DESIGN AND DEVELOPMENT AN EMBEDDED CONTROLLER FOR AN AUTONOMOUS UNDERWATER VEHICLE *(AUV)* ~ USING PERIPHERAL INTERFACE CONTROLLLER *(PIC)*

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A report submitted in partial fulfillment of requirements for the Degree of Bachelor in Mechatronic Engineering

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2010

"I hereby declared that I have read through this report "*Design and Development an Embedded Controller for an Autonomous Underwater Vehicle (AUV) – Using Peripheral Interface Controller (PIC)*" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronic Engineering".

Signature : ....

Supervisor's Name : MOHD SHAHRIEEL BIN MOHD ARAS PENSYARAH Fakulti Kejuruteraan Elektrik Universiti Teknikal Malaysia Melaka

Date : 7/5/2010

I declare that this report entitle "*Design and Development an Embedded Controller for an Autonomous Underwater Vehicle (AUV)-Using Peripheral Interface Controller (PIC)*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : NOR RAJERAH MOHD SHAMSUDDIN

Date : 7/5/2010

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Bismillahirrahmanirrahim. In the name of ALLAH, who is the most Gracious and most Merciful. Without HIS blessing I'm not here now and would not be able to complete this report.

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ABSTRACT

Autonomous Underwater Vehicles (AUV), also known as unmanned underwater vehicles, can be used to perform underwater survey missions such as detecting and mapping submerged wrecks, rocks, and obstructions that pose a hazard to navigation for commercial and recreational vessels. The AUV conducts its survey mission without operator intervention. An AUV can be equipped with a DC Motor and two Servo motor to generate the movement. Dc motor will control the movement of forward and reverse of the propeller whereas the movement of the thrusters will be controlled of servo motors. The movement of those motors are programmed by a microcontroller which type is PIC 16F877A is used. MicroC software and Proteus will be merged together in the PIC for simulation running test before it can be applied on real AUV. Besides, the knowledge and fundamental concepts are very essential before design any underwater vehicle. These include the processes and physical laws governing the vehicle in its environment. With regard to an AUV, factors such as buoyancy, stability, hydrodynamic damping and pressure have to be taken into consideration.

ABSTRAK

Kenderaan Dalam Air Berautonomi (AUV), turut dikenali kenderaan tanpa kawalan oleh manusia. Dibangunkan untuk menjalankan aktiviti tinjauan dalam air misi-misi seperti mengesan dan kehancuran tenggelam pemetaan, batu-batu, dan halangan-halangan yang bakal membahaya pelayaran untuk kapal-kapal komersial dan rekreasi. Kenderaan berautomasi ini mengendalikan misi tinjauannya tanpa pengendali. Kenderaan yang bakal dibangunkan ini dilengkapkan dengan satu motor arus terus dan dua enjin Servo untuk menjana pergerakan. Motor arus terus akan mengawal pergerakan ke hadapan dan belakang kipas manakala pergerakan penolak-penolak itu akan dikawal servo motor. Pergerakan motor-motor tersebut akan diprogramkan, dengan menggunakan mikropengawal yang jenisnya iaitu PIC 16F877A. Perisian MicroC dan Proteus akan menjadi bergabung sesama dalam untuk mensimulasikan PIC sebelum ia boleh digunakan ke atas AUV yang sebenar. Selain daripada itu, pengetahuan dan konsep-konsep asas sangat penting sebelum kerja-kerja merekabentuk mana-mana kenderaan dalam air. Ini termasuk proses-proses dan pematuhan hukum fizik kenderaan dalam persekitarannya. Beberapa faktor seperti ampungan, kestabilan, redaman hidrodinamik dan tekanan perlu diambilkira dalam membangunkan kenderaan dalam air berautomasi ini.

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LIST OF SYMBOLS & TERMS

AUV	Autonomous Underwater Vehicle
DOF	Degree of Freedom
B	buoyant force
W	weight of the body
CAD	Computer Aided Design
MCAD	Mechanical Computer Aided Design
PIC	Peripheral Interface Controller
IC	Integrated Circuit

CHAPTER 1

INTRODUCTION

1.0 Introduction

An Autonomous Underwater Vehicle (AUV) is a robotic device that is driven through the water by a propulsion system, controlled and piloted by an onboard computer, and maneuverable in three dimensions. This level of control, under most environmental conditions, permits the vehicle to follow precise preprogrammed trajectories wherever and whenever required [1].

These few years, a number of commercial AUV have been developed for various practical application, many foreign companies all over world tries to compete into develop and produce several of Autonomous Underwater Vehicle (AUV) for participate with an advance submarine activities in the future. The task of the designer would to develop an AUV that most efficient movement system for activities undersea for replaces the conventional technique. Lots of benefits can be gained from this new technique such as the movement system of the Autonomous Underwater Vehicles (AUV) can be control without umbilical cables than Remotely Operate Vehicle (ROV).

This project focuses on the propulsion part, the main part of an AUV where these allows an AUV moving. Most of AUVs use motors for propulsion due to the scarcity and cost of alternative systems. The location of the motors affects which degrees of freedom can be controlled. The positioning of the motors can also affect noise interference with onboard electronic components, as well as propeller-to-hull and propeller-to-propeller interactions. Propeller-to-hull and propeller-to-propeller interactions can have unwanted effects in the dynamics of an AUV. The development of the AUV is presented as an example of the implementation process for a mechatronic product. The difficulties occurring in such a process are discussed. Possible methods and process models to overcome these problems are also proposed and discussed

1.1 Problem Statement

Today the dry land of the Earth just remains thirty percent and seventy percent is covered with water. Hence, exploring activities in underwater application such as monitoring and control purpose caused limited human investigation and dangerous or impractical to have human working because human has limitation in underwater. One of the safest ways to explore deep waters is using small unmanned vehicles to carry out various missions and measurements.

Several internal and external factors need to be considered when to design and develop an AUV especially parts of mechanical. Complicated architecture of an AUV will be contributed larger cost to consumers. One of the way to overcome this problem, reduce of utilization of electronic chips and replaces with advance microcontroller and then programmed by using appropriate software. Consequently, the size or architecture of an AUV will be reduced. Implementation of the technology, will encourages producer to produce many unmanned vehicles, relatively simple and inexpensive autonomous submarine needs to be designed.

1.2 Objective

The objective of this project was to design and develop an embedded controller for an Autonomous Underwater Vehicle (AUV) using Peripheral Interface Controller (PIC).

1.3 Scopes of Project

The goals of this project are to design and develop the propulsion parts by referring existing of several samples of the underwater vehicles was developed. Those parts will be controlled the mechanism of an underwater vehicle which allows movement of forward, reverse, left and right with the helps from a DC motor and Servo motor which are programmed by the peripheral interface controller (PIC).

1.4 Organization of Report

This project report are divided into five chapter which are Chapter 1 for Introduction, Chapter 2 for Literature Review, Chapter 3 for Methodology, Chapter 4 for Result and Discussion and the last Chapter is Conclusion and Recommendation.

Chapter 1 will state and explain about background of the Autonomous Underwater Vehicle (AUV), problem statement for the project, objective for doing the project and the scopes set for this project. Chapter 2 is about the Literature Review had been quote from few recourses such as thesis, IEEE's journal and several information was taken from the internet.

Chapter 3 discussed the basic idea to understanding the AUV performance such as basic concept, coordination system of AUV theories, factors consideration and so on. In this chapter also explained detail about propeller and thruster parameter of AUV.

Then, the Chapter 4 is explaining about methodology used during developing this project. The methodology explains from the first step until the last step which is from literature review, hardware development, software development, integration between software and hardware and lastly the troubleshooting or analysis.

The next chapter is Chapter 5 that focuses in explaining and discusses the result of the analysis. Chapter 6 as the last chapter is about the summary or conclusion for overall this project that has been done during this period.

1.5 Summary

In this chapter, the main purpose that needs to be perceived is the general understanding on the objective, problem statement and scope of project that would help the reader to have a better understanding the general idea about the project. Anything related about the project will be explained in the in upcoming chapter.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter introduces some of these theory knowledge and ideas about underwater vehicles that are as literature review. All these information might helps the reader to understand more about the project due to theory concept that been applied to the project. The sources are taken from the previous thesis, journal and internet.

2.1 Echo Mapper AUV

The fully air transportable Echo Mapper Autonomous Underwater Vehicle (AUV) is one multiple AUV solutions offered by Fugro worldwide as shown in Figure 2.0. Echo Mapper is a Bluefin 21 AUV and is operated by Fugro Seafloor Survey which is designed for efficient survey operations in water depths down to 3000m.

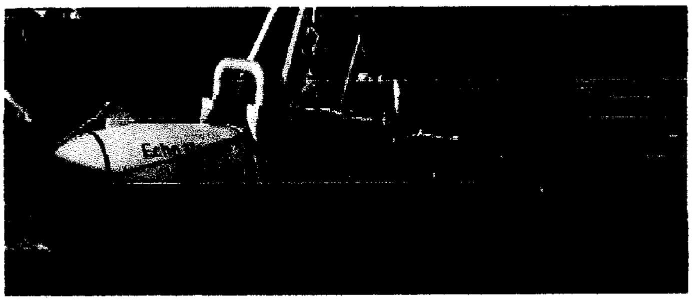

Figure 2.0: Echo Mapper AUV

AUVs are the best choice of instrument platforms for deep sea surveys. By placing the survey instruments on board an Autonomous Underwater Vehicle (AUV), the geophysical measurements take place close to the seafloor, dramatically improving the resolution and accuracy of the acquired data. With bring the best performance in deep water, Echo Mapper which able to gather data with a very low signal-to-noise ratio and thus return returns cleaner data with higher resolution.

The Echo Mapper is equipped with physical data and sub system as shown Table 2.0:-

Table 2.0: Specification of Echo Mapper AUV

Item	Specification
Mass	530 kg
Length	4.1 meter
Diameter	0.5 meter
Battery	Lithium-Polymer
Battery capacity	10.5 kWh
Sensor	Acoustic navigation Side scan sensor Additional sensor

2.2 Nessie II Autonomous Underwater Vehicle

Nessie II autonomous underwater vehicle has been developed in Ocean Systems Laboratory at Heriot-Watt University for to compete in the 2007 Student Autonomous Underwater Challenge Europe (SAUC-E) competition held the Haslar Ocean Basin Tank in Gosport, UK. This paper will describe about the robust hardware and software design the vehicle is able to successfully complete the tasks set out in the competition and will be an excellent platform for further development [2].

The main hardware of the Nessie II vehicle is made up of two 22cm diameter cylindrical aluminium hulls surrounded by a protective metal cage. On hull contains the batteries, the other is dedicated to the electronics. An image of the vehicle can be seen in Figure 2.1. The vehicle is powered by four packs of ten alkaline GP476A batteries each amounting to 12V. The batteries are contained in their own separate vessel. Two packs of batteries are connected in parallel to supply 12V to the electronics. The other two packs are used to supply 12V to the motors.

The vehicle is controlled by 4 thrusters giving it a full 6 degrees of movement. These thrusters can produce 80W of power by using 19V at approximately 4.5A. They weight 700g in air and 350g in water. The thrusters are driven by four H-Bridges that are controlled using pulse width modulation (PWM). The PWM is created by the PIC18F6525 and has the capability of controlling the speed and direction of the thrusters.

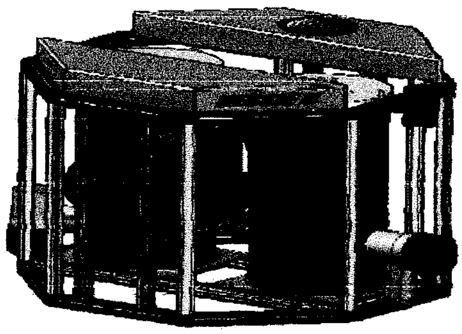

Figure 2.1: The Nessie II autonomous underwater vehicle

2.3 Seawolf II Autonomous Underwater Vehicle

Seawolf II was developed by engineering students at NC State University consist of three thruster providing propulsion in five degree of freedom (DOF) as shown in Figure 2.2. This vehicle triangular chassis is cut off from High-Density Polyethylene (HDPE), it was chosen based on cost, ease machining and rigidity. Surrounding the chassis are custom-fitted fiberglass flow-hulls, designed to present a uniform drag surface to the water. Fiberglass was chosen because of its ease of availability. Closed-cell urethane foam and lead fishing weights were attached to the hulls to tune trim and buoyancy.

Three Seabotix thrusters are mounted to the chassis. The two front thrusters, positioned on either side of the electronics tube, are able to rotate 120 degrees. The aft thruster is vertically mounted and aids the vehicle in rising/ diving and in controlling pitch. This configuration gives the vehicle a total of 5 degrees of freedom. The remote control also is used for monitoring and manual control of Seawolf II. The remote consists of GUIs that allow monitoring of broadcasted telemetry data and video and for sending control data such as target depth and controller gains [4].

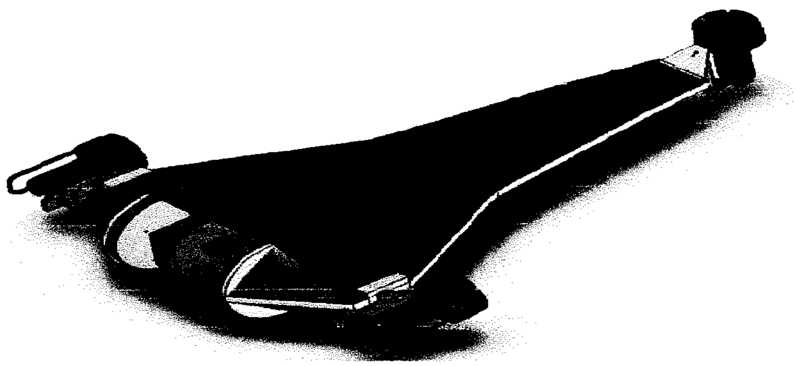

Figure 2.2: Seawolf II AUV

2.4 2009 Stingray AUV

After achievement elements of the 2008 Stingray have been retained and improved including the Stingray's signature flooded carbon - fiber hull and its distinctive propulsion system consisting of Voith - Schneider propellers and compact, custom - built thrusters. Additionally, many all new features and components have been added to the Stingray for 2009 including robust controls software, an all - custom - designed passive sonar system, and 3 - D printed wings and tail that improve the Stingray's weight and buoyancy as shown in Figure 2.3.

The Stingray implements two types of propulsion which are Voith- Schneider propellers and vertical thrusters. The Voith - Schneider propellers are a novel approach to underwater propulsion. By utilizing two of the Graupner 2358 Voith - Schneider assemblies in a counter rotating configuration, that with only two of these propellers, the Stingray can move forward or backward, strafe left or right, turn on a dime or any combination thereof. The vertical thrusters are used by the Stingray to control pitch, roll, and depth. A total of three vertical thrusters are used on the Stingray: one vertical thruster in each of the wings and one in the tail. Each thruster contains a Scorpion 22mm brushless motor with an attached 2 - blade RC boat propeller.

Totally, five DC brushless motors on the Stingray, where is three for vertical thrusters and two that drive the Voith- Schneider propellers. The waterproof procedure used on this Stingray involves disassembling each motor to apply a specialized conformal coating to the stator windings. Besides, to operate the Stingray autonomously, there are two control switches, one on the computer power switch and second ones on the kill switch. Both of these switches are potted in epoxy and operated magnetically.

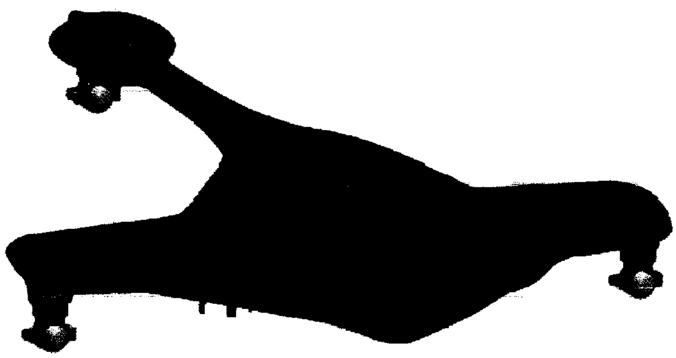

Figure 2.3: The Stingray AUV

2.5 The USAL-Submarine

The idea from the project of Mako is to build a second, smaller and lighter AUV that called USAL-Submarine. USAL developed this submarine as a toy in the beginning of the 1990s as shown in Figure 2.4. The submarine could be remotely controlled via a connection cable. It is about 60 cm long and weighs about 9 kg. The submarine is forced by a propeller in the back that is driven by a DC-motor inside the hull. Using a magnet coupling connects propeller and motor. Two pairs of rudders, which are driven by servomotors, can govern the direction of the movement. The video signal from a camera in the front bulb could be watched on a monitor.

Figure 2.4: USAL-submarine

The batteries, the camera and parts of the electronic were attached inside the USAL. A translucent front part of the submarine could also be acquired as well. The stern propellers were working. The servo motors for the rudders however were too weak to overcome the friction in the bearings. Lead weights and a rack that holds them were delivered with the submarine and could be used for trimming.