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TITLE: UNDERWATER VEHICLE BUOYANCY CONTROL (SURFACE)

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Bachelor of Electrical Engineering
(Control, Instrumentation and Automation)

Jun 2014

“I hereby declare that I have read through this report entitle “Underwater Vehicle Buoyancy Control (Surface)” and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)”.

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Supervisor’s Name : …………………………………………

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UNDERWATER VEHICLE BUOYANCY CONTROL
(SURFACE)

KHAIRUL HAFIZ BIN SHAFAD

A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Control, Instrumentation and Automation)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

“I hereby declare that this report entitle “Underwater Vehicle Buoyancy Control (Surface)” is the result of my own research except as cited in the references. This report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature :……………………………………………

Name : ……………………………………………

Date : ……………………………………………

Specially dedicated to my family, lecturers and friends.

Thanks for all the encouragement and support

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ABSTRACT

In general the Remotely Operated Vehicle (ROV) consists of two methods which are using thruster and buoyancy control. Since the thruster required high power demand, so this project will used ballast tank as buoyancy control based on the Archimedes principle. This project consists of three objectives which are to design a ballast tank, to design PID controller in order to improve the performance of the ballast tank, and to compare the algorithm system of the ballast tank between the system control level from surface and the system control level from bottom. Pressure sensor from model MPX4250GP is used in this project as control feedback system. Besides, pressure sensor also converts analog input to voltage (v) in order to compare with desired input set. In this project, mechanical design will focus on the construction of the ballast tank that can move the piston to pump water in and pump water out effectively. Next, PID controller will be implemented in the real hardware in order to improve the performance of the ballast tank. This PID controller will be design by using PID tuning method in the Matlab. Experiment results shown that the system with PID controller is able to perform better performance in term of rise time and settling time, and able to maintain disturbance up to 120g for 300rpm and 80g for 200rpm. At the end of this project, the algorithm system of the ballast tank have been compared between the system control level from surface and the system control level from bottom. It is found that future ballast tank can use both algorithms system (by switching) to control depth level based on suitable depth error.

ABSTRAK

Secara umum, “Remotely Operated Vehicles” (ROV) terdiri daripada dua kaedah iaitu dengan menggunakan pendorong dan kawalan keapungan. Oleh sebab, pendorong memerlukan kuasa yang tinggi, maka projek ini akan mengunakan tangki sebagai kawalan keapungan berdasarkan prinsip Archimedes. Projek ini terdiri daripada tiga objektif, iaitu untuk mereka bentuk tangki, untuk mereka bentuk pengawal PID untuk meningkatkan prestasi tangki, dan untuk membandingkan sistem algoritma tangki antara kawalan sistem dari permukaan dan kawalan sistem dari bawah. Sensor tekanan daripada model MPX4250GP digunakan dalam projek ini sebagai sistem kawalan maklum balas. Selain itu, sensor tekanan juga menukarkan masukan analog kepada voltan (v) untuk membandingkan dengan set masukan yang dikehendaki. Dalam projek ini, reka bentuk mekanikal akan di tumpukan kepada pembinaan tangki yang boleh menggerakkan omboh untuk mengepam air ke dalam dan mengepam air keluar dengan berkesan. Seterusnya, kawalan PID akan dilaksanakan dalam perkakasan sebenar untuk meningkatkan prestasi tangki. Kawalan PID ini akan di reka dengan menggunakan kaedah “PID tuning method” di dalam Matlab. Hasil ujikaji menunjukkan bahawa sistem dengan pengawal PID mampu melakukan pr estasi yang lebih baik dari segi masa naik dan masa penetapan, dan mampu mengekalkan gangguan sehingga 120g untuk 300rpm dan 80g untuk 200rpm. Pada akhir projek ini, algoritma sistem tangki telah dibandingkan antara tahap kawalan sistem dari permukaan dan peringkat kawalan sistem dari bawah. Ia didapati bahawa tangki masa depan boleh mengunakan kedua-dua sistem algoritma (dengan beralih) untuk mengawal tahap kedalaman yang berdasarkan kesilapan kedalaman yang sesuai.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

The aim of this chapter is to describe in general about underwater vehicles. The problem statement is identified based on regarding problem and the objectives are created in order to solve this problem statement. Then, the project scope will be mentioned the limitation of this project.

1.1 Project Background

Remotely Operated Vehicles (ROV) is essentially an underwater robot that is widely used in lot of underwater exploration such as industrial, marine study or work [1]. The ROV is used for operation either in hazardous environment or at high depths pressurized where human cannot withstand. The applications of the ROV can be seen in exploring hydrothermal vents, surveying archaeological sites, and fixing underwater infrastructure such as cabling and piping, mostly construction of oil facilities and offshore gas [1]. There are two mains part in the ROV which are mechanical part and controlling part that used to protect the electronic component. Figure 1.1 shows example of ROV prototype model. A ROV differs from autonomous underwater vehicle (AUV) in a way that ROV always take command from its operator and takes no action autonomously [2].

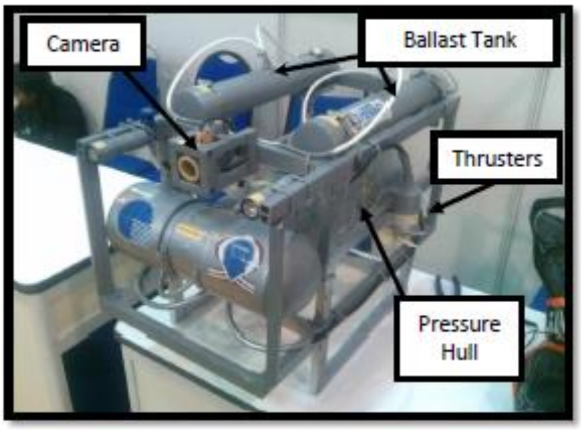

Figure 1.1 : Prototype of UTeRG ROV [3]

The main drawback in current underwater tasks performance is that, the components used such as thruster, lamp and camera consumed high power usage. Therefore, in order to solve high power consumption problems, one of the best ways is performing ROV operation without thruster [4]. Drawback of thruster also had proved by the research conducted by National Oceanic and Atmospheric Administration (NOAA) discover that the performance of the thruster become worst when reaching the saturated point at depth pressure is high[3]. Then, the ROV will no longer can be move downward at this saturated point. Since the thruster will not give good performance in underwater tasks, another alternative method to replace thruster is ballast tank. Ballast tank use the concept of the buoyancy force corresponds to displacement of water. When the ballast tank is filled with water, the ROV will add its weight, so the ROV will move downward. Other than that, by using ballast tank also can make the ROV travel deeper in the underwater application. Figure 1.2 shows the comparison of the performance.

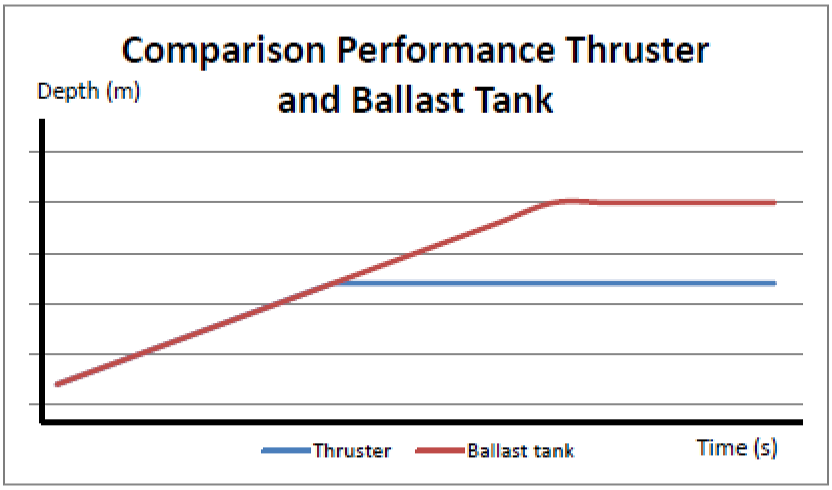

Figure 1.2 Comparison of thruster and ballast tank performance against depth[3]

Pressure sensor from model MPX4250GP is used in this project to detect the water level pressure and also used as feedback system in order to control the piston movement. Therefore, this pressure sensor can help the ballast tank to estimate and maintain at certain depth from the water surface.

1.2 Project Motivation

There a certain limitation when dealing with the underwater exploration such as risk of harsh environment and variety of problems. Figure 1.3 shows the relationship of temperature, salinity, and pressure when the depth is more increase.

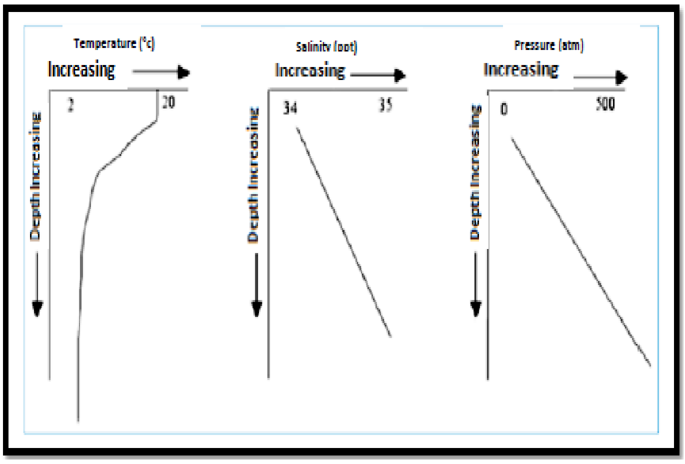

Figure 1.3: Variation of depth against temperature, salinity, and pressure [3]

Based on Figure 1.3 shows that temperature is decreasing when the depth increase. However, the salinity and pressure is increased linearly with depth increase. Human need to carry oxygen tank and suitable clothes in order to protect their body. This might possible to be not function and will cause risk to human. Hence, it is not suitable for a human to do an exploration under depth water level. Then, ROV will be used to replace the human in performing a high risk during underwater. Therefore, the main motivation of this project is to control the buoyancy of the ballast tank model.

1.3 Problem Statement

When performing underwater task, minimum power consumption is required to maintain at certain depth. There are two types of buoyancy control which is either using thruster or ballast tank. However, thruster required high power consumption to control buoyancy compared to ballast tank. Therefore, the ballast tank is more suitable to be used in this project to control buoyancy.

Based on the previous underwater vehicle final year project was developed by last year UTeM student, it seems that the objective to buoyant the remotely operated vehicle (ROV) in the desired depth was not achieved because the limitation design of ballast tank. The ballast tank was too small and can pump in the water only for a small quantity. Thus, the vehicle cannot achieve to maintain 5m based on the objective set. Therefore, the main goal of this project is to design the ballast tank based on the objectives set.

1.4 Objective (s) of the Project

The objectives of this project are to:

1. To design a ballast tank.
2. To design proportional integral and derivatives (PID) controller in order to improve the performance of the ballast tank system.
3. To compare the algorithm system of the ballast tank between the systems control level from surface and the system control level from bottom.

1.5 Project Scope

The scopes of work for this project are:

1. Design a new ballast tank in order to overcome last year's problem.
2. Using proportional integral and derivatives (PID) control system in (MATLAB) and Arduino microcontroller to improve performance of ballast tank.
3. The ballast tank movements only focus in one degree of freedom (up and down).
4. The ballast tank is tested at laboratory pool which has maximum depth of 1.2m.
5. The ballast tank can maintain up to 30cm for open loop system, while at 50cm at close loop system.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will describe general concepts about the underwater vehicles and the ROV. This literature review will explain the factor that affecting the buoyancy, type of sensor uses, types of ballast tank, stepper motor, and microcontroller. Besides that, this chapter also will review on other people research regarding to underwater vehicles using buoyancy concept. This chapter also will conclude the proposed design for this project after analyze all the facts, data, information, and study on previous research.

2.1 Underwater Vehicle Classification

There are two different categories to classify the underwater vehicles. These two categories are manned underwater vehicles (MUV) and unmanned underwater vehicles (UUV). The first category MUV is divided into sub-classes that are military submarine and non-military submarines. This submarine type allow human to descend into ocean to perform military task and gather information by observation [5]. Next, the second category UUV can be separate into two branches that are Autonomous Underwater Vehicles (AUV) and Remotely Operated Vehicles (ROV). AUV class is intelligence which allows it to perform task autonomously, while for ROV need remotely control by a human when performing some task. This project is in ROV class. Figure 2.1 shows the category of underwater vehicles.

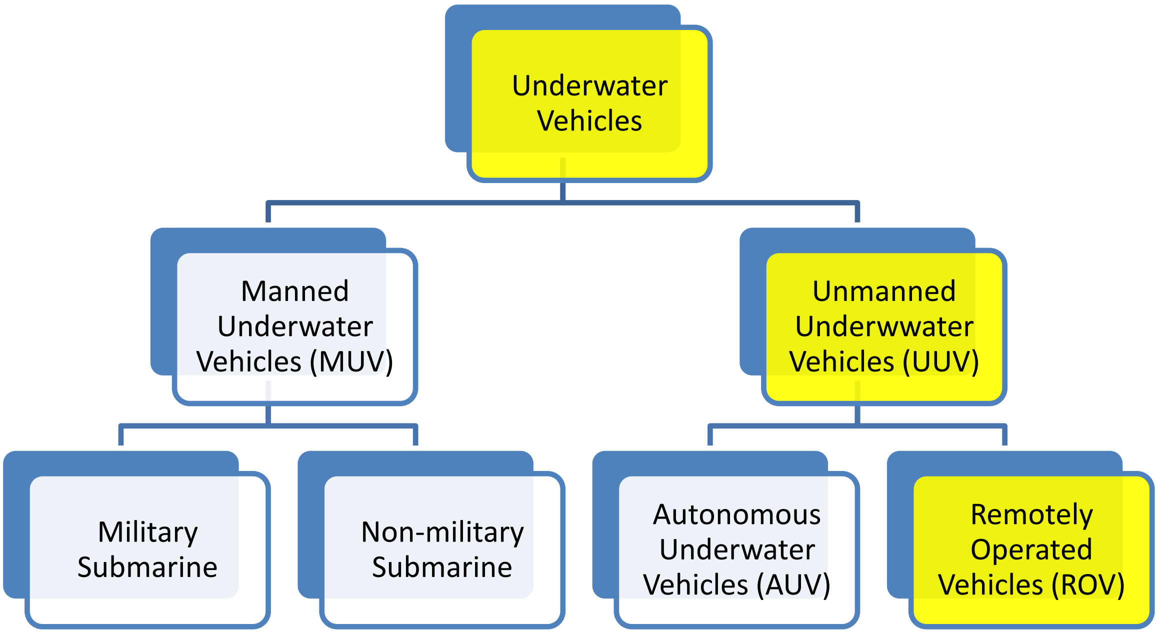

Figure 2.1: Underwater vehicles classification [5]

2.2 Factor affecting ROV Buoyancy Control

The factors such as buoyancy, stability, added mass, pressure and environmental force are needs to be considered when designing ballast tank. These factors will help to design a ballast tank that has a good performance and most important to meets requirement. Ballast tank is the practice adding, removing, or relocating weight of floatation on an underwater vehicle to correct its buoyancy and pitch and roll [6].