in Figure 1-1 and Figure 1-2.

The devices are differentiated from each other in six ways:

1. Flash program memory (24 Kbytes for PIC18FX455 devices, 32 Kbytes for PIC18FX550).
2. A/D channels (10 for 28-pin devices, 13 for 40/44-pin devices).
3. I/O ports (3 bidirectional ports and 1 input only port on 28-pin devices, 5 bidirectional ports on 40/44-pin devices).
4. CCP and Enhanced CCP implementation (28-pin devices have two standard CCP modules, 40/44-pin devices have one standard CCP module and one ECCP module).
5. Streaming Parallel Port (present only on 40/44-pin devices).

All other features for devices in this family are identical. These are summarized in Table 1-1.

The pinouts for all devices are listed in Table 1-2 and Table 1-3.

Like all Microchip PIC18 devices, members of the PIC18F2455/2550/4455/4550 family are available as both standard and low-voltage devices. Standard devices with Enhanced Flash memory, designated with an "F" in the part number (such as PIC18F2550), accommodate an operating V_{DD} range of 4.2V to 5.5V. Low-voltage parts, designated by "LF" (such as PIC18**LF**2550), function over an extended V_{DD} range of 2.0V to 5.5V.

TABLE 1-1: DEVICE FEATURES

Features	PIC18F2455	PIC18F2550	PIC18F4455	PIC18F4550
Operating Frequency	DC – 48 MHz	DC – 48 MHz	DC – 48 MHz	DC – 48 MHz
Program Memory (Bytes)	24576	32768	24576	32768
Program Memory (Instructions)	12288	16384	12288	16384
Data Memory (Bytes)	2048	2048	2048	2048
Data EEPROM Memory (Bytes)	256	256	256	256
Interrupt Sources	19	19	20	20
I/O Ports	Ports A, B, C, (E)	Ports A, B, C, (E)	Ports A, B, C, D, E	Ports A, B, C, D, E
Timers	4	4	4	4
Capture/Compare/PWM Modules	2	2	1	1
Enhanced Capture/ Compare/PWM Modules	0	0	1	1
Serial Communications	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART	MSSP, Enhanced USART
Universal Serial Bus (USB) Module	1	1	1	1
Streaming Parallel Port (SPP)	No	No	Yes	Yes
10-Bit Analog-to-Digital Module	10 Input Channels	10 Input Channels	13 Input Channels	13 Input Channels
Comparators	2	2	2	2
Resets (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), $\overline{MCLR}$ (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), $\overline{MCLR}$ (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), $\overline{MCLR}$ (optional), WDT	POR, BOR, RESET Instruction, Stack Full, Stack Underflow (PWRT, OST), $\overline{MCLR}$ (optional), WDT
Programmable Low-Voltage Detect	Yes	Yes	Yes	Yes
Programmable Brown-out Reset	Yes	Yes	Yes	Yes
Instruction Set	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled	75 Instructions; 83 with Extended Instruction Set enabled
Packages	28-pin PDIP 28-pin SOIC	28-pin PDIP 28-pin SOIC	40-pin PDIP 44-pin QFN 44-pin TQFP	40-pin PDIP 44-pin QFN 44-pin TQFP

APPENDIX B

L293D MOTOR DRIVER

SGS-THOMSON MICROELECTRONICS

L293D
L293DD

PUSH-PULL FOUR CHANNEL DRIVER WITH DIODES

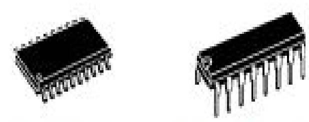
- 600mA OUTPUT CURRENT CAPABILITY PER CHANNEL
- 1.2A PEAK OUTPUT CURRENT (non repetitive) PER CHANNEL
- ENABLE FACILITY
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)
- INTERNAL CLAMP DIODES

DESCRIPTION

The Device is a monolithic integrated high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads (such as relays solenoides, DC and stepping motors) and switching power transistors.

To simplify use as two bridges each pair of channels is equipped with an enable input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included.

This device is suitable for use in switching applications at frequencies up to 5 kHz.



SO(12+4+4) Powerdip (12+2+2)

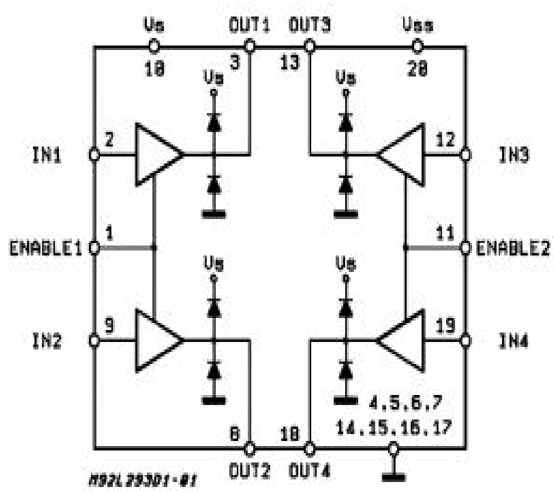
ORDERING NUMBERS:

L293DD L293D

The L293D is assembled in a 16 lead plastic packaage which has 4 center pins connected together and used for heatsinking

The L293DD is assembled in a 20 lead surface mount which has 8 center pins connected together and used for heatsinking.

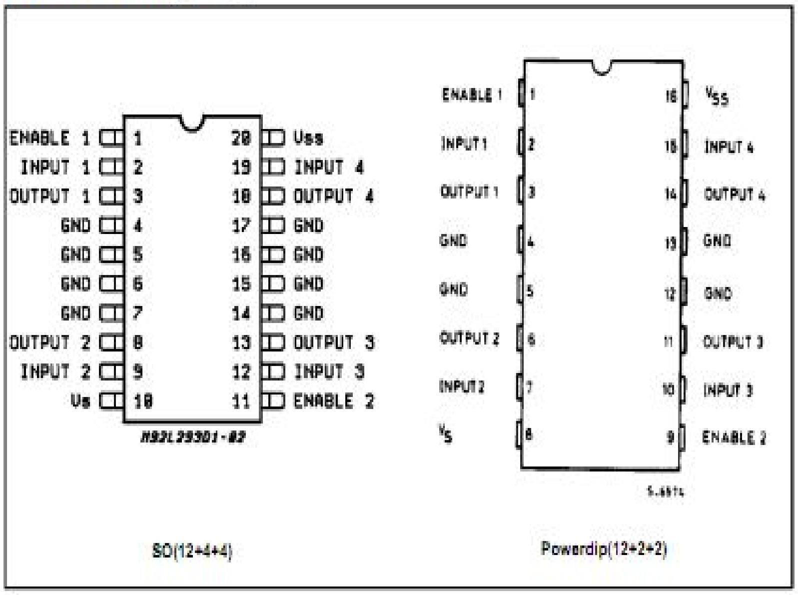
BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_s	Supply Voltage	36	V
Vss	Logic Supply Voltage	36	V
V_i	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 µs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

PIN CONNECTIONS (Top view)



THERMAL DATA

Symbol	Decription		DIP	SO	Unit
$R_{th\,j\text{-}pins}$	Thermal Resistance Junction-pins	max.	–	14	°C/W
$R_{th\,j\text{-}amb}$	Thermal Resistance junction-ambient	max.	80	50 (*)	°C/W
$R_{th\,j\text{-}case}$	Thermal Resistance Junction-case	max.	14	–	

(*) With 6sq. cm on board heatsink.

ELECTRICAL CHARACTERISTICS (for each channel, V_S = 24 V, V_{SS} = 5 V, T_{amb} = 25 °C, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 10)		V_{SS}		36	V
V_{SS}	Logic Supply Voltage (pin 20)		4.5		36	V
I_S	Total Quiescent Supply Current (pin 10)	V_i = L ; I_O = 0 ; V_{en} = H		2	6	mA
		V_i = H ; I_O = 0 ; V_{en} = H		16	24	mA
		V_{en} = L			4	mA
I_{SS}	Total Quiescent Logic Supply Current (pin 20)	V_i = L ; I_O = 0 ; V_{en} = H		44	60	mA
		V_i = H ; I_O = 0 ; V_{en} = H		16	22	mA
		V_{en} = L		16	24	mA
V_{IL}	Input Low Voltage (pin 2, 9, 12, 19)		– 0.3		1.5	V
V_{IH}	Input High Voltage (pin 2, 9, 12, 19)	$V_{SS} \leq 7$ V	2.3		V_{SS}	V
		$V_{SS} > 7$ V	2.3		7	V
I_{IL}	Low Voltage Input Current (pin 2, 9, 12, 19)	V_{IL} = 1.5 V			– 10	µA
I_{IH}	High Voltage Input Current (pin 2, 9, 12, 19)	2.3 V $\leq V_{IH} \leq V_{SS}$ – 0.6 V		30	100	µA
$V_{en\ L}$	Enable Low Voltage (pin 1, 11)		– 0.3		1.5	V
$V_{en\ H}$	Enable High Voltage (pin 1, 11)	$V_{SS} \leq 7$ V	2.3		V_{SS}	V
		$V_{SS} > 7$ V	2.3		7	V
$I_{en\ L}$	Low Voltage Enable Current (pin 1, 11)	$V_{en\ L}$ = 1.5 V		– 30	– 100	µA
$I_{en\ H}$	High Voltage Enable Current (pin 1, 11)	2.3 V $\leq V_{en\ H} \leq V_{SS}$ – 0.6 V			± 10	µA
$V_{CE(sat)H}$	Source Output Saturation Voltage (pins 3, 8, 13, 18)	I_O = – 0.6 A		1.4	1.8	V
$V_{CE(sat)L}$	Sink Output Saturation Voltage (pins 3, 8, 13, 18)	I_O = + 0.6 A		1.2	1.8	V
V_F	Clamp Diode Forward Voltage	I_O = 600nA		1.3		V
t_r	Rise Time (*)	0.1 to 0.9 V_O		250		ns
t_f	Fall Time (*)	0.9 to 0.1 V_O		250		ns
t_{on}	Turn-on Delay (*)	0.5 V_i to 0.5 V_O		750		ns
t_{off}	Turn-off Delay (*)	0.5 V_i to 0.5 V_O		200		ns

(*) See fig. 1.

APPENDIX C

PROGRAM SOURCE CODE

```
#include <18f4550.h>
#fuses HS,NOWDT,NOLVP,NOPROTECT
#use delay (clock=20M)

#define   IN1        PIN_A0//moto 1
#define   IN2        PIN_A1//moto 1
#define   IN3        PIN_D0//moto 2
#define   IN4        PIN_D1//moto 2
#define   IN5        PIN_A2//moto 3
#define   IN6        PIN_A3//moto 3
#define   IN7        PIN_D2//moto 4
#define   IN8        PIN_D3//moto 4

#define   LAMP_IN1    PIN_D4
#define   LAMP_IN2    PIN_D5
#define   LAMP_IN3    PIN_D6
#define   LAMP_IN4    PIN_D7

//pwm port//
#define   EN1        PIN_C2
#define   EN2        PIN_C1

//button //
#define  START       PIN_B0
#define  STOP        PIN_B1

void main()
{

set_tris_b(0xFF);
set_tris_a(0x00);
set_tris_d(0x00);
```

```
output_b(0xFF);
output_d(0x00);
output_a(0x00);

setup_timer_2 (T2_DIV_BY_1,254,1);
setup_ccp1(CCP_PWM);
setup_ccp2(CCP_PWM);

while (true)
{
if (!input(START))
{
//initiallize//
output_low (IN1);   //moto 1
output_low (IN2);
set_pwm1_duty(0);

output_low (IN3);   //moto 2
output_low (IN4);
set_pwm2_duty(0);

output_low (IN5);   //moto 3
output_low (IN6);
set_pwm1_duty(0);

output_low (IN7);   //moto 4
output_low (IN8);
set_pwm2_duty(0);

output_low (LAMP_IN1);
output_low (LAMP_IN2);
output_low (LAMP_IN3);
output_low (LAMP_IN4);

delay_ms(5000);

//pattern 1 //

output_high (LAMP_IN1);
output_low (LAMP_IN2);
output_high (LAMP_IN3);
output_low (LAMP_IN4);

output_high (IN5);   //moto 3 forward//
output_low (IN6);
set_pwm1_duty(250);

output_high (IN7);   //moto 4 forward //
output_low (IN8);
set_pwm2_duty(250);
```

```
delay_ms(10000);   //delay 5 second//

output_low (IN5);   //moto 3 stop//
output_low (IN6);
set_pwm1_duty(0);

output_low (IN7);   //moto 4 stop//
output_low (IN8);
set_pwm2_duty(0);

delay_ms(10000); // delay 5 second//

//pattern 2//

output_high (LAMP_IN1);
output_low (LAMP_IN2);
output_low (LAMP_IN1);
output_low (LAMP_IN2);
output_high (LAMP_IN3);
output_low (LAMP_IN4);
output_low (LAMP_IN3);
output_low (LAMP_IN4);

output_low (IN5);   //moto 3 backward//
output_high (IN6);
set_pwm1_duty(250);

output_high (LAMP_IN1);
output_low (LAMP_IN2);
output_low (LAMP_IN1);
output_low (LAMP_IN2);
output_high (LAMP_IN3);
output_low (LAMP_IN4);
output_low (LAMP_IN3);
output_low (LAMP_IN4);

output_low (IN7);   //moto 4 backward //
output_high (IN8);
set_pwm2_duty(250);

delay_ms(10000);   //delay 5 second//

output_low (IN5);   //moto 3 stop//
output_low (IN6);
set_pwm1_duty(0);

output_low (IN7);   //moto 4 stop//
output_low (IN8);
set_pwm2_duty(0);
```

```
delay_ms(10000); // delay 5 second//

//pattern 3 submerge//

output_high (LAMP_IN1);
output_low (LAMP_IN2);
output_high (LAMP_IN3);
output_low (LAMP_IN4);

output_high (IN1);   //moto 1 submerge//
output_low (IN2);
set_pwm1_duty(250);

output_high (IN3);   //moto 2 submerge //
output_low (IN4);
set_pwm2_duty(250);

delay_ms(5000); //delay 3 second//

output_high (IN5);   //moto 3 forward//
output_low (IN6);
set_pwm1_duty(250);

output_high (IN7);   //moto 4 forward //
output_low (IN8);
set_pwm2_duty(250);

delay_ms(20000); //delay 10 second//

output_high (IN5);   //moto 3 stop//
output_low (IN6);
set_pwm1_duty(0);

output_high (IN7);   //moto 4 stop //
output_low (IN8);
set_pwm2_duty(0);

delay_ms(5000); //delay 3 second//

//pattern 4//
output_high (LAMP_IN1);
output_low (LAMP_IN2);
output_low (LAMP_IN1);
output_low (LAMP_IN2);
output_high (LAMP_IN3);
output_low (LAMP_IN4);
output_low (LAMP_IN3);
output_low (LAMP_IN4);
```

```
output_high (IN1);   //moto 1 submerge//
output_low (IN2);
set_pwm1_duty(250);

output_high (IN3);   //moto 2 submerge //
output_low (IN4);
set_pwm2_duty(250);

output_low (IN5);   //moto 3 backward//
output_high (IN6);
set_pwm1_duty(250);

output_low (IN7);   //moto 4 backward //
output_high (IN8);
set_pwm2_duty(250);

delay_ms(20000); //delay 10 second//

output_high (IN5);   //moto 3 stop//
output_low (IN6);
set_pwm1_duty(0);

output_high (IN7);   //moto 4 stop //
output_low (IN8);
set_pwm2_duty(0);

delay_ms(5000); //delay 3 second//

output_low (IN1);   //moto 1
output_low (IN2);
set_pwm1_duty(0);

output_low (IN3);   //moto 2
output_low (IN4);
set_pwm2_duty(0);

output_low (IN5);   //moto 3
output_low (IN6);
set_pwm1_duty(0);

output_low (IN7);   //moto 4
output_low (IN8);
set_pwm2_duty(0);

delay_ms(5000);

}
}
}
```